LANGUAGE ACQUISITION
IN WILLIAMS SYNDROME:
LEXICAL CONSTRAINTS AND
SEMANTIC ORGANISATION

submitted as PhD thesis by

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ABSTRACT

It has been commonly reported that WS individuals show 'bizarre' semantics. If this is true, one can predict differences in the way WS individuals learn new words. This thesis sets out to test this prediction. Lexical constraints on word-learning (after Golinkoff et al. and Markman) were tested on WS children and adults and on a wide age range of normal control children. Object scope constraints were present in a weaker form in WS individuals, but category type constraints were absent. All constraints were consistently demonstrated in normal controls between 3 to 9 years, i.e. a much wider age range than previous research. This points to later acquisition and weaker operation of constraints in people with WS, even in adulthood. The thesis used a variety of other experiments, both on-line and off-line, and demonstrated that semantics in WS are not 'bizarre'. Rather they are delayed in development, and apart from some subtle differences, WS adults tend to resemble the performance of normal 9 year olds.
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portrait of the author
by a child with Williams Syndrome
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part A

WILLIAMS SYNDROME
A.0 THE FOCUS OF THIS THESIS

Williams Syndrome (hereafter referred to as WS) is a rare developmental disorder. It was first identified on the basis of physical symptoms in 1961, but only in the last 10 to 15 years have researchers made inroads into describing its psychological profile. The following is a fair description of the common impression of the syndrome:

...a rare form of retardation called Williams Syndrome. The syndrome appears to be associated with a defective gene on chromosome 11 involved in the regulation of calcium, and it acts in complex ways on the brain, skull, and internal organs during development, though no one knows why it has the effects it does. The children have an unusual appearance: they are short and slight, with narrow faces and broad foreheads, flat nasal bridges, sharp chins, star-shaped patterns in their irises, and full lips. They are sometimes called "elfin-faced" or "pixie people," but to me they look more like Mick Jagger. They are significantly retarded, with an IQ of about 50, and are incompetent at ordinary tasks like tying their shoes, finding their way, retrieving items from a cupboard, telling left from right, adding two numbers, drawing a bicycle, and suppressing their natural tendency to hug strangers. But... they are fluent, if somewhat prim, conversationalists...

Language tests confirm the impression of competence at grammar; the children understand complex sentences, and fix up ungrammatical sentences, at normal levels. And they have an especially charming quirk: they are fond of unusual words. Ask a normal child to name some animals, and you will get the standard inventory of pet-store and barnyard: dog, cat, horse, cow, pig. Ask a Williams Syndrome child, and you get a more interesting menagerie: unicorn, pteranodon, yak, ibex, water-buffalo, sealion, saber-tooth tiger, vulture, koala, dragon, and one that should be especially interesting to paleontologists, "brontosaurus rex." One eleven year-old poured a glass of milk into the sink and said, "I'll have to evacuate it;" another handed Bellugi a drawing and announced, "Here Doc this is in remembrance of you..."
Complex grammar is displayed across the full range of human habitats... you can possess all these advantages and still not be a competent language user, if you lack just the right genes or just the right bits of brain. (Pinker, 1994, p.52-54).

This was written for a popular book, and to be sure, cuts corners in detail. Yet, if I summarise the picture that it presents, there is left a portrait in broad strokes that is the generally accepted view of WS: general retardation in most areas of cognition, with islands of spared ability in language and social skills; within language, syntactic ability is seen as relatively intact, whereas semantic ability is seen as being somewhat bizarre.

The syndrome is now known to have a genetic basis, with more recent research having shifted the focus of investigation onto a locus on chromosome 7 rather than chromosome 11. What excites researchers about WS is that it may offer a window into the relationship between language and the rest of cognition. Since WS may hold the key to a "general neural dissociation between lexicon and grammar" (Bromberg, Ullman, Marcus, Kelley & Levine, 1994), the gene or set of genes that is abnormal in WS is considered to be responsible not only for controlling the neural systems that underlie their semantic system, but those in normal development also.

The aim of this thesis is two-fold. Firstly, if the semantics of WS are in any way unusual, then it might be expected that the mechanisms that help language-learners to acquire and to organise new words might operate differently, if at all, in WS subjects. This is examined in a series of experiments in part B. Secondly, exactly how is the semantic organisation or access to semantics different in WS than in normal people. This is examined in a series of experiments in part C.

In the rest of part A, research to date on relevant aspects of WS is summarised, so that it can be ascertained just how accurate is the picture that

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1 I accept the view that use of the term "subject" in experimental psychology is somewhat paradoxical, in that it objectifies the people that we are testing, and seeks to flatten out any individuality that they may have as people. However, politically-correct terms such as "individuals with WS" are more cumbersome than the convenient "WS subject". For the sake of convenience alone, the latter is used throughout.

2 In a similar vein to the last footnote, use of the terms "normal" and "abnormal" are not meant to carry any judgmental or pejorative sense. Rather they are used as convenient shorthands for typically and atypically developing individuals.
Pinker and other researchers paint. Before proceeding with the main focus of this thesis, it is essential to characterise WS itself.

**A.1 WHAT IS WILLIAMS SYNDROME?**

In a rare congenital condition, WS, there is astonishing verbal (and social) precocity, and marked musical ability, combined with gross intellectual (and graphic) defects - an extreme scatter between different intelligences. The combination of linguistic giftedness with intellectual deficiency is especially startling: children with WS often appear exceptionally self-possessed, articulate, and witty, and only gradually is their mental deficit borne in on one. (Sacks, 1995, p.263).

WS is a rare disorder that occurs in around 1 in 20,000-50,000 live births (Martin, Snodgrass & Cohen, 1984). It was first described as a syndrome by Williams et al. (1961), and hence was given the name most commonly used today.

WS patients show a wide constellation of symptoms: medical and physical; biochemical; neurological; psychological. Although the neurological and psychological symptoms will obviously be the focus of this review, it is important to first classify the medical and biochemical symptoms. These are usually the basis for diagnosis of WS in a given individual. They also have lent themselves to other names for the syndrome. Often, earlier research may use these names to describe the disorder.

The name used often reflects the academic background of the researchers and the state of the art at the time: psychologists may use WS (WS), biologists and doctors may use supravalvular aortic stenosis (SVAS)$^3$, or use idiopathic infantile hypercalcaemia (IIH). In addition, in Europe the syndrome is often known as Beuren's syndrome, after work by Beuren (1972). Historically, the focus of research has shifted, and this is also reflected in the use of name (Jones, 1990). The initial documentation in the early fifties was of hypercalcaemia without apparent cause. The focus then shifted to the frequently associated cardiovascular problems such as SVAS, and Williams' paper that gave the name now most commonly used was researched during this period.

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$^3$ referred to as such in papers before it was recognised that SVAS does not necessarily co-occur with WS.
A.2 PHYSICAL SYMPTOMS

A.2.1 ELFIN FACIES

A facies is a pattern of facial structures. WS patients have a distinctive elfin facies, which is characterised by a wide mouth, full cheeks, a flat nasal bridge, retroussé\(^4\) nose and heavy orbital ridges\(^5\) (Joseph & Parrott, 1958), also by a long, smooth philtrum\(^6\), long neck, and flat malar eminences\(^7\) (Dilts, Morris & Leonard, 1990), also by a broad forehead, medial eyebrow flare, strabismus\(^8\), stellate\(^9\) iris pattern (Holmstrom, Almond, Temple, Taylor & Baraitser, 1990) and a rather pointed chin (Burn, 1986). Burn demonstrates that the characteristic facial features develop with age. What he terms a 'coarseness' of the face also develops with age, which could be described then as premature ageing of the skin.

Burn also writes:

**Whether or not these children have elfin facies is difficult to establish, for while examples of the syndrome are common, this author has never seen an elf. The term should be dropped.** (p.43)

Pinker (1994) adds:

**to me they look more like Mick Jagger.** (p.52)

Burn and Pinker's opinions notwithstanding, Jones and Smith (1975) and Kataria, Goldstein and Kushnick (1984) refer to the syndrome as Williams Elfin Facies Syndrome.

A.2.2 HYPERACUSIS

WS subjects often show an abnormal hypersensitivity to sound, known as hyperacusis. Arnold, Yule and Martin (1985) for instance reported that a majority of their WS subjects were "hypersensitive to electrical noises such as lawn mowers, vacuum cleaners, pneumatic drills and sudden noises such as bursting balloons or exploding fireworks...younger children tended to cry or

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4 retroussé: short and upturned
5 orbital ridges: the edges of the eye socket
6 philtrum: groove in the midline of the upper lip
7 malar eminences: visible cheekbone
8 strabismus: squint
9 stellate: star-shaped
scream while older children either block their ears or avoid the noise...children were also reported to enjoy some sounds. Listening to music is a favourite pastime for many" (p.55-56). Bradley and Udwin (1989) also report on a case study of a 43 year old WS subject who "did not like the noise of trains although he was to develop a great interest in trains" (p. 179). It is reported, however, that this hyperacusis tends to become less acute as the subject grows older (Marriage, 1994).

Parental questionnaires reveal that hyperacusis is very prevalent in WS. A survey of 65 subjects aged between 1 and 28 years showed that 95% had suffered from hyperacusis, and 61% from otitis media, inflammation of the middle ear (Klein, Armstrong, Greer, & Brown, 1990). In contrast, in the normal population, hyperacusis is extremely rare, at an occurrence rate of less than 1 in 1000 (Vernon, 1987). Hyperacusis is probably a diagnostic feature of WS, especially in younger subjects.

In contrast to the finding of Klein et al. (1990) that hyperacusis in WS is often accompanied by otitis media, Marriage (1994) in a sample of 54 WS subjects found no indication of any consistent damage to the peripheral auditory system linked with hyperacusis. She therefore argues that the hyperacusis must be of central system aetiology. Marriage links the hyperacusis shown by WS subjects to disturbance of the systems underlying serotonin (5HT) function. This is discussed in more detail in section A.3.2.

Work using a combined behavioural-electrophysiological approach has attempted to ascertain the possible effects of this hypersensitivity to sound on the development of systems in the brain relevant to language (Neville, Holcomb & Mills, 1989; Neville et al., 1993; Neville, Mills & Bellugi, 1994). This work is discussed in section A.17.

A.2.3 CARDIOVASCULAR ANOMALIES

Cardiovascular problems in WS patients are common. These may take a variety of forms, and it is not necessarily the case that any particular problem is associated with the syndrome. The cardiovascular problem that is most commonly connected with WS is supravalvular aortic stenosis\(^{10}\) (SVAS).

\(^{10}\) SVAS: narrowing of the aorta (major artery leading from the heart) above the aortic valve
These problems may surface in infancy or early childhood, but will persist into later life. Pagon, Bennett, LaVeck Stewart and Johnson (1987) noted SVAS present in eight of the nine patients that they examined, who ranged in age from 10 to 20 years. Morris et al. (1988) noted that vascular stenoses\(^{11}\) of pulmonary arteries often develop in older WS children. Zalstein, Moes, Musewe and Freedom (1991) review the various cardiovascular disorders that can co-occur with WS. There may also be disorders of the kidneys and renal system (Ingelfinger & Newburger, 1991).

A.3 BIOCHEMICAL SYMPTOMS

A.3.1 IDIOPATHIC INFANTILE HYPERCALCAEMIA (IIH OR IHC)

As the name suggests, IIH is an elevated level of calcium (hypercalcaemia), present in infancy (infantile) and not caused by any side-effect of treatment (idiopathic). Two forms of IIH can be distinguished: mild and severe.

Mild IIH is characterised by complete recovery following dietary treatment. Infants with mild IIH tend to have normal birth weights, equal sex distribution and no other characteristic features that are now associated with WS (Fraser, Langford Kidd, Kooh & Paunier, 1966).

Severe IIH is associated with other problems, which can be recognised from the list of various physical symptoms associated with WS. It is also sometimes distinguished from mild IIH by being called IIHF (IIH of the Fanconi type) as it was first identified and described by Fanconi. Many researchers have referred to the syndrome as IIHF (Udwin, Yule & Martin, 1987), although the titles of papers may often simply say IIH leading to possible confusion. Although it is likely that many children identified as having severe IIH or IIHF had also WS, it cannot be assumed that the two syndromes are exactly congruent.

In both IIH and IIHF, the elevated calcium level tends to return to normal, either after dietary treatment or simply over the passage of time. In IIHF (or WS), obviously, the other characteristic symptoms do persist.

\(^{11}\) stenosis: narrowing or constricture
A.3.2 SEROTONIN (5HT) SYSTEMS
- LINK TO CENTRAL HYPERACUSIS

As mentioned previously in section A.2.2, Marriage (1994) argued that the hyperacusis shown by WS subjects is central and not peripheral in basis. The aetiologies for the two forms of hyperacusis, central and peripheral, are probably distinct, as are the symptom profiles of the two. A common factor to all neurological conditions with hyperacusis is disturbance of the functions of the monoamine 5-HT (5-hydroxytryptamine) or serotonin. In WS, serotonin levels in the blood are significantly lower than in matched normal controls (Makwana, Barnes, Marriage, & Davies, under submission). Serotonin is also implicated as controlling 'auditory startle', an analogue to hyperacusis in animal research. It is likely then that 5-HT dysfunction is a probable cause of increased auditory sensitivity manifested as central hyperacusis in WS (Marriage & Barnes, 1995). As well as hyperacusis, serotonin dysfunction in other groups causes the following clinical symptoms: vomiting and failure to thrive; irritability; insomnia; constipation. These symptoms are also characteristic of young WS subjects.

A.3.3 HORMONAL DIFFERENCES

Although short stature characterises about half of individuals with WS, analysis of growth curves reveals a pubertal growth spurt in both sexes, just as in normally developing children. This spurt is regulated by coincident hormonal changes. Partsch, Pankau, Blum, Gosch and Wessel (1994) analysed hormonal regulation in 23 female and 33 male WS subjects. Although for most subjects, levels of hormones such as sex steroids and adrenal androgens were comparable to normal levels, for a significant minority, hormonal levels were considerably elevated. This avenue of research is too young for any significant conclusions to be drawn about the possible causes of these differences in hormonal levels on a genetic level, and possible effects of these differences on biochemical or even behavioural levels. Yet as many of the most striking features of the syndrome, such as great conversational fluency, often seem apparent only from puberty onwards, the possible effects of elevated hormonal levels may be worthy of investigation.
A.4 GENETIC PROFILE

There are various methodological approaches which can be used to investigate the genetic syndrome which can underlie and possibly directly cause the psychological syndrome.

A.4.1 TWIN STUDIES

One of the most prevalent methods of establishing that a particular syndrome may have a genetic underpinning is twin studies. Monozygotic (MZ) twins, as they have come from the same fertilised egg, have exactly the same genotype as well as sharing the same pre-natal environment in the womb. They also tend to receive similar attention and affection after they are born. Dizygotic (DZ) twins come from two eggs. They have different genotypes, but otherwise share all the above mentioned factors. Therefore any differences between MZ and DZ twins in the likelihood of both having a particular disorder (concordance) indicate that the disorder is likely to be genetic.

Unfortunately, the occurrence of DZ twins is small, and that of MZ twins even smaller. That, coupled with the low occurrence of WS itself, means that WS twin pairs will be rare. However, Murphy, Greenberg, Wilson, Hughes and DiLiberti (1990) report two sets of identical twins with WS. These were diagnosed on the presence in both of certain physical, behavioural, biochemical and cardiovascular manifestations. Pankau, Gosch, Simeoni, and Wessel (1993) report a case of MZ twins with variable expression of the physical and medical symptoms of WS.

There have been five reported cases of concordance in MZ twins for WS, and no cases of discordance. There have been no reported cases of concordance in DZ twins for WS, but there have been three cases of discordance (Crichton & Morgan, 1967 - based on IIH and SVAS; Neilson & Hossack, 1978 - based on SVAS; Hokama & Rogers, 1991). Although the number of pairs is still small, and many were identified on SVAS or IIH instead of WS itself, this is still indicative of a genetic disorder underpinning WS.
A.4.2 FAMILY STUDIES

Family studies involve searching for a pedigree where several closely related people all suffer from the same syndrome, but other relatives do not. The pattern of the pedigree may then indicate probable genetic mechanisms of inheritance. Morris and Moore (1991), who identified a parent-child transmission of WS, argued that WS shows an autosomal dominant pattern of inheritance. Sadler, Robinson, Verdaasdonk, and Gingell (1993) also found in 2 generations of a particular pedigree evidence for autosomal dominant inheritance in at least some cases of the syndrome. Cortada, Taysi and Hartmann (1980) identified mother-DZ twin daughter transmission of the syndrome, which to them suggested autosomal dominant, multifactorial or X-linked chromosome patterns of inheritance. As WS affects both sexes equally, it is unlikely that a pattern of X- or Y-linked chromosome inheritance is involved. It is likely then that inheritance is autosomal dominant or multifactorial. Were it multifactorial, it would remain unclear whether the same gene loci would be implicated in every case of the syndrome.

A.4.3 CHROMOSOMAL ABNORMALITIES

Family studies may also indicate a possible locus in the genotype for the syndrome. If two or more members of the same family show the same chromosomal abnormality and also display the syndrome, whereas other members of the family without that chromosomal abnormality do not display the syndrome, then that chromosome is probably the locus of the syndrome in the genotype. Loci on a number of chromosomes have been identified as possible candidates for the genetic basis of WS.

A.4.3.1 Chromosome 7

One line of attack has been to examine family pedigrees of SVAS. Ewart, Morris, Atkinson, Jin, Sternes, Spallone, Dean Stock, Leppert, and Keating (1993) demonstrated a link between SVAS and the elastin gene on chromosome 7. All family cases tested showed hemizygosity at the elastin locus. Other non-family cases showed either this pattern of inheritance with an abnormality at the elastin locus, or a new mutation consisting of a deletion of one allele at the elastin locus. Only the cardiovascular anomalies of WS

hemizygosity: state of having unpaired genes in an otherwise diploid cell.

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(including SVAS) can be directly explained by this genetic abnormality, although there may be some complex knock-on effect in phenotypic expression that leads to the other symptoms of WS. Links between SVAS and the elastin gene, precisely located at 7q11.23 have also been demonstrated by Olson, Michels, Lindor, Pastores, Weber, Schaid, Driscoll, Feldt, and Thibodeau (1993) and Morris, Loker, Ensing, and Stock (1993).

What, however, of a link between the 7q11.23 locus and WS itself? Three separate studies using both molecular analysis and FISH\textsuperscript{13} techniques have shown that there is a microdeletion at this locus in a majority but not all patients in a WS sample (Kotzot, Bernasconi, Brecevic, Robinson, Kiss, Kosztolanyi, Lurie, Superti-Furga, & Schinzel, 1995; Nickerson, Greenberg, Keating, McCaskill, & Shaffer, 1995; Lowery, Morris, Ewart, Brothman, Zhu, Leonard, Carey, Keating, & Brothman, 1995). The percentage of subjects in the sample, diagnosed clinically as WS, showing this microdeletion varied from 75% to 95% between studies. The evidence for implicating this locus is overwhelming, yet the fact that not all WS subjects show a microdeletion implies that there may be heterogeneity in the genetic basis of WS.

Ewart et al. (1993) also suggested that the severity of mental retardation seen in WS is related to the size of a microdeletion around the elastin locus. Thus crudely put, the more genes you lose the worse you are. It seems to me, however, that the deletion of a variable number of genes would not be likely to lead to a linear behavioural pattern in the phenotype.

If WS is associated with a hemizygous deletion including elastin locus (7q11.23) and contiguous genes, one would expect to find abnormal expression of elastin and laminin B1, and possibly acetyl cholinesterase (AchE) which is involved in metabolic pathways including elastin. Galaburda, Wang, Bellugi, and Rossen (1994b) examined the brain of an 8 month old WS subject fixed and stained for these markers. They found in infant laminin B1, CGRP, laminin and AchE in cerebrocortical neurons, but curiously no elastin. Testing for the density of these markers relative to matched controls is still under examination.

\textsuperscript{13} FISH: fluorescent in-situ hybridisation
A.4.3.2 Contiguous genes - LIM-Kinase1

Recent research has indicated that WS is also associated with deletion of a chromosomal locus contiguous to the elastin locus. This locus is associated with the protein LIM-Kinase1 (Frangiskakis et al., 1996; Tassabehji et al., 1996). Studies of families with this deletion alone, and not a deletion at the elastin locus, reveal a partial WS phenotype, with cognitive profile and vascular disorders similar to WS, but with no other syndrome features. This implies that the full range of the WS phenotype is expressed by not only an elastin deletion, but contiguous gene deletion also.

A.5 NEUROLOGICAL SYMPTOMS

A.5.1 BASIC NEUROLOGICAL SIGNS

Comparison was made of WS and Down Syndrome (hereafter referred to as DS) populations for basic or elemental neurological signs. The WS group had a high incidence of left hand dominance. It is not clear from the rest of the literature as to whether this was an oddity of this particular group or whether such dominance is typical of WS. If typical, it would have important implications; left-handers are much more likely to have certain language processing areas in the right hemisphere than right-handers (Bellugi, Poizner & Klima, 1989).

Head size, as measured by circumference and converted into centile scores for age, of the WS group was significantly higher than that of the DS group. The WS group had normal size heads for age whereas the DS group predominantly had microcephaly\textsuperscript{14}. The DS group also tended to have brachycephaly\textsuperscript{15} whereas the WS group had dolichocephaly\textsuperscript{16}. MRI\textsuperscript{17} scans showed that this dolichocephaly is also present in the brains of WS subjects, with relatively decreased posterior width and lengthened posterior to anterior distance (Bellugi, Bihrle, Jernigan, Trauner & Doherty, 1990; Trauner, Bellugi & Chase, 1989).

\textsuperscript{14} microcephaly: abnormally small head
\textsuperscript{15} brachycephaly: rounded or foreshortened head shape.
\textsuperscript{16} dolichocephaly: long-headed, the skull has a width <4/5 of the length
\textsuperscript{17} MRI: Magnetic Resonance Imaging
The WS group also exhibited generalised hypotonia\textsuperscript{18}, and evidence of cerebellar dysfunction. They displayed an intention tremor\textsuperscript{19} and midline balance problems (which can exhibit itself as difficulty in walking across uneven surfaces). They also had difficulty with oromotor\textsuperscript{20} skills. The WS group also frequently displayed hyperactive tendon stretch reflexes\textsuperscript{21} and positive Babinski signs\textsuperscript{22}. None of these symptoms were present in the DS group, although both groups had problems with fine and gross motor skills and co-ordination.

\subsection*{A.5.2 Neuroanatomical Signs}

Lucquid, Chantepie, Laugier, Garreau, and Sauvage (1990) conducted an analysis of early neuropsychological signs relating to WS, and also made three case studies of WS subjects. According to these authors, the clinical pictures presented parallel aspects of a frontal neuropsychological syndrome in adults. These would include psychomotor problems in development, functional problems in motor ability and personality, as well as neurological signs.

More recently, there has been much research on the anatomical profile of WS using Magnetic Resonance Imaging or MRI (Wang & Jernigan, 1994). In both DS and WS subjects, the overall cerebral volume is typically reduced to around the same level, 77\% of normal in DS and 80\% of normal in WS (Bellugi et al, 1990). However, the cerebellum, which typically grows later within the cerebrum, is differentially affected in the two groups. Cerebellar volume in DS is around 69\% of normal, in line with the general reduction in cerebral volume. This matches earlier findings by Crome, Cowie and Slater (1966), who found a general reduction in the volume of the cerebellum and brain-stem in DS. However in WS, cerebellar volume is typically unaffected, with perhaps only a 1\% reduction in volume (Jernigan & Bellugi, 1990).

\begin{footnotesize}
\begin{itemize}
\item hypotonia: general reduction or loss of muscular tonicity, the normal tension of muscles. As a result, muscles may be stretched beyond their normal limits.
\item intention tremor is an involuntary trembling movement that occurs when a voluntary movement is made.
\item oromotor: motor skills connected with the mouth, typically for talking.
\item Babinski reflex is a deep reflex in which the muscle stretch receptors are stimulated by percussing or tapping of the tendon of a muscle.
\item Babinski signs may include: extension of the big toe and abduction of the other toes instead of the normal flexion reflex to stimulation on the sole of the foot. This may indicate involvement of the pyramidal tracts. Other signs are more typically connected with hemiplegia, paralysis of one side of the body.
\end{itemize}
\end{footnotesize}
Using a MRI scan, Wang, Doherty, Hesselink and Bellugi (1992) and Jernigan and Bellugi (1990), measured the volume of the neocerebellar tonsils in WS subjects, in DS subjects matched for age, IQ and cerebral volume, and in chronological age-matched normals. Proportional to the cerebrum, the tonsils were preserved in size in the WS subjects and were thus larger than those of controls. Specifically vermal I-V area was not significantly larger than in controls, but vermal area VI-VII was enlarged. This was to an extent such that there was no overlap between WS subjects and controls of the range of ratios of VI-VII to I-V areas. Hence it can be concluded that these vermal areas of the cerebellum are specifically enlarged in WS (or show hyperplasia).

This is particularly interesting because numerous studies have shown exactly the opposite pattern in autism. Thus in autism, vermal areas I-V are the same as those in normal controls, but areas VI-VII are hypoplastic and show specific reduction in volume (Courchesne, Yeung-Courchesne, Press, Hesselink & Jernigan, 1988; Courchesne, 1991; Bauman, 1991). Courchesne, Bellugi & Singer (1994) characterise the neuroanatomical profile of WS as showing global anatomic damage with some islands of focal sparing (Wang, Hesselink, Jernigan, Doherty, & Bellugi, 1992), whereas that of autism involves islands of focal anatomical damage with apparent global sparing. The 'island' in question is the cerebellum and the vermal areas therein. Abnormality is present throughout the cerebrum in WS; cerebral volume is as great in the anterior cortical regions as in posterior regions, although one WS subject has demonstrated pathology in the occipital regions (Galaburda, Wang, Bellugi & Rossen, 1994a). In autism, there is little overall damage; rather, damage is localised to the parietal lobes.

The cerebellum has recently been implicated in control of higher cognitive functions. Earlier, it was considered to be involved only in motor control, for example in balance. Recently it has been suggested that the neocerebellum, which evolved to its largest size in man and the primates in line with the frontal lobes, may be involved in the regulation of emotion and the cognitive resources needed for the fluency and expressiveness of language (Leiner, Leiner, & Dow, 1989). This differentiation in volume of areas of the cerebellum which are preserved in WS and impaired in autism is particularly important.

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23 neocerebellum: the larger lateral portion of the cerebellar hemisphere, phylogenetically more recent than other areas of the cerebellum.
The cerebellum is implicated in regulating the growth in development of frontal and limbic areas of the brain. Jernigan, Bellugi, Sowell and Doherty (1993) found that whereas in WS subjects, frontal and cerebellar areas were relatively spared, in DS these areas and limbic areas were poorly developed. This, they argue, may go some way to explaining the different linguistic and social-cognitive profiles of the two syndromes, as the frontal and limbic areas are traditionally associated with language, and the cerebellum is implicated in regulation of emotional development (Trevarthen & Aitken, 1994). The parts of the corpus callosum that serve uptake to frontal areas were similarly damaged in DS subjects, whereas in WS subjects they are well preserved relative to normal controls (Wang, Doherty, Hesselink & Bellugi, 1992).

**A.5.3 NEUROCELLULAR DIFFERENCES**

Post-mortem examination of the brain of a 31 year old WS subject showed cytoarchitectonic anomalies including exaggerated organisation of neurons within layers, horizontal or vertical depending on the area; increased cell packing density throughout brain regions; abnormally clustered and oriented neurons (Galaburda, Wang, Bellugi & Rossen, 1994a). The unusual cellular differentiation, increased cell packing density, horizontal neurons and weak myelination suggests a developmental arrest between the end of 2nd trimester of intrauterine life and 2 years of postnatal life, which would involve interference with natural cell death, and an increased presence of neurotrophic factors, which stimulate neural growth.

Interestingly, one study has shown that in polymorphic analysis of the genome of autistic subjects, only one gene locus was found to differentiate significantly between this group and a group of normal controls. This locus is linked to the Harvey-RAS gene, which is involved in regulation of neurotrophic growth factors and thus indirectly affecting neural cell growth (Lelord, Herault, Perrot, Hameury, Lenoir, Adrien, Mallet & Muh, 1993). Once again, the main area of affect is the cerebellum. Given increasing neuroanatomical evidence (and psychological evidence to be discussed later) which paints autism as in some ways the opposite end of a continuum to WS, it is very relevant that this study describes autism as suffering a difference in genetic regulation of neurotrophic factors that may stifle cerebellar neural growth. The post-mortem study by Galaburda et al. (1994a) suggests that on this level of description too, WS may show the opposite phenotype to autism.
A.5.4 SUMMARY: NEUROLOGICAL PROFILE OF WS

On both a neuroanatomical level and a neurocellular level, three points constantly recur in describing WS. Firstly, that the abnormal profile of the syndrome on these levels arises through development - it is quite clear that this is a developmental disorder. Secondly, that as the cerebellum is implicated in development of neocortical, especially frontal and limbic, areas that are theoretically tied to linguistic function, it is unsurprising that it is cerebellar areas that appear to be relatively spared in WS. Thirdly, that many of the features of WS on both these levels appear to be directly opposite to those shown by autism.

A.6 - A.19 PSYCHOLOGICAL/COGNITIVE PROFILE

The following sections describe the features of the psychological and cognitive profile of WS.

A.6 VISUOSPATIAL PROCESSING

A.6.1 HIERARCHICAL VISUOSPATIAL PROCESSING

Hierarchical visuospatial processing is reportedly impaired in WS. For example, Thal, Bates and Bellugi (1989), examining two WS subjects of ages 1;11 and 5;6, noted that such was impaired. Specifically, this was an inability to reproduce five different block structures which the experimenter modelled for the subjects. This matched a similar deficit noted in older WS subjects by Bellugi, Marks, Bihrlle, and Sabo (1988). It is likely that the deficit in this task relates to a specific problem in WS in hierarchical visual processing.

Bihrlle, Bellugi, Delis and Marks (1989) examined one particular aspect of visuospatial processing, global versus local processing of hierarchical visual stimuli. In patients with unilateral focal damage, it has been demonstrated that those with left hemisphere damage have difficulty in drawing the local forms whereas those with right hemisphere damage have difficulty in the global forms. Bihrlle et al. examined WS and DS populations, neither of whom have localised cerebral damage.
The DS group concentrated on the global form of the stimulus, ignoring the local components, whereas the WS group demonstrated the opposite effect. This dissociation can also be seen in samples of WS and DS subjects' spontaneous drawing. Interestingly Bellugi et al. (1988) noted that WS subjects would often "talk themselves through the drawings", indicating perhaps that their linguistic ability is harnessed to help them through tasks that they find difficult. Bellugi et al. (1988) also note that in copying geometric figures, WS children could cope with straight lines and circles, but were unable to copy any more complex figures. Similar results for the hierarchical drawing task for WS subjects were found by Milani, Dall'Oglio and Vicari (1994).

Bihrle et al. (1989) claim that these results are "provocative, because, in the absence of focal unilateral brain damage, they suggest a relationship between language and components of visuospatial processing" (p.38). They make this claim because of the reported dissociations between linguistic and cognitive abilities in WS but not DS, and the reported association between the left hemisphere and linguistic capacity in normal subjects. However, the correlation between these does not imply causation from one to the other. There is also no firm evidence to suggest that the areas of the brain involved in language in WS are necessarily the same as those in normal subjects.

Bellugi et al. (1990) tested a WS adolescent group and a control DS group on another visuospatial task, the Developmental Test of Motor Integration (Beery & Bucktenica, 1967). WS subjects scored a mean age-equivalent score of 4;8 years whilst DS subjects scored a mean of 5;6 years. This difference was not significant, but Bellugi et al. (1990) note that the WS subjects demonstrated a selective disability on items requiring the integration of component parts. This difference again shows that WS subjects have problems in tasks integrating the relationships from parts to wholes of objects or hierarchical relationships.

A.6.2 FACE PROCESSING

Bellugi et al. (1988) demonstrated that WS subjects score highly on the Benton Face Recognition Task. This contrasts with a very low performance on what for normal subjects is a much easier task, the Benton Line Orientation task. Udwin and Yule (1991) matched WS subjects of mean age 10;4 (range
from 6;5 to 14;5) with DS controls on a recognition memory task, the Rivermead Behavioural Memory Task (Wilson, Cockburn & Baddeley, 1985). WS children scored significantly better on those items that included face recognition.

These kind of tests indicate that ability of WS subjects at facial recognition may exceed that which is normal for both their chronological and mental ages, in both pre- and post-adolescence (Bellugi et al., 1988; Karmiloff-Smith & Grant, 1992). This might seem paradoxical. Facial recognition is typically thought to involve holistic or global processing, but as was discussed in section A.6.1, WS subjects reportedly tend to focus on the components of a stimulus in visuospatial processing rather than the whole.

The existence of cases of prosopagnosia in focally damaged adult patients indicate that facial processing might be a modular ability rather than part of general visuospatial processing (Johnson & Morton, 1991). However, there may be alternative routes to solving the problem of recognising faces. WS subjects are almost as skilled at recognising faces presented upside-down as they are for faces presented in the normal orientation, unlike normal subjects (Bellugi et al., 1988). This skill could result from an alternative pathway in facial processing to that of normals, or possibly as a result of greater experience of faces caused by WS subjects' natural predisposition to attend to faces.

A.7 PERFORMANCE IQ VERSUS VERBAL IQ

Much of the literature on the overall cognitive profile in WS has concentrated on standard IQ tests and achievement measures, rather than examining specific cognitive and linguistic abilities. Even within these standard measures, there is conflict over whether or not there is a greater ability for verbal tasks as opposed to non-verbal tasks.

A.7.1 IS VERBAL IQ HIGHER THAN GENERAL PERFORMANCE IQ?

Even some of the earliest psychological studies of WS demonstrated that their linguistic ability seemed to surpass their general mental ability. For example, Von Arnim and Engel (1964) characterised their 4 case studies of WS
as having an unusual command of language combined with an unexpectedly polite, open and gentle manner.

A.7.2 STUDIES REPORTING A DISSOCIATION BETWEEN VERBAL AND PERFORMANCE SCORES

Many other studies have also suggested that verbal abilities outstrip nonverbal performance in WS. For example, Udwin, Yule and Martin (1987) tested 44 WS children with a mean age of 11;1 years and a range from 6;0 to 15;9 years. Subjects were tested on the WISC-R test (Weschler, 1976). 18% of children scored below floor on verbal subscales, compared to 34% on the performance scale. The remaining children had a range of verbal IQ from 45 to 109, with a mean of 62.4, whereas the range of performance IQ was from 45 to 73, with a mean of 55.9. For these children, verbal IQ was significantly higher than performance IQ. Analysis of the verbal subscales showed that performance on the Similarities and Vocabulary subscales was significantly higher than on the Comprehension, Arithmetic and Information subscales. These latter were no greater than scores on the Performance IQ subscale components.24

Another study showed that verbal ability was relatively better than performance ability, but implied that this was largely because performance scores were much lower than those of controls, rather than verbal scores being higher. Udwin and Yule (1991) compared WS children of mean age 10;4 (range from 6;5 to 14;5) with matched controls for age, sex, social class and verbal IQ, who had either DS or some non-specific developmental difficulty. The verbal IQ of each child was assessed using the WISC-R Verbal scale. Their level of cognitive ability was assessed using the full WISC-R Performance scale. The control group scored significantly higher on general performance ability than the Williams group, which was almost at floor level on these tasks.

24 All children tested by Udwin et al. had documented IIHF. These findings were also presented in an annotated form in Udwin, Yule and Martin (1987), with an emphasis on the possible relation to IIHF.
A.7.3 STUDIES SHOWING NO DISSOCIATION BETWEEN VERBAL AND PERFORMANCE SCORES

Many other studies have, however, shown no dissociation between verbal and performance ability in WS. Arnold, Yule and Martin (1985) examined 23 WS subjects with a mean age of 10:4 years, and a range from 7 to 12 years. Verbal and Performance IQs were assessed using the WISC-R (Weschler, 1976). No significant differences were found between verbal and performance scores, although verbal scores did often exceed performance and fewer subjects failed to score above floor on the verbal tests than on the performance tests. Arnold et al. concluded that there was no support for verbal ability being greater than performance ability. However, there was no demonstrable homogeneity in the scores for the group, which begs the question of whether some of the children included in the group had performance ability so low that it interfered with performance on the verbal tests. Other researchers using similar tasks have found no difference between verbal and performance IQ scores (Crisco & Dobbs, 1988; Kataria et al., 1984).

Bradley and Udwin (1989) tested a 43 year old WS subject on the WAIS-R scale. No significant differences were found between verbal IQ (60) and performance IQ (57) scores. However, as they point out, it may be that tests such as the WAIS-R and the WISC-R are not subtle enough to differentiate abilities of subjects at the lower ends of the scales.

A.7.4 POSSIBLE REASONS FOR CONFLICT BETWEEN STUDIES

There are a variety of reasons why studies have disagreed as to whether or not there is a dissociation between linguistic and general cognitive performance scores in WS. WS subjects may feel easier in more familiar surroundings and thus perform better. This familiarity may even arise if the same subjects are being used by the same researchers for a number of studies, as is the case with Udwin and Yule, for example. In more unstructured settings, WS subjects may be able to use alternative strategies based on their talent for mimicry or echolalia.

Inter-individual differences in WS may exist. Obviously, there is great heterogeneity in the general performance IQ scores and in the linguistic IQ
scores in WS. There is no firm evidence to suggest that the difference between the two is homogeneous across the syndrome.

Another important difference between the studies relates to the age of the subject groups examined. Kataria et al. (1984) used WS subjects aged between 1 and 6 years, whereas other studies have used WS adolescents and adults. There could be important developmental changes in the language domain between these two age groups, resulting in different linguistic abilities relative to normal children. It has indeed been argued that different developmental milestones exist in WS as compared to normal children (Thal, Bates & Bellugi, 1989).

Perhaps most importantly, inconsistencies between studies may be explained by the use of amalgamation scores like verbal IQ, which takes no account of within-domain differences. It is far better to assess the ability of WS subjects on specific tasks within the linguistic and cognitive domains. Such within-domain dissociations will be examined in sections A.10 to A.16.

**A.7.5 AN ALTERNATIVE METHOD OF MEASURING DISSOCIATION IN DEVELOPMENT**

An alternative way to measure the difference between linguistic and cognitive ability, also suitable for younger children, was developed by Mervis and Bertrand (1993). They tested 6 children with WS, whose mental ages ranged from 2 to 6 years. They also tested a group of DS and normally developing children of similar mental ages. They assigned a cognitive-linguistic index, based on performance on cognitive and linguistic elements of the Mental Scale of the Bayley test. Linguistic items included syllable production, linguistic imitation, language comprehension and language production. Cognitive items included object permanence, means-end relations, form boards, peg boards, block boards and drawing.
The index was calculated by the following equation:

\[
\text{INDEX} = \frac{\text{LINGUISTIC ITEMS PASSED}}{\text{LINGUISTIC ITEMS ATTEMPTED}} - \frac{\text{COGNITIVE ITEMS PASSED}}{\text{COGNITIVE ITEMS ATTEMPTED}}
\]

If linguistic and cognitive development are running exactly in parallel, then one would expect an index score of 0.00. A score of +0.05 was derived for normal children, suggesting then that if linguistic performance and cognitive performance is assumed to be at the same rate of development in normal children, then this index has a certain degree of validity. For DS children, the index was -0.210, suggesting cognitive performance in advance of linguistic performance. For WS children, the index was +0.239, suggesting the reverse. This again indicates that even in an earlier stage of development, WS subjects' verbal ability is in advance of their non-verbal cognitive ability, and that the reverse is true for DS subjects. This method could be usefully upgraded to include other linguistic and cognitive tests, after validation of the index with normal subjects.

**A.8 PIAGETTIAN MILESTONES**

Two of the developmental cognitive milestones identified by Piaget are seriation and conservation (Piaget, 1952). In seriation tasks, the subject must arrange a series of objects into an order dependent on their critical property, such as arranging rods of different lengths into ascending order of size. In conservation tasks, the subject must be able to recognise that certain properties such as weight, number and volume will remain unchanged after solely perceptual transformations. Bellugi et al. (1988) demonstrated that three WS adolescent subjects were unable to do either of these tasks.

**A.9 NUMBER**

Karmiloff-Smith (1992) reports on four case-studies of knowledge of number in WS adolescents. All subjects were able to recite the number sequence, presumably as they, like all children, initially learn this by rote. However, any computation in the number domain, no matter how simple, proved extremely difficult.
An example is counting up to nine objects arranged in a circle, a task in which normal 4 to 5 year olds perform at ceiling. WS adolescents were incapable of performing this task, apparently because they cannot remember where they started counting. Even a marker placed to help them on the first object counted proved of no assistance. It could be argued that the poor performance on this task results from their deficit in visuospatial memory. However, without being able to do a task as simple as this, it is difficult to see how they could perform any more complex arithmetical task.

Karmiloff-Smith also replicated findings of Bellugi et al. (1988) in demonstrating that WS subjects are incapable of conserving number.

A.10 CONCEPTUAL DEVELOPMENT

Johnson (Johnson, Carey & Levine, 1994; Johnson & Carey, 1996) has studied the processes of conceptual change and development in WS and normal children (verbal mental age-matches and 6 year olds) in the domain of intuitive biology. This domain consists of non-scientific knowledge about the 'facts of life'. The knowledge in this domain was divided into 2 batteries. The Enrichment Battery consisted of facts that could be elaborated on the existing conceptual knowledge of children younger than 5 years old. An example would be projecting animistic properties, e.g. having a heart, from one animal onto another. The Conceptual Change Battery consisted of knowledge that is normally developed by children between the ages of 7 and 12 years, which cannot be derived from knowledge bases tapped by the Enrichment Battery. An example would be predicting that a mammal such as a rat, could not live underwater since a mammal such as a dog could also not do so.

WS subjects matched their verbal mental age-controls on the Enrichment Battery, but only the younger control group on the Conceptual Change Battery. Johnson concludes that in this domain at least, the conceptual knowledge of WS adults is rather superficial, because WS subjects are incapable of conceptual development and change. There seems no valid reason as to why this particular knowledge-domain should be different from any other.
A.11 MEMORY

A.11.1 VERBAL MEMORY

Bradley and Udwin (1989) report a high score for the Digit Span subscale on the WAIS-R test for a 43 year old WS subject. The performance of WS subjects on repetition of nonce terms has also been tested. It appears that their ability on this type of task is not as high as for digits (Grant, Karmiloff-Smith et al., in press).

Karmiloff-Smith (1992) reports anecdotal evidence on the learning of lengthy amounts of verbal material by rote in WS. She taught one WS adolescent the capitals of a number of countries of the world, by giving first the country name, then the capital name. The subject had no problem in later giving the correct capital name in response to the country name, even for a country like Tanzania whose capital I would know only after several weeks spent reading the papers. However, this knowledge seems to be stored only in a mapping unidirectionally from country to capital. The subject, given the name of any capital even such as Paris, was not be able to say in which country that was. The information seems to have been learned and stored with no reference to any other relevant semantic knowledge that might be stored. This type of enquiry may yield results of important consequence for theories about how lexical and semantic knowledge is stored in WS.

Wang and Bellugi (1994) examined the double dissociation between sparing and impairment of verbal and visuospatial short-term memory in WS and DS. According to these authors, this dissociation across "two genetic syndromes" shows "neurogenetic" evidence for a double dissociation. This is perhaps too strong a claim. Given that WS is a developmental disorder, there is not enough known about the development of systems supporting these two domains of memory.

A.11.2 METAMEMORY

WS subjects are also weaker than normal controls in tasks involving metamemory - the understanding and management of memory and memory strategies (Bertrand, Mervis, Armstrong & Hutchins, 1994). WS subjects

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between 16 to 32 years of age were no better than normals younger than 5 years old on such tasks. They had difficulty in using novel memory strategies, but rather preferred rote-learning type strategies, and would only use this one strategy rather than varying methods to suit the task at hand. If they used a strategy external to themselves, they would anchor it on help from another person - "I'd get my mum to remember it for me" - rather than using an object-based strategy, like tying a knot in a handkerchief. This may, however, reflect the fact that many WS subjects are still dependent on their parents for help in everyday life even when adult; in this, they also resemble very young normally developing children but not normal adults.

A.12 LINGUISTIC ABILITY

A.12.1 LINGUISTIC ABILITY OF WS SUBJECTS

One may feel confident in postulating that there is a difference between the verbal IQ and performance IQ for WS subjects or at least adults, in that the verbal IQ exceeds the performance IQ. It is not enough to say, however, that WS subjects show a general superiority in linguistic skills, as compared to non-linguistic skills. This would show an across-domain difference in ability, and one might then feel confident in suggesting the presence of a language module. However, what is taken to be a general language superiority may result from differences in ability for WS subjects on various linguistic tasks, or within-domain differences.

A test of syntactic language ability such as the TROG, which examines comprehension ability of a variety of grammatical structures of increasing difficulty, may, in its total low score for a WS subject mask ability in certain micro-domains of language. Inspection of scores on the sub-units is necessary to give a truer picture of the linguistic ability of WS subjects.

Language ability can be examined within a number of different microdomains, all of which will of course be interrelated to some extent but can still be isolated for the point of study. One of the most important divisions in performance is that between comprehension of language and production. The knowledge base for language can be divided into morphosyntax, semantics and vocabulary (lexicon), as well as some sense of pragmatics.
A.12.2 PRODUCTION AND COMPREHENSION IN DEVELOPMENT

Thai et al. (1989) examined two WS children aged 5;6 and 1;11. Both were in the single-word stage of language acquisition. They were compared with a group of young normal children in a similar stage of language acquisition (mean age: 14.8 months), with a group of single-word stage children 6-18 months delayed (late talkers), and with a group of older normal children (mean age: 23.5 months).

The WS children both had a MLU of 1.00, compared to 1.8 for the older normal group. The younger WS subject had a productive vocabulary similar in size to that of the late talkers, and was also of a similar age. The older WS subject, however, had a productive vocabulary intermediate in size between those of the younger and older normal groups, although she was in fact much older than the older normals. She did not combine any words in production, which deviates from expected language development. This tallies with other anecdotal evidence that language production is delayed in development of young WS children.

Parental reports suggested that both WS children understood many more words than the young normals' group, who were at a similar stage of productive language. However, the younger subject performed poorly on an experimental task of language comprehension, a two-way forced choice picture identification task. The experimental performance of the older subject matched those of the older normal and late talker groups. One would expect that the experimental task is more divorced from a supportive context than any comprehension situations in the child's home, on which the parental report is based. Thal et al. suggest that "both WS children performed best in conditions in which they could use rote or holistic strategies successfully" (Thal et al., 1989, p.497).

A.12.3 NARRATIVE ABILITY AND EXPRESSIVE LANGUAGE

Older WS subjects, however, do demonstrate superior expressive language skills relative to their general cognitive profile. For example, a subject of say 18 years asked to draw a bicycle will struggle for some time to produce a few squiggles, which then they may go on to label as the various parts of a bicycle. Asked, however, to describe a bicycle, they will speak
fluently for many minutes on what a bicycle is, what it does, what it is like to ride, in fact any subject related to the theme of "bicycle". However, this fluency may paradoxically mask a lack of comprehension of the conversation subject (Bellugi et al., 1988).

Bradley and Udwin (1989) report a case study of a 43 year old WS subject. Analysis of a 30-minute unstructured conversation between subject and experimenter revealed that the subject contributed relatively more to the conversation. However, 12% of utterances were at least partly unintelligible, 17% contained hesitations and reformulations. As seems characteristic of all WS adult conversation, 11% of utterances could be classified as filler words with little content such as 'Well', 'Actually' and 'Really'. Over 20% of the utterances also contained clichéd idioms such as "Justice will be done...Let's say mum's the word...Well, let's put it like this...As true as I sit here" (p.181).

Arnold et al. (1985) derived age-related scores for expressive language and verbal comprehension from the Reynell Development Language Scales (Reynell, 1977) for 23 WS subjects with a mean age of 10;4 years. The mean score for expressive language was 5;9 years and for verbal comprehension 5;5 years. The range of scores was similar, but the greater difference on expressive ability was significant across the group. For most of the subjects, care-givers remarked on their talkativeness although during testing, subjects were not particularly loquacious. Care-givers reported that subjects would talk "excessively to gain adult attention, often talking nonsense or appearing to mimic others" (p.53). It may be then that the pressures of the experimental situation affect the productive ability of WS subjects. Alternatively, subjects may use language for a different function than communication, for example to gain attention. This ability would then not be tapped on a scale such as Reynell's.

Udwin and Yule (1991) suggest that this propensity to use social filler phrases and other such devices is not necessarily characteristically consistent with the syndrome. Rather, it may be a property of a subgroup of WS which they deem hyperveral or like 'cocktail party syndrome' (CPS). They analysed the spoken language of 43 WS children of mean age 11;1 years, with a range from 6;0 to 15;9 years. Of these, only just over a third demonstrated CPS properties in speech. These children were more verbose, and used significantly more rhetorical questions, evaluations and explanations. They
also used more social phrases and filler words. Non-CPS WS children used significantly more simple identification phrases. Udwin and Yule also compared the speech of the WS group as a whole to that of matched DS controls. They found no significant differences in the range of communicative functions used. Nor did they find any difference in the amount of repetition of adult utterances used by the two groups. The WS group did, however, use more idioms, social phrases and filler words than the DS controls.

Udwin and Yule attempted to differentiate characteristics between the CPS and non-CPS WS subjects, and could find no significant differences between the two groups. Importantly however, they do note a non-significant trend for the CPS subjects to be older than their non-CPS counterparts.

**A.12.4 AFFECTIVE CONTENT OF NARRATIVE**

Reilly, Klima and Bellugi (1991) compared the ability of WS subjects to construct a narrative based on a wordless picture book. Controls of matched DS children and normal children of ages 7-8 years (same mental age) were used for comparison. Reilly et al. attempted to measure what they deem the 'evaluative function' of narrative, where paralinguistic devices such as affective prosody, gesture and facial expression are used to enhance the affective or dramatic effect on the audience of the story told.

Previous work by Reilly (1990) had established a developmental trend in the use of affective prosody and other such devices in story-telling by children. Young children of ages 3-4 years would provide a highly affective narrative that was often structurally incomplete and hard to follow. 7-8 year old children in contrast provide narratives that are structurally coherent but lack much use of paralinguistic devices. The resulting stories are rather bland, no matter what age their audience. However, 10-11 year old children can provide a structurally coherent narrative but also can increase the affective content of their speech if they are addressing it to a younger audience.

Reilly et al. first established that if only the purely propositional element of narrative was taken into account, then the average narrative produced by a WS subject was twice that of a DS subject. All WS narratives also provided an orientation for the audience, giving an indication of time.
and place, and the majority also used a phrase to indicate that a story was being told, such as "Once upon a time".

Measures of the affective prosody taken were of pitch changes, vocalic lengthening and modifications in volume. The index derived for each of the groups showed that WS subjects produced significantly more affective prosody similar to normal 10-11 year olds than both DS subjects and normal 3-4 year olds. There was no significant difference between the latter two groups. All these three groups provided more prosody than normal 7-8 year olds.

WS subjects used a variety of lexical expressions to convey affect. None of the pictures in the book provided clues for the use of these. Examples of each are:

Affective states: And ah! he was amazed.
Character speech: He goes, Ouch! oh uh get outta here bumblebees!
Onomatopoeia: And the light goes ching.
Audience hookers: Suddenly, the frog jumped out.
Emphatic markers: The boy searched and searched and searched.
Mental states: He was wondering where the frog was.
Inferences: It was nighttime.
Causality: The boy got mad because he licked his face.

Of these devices, all types were used significantly more by the WS than by the DS subjects. Most were also used more by WS subjects than the normal controls. Only in the use of emphatics and causality did normal controls come close to or actually exceed the usage of WS subjects.

Reilly, Harrison and Klima (1994) in a similar study found that WS subjects outperformed both DS and mental age-matched normal controls on the use of evaluative devices that encoded affect; these were not merely imitative, but rather "hyperexpressive", demonstrating empathy of speaker to listener.

A number of studies have demonstrated DS subjects to be superior to autistics in their ability to produce social communication and to be aware of

the pragmatics of language use (Beeghly & Cicchetti, 1987). As WS subjects seem to exceed DS subjects and normal subjects in the expressive and affective use of language, this provides more evidence for a theory that WS and autism may lie at opposite ends of a continuum of ability in social cognition and communication.

A.13 SEMANTICS

Some anecdotal evidence exists regarding observations of unusual language production in older WS subjects. Intuitively it appears that these may reveal something about the categorical structure of the lexicon in WS. Subjects may demonstrate interesting substitutions of words. For example, when finishing a glass of milk, one WS adolescent said "I just evacuated my glass" (Bellugi et al., 1988). There seems to be no detailed corpus of observational work of such productions, but examples such as these suggest that links between entries in the lexicon may be over-represented.

A.13.1 VOCABULARY

A number of studies have reported anecdotally that WS subjects often have unusually large vocabularies compared to normal children of a similar mental age. For instance, Bellugi et al. (1988) collected various examples of unusual words used by three WS adolescents. All usage tended to appear in the correct semantic and syntactic context.

Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test - Revised. All three subjects achieved scores only a few years below their actual chronological age and much in advance of their performance mental age.

On being asked to define common words on the Oral Vocabulary subtest of the Test of Language Development, subjects performed slightly worse than the mean for their ages, largely because their definitions did not always include the most salient features of the word defined. Often instead they would use experientially-based anecdotes. For example when asked to define "sad", one responded:

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27 The sense in which "over-represented" is used will be discussed in part C.
When you lost somebody that you love and care about. It means something happens to you like your grandmother died or some part of your family or your cousin (p.185).

Bellugi et al. also assessed the fluency and speed with which names of objects could be accessed automatically, using the Clinical Evaluation of Language Functions - Subtest 9: Producing Word Associations. In this test subjects are asked to provide as many words as possible from a particular category, such as animal names, in one minute. An example of one subject's response to this was:

Sea lion, zebra, hippopotamus, lizard, beaver, kangaroo, chihuahua, crocodile, tiger, owl, turtle, reptile, frog, giraffe (p.186).

As is reportedly common to most of the subjects' responses to this test, the examples generated are not always general subclasses of animal but unusual and often nonprototypical examples of animals. Given the apparent delayed onset in language ability, it is intriguing as to how and by what processes WS subjects are able to acquire such a rich and varied vocabulary as reported here. Are these processes the same as those that operate in lexical acquisition by normal subjects?

A.13.2 UNDERSTANDING OF METAPHOR

Experimental evidence cited by Karmiloff-Smith et al. (1995) suggests that older WS subjects are capable of explaining metaphor. For example, a 19 year old girl asked to explain "you're like a ship without a captain" at the end of a story responded:

Well, the ship doesn't know where it's going, therefore it means that he doesn't know what he wants. (p.202).

A.13.3 OTHER SEMANTIC FIELDS

Rubba and Klima (1991) examined the use of prepositions by three adolescent WS subjects. They had a data-set of 130 prepositions from samples of speech produced by the subjects. It should be noted that the speech samples were generated spontaneously by the subjects, in the form of two short narratives and various other miscellaneous sentences which Rubba and
Klima take out of context. One cannot therefore be certain exactly how representative these data actually are of WS production of prepositions. Out of the 130 tokens produced, the experimenters judged that 25 tokens were divergent from normal usage, around 20% of the total. The other 80% of tokens used were judged to be in correct usage, and covered a variety of domains, both abstract and concrete usage. The subjects also seemed to demonstrate polysemy, where a particular preposition such as 'to' is used in a variety of different senses. These would correspond to normal adult usage of such prepositions.

All the deviant uses of prepositions noted were either substitutions, choice of a different preposition than would be expected, or omissions, not using a preposition where its use would be expected. However, certain deviant uses were repeated, with several substitutions in the same sense of through and for, and many omissions of to.

However, it is difficult to draw much of a conclusion from Rubba and Klima's paper. They compare their WS preposition data-set to that of normal adults, although they acknowledge that a comparison with normal children would be more apt. It has been demonstrated that children may overextend and misuse systematically various prepositions (Clark & Carpenter, 1989).

The impression to be garnered from their data set is that throughout each narrative there seems to be one major systematic error, which the subject seems to repeat in every situation where at least some part of the conceptual representation of the situation described is similar to that before. For example: "he looked through his boots" and later in the same narrative "he looked through his slippers", where the correct usage would instead be in. This would be consistent with the notion that the representation of the lexical item through is not linked to all the other possible representations relating to the mental model of the situation (Garrod & Sanford, 1987).

A.13.4 SUMMARY OF SEMANTICS

The discussion of the semantic abilities of WS has been limited here, as it will be examined in full in the introduction to part C. More recent and systematic studies by Rossen et al. (1994) and Scott, Mervis, Bertrand, Klein, Armstrong and Ford (1994), which examine in particular productions by WS
subjects in the word-fluency task, will also be discussed. Research discussed in this section does suggest that there are very interesting differences in semantic use between WS subjects and matched normals. Whether this is a true characterisation of the semantic abilities of individuals with WS will be examined in the experimental sections of part C.

A.14 MORPHOSYNTAX

A.14.1 COMPREHENSION AND PRODUCTION OF COMPLEX GRAMMATICAL STRUCTURES

Bellugi et al. (1988) assessed grammatical comprehension using the Test for Reception of Grammar or TROG test (Bishop, 1983). In this, subjects are required to select from an array of four pictures the one that corresponds to a sentence spoken simultaneously by the experimenter. That sentence will contain a complex grammatical structure, such as a passive or relative clause. Sentences are grouped into blocks of four; each block tests one particular grammatical structure. Under the strict scoring criteria, if the subject gets one sentence wrong, then the whole block is failed. The age-equivalent scores for the three adolescent subjects tested were at verbal mental age levels. However, some of the failed blocks involved failure on only one of the four items tested in that block. WS subjects were at ceiling for structures such as passives and conditionals. The weakest area appeared to be that of negation, although WS subjects still scored better than the DS controls on this subset.

A production test of syntactic ability, the Sentence Completion test, used by Bellugi et al. (1988) demonstrated that although scores were again comparable to the verbal mental age of the subject, particular errors were made. These included absence or incorrect use of grammatical markers, incorrect choice of lexical items, and predominantly incorrect pronoun use.

This would suggest that WS subjects do have ability in the grasp and use of complex grammatical structures. In narrative production too, WS subjects at least match mental age-matched normals and outperform DS controls on use of complex syntactic constructions (Reilly, Harrison & Klima, 1994). However, there are examples of areas of syntactic ability where WS subjects have serious problems. One such is that of grammatical gender in
French, another is the formation of irregular plurals in English (and also tested in German).

**A.14.2 GENDER AGREEMENT, VERB PAST TENSE FORMATION & NOUN PLURAL-SINGULAR FORMATION**

French-speaking WS subjects are poor on tests of grammatical gender (Karmiloff-Smith et al., 1997; discussed also in Karmiloff-Smith, 1992). Gender in French can be assigned from noting the appropriate article or can be guessed from the partially regular system of phonological oppositions on word endings (e.g., -on/-onne). WS subjects made significantly more errors in assigning gender to nonce words than normal controls (of younger verbal mental age). Given that normal children succeed on gender tasks at age 4-5 years, this points to an aspect of morphosyntax particularly impaired in WS.

The microdomains of morphosyntax in WS that have been most tested are those of regular/irregular verb past-tense formation and regular/irregular noun plural formation. These have been the focus of much research with other syndromes, because of a theoretical debate as to whether such formations follow a singular route for both regulars and irregulars, or a dual route (Pinker, 1991). WS subjects tend to have more problems with the irregulars, whether verb past-tense formation (Pinker, 1991; Bromberg et al., 1994) or noun plural-formation (Bromberg et al., 1994; see also Gosch, Pankau & Städing, 1994, for results in German). Often, WS subjects "over-regularise" the irregulars, producing such forms as "goed" or "mouses". This is taken as evidence not only for the dual-route theory, but also that WS subjects have intact morphosyntactic systems but unusual lexical retrieval.

This research is rather like "the mouse that roared". The claim, that morphosyntax is intact in WS but semantics deviant, seems often to be trumpeted on the basis of these studies alone. What is not clear is the extent to which such over-regularisations are produced in spontaneous speech. My own experience, admittedly anecdotal, suggests that over-regularisation is extremely rare. The question then is whether the protocol of these experiments primes WS subjects in some way to focus on the rules of regular ending-formation, leading to task-specific over-regularisation.
A.15 PRAGMATICS

Many reports also suggest that WS subjects may have a favourite topic of conversation or fascination with a particular subject. For example Udwin et al. (1987) state that over half of their sample of 44 WS children were obsessed with objects or topics such as machinery, electrical gadgets, trains, refuse and babies! Anecdotal evidence also exists that WS subjects in conversation may have difficulty in maintaining a topic of conversation set by their conversational partner. There is nothing else known as yet about the pragmatic skills of individuals with WS.

A.16 RELATIONSHIP BETWEEN LINGUISTIC DEVELOPMENT AND PARTICULAR COGNITIVE ABILITIES

A.16.1 OBJECT CATEGORIES AND LABELS

Mervis and Bertrand (1993) found that all three groups of children that they examined - WS, DS and normal subjects - used basic-level object labels to apply to basic-level or child categories. An example they give is that of ball. A basic-level category, they argue, like all categories is based on the relation between form and function. As form-function relations, such as spherical versus rollability of a ball, are most salient at the basic level, these categories are formed and labelled first. This is in accordance with the work of Markman (1990) and others, which suggests that basic-level categories are the most primary for the child, although Markman would claim that this primacy is based on a hard-wired default bias rather than on a default bias based on perceptual and experiential saliency. Mervis and Bertrand then conclude that this primacy of the basic-level in both early cognitive categories and early linguistic labels is a universal across all groups, or at least those tested so far.

A.16.2 SPONTANEOUS EXHAUSTIVE SORTING, FAST-MAPPING AND THE VOCABULARY EXPLOSION

Exhaustive sorting is the separation of a set of objects from various categories into groups of objects of a similar basic-level category. Cross-sectional and longitudinal data from normally developing toddlers and from children with DS indicates that spontaneous exhaustive sorting coincides
with the vocabulary spurt, the time when the number of words that children produce and comprehend suddenly and exponentially increases.

Mervis and Bertrand (1993) examined 6 WS children. Five of the six had undergone some kind of vocabulary spurt, but none of them at that time could sort exhaustively. This skill was only acquired by two of the children when their vocabularies reached around 500 words.

Fast-mapping is defined by Mervis and Bertrand (1993) as "the realisation that if you hear a new word in the presence of a group of objects, including an object for which you do not yet have a name, the new word is probably the label for that object" (p.6). The term "fast-mapping" is used in other senses in psychology, but all usage in this thesis follows the above definition of Mervis and Bertrand. Fast-mapping would then correspond in Markman's terminology to a combination of the whole object assumption and the mutual exclusivity assumption (Markman, 1990). Mutual exclusivity is the bias that an object cannot have more than one name; the whole object assumption is the bias that a novel label heard in the presence of an object refers to the whole object and not to any of its features.

Data from normally developing children and DS children indicate that for both these groups, the appearance of fast-mapping coincides with the onset of spontaneous exhaustive sorting. This is also true for WS, despite there being no apparent link in WS between the onset of spontaneous exhaustive sorting and the vocabulary explosion. Fast-mapping therefore does not coincide with the vocabulary explosion in WS. Although fast-mapping may be one method of quickly increasing one's vocabulary, and indeed be used by normal and DS children, it is not in fact the only one. WS children must use some alternative method. Mervis and Bertrand speculate that this might be an increase in the auditory short-term memory for words, or that it might involve giving more attention to verbal input. As was discussed in section A.11.1, WS subjects do seem to have a good ability to recall verbal material.

It is important to point out, however, that what Mervis and Bertrand deem to be one process - fast-mapping - has been separated into two processes by Markman and others, the whole object and mutual exclusivity assumptions. Failure in fast-mapping does not necessarily imply that both of
the latter biases are also not present in WS. The correlation in normal
development of fast-mapping and success in reaching the vocabulary
explosion does not imply that both processes involved in fast-mapping are
needed for that success. Testing for the presence of both processes in WS
children will be valuable.

The two constraints on lexical acquisition of the whole object
assumption and mutual exclusivity are taken by Markman to be essential for
fast establishment of reference for a novel word. Without them, the child
should be unable to acquire new words quickly. And yet WS children,
although their acquisition of language appears to be delayed, can increase
exponentially their vocabulary before the fast-mapping ability appears to be
present. The question to which I will return in part B is whether these
constraints in acquisition are actually essential in normal children for learning
new words quickly. If they are used by normal children to help their lexical
acquisition, then clearly WS children are using different strategies to learn
new words. And the question, around which much of my thesis will be based,
is to discover what these are. I will discuss these issues in part B.

A.16.3 POINTING/ GESTURE

Thal et al. (1989) also compared their two young WS subjects to their
control groups on tasks involving single gestures and gesture-combination.
These again seemed to be easier for the WS subjects when a supportive
context was present. In comparison with the normals and late talker groups,
the older WS subject performed both tasks at a similar level. However, the
younger subject on the single gesture task performed closer to the late talkers,
and was only at the level of the young normals on the gesture-combination
task, i.e. almost at floor.

Mervis and Bertrand (1993) examined the relation of pointing gestures
and referential speech, such as a referential object label. Normally developing
children, as well as their DS controls, produced pointing gestures in advance
of referential speech. For WS children however, the reverse was true. All 6
children started producing referential speech in advance of pointing gestures.
For Mervis and Bertrand, this implies that the link between pointing and
referential language is not universal. A dissociation between referential
language and pointing is also shown in work by Goodman (1994), where
although WS children aged 3;6 had a larger vocabulary than DS controls, they lagged behind in use of deictic gesture. Pointing may be one method of establishing joint attention, which they posit is essential for the emergence of referential language. It is, however, not the only method. Alternatives include the use of eye gaze, by both children and caretakers, and the more direct placement by the caretaker of the relevant object where the child is already attending. Mervis and Bertrand speculate that WS children must use one of these alternative routes for establishing joint attention, such as comprehending eye gaze. A question yet to be answered is whether WS children are able to produce words before they are able to comprehend eye gaze.

A.16.4 DEVELOPMENT OF JOINT ATTENTION IN WS

Bertrand et al. (1993) have charted the development of joint attention in one WS child from the age of 1;8 to 2;8 years. In normal children, there are three phases of attentional development. In the first phase, typically from 1 to 6 months, infants are focused on interactions face to face. In the second phase, typically from 6 to 9 months, infants will attend to objects as well, but this object-directed attention will preclude any person-directed attention. Only in the third phase, typically from around 9 months, will infants begin to engage in joint attention, where they can regulate interaction of attention between a person and an object. As infants grow older, they increase the time they spend in co-ordinated joint attention looking at person to object to person (Bakeman & Adamson, 1984).

The WS child observed had at first what Bertrand et al deem "an inordinate fascination with faces"²⁸, and would gaze at the faces of other persons, with a preference for the unfamiliar. It made no difference how much they tried to get her to attend to other objects. This face-oriented attention differed from that displayed by normal infants up to 6 months in that it was passive; she would make no attempt by use of gesture, vocalisation or facial expression to engage with that person. Any experimenter who has worked with WS will know that this propensity to fixate on an unfamiliar face, like that of the experimenter, to the exclusion of anything else, like the experiment, is present in WS subjects of all ages!

Only from the age of about 2;2 years did the subject begin to spend a large proportion of time engaged in joint attention. Before that only a small proportion of time was spent in joint attention. In this advanced period, the amount of time spent in joint attention corresponded to that spent by normal 18 month olds, of the same general mental age as the WS subject.

Analysis of development of the size of the vocabulary of the subject indicated that a vocabulary explosion had occurred before the subject began her period of co-ordinated joint attention. Bertrand et al. speculate that this might be because the subject's caretaker took advantage of any small time spent in joint attention in the earlier period to present object labels to the child. It might be of course because WS subjects utilise an alternative route not requiring joint attention to start to produce referential language at the rate seen during the vocabulary explosion.

A.17 ELECTROPHYSIOLOGICAL RESEARCH: INVESTIGATING RELATIONSHIP BETWEEN LINGUISTIC ABILITY AND FUNCTIONAL NEUROANATOMY

A.17.1 ELECTROPHYSIOLOGICAL WORK IN WS

Measurement of 'brainwaves' is a recent addition to methodologies used in neuropsychology. The electrical activity of neural systems in response to various mental activities can be measured, over a time-course of milliseconds. The resulting waves of changing electrochemical potential in neural systems that can be measured are known as Event Related Potentials (ERPs). This technique can be used to index the temporal activity and gross location information for sensory and cognitive processes, and is sensitive to alterations in related neural systems.

ERP work (Neville et al., 1989; Neville et al., 1993; Neville et al., 1994) is attempting to tap the neurological basis of the hyperacusis in WS. If hyperacusis is caused by some 'hyperexcitability' of neurons in brain tissue, then its neural basis could be measured by ERPs. The question of whether this neural substrate occurs at a cortical or subcortical level can then be examined. There are many teething problems with this work at present, which should be surmounted as research progresses. One problem is that only a small number of subjects have been tested so far, precluding statistical analysis. Individual
differences can be large, related to large individual differences in neuroanatomy, so single case ERP studies in WS cannot be used. Some subjects may also systematically blink in response to auditory stimuli so that ERP data is then contaminated with EOG (electrooculogram) activity. This blinking is probably related to the hyperacusis.

A.17.2 AUDITORY RECOVERY CYCLES

Auditory recovery cycles are the earliest stages of auditory sensory processing, and it is at this level that the basis for the hyperacusis probably exists. Brain stem (subcortical) auditory evoked potentials are similar in WS and control subjects. Hyperexcitability is therefore not caused at the level of the brainstem. However, the early components of the cortical ERP to tones display abnormally high amplitudes at fast repetition rates. They are less refractory than normal. These components are the N100 and P200. There is, however, no effect on the visual evoked potentials; these results are confined to the auditory modality. These results happen for both left and right ear stimuli.

Various studies suggest that the N100 and P200 auditory potentials are generated in different fields within the transverse gyrus (Heschls) of the superior temporal lobe (Pantev, Hoke, Lehnertz, Lutkenhoner, Fahrendorf & Stober, 1990). The P200 generating field is some centimetres anterior to the N100 generating field. There may then be pharmacological or neuroanatomical differences relating to a distinction between these two areas in WS.

A.17.3 SENTENCE PROCESSING IN THE AUDITORY AND VISUAL MODALITIES

For auditory sentence processing in normal subjects, there is a large decrease in the overall amplitude of the ERP with age. The morphology of the ERP also changes with age. The P100 subcomponent is large in young kids, but absent in adults. The latency of the N100 subcomponent decreases with age, and the P200 subcomponent is never prominent in normal subjects.

In WS subjects, there is a similar overall gain in amplitude of the ERP, but it shows a different morphology. The P200 subcomponent is prominent,
and is always so. It is therefore not developmentally indexed. This suggests that the initial stages of auditory language processing in WS do not involve the same neural systems as those in normal subjects.

The ERP in auditory sentence processing is similar in morphology to those of the recovery cycle. This suggests that the changes in the ERP for WS subjects relate to the hyperexcitability of the auditory system. This hypothesis is backed up by the existence of no similar P200 response in visual sentence processing tasks, where the response of WS subjects is similar to age-matched controls, in amplitude, latency and morphology.

A.17.4 DIFFERENCES IN EXPOSURE TO LANGUAGE MAP TO DIFFERENCES IN HEMISPHERIC ASYMMETRY?

In normal subjects, the N400 response is markedly reduced between 9 and 13 years of age. This ERP component has been positively related to search and/or integration of word-meaning, and is negatively correlated with word frequency (Holcomb & Neville, 1990). In WS adults, the amplitude of the N400 is larger than that in age-matched controls. This is a less mature response, correlating with a later onset of reading ability in this group. The ten year old WS subjects showed N400 responses similar to those of controls.

If closed-class words, such as articles or conjunctions, are visually presented, then one can elicit ERPs that are asymmetrical across the two hemispheres. The development of this asymmetry may be dependent on early exposure to language, as it is absent in congenitally deaf subjects who acquire reading skills relatively late (Neville, 1991). The asymmetry develops, as younger normals show a marked reduction from adult normals. WS adults who did not learn to read until later, showed no asymmetry. They give a normal morphology, but the negative component is apparent over both hemispheres. However, those younger WS children who did learn to read at an earlier age, did show a normal asymmetry. This then may be the result of differing exposures to written language within the WS population or of different strategies and processes used by WS subjects compared to normal subjects.

It is important to note that this research has focused on written language. There are probably essential differences between the activity and
location of systems for spoken and written language in all populations of subjects, WS or otherwise.

A.17.5 SEMANTIC PRIMING

In semantic priming tasks, sentences are presented in the auditory and visual modalities. Half end in a very likely sentence ending, e.g. "I lie on the floor", whereas half end in a semantically anomalous sentence ending, e.g. "I don't go to school on Saturday or floor". Anomalous words at the end of sentences elicit a large negative response - the N400. This response decreases with age. Congruent words in younger children also elicit a negative component, but by about 15 years of age, this is replaced by a positive response (LPC) that indexes greater priming.

WS adults and children display a larger LPC than that of normals in the left hemisphere. This is consistent with normal or enhanced connections between representations of related lexical items in the auditory modality. If this is related to auditory hypersensitivity, then it should not be visible when sentences are presented in the visual modality. However, for visually presented sentences, WS children showed a normal LPC whilst adults showed less than normal. This may be related to the differing starting ages for reading within this subject population, with the younger subjects having learned to read at an earlier age than the older ones.

A.17.6 SUMMARY OF ELECTROPHYSIOLOGICAL FINDINGS

Neville et al. (1994) argue that although some of these results are difficult to interpret, some working hypotheses can be invoked. They claim that the age of exposure to language is important, both exposure to spoken and written language. Thal et al. (1989) and other researchers have demonstrated that there is delay in acquisition of spoken language in WS. However, it is highly unlikely that there is any difference in exposure to spoken language in childhood for WS subjects, either within the population or compared to normal subjects. Neville et al. make their claims on the basis of differing starting ages for reading within their subject population, and therefore judgement of their position is difficult.
Changes in early sensory processing may alter the operation and organisation of cognitive systems, such as language. It is possible then that the hypersensitivity of the auditory system in WS at least partly underlies their hyperfluency of language. It is unclear, however, just how this hyperacusis would then underlie the cause of the abnormal delays in acquisition of spoken language in WS.

Neville et al. also claim that hemispheric differentiation of language systems requires language acquisition to occur at specific times within normal development. This in itself is non-controversial; it would match the critical periods of exposure that are required by nestling song-birds to develop later full song (Marler, 1991). However, there is no evidence as yet as to whether such hemispheric differentiation occurs in WS. There are too few details of the WS subjects used by Neville et al., such as their exposures to language and their IQ scores, for a review of these studies to draw such a conclusion. Certainly however, this methodological approach is yielding valuable insight into the way that language systems may develop, and the possible relationship to this development of the early hyperacusis seen in WS.

A.17.7 FURTHER RESEARCH: ORGANISATION OF THE LEXICON

According to previous research, WS subjects generate more, less frequent and less prototypical responses to category names than IQ-matched controls (Bellugi et al., 1988; discussed in section A.13.1). Neville et al. (1994) hypothesise that this might be because of an increased facilitation between lexical items and representation thereof, caused by more interconnection between neural representations of words, in turn caused by lower thresholds due to increased hyperexcitability within the auditory system. They therefore predict possibly greater than normal semantic priming effects in WS subjects in the auditory but not visual modality. This is an experimental approach which may lead to greater understanding of the organisation of the lexicon in WS. I will return to discuss this in part C.

A.18 SOCIAL COGNITION

A variety of abilities can together be taken under the general heading of "social cognition", cognitive abilities which relate to people and social situations. These include face processing and memory for faces, discussed in
A.6.2., and fluent conversational language, discussed in A.12. WS are relatively proficient in both these fields, and can be described as "hypersocial" in their temperament. The remaining cognitive ability that is included within the domain of social cognition is "Theory of Mind".

A.18.1 THEORY-OF-MIND

"Theory-of-mind" is the ability to recognise that other organisms of the same species have minds, and thus an intentionality: beliefs and desires which will affect its behaviour in the same way that they will drive the behaviour of self. If an organism has a "theory-of-mind", then it will be able to evaluate and respond to the mental states of another conspecific. Human children, and possibly some other species of primate, do possess a theory-of-mind.

A huge body of experimental work has demonstrated that ability in tasks requiring theory-of-mind is impaired in autism. Thus tasks which require use of propositional (intentional) attitudes and attribution of mental states to others, require understanding of non-literal intentional language such as irony, or require understanding of the use of direction of eye-gaze as an indicator of another person's attention or mental state, are very difficult for subjects with autism (all research reviewed in Baron-Cohen, Tager-Flusberg & Cohen, 1993). These sort of tasks are, however, very easy for young normal children of 3 - 4 years.

In contrast, WS subjects are very able at tasks which require first-order theory-of-mind ability; second-order tasks, with a higher cognitive load, are sometimes too difficult. Karmiloff-Smith et al. (1995) tested WS subjects on a variety of such tasks, and either compared them directly with subjects with autism and normal controls, or compared their results with similar previous studies which had used autistic subjects and normal controls. The chronological age of the WS subjects ranged from 9 to 23 years. WS subjects were shown to be as able as normals and significantly better than subjects with autism on the following tasks which demonstrate use of theory-of-mind: judgement of intention from eye-gaze; understanding of false belief in others and how it will affect their behaviour; understanding of irony or sarcasm.

These results are particularly interesting, given the previously discussed neuropsychological profile comparison of WS and autism. WS
subjects show increases in neocerebellar lobule volume contrasting with decreases in the same in autism (Wang, Doherty et al., 1992). Limbic structures in the temporal lobe of WS are also selectively preserved (Jernigan & Bellugi, 1990). The temporal limbic areas of the brain appear to be involved in the processing of socially-oriented information (Price, Russchen & Amaral, 1987). It appears that there may be a double dissociation between social cognition and cerebellar/limbic area damage (from impaired development not focal lesions) which is demonstrated by WS and autism.

A.18.2 INTENTIONAL ABILITY - THE SOCIAL COGNITION 'MODULE'

Brothers and Ring (1992) have argued that there may exist a module in Fodorian terms (Fodor, 1983) for processing all information that is relevant to social interaction. All elements of social cognition, which would include language, face processing and theory-of-mind, would be encompassed within this module. Within their specifications, the module would be functionally encapsulated with access to representations of social stimuli, stimuli relating to the same species as the organism. Brothers and Ring developed their theory from experimental work with macaque monkeys, but there is no doubt that they intend it to be thought of as something that would have evolved and been refined in humans.

As already seen in sections A.6.2, A.18.1 and A.12 respectively, WS subjects are relatively much better at face processing, theory-of-mind and language tasks than they are on tasks involving other areas of cognition. Of particular note is the peculiar affective quality of their language, the value given to emotional prosody and the number of what are termed 'social filler' words (Udwin & Yule, 1991). It could be argued that these qualities of productive language are those that serve the most social or pragmatic function. Subjects with autism, on the other hand, are impaired in most of these same abilities (Frith, 1989; and others), particularly in theory-of-mind as was discussed in section A.18.1 (Karmiloff-Smith et al., 1995). Compare the following descriptions of an autistic subject:

He paid no attention to people around him...he completely disregarded the people (in a room) and instantly went for objects...he was happiest when left alone.
Kanner (1943);
and of a WS subject:

*He drew people to him as though he had a (social) magnet in him.*


This is then suggestive of a dissociation between the two syndromes with respect to social cognition, and might be support for some version of a 'social module'. A ready neurological base for this module of the brain would perhaps appear to be certain regions of the vermal lobules of the neocerebellum. As was discussed in section A.5.2, regions VI-VII are selectively preserved and increased in volume in WS whilst they are impaired and reduced in volume in autism. However, before this is taken as firm evidence of a double dissociation of function and neuroanatomy, it should be pointed out that the neocerebellum is a phylogenetically recent adaptation to the cerebellum, and there is no evidence as yet to suggest that these areas are to be found in species like the macaque, on which Brothers and Ring based their original work. More pertinently, Karmiloff-Smith et al. (1995) argue that rather than social cognition being viewed as a module hard-wired from birth, it should instead be viewed as the product of development. Rather than modelled as hard-wired modules, social cognition becomes gradually modularised. They point out that dissociations may exist between the three areas of 'social cognition' in other syndromes such as DS, where subjects have problems in face-processing and some aspects of language yet perform well on theory-of-mind tasks (Bihrle et al., 1989).
### A.19 SUMMARY OF COGNITIVE PROFILE

The linguistic-cognitive profile of WS can be summarised as follows in Table A.I following:

#### TABLE A.I

Summary of cognitive and linguistic profile of WS

<table>
<thead>
<tr>
<th>'Cognitive ability'</th>
<th>Micro-domains</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Visuospatial processing</td>
<td>local analysis strong</td>
<td>global analysis weak</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>But</td>
<td>face processing strong, and possibly using different strategies to normals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>weak</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td>weak</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory-of-mind</td>
<td>strong, provided low cognitive load on task</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal memory</td>
<td>Strong (almost ceiling for s-t-m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-verbal memory</td>
<td>Weak, but memory for faces strong</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linguistic ability</td>
<td>(relatively) strong (leads to higher verbal IQ in some studies)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-domains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semantics</td>
<td>Entries underspecified (anecdotal evidence, ≥11 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure of lexicon</td>
<td>High bindings between items? (electrophysiological work, 6 &lt; age &lt; 16 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>weak when young (&lt;5 years) stronger when older (&gt;13 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syntax</td>
<td>(relatively) strong in production &amp; comprehension (≥7 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affective language</td>
<td>strong, particularly in prosody (≥10-11 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As can be seen from Table A.I, WS is characterised in what might be termed a strict cognitive profile as being impaired in most domains, bar those of face processing and theory-of-mind. As was discussed in A.18, these domains may fall into the category of social cognition, or at least functionally able to deal with representations of social stimuli.

For linguistic abilities, the story is more complex. Unfortunately, there has not been enough testing of younger WS subjects for any definite conclusions to be drawn about a developmental trend. None the less, the initial impression is that somewhere along the line of development, maybe around 7 years to 11 years, something happens and linguistic development really starts to ‘kick in’.

The first important conclusion to be drawn with respect to future research is that it is absolutely essential to devise and run not just general tests of general language ability, such as verbal IQ tests, but tests capable of tapping ability in tiny micro-domains of language. Preferably, they must also tap language abilities that already have been marked as a developmental milestone in the language of normal children.

The first avenue of research in this thesis is at the level of the word. How do WS children acquire new words into their lexicons, and why is the developmental path so delayed in comparison with normal subjects? How are these entries stored, and what does that reveal about the categorisation and conceptual organisation of the lexicon? And how are words retrieved from the lexicon, this being very much bound up with the second question of storage?

Throughout this review certain points have been made which illuminate pieces of these puzzles. Often they are smaller asides and observations of experimenters in another field of interest. But it should be clear that work on the electrophysiological methodology and hyperacusis, on verbal and non-verbal memory and on productive vocabulary and the \textit{way} that it is produced in discourse, will all be likely to be relevant to this research.

First, however, I wish to mention one line of attack that arises in conjunction with the work of Mervis and Bertrand (1993) discussed in section
A.16.2. They found that the ability to fast-map objects tends to coincide with the start of the vocabulary explosion in normal children. Dividing fast-mapping into two separate components, the whole object and mutual exclusivity assumptions, by Markman and others has demonstrated that children are capable of using these component assumptions from an early age. It is also demonstrated that theoretically the assumptions are essential for a child to be able to narrow quickly the reference of a new word and hence acquire new lexical items rapidly. This approach to word-learning in WS is examined in part B.

What, then, of the portrait of the profile of WS that was painted by Pinker in the opening to this part of the thesis? It is not accurate in its description of the basic characteristics of the syndrome, and is outdated by more recent research. It falls short on 3 important counts. First, it does not stress that WS is a developmental disorder. On all of neuropsychological, cognitive and linguistic levels, the characteristics of WS change dramatically over time. Second, it implies that WS is best characterised as representing a split between language and the rest of cognition. In contrast, this review has demonstrated that both in description of developing and adult WS abilities, and in consideration of the likely aetiology of the syndrome, WS is best characterised as ability in the domain of social-cognition, in direct contrast to autism. Third, in the domain of language, Pinker characterises WS as possessing intact syntactic systems and unusual semantic systems. However, this review has pinpointed dissociations in ability within the syntactic domain itself. The characteristics of WS semantic organisation of the lexicon and access to that organisation will be tested in the experiments of part C, in which I shall also challenge Pinker’s conclusions.

A.20 COMPARISON TO OTHER POPULATIONS: CONTROL GROUPS

WS, like all disorders, must be compared to other groups which are selected as control subjects in order for valid conclusions to be drawn from the WS results. The selection of control groups that has been made by previous researchers, reflects a priori assumptions by researchers as to the nature of WS in comparison to the control group.
Of course, every syndrome is different from every other. However, selection of control groups implies certain assumptions about the causal basis of the disorder. In the vast majority of previous studies, researchers use control groups of DS subjects and normal subjects matched for mental age. Thus the implicit view of WS is of a generally retarded cognitive ability, matched by the DS group, yet with a relatively spared linguistic capacity, matched by the choice of this normal group. Yet as was seen in section A.5 and section A.18, on neuroanatomical and psychological levels the most telling comparison seems to be that made with autism. The sense is that on a neuroanatomical level, and the psychological level too, WS and autism demonstrate marked differences. In that sense, a matched autistic control group should be included in further research.

However, the most important comparisons to be made in the semantic domain are those with normal developing children. One can peg where on a developmental trajectory (Jones, Rossen & Bellugi, 1994) occur the linguistic milestones examined in WS, compared to the developmental trajectory on the same task for normal children. Further research could profitably test additional groups on those studies that seem to reveal most about WS language abilities.

**A.21 EXPERIMENTAL WS POPULATION TESTED**

The results of a total of 17 people with WS are included in the experimental parts B and C. Even more were interviewed for studies in this research, but the remainder could not be tested for various reasons, usually because their general level of ability was too low to allow satisfactory performance in test situations. None the less, a subject population in double figures is far higher than most previous studies with WS; for example, category production on the CELF test by Bellugi's lab was tested with only 4 people with WS (Bellugi et al., 1988).

Not all 17 subjects have results included in all studies, however. Some were tested, but unable to satisfactorily complete a particular test. Some were only unavailable for one-off short test sessions, and so only have results included for those experiments.
Usually, a maximum of 3 to 4 experiments were run with any subject in any one session. A period of at least a month would elapse before further experimental work with that same subject. Experimental work for this research took around eighteen months to complete. Where the same nonce terms were used in more than one study with the same subject, the test sessions were at least 9 months apart.

In the following table, the date of birth and sex of each person with WS tested are given. Throughout this thesis, subjects are identified with an anonymous ID. Further tables in this section give scores for standardised tests for all subjects, and also detail the experiments completed by each subject.

**TABLE A.II**
**Date of birth and sex of all subjects tested**

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<th>SUBJECT ID</th>
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<th>SEX</th>
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<td>m</td>
</tr>
<tr>
<td>BB</td>
<td>29/8/76</td>
<td>f</td>
</tr>
<tr>
<td>CC</td>
<td>30/6/71</td>
<td>f</td>
</tr>
<tr>
<td>DD</td>
<td>13/9/77</td>
<td>f</td>
</tr>
<tr>
<td>EE</td>
<td>5/12/86</td>
<td>m</td>
</tr>
<tr>
<td>FF</td>
<td>31/10/64</td>
<td>f</td>
</tr>
<tr>
<td>GG</td>
<td>17/9/81</td>
<td>f</td>
</tr>
<tr>
<td>HH</td>
<td>11/7/77</td>
<td>f</td>
</tr>
<tr>
<td>II</td>
<td>10/10/84</td>
<td>f</td>
</tr>
<tr>
<td>JJ</td>
<td>5/9/83</td>
<td>f</td>
</tr>
<tr>
<td>KK</td>
<td>2/8/80</td>
<td>f</td>
</tr>
<tr>
<td>LL</td>
<td>13/3/70</td>
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<td>MM</td>
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<td>26/12/73</td>
<td>m</td>
</tr>
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<td>PP</td>
<td>9/11/71</td>
<td>f</td>
</tr>
<tr>
<td>QQ</td>
<td>3/7/64</td>
<td>m</td>
</tr>
</tbody>
</table>

**STANDARDISED TEST RESULTS**

In the following tables, data for all subjects for standardised tests are given. In Table A.III, results on the WISC-R and WAIS-R IQ tests are given, for both verbal and performance components. In Table A.IV, results in the form of test ages (TAs) relative to a normative population are given for the BPVS (Dunn, Dunn, Whetten, & Pintilie 1982; a test of receptive vocabulary) for the TROG (Bishop, 1983; a test of receptive grammar) and for the Ravens Progressive Matrices (Raven, 1986; a non-verbal test of spatial intelligence). In
Table A.V, results are given for a test of non-word repetition (NWR) in the form of normative test ages (Gathercole & Baddeley, 1996; Grant, Karmiloff-Smith, Gathercole, Paterson, Davies, Howlin & Udwin, in press), and for the Inspection Time Task (IT) (Anderson, 1986). Data for these tests are not available for all subjects.

### TABLE A.III
Scores for WISC-R and WAIS-R for all subjects tested

<table>
<thead>
<tr>
<th>SUBJECT ID</th>
<th>VERBAL IQ</th>
<th>PERFORMANCE IQ</th>
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<td>AA</td>
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<td>47</td>
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<tr>
<td>FF</td>
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<td>61</td>
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<tr>
<td>GG</td>
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<td>•</td>
</tr>
<tr>
<td>HH</td>
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<td>45</td>
</tr>
<tr>
<td>II</td>
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<td>KK</td>
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<td>64</td>
</tr>
<tr>
<td>QQ</td>
<td>73</td>
<td>66</td>
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TABLE A.IV
Scores for BPVS, TROG and RAVENS for all subjects tested

<table>
<thead>
<tr>
<th>SUBJECT ID</th>
<th>BPVS TA</th>
<th>TROG TA</th>
<th>RAVENS TA</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>16.33</td>
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<td>8</td>
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<tr>
<td>BB</td>
<td>7.41</td>
<td>6</td>
<td>7.5</td>
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<tr>
<td>CC</td>
<td>8.33</td>
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</tr>
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<td>DD</td>
<td>10.08</td>
<td>•</td>
<td>6</td>
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<td>EE</td>
<td>6.67</td>
<td>7</td>
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<td>FF</td>
<td>11.58</td>
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<td>4.5</td>
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</tr>
<tr>
<td>KK</td>
<td>11.83</td>
<td>9</td>
<td>7.5</td>
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TABLE A.V
Scores for Non-Word Repetition and Inspection Time for all subjects tested

<table>
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<tr>
<th>SUBJECT ID</th>
<th>NWR TA</th>
<th>IT</th>
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<td>AA</td>
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EXPERIMENTS COMPLETED BY WS SUBJECTS

FOR PART B

Lexical Acquisition

Table A.VI shows the experiments completed by WS subjects in part B. Experiments are identified by their section numbers.

**TABLE A.VI**

Experiments completed by WS subjects in part B

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FOR PART C

Semantic Organisation

Table A.VII shows the experiments completed by WS subjects in part C. Experiments are identified by their section numbers. For Section C.2.2, o refers to a subject in the old WS group and y refers to a subject in the young WS group.

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part B

LEXICAL ACQUISITION
B.1 GENERAL INTRODUCTION

B.1.1 WHAT IS LEXICAL ACQUISITION?

Lexical acquisition translates as the learning of new words. That this occurs at all is obvious. What is not so apparent is the mechanism by which it occurs. For a child to be said to have learned a word, s/he must be able to use that word as a referent for something in the real world - mere imitation of a phonological string does not constitute word learning. The child must convert what s/he hears spoken or sees written into a referent for something that occurs or has occurred in the real world, be it object, action, event or attributes thereof. That referent can then be used in verbal elaboration of the child's knowledge about or desires towards that real-world reference.

B.1.2 THE PROBLEM OF INDUCTION AND ITS SOLUTION: LEXICAL ACQUISITION CONSTRAINTS

The central theoretical problem in lexical acquisition is that of induction. Given a novel word introduced by a caretaker in response to a new object or situation, how does the child work out to what the adult is referring exactly?

For example, imagine that a lobster waddles into a room. The adult, stifling surprise, attracts the child's attention, points at the lobster and says "That's a lobster". How does the child know that "Lobster" refers indeed to the whole lobster and not to its red colour, its action of waddling, its entrance into the room, one of its claws, or indeed a warning to be wary of this peculiar creature?

If the adult said "Lobster" when the child is presented with another object sharing the lobster's features, then perhaps the child will guess that the word will refer to that common feature. For example, the presentation of a Washington Red apple eliciting the word "Lobster" may indeed suggest that "Lobster" refers to the common red colour. However, as Quine (1960) pointed out, that cannot be logically assumed. There will be an infinite number of theoretically possible common features between an apple and a lobster, such as the fact that both are edible, and one will never be able to distinguish exactly to which mapping the novel label is referring.
A number of researchers have suggested different mechanisms by which the child may circumvent this problem, and establish a single referent for the label "Lobster". These mechanisms all share the same function: they allow the child to narrow the potentially infinite hypothesis space of possible referents for the novel label into a more manageable set.

There are two main theoretical models of sets of lexical acquisition constraint mechanisms that operate in normal developing children. The first set is an innately specified set of 3 principles (Markman, 1990). The second set is rather 2 sets of 3 principles that are learned or instantiated in order in development, acquisition of one set always preceding that of the other (Golinkoff, Mervis & Hirsh-Pasek, 1994). These models, and further differences between them, are discussed in sections B.1.7 - B.1.9. Both theoretical models specify mechanisms that constrain lexical acquisition. These constraints operate within the child.

However, there are further constraints on word-learning, given by the caretaker to the child, or more generally within the word-learning situation itself external to the child. These may also direct the attention of the child to the salient object/attribute that is the referent of a novel word. These are discussed in section B.1.3.

The experimental protocols that test lexical acquisition constraints within the child rely on ostensive teaching of a word by an adult to a child, that may not be the only or predominant method of teaching. This is discussed in section B.1.4. Experimental protocols have tended to focus on acquisition of count nouns, rather than that of any other lexical unit. Reasons for this focus are discussed in section B.1.5.

B.1.3 DRAWING ATTENTION TO WHAT IS RELEVANT: PERCEPTUAL PROPERTIES VERSUS THE INTENTIONAL STANCE

Most words do not correspond to perceptual features of objects. Yet the fact that concepts have origins in perceptual reference is assumed by classical models, such as Richards and Goldfarb (1986), drawing on a long philosophical tradition that can be traced from Locke through to Quine.
That perceptual properties are not necessarily the core meanings of object names has been demonstrated by Keil (1989) with 3-year-old children. If a racoon is transformed into a skunk for a child, by it putting on a costume or by major surgery, then the more superficial the transformation, the more likely that the child will accept that the creature is still the original racoon, and not the masquerading skunk.

As well as perceptual properties, a crucial factor in word-learning is something more intangible - the factor that is intended most relevant by the adult for the child. This will be implemented by the adult focusing the child's attention on what is most relevant.

Dunham, Dunham and Curwin (1993) demonstrated that an 18-month-old child is more likely to learn a novel label for an object when the child's attention is focused on that object than when it was focused on another object. Word learning is also more easily facilitated when the adult and child are regulating equal amounts of time in leading the direction of joint attention and following the other's direction (Tomasello & Todd, 1983).

The intentional stance of the child itself may also be relevant. If an infant of 9- to 16-months old is presented with two toys, it will spend more time playing with the toy with the most interesting property. The toy's interest could result from a surprising violation of expectation of the infant of the function of that toy. The child can draw inferences on these non-obvious properties of such toys from experience with only one exemplar (Baldwin, Markman & Melartin, 1993). More unusual and infrequent language labels may also draw the child's attention, leading to faster lexical acquisition than more frequent labels (Schwartz & Terrell, 1983).

It is very likely that there are differences in regulation of attentional mechanisms that will be crucial to understanding possible differences in word-learning by subjects with WS. WS subjects tend to be fixated and fascinated by faces, and that alone may make more difficult for them word-learning situations which require efficient regulation of joint attention by the subject. Their face-fixation may bias them too much towards the caretaker, and not enough towards the relevant object. This would be a profitable avenue for future research, but will not be examined in this thesis.

For instance, a child is more likely to attend to a 'talking' Barbie doll that (through some manufacturer's fault) says 'Ken must die horribly' rather than 'I love Ken'.

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B.1.4 OSTENSIVE VERSUS NON-OSTENSIVE WORD-LEARNING SITUATIONS

An ostensive word-learning situation is one in which the 'teacher' makes explicit the link between reference object and referent label. In our previous example, an ostensive way to teach the word 'Lobster' is to say "That is a lobster" when the lobster is in the room. There is then a spatio-temporal contiguity between the word label and the referred object. However, as Gleitman (1990) suggests, these are not often the situations in which children actually acquire new words. The typical sentences that caretakers present to children are more non-ostensive: e.g. a social commentary, such as asking what the child did that day, rather than necessarily presenting a word alongside the referent object. There may also be commentary on either the immediate past or the immediate future - what the child just did or what the child is about to do. In all such cases, the referent object will not be present when words are used in reference to it.

The middle-class Western society in which most psychological research operates is still more ostensively orientated than most. Our dominant ideology in schools and nurseries is Skinnerian in outlook. We play with our children and give them picture-books and flash-cards, to constantly teach them what words refer to. The caretakers amongst the Kaluli tribe of Papua New Guinea do not give their children ostensive definition of words (Schieffelin, 1985).

Ostensive word-learning procedures are attractive to experimenters for the very reason that they are also weak: they are simplistic. This simplicity makes it more difficult to generalise to all possible situations of word-learning, hence their weakness. However, experimental procedures demand a simplification of the factors involved in order to make analysis and understanding manageable. So long this is recognised, such ostensive procedures are valid.

Others have defended ostensive procedures more strongly. Hall (1994b) has demonstrated that caretakers will use ostensive definition alone to define a basic level count noun. However, if that count noun is instead situation-restricted (for example passenger is a situation-restricted noun compared to the basic level noun of person), then they will provide further
information to demonstrate the constraints of the word's use. Mervis (1983) also argues that "parent and child have a tacit agreement that labels refer to entire objects rather than to actions, attributes, or parts of objects". This agreement will inform the child's comprehension as well as the parent's production in ostensive situations.

The caretaker may vary the information used to name an object for a child, and provide the right amount of information for the child. It is as if they are unconsciously aware of the constraints that the child will use to determine to what the caretaker is referring. All the same, it is likely that this is more true of Western middle-class society than it is a universal.

Arguably though, the mechanisms that govern word-learning in ostensive teaching situations may also be important in non-ostensive situations. In that case, it is most important to start with the simplest procedures, identify those mechanisms involved therein, and only then explore other more complex and naturalistic paradigms.

In comparison to the volume of work on word-learning in ostensive situations, there has been little on word-learning in non-ostensive situations. Tomasello and Barton (1994) studied situations with 2-year-old children, where the experimenter used a novel word to announce her intention to perform an action or to find an object. It was found that a knowledge of what action or object was impending, established through scripted events before the word's introduction, was not necessary for children to learn the words. Rather than acquisitional constraints such as those discussed in the rest of this section, which narrow the hypothesis space as to what the adult might be referring, a variety of socio-pragmatic cues were found to be more relevant to the child in establishing the reference for a novel word in these experimental situations. These cues all involved a sense of what the adult's intended object or action was within that situation. A knowledge of the adult's intentional stance is probably established by attentional mechanisms, discussed in the previous section, B.1.3.

B.1.5 ACQUISITION OF COUNT NOUNS

Count nouns and concrete nouns are perhaps the most important parts of speech, as they are the most primary in the first output of children's speech
production. An analysis of vocabulary composition from 45 20-month-old children indicates that more nouns are acquired than all other word classes, and that of the nouns acquired 67% are concrete 'count nouns'. Only about 50% are the names of basic level object classes (Nelson, Hampson & Shaw, 1993). For adults too, count nouns are prominent, but less so than for young children. Of the 500 nouns most frequent in a typical adult lexicon, 37% are count nouns (Nelson et al, 1993). As count nouns are so primary in a young child's output, this study will focus on their acquisition. It is likely that any differences found in the count noun acquisition of WS subjects will extend to other parts of speech.

Leonard (1982) compared comprehension and production of novel words taught as referents to two groups matched for linguistic development: language-impaired children (aged 2 yrs 8 months to 4 yrs 2 months) and normal children (aged 1 yr 5 month to 1 yr 10 month) matched for level of linguistic development. Both groups showed greater comprehension and production of words referring to objects than words referring to actions. However, the language-impaired subjects' object word bias was not as marked as that of the normal subjects. It is possible then that WS children may also not show as great a noun bias in early output as do normal children, but it is still likely that such a bias will exist.

**B.1.6 SUMMARY**

The simplicity of these experimental procedures and the mechanisms they elaborate is also a strength. It is undeniable that in these artificially simple situations at least, the mechanisms to be described are very relevant. In naturalistic situations, it is safe to assume that they also do operate, all other factors being equal. It is undeniably true too that children are able to learn new words in these artificially simplistic and ostensive teaching situations. That being the case, they must be utilising the mechanisms discussed.

It is essential also to realise that this section does not attempt to demonstrate what may be the most important mechanisms of lexical acquisition by subjects with WS. Rather, it examines whether the simplistic constraint principles that have been the core of research so far on lexical acquisition in normal children also operate in lexical acquisition in WS.
B.1.7 GENERAL OUTLINE OF LEXICAL CONSTRAINT PRINCIPLES
THEORY

All the theoretical frameworks discussed in this section share the same basic assumption. They consider that the child has the onus in solving the induction problem, that this is achieved without any direction from the intentional stance of the adult or the relevance of the situation. The child is considered to make the problem of induction more manageable by using various default principles that constrain the hypothesis space of what the reference is of a novel label used by a caretaker in a word-learning situation.

Language itself is seen within these frameworks as the most important factor that focuses the child's attention on the relevant features of the situation. Baldwin and Markman (1989) demonstrated that infants in two groups of 10-14 months and 17-20 months old attended more to objects labelled with both language and a pointing gesture, than to objects labelled gesturally alone. This increase in attention persisted far beyond the time that labelling actually occurred.

B.1.7.1 Default constraints:
Whole Object Assumption and Mutual Exclusivity Assumption

The first of the frameworks considered is that of Markman (1990). She postulates three default constraints on the hypothesis space of a novel referent which, in the absence of further information supplied by the caretaker, the child will use to constrain the word referent to be a basic level count noun, referring to a whole object.

Children as young as two years of age seem to assume that a novel word applied in ostensive definition to an unfamiliar solid object refers to a kind of object, rather than to any of its possible features, such as a salient property like colour (Baldwin, 1989), the substance it is made of (Markman & Wachtel, 1988), or indeed the named individual itself (Hall, 1991). This initial constraint has been called the Whole Object Assumption (Markman, 1989).

If a novel word is applied to a familiar object for which the child already has a label, then the child will assume that the new word applies to some sub-part or feature of the object, rather than to the whole object itself.
This constraint has been termed the **Mutual Exclusivity Assumption** (Markman, 1989). Markman and Wachtel (1988) discuss the relation of mutual exclusivity to other principles hypothesised to be necessary for language acquisition, for example the principle of one-to-one mapping (Slobin, 1973), the uniqueness principle (Pinker, 1984) and the principle of lexical contrast (Clark, 1973, 1987; Taylor & Gelman, 1988).

Markman and Wachtel (1988) demonstrated Mutual Exclusivity in children aged 3- to 5-years-old. Subjects would treat a possible second label for an object as instead a label for a novel object. If this option was precluded, then subjects would treat the second label as a label for a part or substance of that first familiar object. Use of a mutual exclusivity bias has also been shown for 4-year-old Japanese children (Haryu, 1991; Haryu, 1992).

In second-language learning, it is obvious that a second label from the new language must be applied to an object that already has a label from the first language. Children are capable of suspending the mutual exclusivity bias and accepting a second label if and only if it clearly comes from the second language (Au & Glusman, 1990; Haryu, 1993).

These two constraints, the mutual exclusivity assumption and the whole object assumption, operating in tandem will enable a child to begin to acquire words as labels for objects. The child hears a novel label, "Lobster", in the presence of a lobster, and then assumes that the word label refers to that whole lobster. However, if she already has a word taken to refer as a label for that whole lobster, she will assume that it refers to some other feature of the lobster, such as a claw. There also appears to be a hierarchy of importance of other attributes of an object. A child is more likely to use these contrast-type principles to map an unknown adjective to the material of an object than to the object's colour (Au & Markman, 1987).

**B.1.7.2 Fast-mapping**

The combination of these two constraints, the whole object and mutual exclusivity assumptions, can be considered equivalent to one mechanism of lexical acquisition, fast-mapping. Fast-mapping is a process by which a

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30 The term 'fast-mapping' was coined by Carey (1985). It is in this sense that the term is used throughout this thesis.
child will quickly identify a novel object as the most likely referent to a novel label. Take the following scenario:

For the past week, 18-month-old Sandra has been spending a lot of time at day-care playing with a toy tool set. She has even learned the names for the three tools included in the set: "saw", "hammer", and "screwdriver". Sandra's father buys Sandra her own set of toy tools. As the two of them look into the jumble of tools in the new box, her father says, "Daddy sees a wrench!" Sandra looks through the objects in the box and then triumphantly pulls out the wrench, even though she had not known the word "wrench". (Mervis and Bertrand, 1994)

Fast-mapping has been demonstrated by Dollaghan (1985) to be available to children from 2-years-old. One exposure to a monosyllabic nonce word and its novel object referent was enough for 81% of the children to then identify the referent from the label alone, and for nearly half to produce at least 2 of the phonemes of the nonce label in labelling the referent themselves. Heibeck and Markman (1987) demonstrated fast-mapping in 2- to 4-year-olds, where children were able to figure out the referent for a novel label without help from any contrasting lexical terms. They examined three semantic domains: colour, shape and texture. Fast-mapping was applicable in all domains, although children learned more about shape terms than colour or texture words. Language-impaired children (Dollaghan, 1987) and children with Down's Syndrome (Chapman, Kay-Raining-Bird, & Schwartz, 1990) also show fast-mapping skills comparable to those of matched controls.

Merriman, Marazita and Harvis (1993) also demonstrated that 4-year-old children would show fast-mapping in mapping a novel verb onto an unfamiliar action, as well as mapping a novel noun onto an unfamiliar object. They hypothesise that in addition to a mutual-exclusivity-type principle, a second principle, 'feeling of novelty', applies to action words.

B.1.7.3 Default constraints: taxonomic assumption

The third of Markman's constraints is the Taxonomic Assumption (Markman, 1990). This predisposes the child to consider labels as referring to objects of like kind. The taxonomic assumption differs from the previous assumption constraints in that rather than establishing the referent for just
one individual object, it helps establish that for an object-kind. It is therefore discussed separately in more depth in section B.1.10.

It is important to emphasise that all these are default constraints. They do not guide the child’s lexical acquisition above all other factors - rather they can only be seen to operate when no other factors are salient. They are also probabilistic. The mutual exclusivity assumption, for example, does not preclude a child from giving a second label to an already labelled object. Rather the child will be more likely to use that second label to label some other feature or attribute of the object or situation.

B.1.8 WHEN ARE THESE CONSTRAINTS OPERATIONAL?

B.1.8.1 Relationship to the vocabulary explosion

Children’s vocabulary acquisition follows a common universal developmental trajectory. Early word learning, from around 9-months of age, is slow. At around 15-months of age, when the child typically has a vocabulary of around 100-150 words, there is an explosion in the rate of acquisition.

One caveat to the universality of this phenomenon is that it may be specific to those children who focus early linguistic effort on learning names for objects. Goldfield and Reznick (1990) used a diary method to study the transition from slow to rapid word learning in 18 children. 13 children underwent a period of around 3 months during which the rate of acquisition exploded. The majority of words learned during this period by these children were nouns. The remaining 5 children, however, underwent more gradual word learning. They acquired more of a balance of nouns and other word classes. That the explosion in the rate of acquisition is known as the 'vocabulary explosion' reflects in any case an implicit assumption that names for objects are learned most rapidly during this period. Cromer (1983) however, examining the acquisition of non-nominal words in a micro-domain of language with older children (6- to 9-years-old), demonstrated that a notional process of gradual acquisition was inadequate to explain the changes in acquisition. Rather, some radical reorganisational process must be

\[\text{Cromer used children (6- to 9-years-old) much older than those entering the phase of the vocabulary explosion (typically 13- to 14-months-old). All the same, we can assume for now his conclusion that an acquisition of vocabulary in a domain will involve a radical reorganisational process, whatever the age of the word-learner. Older word-learners will likely}\]
hypothesised during lexical acquisition. The question relevant here is whether that reorganisational process necessary for the vocabulary explosion to occur involves the use of default lexical constraints.

Markman (1990) argues that default constraints must be operational some time prior to the vocabulary explosion, if not perhaps innate predispositions. This explosion is then only possible if the child can use these constraints to narrow the hypothesis space for the referent of a word. Comprehension tests show that children can learn new object labels quickly just prior (13-months-old) as well as after (18-months-old) the vocabulary explosion (Woodward, Markman, & Fitzsimmons, 1994). Are these default constraints then operationalised prior to the vocabulary explosion?

**B.1.8.2 Age of onset of default constraints**

Merriman and Bowman (1989) argue that the mutual exclusivity bias is an acquired bias, and one that does not gain full strength until the child is at least 3-years-old. After this point, it remains as a default bias even into adulthood, although it still may be counteracted by extra contextual information or a belief that the intended reference is an extra label to a familiar object. Merriman and Schuster (1991) reaffirmed this position, and further added that any apparent mutual exclusivity bias in children younger than 3-years-old was in actual fact due to an attraction to any novelty within the procedure. This claim was based on results showing a stronger tendency to avoid giving a second label to an already labelled object in 4-year-olds compared to 2-year-olds.

Woodward and Markman (1991) address these criticisms. They argue that the pre-exposure to all stimuli in Merriman and Bowman's procedure undermines any unfamiliarity of stimuli for younger children, and necessarily weakens the experimental appearance of the mutual exclusivity bias. Merriman (1991) acknowledges these criticisms, but still, the case for the operational presence of default constraints in children younger than 21/2 years old is weakened by difficulties in these experimental procedures. These difficulties seem to arise from the fact that, prior to the experiment, all stimuli are unfamiliar to the child. Training procedures are necessary to familiarise
the subjects with the relevant aspects of the stimuli, but these training procedures appear to place too much of a cognitive load on a young subject.

Liittschwager and Markman (1994) used instead stimuli already familiar or unfamiliar to the child, and shifted the focus of the study to investigate how difficult it was for a child to learn first and second labels for objects. They found that 16-month-old subjects had difficulties learning second labels for objects, but that 24-month-old subjects could learn second labels as easily as first labels, contrary to their predictions. If, however, a second label was introduced in the same experimental session, the extra demand on the processing capacity of the subject led to them having greater difficulties in learning a second label in comparison to the learning of a first label for that object.

Woodward and Markman (1991) argue that the mutual exclusivity constraint is an inborn bias, rather than a fixed limitation, and that its expression during early childhood prior to 3 years of age may be weak and incomplete. But by taking this position, they make it extremely difficult to imagine any test that could falsify the hypothesised principle of an innate basis for the mutual exclusivity constraint. It is impossible then on these criteria to distinguish the late expression of a weak innate bias from acquisition of a learned cognitive strategy designed to deal with increased competition in lexical acquisition, if both should be expressed at a similar point in development (MacWhinney, 1991).

To summarise the debate on fast-mapping, and the related mutual exclusivity and whole object assumptions, it appears that young children prior to the vocabulary explosion do tend to label an unfamiliar object with an unfamiliar label, rather than using that label as a second label for a familiar object. This is a default bias, in the absence of further contextual or intentional cues. It is undeniable that second labels can be applied to objects. John Noakes' dog Shep, for example, can be called an animal, a dog, a collie, or Shep. Second labels are important in establishing hierarchical category levels of superordinate, basic, subordinate and specific individuals. Au and Glusman (1990) showed that from the age of 4-years-old on, children accept two names for the same object if the names selected marked different levels of the categorical hierarchy, but not if they marked the same level.
Markman's opinion now is that it becomes easier for older subjects to apply a second label to an object. However, in situations where there is conflict between possible labels (such as the greater demands on processing capacity in the studies of Liittschwager & Markman), the default mutual exclusivity assumption will apply. It also appears likely that the tendency emerges later to map an unfamiliar label onto an unfamiliar part or other attribute of a familiar object, rather than as a second label for the whole object.

The essential weaknesses in Markman's position is that it is not necessarily true that children avoid giving second labels to objects, and that the causal developmental basis of these constraints is unfalsifiable. The other major theoretical framework of lexical constraint principles refines the description of the active constraint principles and attempts to answer these criticisms.

B.1.9 DEVELOPMENTAL LEXICAL PRINCIPLES FRAMEWORK

B.1.9.1 The theoretical framework

The second major set of theoretical principles in lexical acquisition is the Developmental Lexical Principles Framework (DLPF) proposed by Golinkoff, Mervis and Hirsh-Pasek (1994). In common with Markman's constraints, these principles act by constraining the hypothesis space that the child must consider to establish the referent for a novel label, in Markman's terms, or to reduce the amount of information that language-learning children must consider for what a new word might mean, in Golinkoff et al's terms.

Golinkoff et al. expand the set of constraint principles to six, divided into two developmentally distinct sets of three. The instantiation and operation of these principles may use non-linguistic as well as linguistic information. Although all the principles extend to all classes of word and representations, this discussion will be confined to application to nouns and representations of objects, and of attributes of those objects.

The first set are Reference, Extendibility and Object Scope. The Principle of Reference allows words to be mapped onto representations of objects, or their attributes. Indeed, according to Brown (1973), the fundamental use of language is to make reference. Acquisition of this
principle can be based upon nonlinguistic expression, such as comprehension and production of pointing gestures. The Principle of Extendibility allows a word to be used as reference for similar referents, even if the child has no experience of any previous labelling of a referent with that word. Without this principle, word-use would be radically underextended. The Principle of Object Scope is very similar to Markman's whole object assumption. All other factors equal, words are assumed to label whole objects, rather than parts or attributes of those objects. An extension of this principle supposes that adults will emphasise object words in child-directed speech, through prosodic cues (Fernald & Morikawa, 1993). None of this first set of principles are inconsistent with the position of Markman. In my view, they are essentially non-controversial.

However, Golinkoff et al claim that this set is acquired by the child, rather than being in any way innately prespecified. They also suppose that there is a developmental sequence, with this first set all in operation before any of the second set are instantiated. Word learning using only this first set of principles would be slow and laborious, with the child probably required either to be especially interested in the object labelled (Mervis, 1983) or to need several exposures to a word before acquiring it in the lexicon (Dromi, 1987). Indeed, even in the study by Liittschwager and Markman (1994), 13-month-old children required 9 exposures to map an unfamiliar label onto an unfamiliar object.

The second set are Conventionality, Categorical Scope and Novel Name-Nameless Category. The Principle of Conventionality demands that the child will express meaning using a form conventional to its linguistic community, rather than any form idiosyncratic to the child. It is thus a refinement of the Principle of Reference, and is essentially non-controversial. The Principle of Categorical Scope marks the primary basis for extension of a word as a basic level category assignment. It is thus a refinement of the Principle of Extendibility. It is roughly equivalent to Markman's taxonomic assumption, and will be discussed in more depth in section B.1.10. The Principle of Novel Name-Nameless Category (N3C) marks that novel words will map to objects unfamiliar to the child, which do not have a label. It is thus a refinement of the Principle of Object Scope. Its action will be demonstrated by the child possessing fast-mapping ability. Golinkoff, Hirsh-Pasek, Bailey and Wenger (1992) demonstrated that for both adults and
children as young as 2-years-old, subjects would indeed map a novel word onto a previously unnamed object and would also extend that newly learned word to another similar object, prohibiting another novel label from being applied to that second object.

One essential difference between this framework and that of Markman's is the developmental sequence of the two sets of lexical principles. Expression of the second set develops after that of the first. It is the operation of the two sets in concert that enables rapid vocabulary acquisition by the child. According to Golinkoff et al., it is the expression of the N3C principle that allows fast-mapping and enables the vocabulary explosion.

B.1.9.2 Relationship between lexical principles and other cognitive mechanisms

This framework also predicts specific relationships between the expression of these linguistic principles, and the expression of various non-linguistic, cognitive mechanisms. Mervis and Bertrand (1994) examine the association between the N3C principle, and a relationship between the onset of the vocabulary explosion and the onset of two-category exhaustive sorting. Gopnik and Meltzoff (1987) describe three developmental levels in this exhaustive sorting task; the final level, level 3, is the first in which the child deliberately sorts two types of objects (one type in each category) into separate groups. They argue that this exhaustive categorisation characterises an implicit insight by the child that all objects belong to a category. There is a significant relationship between the emergence of this level 3 categorisation and the onset of the vocabulary explosion, which, Gopnik and Meltzoff argue, characterises an implicit insight that all objects have a name. The spontaneous exhaustive categorisation task of Gopnik and Meltzoff will be discussed in more depth in section B.1.11.

Mervis and Bertrand (1993) and Golinkoff et al. (1994) all argue that expression of the N3C principle characterises an implicit insight that all objects have a basic level name. Mervis and Bertrand (1994) therefore hypothesised that all three mechanisms - the emergence of the N3C principle, as expressed by fast-mapping, the emergence of level 3 exhaustive sorting, and the onset of the vocabulary explosion - should co-occur in children. This was demonstrated to be the case. Children between the ages of 16- and 20-
months-old were tested for fast-mapping ability. Those who demonstrated this ability, and therefore had acquired the N3C principle, were significantly more likely to have large vocabularies and also to demonstrate level 3 exhaustive sorting, than those who did not. Those children not demonstrating fast-mapping were followed longitudinally. When they began to show a vocabulary explosion, they were significantly more likely to be able to fast-map by that time. This is fairly conclusive evidence that at least the expression of lexical principles is both necessary for the onset of the naming explosion and also is acquired during development.

**B.1.9.3 Diverging predictions from the N3C principle and the mutual exclusivity assumption**

The other essential difference between the models of Golinkoff et al. (1994) and of Markman is the differing predictions that are made for certain experimental situations by the N3C principle and the mutual exclusivity assumption. The divergence of these predictions is based on a premise thought necessary for the mutual exclusivity assumption. That is, that the child "must not generalise more than one name to the same thing" (Merriman & Bowman, 1989; Woodward & Markman, 1991). There are undoubtedly cases where this occurs. However, it is important to remember that the mutual exclusivity assumption is a default constraint and is probabilistic. It will only be followed, and the child thus avoid generalising a second name to an object for which it already has a name, where there are no other salient factors. These other salient factors may not always be obvious to inspection of the experimental situation. They may be implicit to the child. Hoek, Ingram and Gibson (1986) studied the overextensions made by an infant girl through the second year of life. Amongst the 6 distinct factors that caused early word extensions, were use of a known word in preference to an unknown word, and overextensions of preferred words. As a generalisation of a second name to an object already named could be deemed an invalid overextension in the mutual exclusivity paradigm, the factors of known words versus unknown words should be very carefully controlled for in any experiments testing diverging predictions. To coin a phrase, the child does not always mean what s/he says or does. The problem is that there is no other way of testing what s/he means.
Mervis, Golinkoff and Bertrand (1994) ran studies with 2- and 3-year-old subjects with a situation where the DLPF model and the default constraints model would indeed give different predictions. This situation is where there is a novel name, but no nameless object available in an array of familiar objects. According to the default constraints model, the novel word would most probably be treated as a salient part for which the child does not yet have a name. According to the DLPF model, argue Mervis et al., the child might rely on other cues within the situation. For example, if the label was couched within a sentence containing the phrase "this is a kind of [basic level] name", then the child might assume the novel label to refer to a subordinate category to which the known label belonged. This is essentially non-controversial, even within Markman's default constraints model. Cueing from other sources, such as syntactic information, will undoubtedly be used by the child to constrain the hypothesis space and may then override the mutual exclusivity assumption to use the label as a second, subordinate, label for the object. If there were no sources of other cueing information obvious, then the child will use the Principle of Object Scope to assume the novel label to be another name for that object. They would then extend the new name to other basic level exemplars of the object's category.

This was indeed what Mervis et al. found with both age groups of children tested. Overwhelmingly, children appeared to assume the novel label to be another name for the familiar object, and extend that label to another exemplar from the same category. They thus gave to the experimenter both exemplars of that category in response to the request "Can you give me the XXXX.", followed by the request "Is there another XXXX? Are there any more XXXXs?", from an array of two exemplars, their parts, and a distractor object. (XXXX here is the novel label). For a child to give the hypothesised result, s/he must have given both whole object exemplars to the experimenter in response to the requests. There is a qualification to this result, however. Once the child has handed the first object in response to the first request, the following request contains the phrase "another XXXX....any more XXXXs". This is clear syntactic cueing to consider another object on the same categorical hierarchical level as the first object, that is, the second exemplar as hypothesised. Even so, the child has still selected the first familiar object in response to the novel label, which in itself violates the mutual exclusivity assumption.
The qualification to this is less strong, yet it is the same criticism that Mervis et al make of the procedure of the Mutual Exclusivity tests of Markman and Wachtel (1988). The salient parts of familiar objects used in both experiments, the parts necessarily hypothesised to be unfamiliar to the child so that they invited labelling, were in actual fact likely to be familiar to the children even if in pre-tests (which Markman and Wachtel admittedly and unforgivably neglected to carry out) they were unable to produce a reliable label for those parts. For example, Markman and Wachtel used the claw of a hammer, and Mervis et al used the handle of a shovel. This is unavoidable, however. Whole objects that are familiar to young children are only familiar in the form used if their part is attached. In that case, the part will also be familiar to the children.

It is possible, too, that Mervis et al. compounded this weakness by having a warm-up session where the child was asked to hand all the parts to the experimenter after a demonstration of what was a part. This was intended to indicate that a part response was a welcome response. In actual fact, it may have had the effect of labelling for the child all the parts used as members of the basic level category "part". Not only then does this give the child a label for all the supposedly unlabelled part-objects, it also biases them towards considering categorical inclusion as a factor in the experimental procedure. This might also have contributed to the child responding to the second request for an "XXXX" by extending the category for the first whole object which it selected, and handing over the second exemplar of its category available.

Other apparently supportive research contains similar pitfalls. Blewitt (1994) demonstrated that children aged 2- and 3-years-old would apply both basic level and superordinate category labels to the same objects, but did not ensure that sufficient salient other choices were available for the subjects.

It is probably impossible to construct an experimental protocol that can settle the debate between the two camps on this issue, without raising further problems of its own. Every experiment to some extent, in that it is designed to answer the hypotheses of the experimenter, will implicitly reflect their intentions. The protocols of the whole object assumption and mutual exclusivity assumptions, in removing all other factors bar the whole objects and their salient parts, to some extent also force the subject's hand in selecting
the unfamiliar parts as hypothesised, with no other salient factors. As will be discussed in section B.2.2, this makes them particularly interesting for testing with WS subjects. These procedures are the only ones to examine the whole object assumption, and by implication its counterpart in the DLPF framework, the Principle of Object Scope.

I will not discuss in any further depth the DLPF Principles of Reference, Extendibility and Conventionality. These are non-controversial. The first two must be followed for any subject to be able to apply a given word to more than just one object. The third is beyond the scope of this thesis. The DLPF N3C principle will be tested on subjects with WS, in a fast-mapping protocol. Prior research in this area with WS subjects is also discussed in section B.2.2. This will also be linked to ability in exhaustive sorting in an extension to the experimental procedure of Gopnik and Meltzoff. This will be further discussed in the following section, B.1.10. In this section, previous research on the taxonomic assumption of Markman and its DLPF counterpart, the Principle of Categorical Scope, will also be reviewed in depth.

B.1.10 PRINCIPLE OF CATEGORICAL SCOPE AND TAXONOMIC ASSUMPTION

B.1.10 The Taxonomic Shift Effect

Both the Principle of Categorical Scope in the DLPF model and the Taxonomic Assumption in the default constraints model are concerned with the same principal phenomenon. Words bias children to attend to the taxonomic categorical relations between objects. This effect is the Taxonomic Shift.

The basic experimental paradigm is to present subjects with a target object (e.g. DOG), an object taxonomically related to the target (e.g. CAT) and any number of other objects related non-taxonomically to the target. In our DOG example, a thematically related object would be BONE. A perceptually similar but non-taxonomically related object would be TEDDY. Situational cues are such that if there is no novel noun referring to the target, then the subject is more likely to attend to the non-taxonomically related objects. However, should a novel noun be used in reference to the target, then the
subject is more likely to attend to the taxonomically related object. Additionally, the basic level of categorisation seems to be most salient. Children attend to relationships between objects at the basic level prior to any other categorical hierarchical level. This is explained in the next section.

**B.1.10.2 Primacy of basic level categories**

Object kinds can be ranked in a hierarchy, from parts of objects through basic objects through to superordinate categories. An example of such a hierarchy would be: TIMMY THE TUNA, TUNA, FISH, ANIMAL. At all levels of the hierarchy, objects will possess a significant number of common attributes, will have similar shapes and be identifiable from an average shape of members of the kind. A basic level object kind is the most inclusive kind in that hierarchy that also refers to only discrete, whole objects (FISH in the above hierarchy). This level is the most primary in word learning. Children will assume that a novel word indicates kinds of objects at the basic level above other levels in the categorical hierarchy.

In categorisation tasks, a developmental acquisition path of basic, superordinate, subordinate levels has been traced in children from 2- to 5-years old (Mervis & Crisafi, 1982). The acquisition of labels for an object in the child's lexicon follows the same trajectory. The basic level name is learned first, followed by the superordinate level, followed by the subordinate level (Mervis, 1983). Children also label objects most frequently at the basic level, although they do also label, albeit less frequently, at other levels (Waxman & Hatch, 1992). Preferred labels tend to be at the basic level (Golinkoff, Blewitt & Alioto, 1994).

**B.1.10.3 Why is the basic level primary?**

Objects in different basic level categories are more easily differentiated than objects in different superordinate or subordinate categories (Mervis & Crisafi, 1982). That basic level categories are more primary may therefore be a result of the fact that relevant features defining those categories are noticed first by the child.

Hall (1994b) argues that basic level kinds share a further property with all object kinds, that of a principle of identity for individuals in the kind. The
identities that basic-level words give the individuals can be traced across changes in time and place. They are non-situation-restricted. For example, PERSON is a basic level kind. CHILD is a situation-restricted subordinate level kind, restricted in the age of the person. PASSENGER is a situation-restricted subordinate level kind, restricted in the location of the person in some kind of vehicle. In that case, basic level categories are functionally most useful. That too may drive the earlier acquisition at this level.

Caretaker input of nouns to children is generally too at the basic level (Blewitt, 1983; Brown, 1973; Shipley, Kuhn & Madden, 1983). Mervis and Mervis (1982) demonstrated that caretakers are aware of differences in children's knowledge about the functions of objects that result in differences in categorisation at the basic level. In those cases, caretaker input is at the child-basic level, rather than the adult-basic level.

**B.1.10.4 Novel labels primarily indicate basic level kinds**

Horton and Markman (1980) demonstrated that a word applied ostensively is taken to refer to the basic level kind in the hierarchy rather than to a superordinate level kind where the individuals do not share a general shape. Taylor and Gelman (1988) showed that this basic level kind is also preferred to the subordinate level kind even though at that level, the individuals share more perceptual similarity than those in the basic level kind. Novel labels do not prohibit the highlighting of categorical relations at other levels. It is rather that in situations where no other salient cues exist to indicate levels other than the basic, the basic level will predominate (Waxman, Shipley and Shepperson, 1991; Mervis, Johnson and Mervis, 1994).

**B.1.10.5 Experimental evidence for the Taxonomic Shift**

Hence, Markman and Hutchison (1984) demonstrated a taxonomic shift away from a thematic target to a taxonomic target in the presence of a novel noun label, in children from 2- to 5-years-old. Two and 3-yr-olds demonstrated the taxonomic shift at the basic level, 4- and 5-yr-olds at the superordinate level also, and 4- and 5-yr-olds also demonstrated a taxonomic shift when taught new taxonomic and new thematic relations for unfamiliar objects. The taxonomic shift at the basic level has also been demonstrated with 3-year-old subjects in the presence of thematic and irrelevant distractors.
(D'Entremont & Dunham, 1992), with 2-year-old subjects with 2 superordinate choices and 2 thematic choices (Waxman & Kosowski, 1990), and even with 16-month-old infants prior to entering the vocabulary explosion (Waxman & Hall, 1993).

Markman and Hutchison also eliminated a possible alternative hypothesis, the translation hypothesis. This would predict that children when confronted with a novel word for an item for which they originally knew a name would translate that novel label into their familiar label, and respond on that basis. After teaching children the names for artificial 'nonce' objects for which translation was obviously impossible, the taxonomic shift was still observed.

Waxman (1990) found that for 3- and 4-year-old children, novel nouns facilitated basic level and superordinate level categorisation, but appeared to hinder subordinate categorisation, whilst finding the opposite effect for novel adjectives. If, however, the novel nouns were presented in conjunction with the familiar basic-level labels, then subordinate classification was also facilitated (Waxman, Shipley & Shepperson, 1991). This is further support for the principle that basic-level categories are attended to first. In naturalistic situations, for the basic-level labels to be presented in conjunction with novel nouns, it presupposes that the child must have already learned those basic-level labels.

**B.1.10.6 Are taxonomic relations or shape similarities between objects the more salient factor?**

There is an important distinction to be made between a taxonomic relation between objects and a shape similarity between objects. The two factors may be confounded, but in certain situations may dissociate. For instance, an upturned hat and a bowl share salient similarities in their shape, but are not taxonomically related. Gelman and Markman (1987; 1986) demonstrated that children from 3- to 5-years-old draw more inferences about objects based on common category membership than on perceptual appearances, when both were available as salient factors. In contrast, there are many reported instances of children's overextensions based on shape, for instance the word MOON extended to a variety of round objects (Clark, 1973). Other researchers have demonstrated that shape similarity is more
important than other perceptual dimensions such as size or texture (Landau et al., 1988), and colour (Baldwin & Markman, 1989), in forming young children's word meanings. Those other factors were salient if shape were controlled for, but shape was focused on as the most salient factor in conflict situations by both young children and adults.

Clearly both the taxonomic relations and shape similarities between objects are important factors in helping young children form inferences about word meanings. It appears that there may be a developmental relationship between the two factors. Shape similarity appears to be more salient than taxonomic category membership in forcing a shift from thematic-based responding in the presence of a novel word for younger children, of age 3-years. By 5-years old, however, a developmental shift has occurred from shape-based responding to taxonomic-based responding (Imai, Gentner & Uchida, 1994). Baldwin (1992) had similar findings with children also aged 3- to 5-years-old. Shape appeared to be the most salient factor for younger children, although they were capable of using taxonomic relations between objects to force a shift from thematic-based responding in the presence of a novel word. Baldwin concludes that children will use whatever sources of information are available, whether that be single or multiple factors.

It is unsurprising that shape is such a salient factor for the younger age groups of children in helping form inferences about word meaning. Most, though not all, objects that have a strong similarity in shape or form, also share strong similarities in function. It is this function-based information that tends to be the basis of basic-level category formation. This information is, however, less transparent to young children than perceptual information, such as shape similarity. Knowledge of the latter will bootstrap them to knowledge of the former, and of resulting taxonomic relations between objects. A prediction arising from this is that non-solid substances, that do not have a form similarity that correlates with function similarity, will not be open to an applicable shape bias (Soja, Carey & Spelke, 1991).

B.1.10.7 Principle of Categorical Scope

There is no difference in the theoretical basis of the operation of the Principle of Categorical Scope and the Taxonomic Assumption. Both assume a taxonomic shift, that children attend more to taxonomic relations between
objects than any other factor-based relations in the presence of a novel noun. The Principle of Categorical Scope, as part of the DLPF model, is argued to emerge as part of the second tier of developmental lexical principles, just prior to the naming explosion. In testability, this does not differ from the Taxonomic Assumption, which Markman (1990) assumes to be operationalised in children at the same point in the developmental cycle.

The only research examining a taxonomic shift from the standpoint of the DLPF model differs on a methodological issue. Golinkoff, Shuff-Bailey, Olguin, and Ruan (1995) argue that the results of Markman and Hutchison (1984), for example, could be explained as readily by what they deem to be an anti-thematic bias. By this hypothesis, young children would know that words could not be used to label thematic categories, and nothing else. Hence, when subjects are presented with only two choices, taxonomically and thematically related to the target, in the presence of a novel word, this anti-thematic bias will lead them to select the taxonomic choice. This would give an apparent taxonomic shift, but would not be based on any knowledge about taxonomic relations. Golinkoff et al. gathered evidence to support this claim, but confounded the results by using superordinate level categorical members as the taxonomic alternative. It has already been demonstrated that superordinate level categories are acquired much later, indeed Golinkoff et al. demonstrated that it was not until 7-years-old that children were able to extend novel labels to superordinate level taxonomically related objects. Golinkoff et al. did find knowledge of the superordinate level categories used in the youngest children when tested as a separate factor. However, given a conflict in the experimental situation between this less accessible superordinate level knowledge and other relevant factors, the results are less than conclusive.

That children could possibly acquire an anti-thematic bias is quite counter-intuitive. It is highly plausible that children can pick up similarities in form between objects, and use this as a boot-strapping mechanism to pick up the taxonomic relations that more often or not correlate. There appears to be no developmental causal basis for an anti-thematic bias that does not emerge in opposition to a taxonomic or shape bias. If either of those is present, then it is more parsimonious to assume that they will be used to guide children's attention to objects, given previous research. It cannot be concluded therefore
that such an apparently counter-intuitive bias could be present on the basis of rather weak experimental evidence.

**B.1.10.8 Summary of relevant evidence**

In the presence of a novel label, children from 3-years of age extend the meaning of that label to objects that are related by similarity in form or shape above other perceptual factors or categorical (taxonomic) factors. These factors, even for the youngest children, are salient if shape similarity is controlled. There is a developmental shift from shape-based responding to taxonomic-based responding in older children. The most primary level of taxonomic categories is the basic level category. The youngest children can extend word meaning to kinds of basic level objects before they can extend to kinds of superordinate or subordinate level objects.

Whether WS subjects will also show a taxonomic shift in the presence of a novel label will be discussed in section B.2.3. One must also consider, however, what categorisation ability WS subjects possess. Without such ability, then WS subjects could not extend word meaning on the basis of the taxonomic categorical relations between objects. A relevant task for measuring this categorisation ability is discussed in the next section, B.1.11.

**B.1.11 SPONTANEOUS EXHAUSTIVE SORTING OF OBJECTS**

Object sorting tasks are one of the most common methodologies used to assess possible developmental differences in conceptual organisation (e.g. Powers, Stavens & Andreasen, 1975; Markman, Cox & Machida, 1981). Performance on a spontaneous object sorting task developed by Gopnik and Meltzoff (1987) was shown to correlate with both fast-mapping ability and the onset of the vocabulary explosion in normal children, as discussed in B.1.9. As this task provides a quantitative assessment of categorisation ability, it was also used to measure this ability in the WS subjects in the study population.
B.2 LEXICAL ACQUISITION IN WS

B.2.1 INTRODUCTION

More is known about the language ability of adult WS individuals than for younger. The end-product of lexical acquisition can be observed, but very little is known about the process of acquisition that leads to the product. It is important therefore to examine that process in WS subjects.

There may be qualitative and/or quantitative differences between WS and normal subjects in lexical acquisition. There has been little previous research for the learning of new words in WS. Reviewing the literature describing the vocabularies of adolescent WS subjects, one is amazed at the size and variety of their reported productive vocabularies (Bellugi et al., 1988) which are closer to what would be expected for their chronological age. Yet Thal et al. (1989) report on the linguistic abilities of two young WS subjects aged 1;4 and 5;3 years, both of whom had productive vocabularies that were lower than would be expected for their chronological age, rather closer to their general mental age. Are there then differences in the mechanisms that children with WS can use in learning new words compared to those demonstrated in normal developing children?

There must therefore be some factor which accounts for differences in lexical acquisition by WS subjects compared with normal subjects. This will manifest itself at some point from infancy to 2 years [the mean age of the older normal control group in the study by Thal et al (1989)]. It may still be manifest in older WS subjects.

B.2.2 FAST-MAPPING, AND THE MUTUAL EXCLUSIVITY AND WHOLE OBJECT ASSUMPTIONS

B.2.2.1 Fast-mapping

One clue comes from work by Mervis and Bertrand (1993) comparing the abilities of normal children and WS children on three related phenomena: exhaustive sorting, spontaneous fast mapping, and the onset of the vocabulary explosion.
Exhaustive sorting is the separation of a set of objects from various categories into groups of objects of a similar basic-level category. Fast mapping is defined by Mervis and Bertrand as "the realisation that if you hear a new word in the presence of a group of objects, including an object for which you do not yet have a name, the new word is probably the label for that object". This corresponds in Markman's default constraint model to a combination of the whole object assumption and the mutual exclusivity assumption (Markman, 1992). As discussed in section B.1.7.1, mutual exclusivity is the bias that an object cannot have more than one name. The whole object assumption is the bias that a novel label heard in the presence of an object refers to the whole object and not to any of its features.

Cross-sectional and longitudinal data from normally developing toddlers and from children with Down Syndrome indicate that spontaneous exhaustive sorting coincides with the vocabulary explosion, the time when the number of words that children produce and comprehend suddenly and exponentially increases, when a lexicon of between 100 to 150 words has been acquired.

Fast-mapping ability is present in Down's Syndrome children. Down's Syndrome subjects aged 5 years 6 months to 20 years 6 months did not differ from mental age matched controls in their ability to infer a connection between the novel label and referent, to comprehend the novel label after a single exposure, to recall the location in which they hid the novel label, and to produce the novel label correctly. These skills were unrelated to any expressive language deficit in subjects with Down syndrome (Chapman, Kay-Raining-Bird & Schwartz, 1990)

Data from normally developing children and Down Syndrome children indicate that for both these groups, the appearance of fast mapping coincides with the onset of spontaneous exhaustive sorting (Mervis & Bertrand, 1993). For Down Syndrome subjects, this is despite a level of vocabulary development that lags behind their general cognitive development (Cardoso-Martins, Mervis & Mervis, 1985).

Mervis and Bertrand examined 6 WS children. Five of the six had undergone some kind of vocabulary spurt, but none of them at that time could sort exhaustively. This skill was only acquired by two of the children,
but not until their vocabularies reached around 500 words. However, the appearance of fast-mapping does coincide in WS with the onset of spontaneous exhaustive sorting, despite there being no apparent link in WS between the onset of spontaneous exhaustive sorting and the vocabulary burst. This then probably implies that fast mapping does not coincide with the vocabulary explosion in WS.

This would then suggest that although fast mapping, reflecting expression of the N3C principle, may be one method of quickly increasing one's vocabulary, and indeed be used by normal and Down Syndrome children, it is not in fact the only one. WS children may use some alternative method. Mervis and Bertrand speculate that this might be an increase in the auditory short-term memory for words, or that it might involve giving more attention to verbal input.

General language-impaired children have more limited fast-mapping ability than children matched for mean length of utterance and normal controls aged 2- to 6-years-old. This is most pronounced on object- and attribute- referencing words (Rice, Buhr & Nemeth, 1990). Given the wide variation in linguistic abilities in WS, it may be that some subjects will also show more limited fast-mapping ability.

B.2.2.2 Default constraints: Mutual Exclusivity and Whole Object assumptions

It is important to recall, however, that what Mervis and Bertrand deem one process, fast mapping, has been separated into two processes by Markman and others, the whole object and mutual exclusivity assumptions. Failure in fast mapping does not necessarily imply that both of the latter biases are also not present in WS. The correlation in normal development of fast mapping and success in reaching the vocabulary burst does not imply that both processes involved in fast mapping are needed for that success.

Fast-mapping ability in this study population of subjects with WS is examined in section B.3.1. The spontaneous exhaustive sorting task is examined in section B.3.6.
The two constraints on lexical acquisition of the whole object assumption and mutual exclusivity are taken by Markman (1992) to be essential for fast establishment of reference for a novel word. A study by Markman and Wachtel (1988) demonstrated that both the whole object assumption and the mutual exclusivity assumption are used by normal children as young as 3 years to identify the referent of a new word.

Of particular interest in examining WS subjects are the whole object and mutual exclusivity assumptions, especially when the alternative choice in the tasks for the reference of a new word is that of a salient part of the object. There is a reported dissociation in one particular aspect of visuo-spatial processing in WS subjects, where subjects attend more to the parts than to the whole of a hierarchical visual stimulus. Bihrl et al. (1989) examined global versus local processing of hierarchical visual stimuli. In patients with unilateral focal damage, it has been demonstrated that those with left hemisphere damage have difficulty in drawing the local forms whereas those with right hemisphere damage have difficulty in the global forms. Bihrl et al. examined WS and Down Syndrome populations, neither of whom have localised cerebral damage but rather a genetic disorder expressed epigenetically through development. The Down Syndrome group concentrated on the global form of the stimulus, ignoring the local components, whereas the WS group demonstrated the opposite effect. This dissociation can also be seen in samples of WS and Down Syndrome subjects' spontaneous drawing (Bellugi et al., 1988). Whether this dissociation exists in the population of WS subjects examined in this study will be investigated in section B.3.4. Presence of the whole object assumption and mutual exclusivity assumption in this study population will be examined in sections B.3.2 and B.3.3 respectively.

**B.2.3 THE TAXONOMIC ASSUMPTION IN WILLIAMS SYNDROME**

No research has yet examined whether there is a taxonomic assumption in WS, that is whether WS subjects can extend word meaning on the basis of taxonomic relations rather than attending to other relations between objects, such as thematic relations. Semantic organisation of the lexicon is based primarily on the hierarchical taxonomic relationships between words. A lexical constraint principle based on the taxonomic
assumption seems most likely therefore to help efficient semantic organisation of the lexicon.

WS subjects have been characterised as possessing bizarre or deviant semantic organisation of the lexicon (Bellugi et al., 1988; Pinker, 1994). Whether this is a valid claim for the syndrome will be examined in part C. Assuming that there may well be some significant differences between semantic organisation in WS subjects and in normal control subjects, it is hypothesised that WS subjects will be less likely to show a taxonomic shift effect. This is examined in section B.3.5.

**B.2.4 RELATIONSHIP BETWEEN THE TAXONOMIC ASSUMPTION AND CATEGORISATION ABILITY IN WILLIAMS SYNDROME**

It is essential to measure also the categorisation ability of WS subjects. One must eliminate the possibility that an apparent inability to extend novel labels to objects related categorically arises from an inability to recognise that category of objects. Only then can it be concluded that the inability to extend words to categories results from the lack of a taxonomic bias.

Ungerer and Sigman (1987) measured categorisation ability on a spontaneous object sorting task and compared that ability with receptive language skills for autistic subjects, chronological-, and mental-age-matched controls. Whereas categorisation ability was closely linked to receptive language skills for both control groups (also see Klein & Safford, 1976; Klein & Safford, 1978), there was no link in the autistic group. It is possible that WS subjects could fall into either of these performance groups. The spontaneous exhaustive categorisation task, examined in section B.3.6, will give a measure of the categorisation abilities of WS subjects.
B.3 EXPERIMENTS

B.3.1 IS THE N3C PRINCIPLE, AS MEASURED BY FAST-MAPPING ABILITY, PRESENT IN WILLIAMS SYNDROME?

INTRODUCTION

As discussed in section B.1.7.2, fast-mapping ability enables a child to apply a novel reference word to an unfamiliar (and therefore previously nameless) object, in an array of other familiar objects. As soon as the N3C principle is available, then fast-mapping under normal conditions is possible. Mervis and Bertrand (1993) found that for both normal and DS populations, the onset of fast-mapping coincided with the onset of spontaneous exhaustive categorisation ability and the vocabulary explosion. For WS subjects, however, fast-mapping and spontaneous exhaustive sorting both emerged much later than the onset of the vocabulary explosion. Whereas for normal children, possession of fast-mapping (and the concomitant N3C principle) is thought necessary for the rapid acquisition of new words of the vocabulary explosion, for WS children this is not so. It is possible then that not all WS subjects tested will show fast-mapping.

No effect of the age of subject has been found for fast-mapping in normal populations. The oldest subjects tested previously have been 3-years-old. Two normal control groups were examined here, of 3-year-old and 9-year-old children. These correspond roughly to the lower and upper ranges for general 'mental age' in the study population of WS. No age differences in fast-mapping ability were hypothesised in the normal groups, however.

It was hypothesised that most, if not all, of the WS subjects tested in this study-population would also possess fast-mapping ability. All were older than the WS subjects tested by Mervis and Bertrand (1993), who found fast-mapping ability in 5 out of 6 of their subjects. All too were old enough to have passed through a vocabulary explosion.

Of interest too, is the difference between expressive (production) and receptive (comprehension) demonstration of fast-mapping in the WS group. The demonstration of fast-mapping through comprehension entails the subject picking out the unfamiliar object in an array of otherwise familiar
objects as a reference for an unfamiliar label. The demonstration of fast mapping through production entails the subject being able to reproduce that label in response to a request to name that previously unfamiliar object. For WS subjects, the production of previously novel names for objects will be tested.

Fast-mapping ability is measured in each subject by calculating the odds that they could have selected the unfamiliar object in reference to a novel label purely by chance over all the experimental trials. If this probability is less than 5%, then the subject significantly shows fast-mapping. This entails that over 4 experimental trials (more would tax subjects' stamina) the subject must get close to a ceiling score in order to demonstrate fast-mapping in the receptive task. The production task will probably give a more sensitive and variable range of scores. If there is a significant relationship between this fast-mapping production score and a score that reflects vocabulary size, such as the BPVS, this would imply that for WS subjects fast-mapping is important in helping learn new words. If however, there is instead a significant relationship only with a score such as the test age for non-word repetition, this would not support the hypothesis that fast-mapping in WS is related to lexical acquisition.

In section B.3.6, WS subjects are tested for spontaneous exhaustive categorisation ability. Following from Mervis and Bertrand (1993), it is hypothesised that only WS subjects who show fast-mapping will also show spontaneous exhaustive categorisation ability, and vice-versa.

METHOD

DESIGN

The experimental design presents the subject with an array of objects, one unfamiliar and the rest familiar. Pre-testing for the familiarity of objects was carried out with normal controls and not WS subjects, to ensure that the subjects had no experience of the unfamiliar objects before testing.

There were two subtrials to each trial. In the first subtrial, two familiar objects and one unfamiliar object were presented. According to the N3C principle, a novel label should be mapped onto the unfamiliar object. In the
second subtrial, the array from the first subtrial plus one additional unfamiliar object were presented. According to the N3C principle, the second novel label should be mapped onto that additional unfamiliar object, as the first unfamiliar object was labelled in the first subtrial. There were four trials, each with two subtrials.

The number of times in each set of subtrials that the subject selected the hypothesised unlabelled object was recorded. For the subject to be said to possess fast-mapping ability, the probability that these objects were selected by chance must be less than 5%.

Two normal control groups of school children, of mean ages 3;6 and 9;7 months;years respectively, and an experimental group of WS subjects were tested. Each subject was asked to select an object as referent to a novel label from an array of objects. There were four trials, each with two subtrials. In the first subtrial of each trial, there were two familiar objects and one unfamiliar object. In the second subtrial of each trial, there were those objects plus a further unfamiliar object. The object selected as referent to that novel label was recorded. In each first subtrial, it was hypothesised that the subject would choose the unfamiliar object. In each second subtrial, it was hypothesised that the subject would choose that second unfamiliar object introduced in that trial. The number of items so selected by each subject was compared against the chance probability of selecting those items.

MATERIALS

Preliminary study to assess familiarity of objects

Two pools of objects were used. One pool contained objects thought to be familiar to children of all ages, the other contained objects thought to be unfamiliar to children of all ages. For the familiar group, 10 3 year olds were asked to name the objects, and an experimental pool of objects was chosen of those named most reliably. For the unfamiliar group, 10 adults were asked to name the objects, and an experimental pool of objects was chosen of those that were not named reliably. A further criterion in the selection of objects in both experimental groups was to ensure that there was an equal number of bright shiny objects in each group, as these might attract more attention from a child simply because they are more immediately attractive.
Eight items were chosen for each group. The items used for familiar and unfamiliar groups in the experiment were as follows:

**TABLE B.I**

**ITEMS USED IN FAMILIAR GROUP**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pencil</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>cork</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>rubber</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>pen</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>key</td>
<td>(shiny)</td>
</tr>
<tr>
<td>pencil sharpener</td>
<td>(shiny)</td>
</tr>
<tr>
<td>padlock</td>
<td>(shiny)</td>
</tr>
<tr>
<td>whistle</td>
<td>(shiny)</td>
</tr>
</tbody>
</table>

**ITEMS USED IN UNFAMILIAR GROUP**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>incense holder</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>guitar bottleneck slide</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>guitar plectrum</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>Christmas tree light cover</td>
<td>(non-shiny)</td>
</tr>
<tr>
<td>poster frame clip</td>
<td>(shiny)</td>
</tr>
<tr>
<td>icing bag nozzle</td>
<td>(shiny)</td>
</tr>
<tr>
<td>video cable junction socket</td>
<td>(shiny)</td>
</tr>
<tr>
<td>video 'C' cable plug</td>
<td>(shiny)</td>
</tr>
</tbody>
</table>

**SUBJECTS**

Two control groups of normal school children were tested, with 12 children in each group. The younger group, the 3 year old group, had a mean age of 3;6 years;months, ranging from 3;0 to 3;10. The older group, the 9 year old group, had a mean age of 9;7, ranging from 9;1 to 9;10. There were an equal number of males and females in each group.

For experimental subjects, 11 WS subjects were tested. The mean age was 20;0, ranging from 8;7 to 31;2. There were 4 males and 7 females in the group.

**PROCEDURE**

Before each experimental session, the objects were divided into four groups of four objects, two familiar objects and two unfamiliar objects. Eight novel names were also assigned to the unfamiliar objects, from a pool of 16 novel names listed below. Eight of this pool were monosyllabic, 8 were
bisyllabic. Four of each were used for each subject. The novel names used were counterbalanced across subjects.

**TABLE B.II**
**NOVEL NAMES USED**

<table>
<thead>
<tr>
<th>Monosyllabic</th>
<th>Bisyllabic</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINK</td>
<td>FRICKLE</td>
</tr>
<tr>
<td>SHAP</td>
<td>ROPPER</td>
</tr>
<tr>
<td>CLUD</td>
<td>VENICK</td>
</tr>
<tr>
<td>PRAST</td>
<td>DREVER</td>
</tr>
<tr>
<td>YIVE</td>
<td>CORSHTER</td>
</tr>
<tr>
<td>ZONK</td>
<td>HOCKREE</td>
</tr>
<tr>
<td>LEK</td>
<td>PUGBAH</td>
</tr>
<tr>
<td>BIV</td>
<td>FELDER</td>
</tr>
</tbody>
</table>

For each trial, the procedure was as follows. The experimenter and subject sat at a table. The experimenter laid out two of the familiar objects and one of the unfamiliar objects in a line on the table, the order of familiar and unfamiliar in the array being counterbalanced across trials. The experimenter then placed both his hands beneath the table, and taking care to look only at the subject and not at the objects, asked "Do you see these. Could you please pass me the XXXX", where XXXX was the novel name assigned beforehand to the unfamiliar object. When the subject had made a choice, the experimenter picked up that object and whether a familiar or unfamiliar object had been selected, said "Good. This is a XXXX..." and then proceeded to give a short description of the use of that object. The experimenter then picked up all the objects, and drawing them under the table, added the second unfamiliar object, then laid all 4 objects on the table in a new array. The procedure was then repeated for this second unfamiliar item in each trial.

After each trial, the experimenter picked up the first unfamiliar item, and asked the child "Can you remember what this is called?". The subject's answer was recorded and this repeated with the second item. This procedure was repeated for all trials.

The experimental hypotheses are:

**CONTROL SUBJECTS HYPOTHESES**

**H1: hypothesis** states that in all trials summed, each subject must select sufficient of the previously unfamiliar objects such that the chance probability
of this is less than 5%. Fast-mapping ability is demonstrated to be possessed by the subject.

**H1:** hypothesis\_states that in all trials summed, each subject must select insufficient of the previously unfamiliar objects such that the chance probability of this is less than 5%. Fast-mapping ability is not demonstrated to be possessed by the subject.

**Idealised results then, to support H1:**

Every subject selects the hypothesised, previously unfamiliar, objects in each of the two subtrials of each of the four trials. This gives a score of 4 in each set of subtrials.

**for effect of age**

**H2:** hypothesis\_states that there will be no significant effect of age on fast-mapping ability in the two groups of normal controls.

**H2:** hypothesis\_states that there will be a significant effect of age on fast-mapping ability in the two groups of normal controls.

**EXPERIMENTAL (WILLIAMS SYNDROME) SUBJECTS HYPOTHESES**

Following the results of Mervis and Bertrand (1993), it is hypothesised that WS subjects will also demonstrate fast-mapping ability. However, given the delay in language acquisition in younger WS subjects followed by great verbal fluency in adolescence, it is possible that they will show less fast mapping ability for unfamiliar items than do normal controls.

**H3:** hypothesis\_states that in all trials summed, each WS subject must select sufficient of the previously unfamiliar objects such that the chance probability of this is less than 5%. Fast-mapping ability is demonstrated to be possessed by the subject.

**H3:** hypothesis\_states that in all trials summed, each WS subject must select insufficient of the previously unfamiliar objects such that the chance
probability of this is less than 5%. Fast-mapping ability is not demonstrated to be possessed by the subject.

RESULTS

There were two subtrials to each trial. The first subtrial involved selecting one object from an array of three, the second selecting one from an array of four.

For each first subtrial, the chance probability of selecting the unfamiliar object as hypothesised is 1 in 3. The chance probability of selecting either of the familiar objects is 2 in 3. The chance probability of selecting the hypothesised unfamiliar object in the first subtrial of a given number of trials is as follows:

TABLE B.III
CHANCE PROBABILITY OF PREDICTED PERFORMANCE ON 1ST SUBTRIALS

<table>
<thead>
<tr>
<th>Number of trials with 1st subtrial correct</th>
<th>Odds of this occurring by chance</th>
<th>Chance probability P1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32/81</td>
<td>0.40</td>
</tr>
<tr>
<td>2</td>
<td>48/81</td>
<td>0.59</td>
</tr>
<tr>
<td>3</td>
<td>8/81</td>
<td>0.10</td>
</tr>
<tr>
<td>4</td>
<td>1/81</td>
<td>0.01</td>
</tr>
</tbody>
</table>

For each second subtrial, the chance probability of selecting the unfamiliar object as hypothesised is 1 in 4. The chance probability of selecting either of the familiar objects is 3 in 4. The chance probability of selecting the hypothesised unfamiliar object in the second subtrial of a given number of trials is as follows:
TABLE B.IV  
CHANCE PROBABILITY OF PREDICTED PERFORMANCE ON 2ND SUBTRIALS  

<table>
<thead>
<tr>
<th>Number of trials with 2nd subtrial correct</th>
<th>Odds of this occurring by chance</th>
<th>Chance probability P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>108/256</td>
<td>0.42</td>
</tr>
<tr>
<td>2</td>
<td>108/256</td>
<td>0.42</td>
</tr>
<tr>
<td>3</td>
<td>12/256</td>
<td>0.05</td>
</tr>
<tr>
<td>4</td>
<td>1/256</td>
<td>0.003</td>
</tr>
</tbody>
</table>

For any subject, the probability that their results demonstrate fast mapping rather than occurring as a result of chance, can be calculated by multiplying the chance probabilities of their score in the first subtrial, \( p_1 \), and in the second subtrial, \( p_2 \). If this resulting score (\( p_1 \times p_2 \)) is less than 0.05, then we may conclude that the subject is demonstrating fast-mapping.

CONTROL SUBJECTS

3 Year Old Group

The number of trials in which the hypothesised object was selected in the first and second subtrials is as follows, for all subjects:

TABLE B.V  
PERFORMANCE OF 3 YEAR OLD SUBJECTS  

<table>
<thead>
<tr>
<th>1st subtrial</th>
<th>2nd subtrial</th>
<th>Chance probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
</tbody>
</table>

94
All subjects in the 3 year old group demonstrated fast-mapping ability, as the chance probability of their scores was less than 0.05.

**9 Year Old Group**

The number of trials in which the hypothesised object was selected in the first and second subtrials is as follows, for all subjects:

**TABLE B.VI**

**PERFORMANCE OF 9 YEAR OLD SUBJECTS**

<table>
<thead>
<tr>
<th>1st subtrial</th>
<th>2nd subtrial</th>
<th>Chance probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
</tbody>
</table>

All subjects in the 9 year old group demonstrated fast-mapping ability, as the chance probability of their scores was less than 0.05.

There is no difference in the fast-mapping ability between the younger and older control groups. This is not a mechanism that is affected by the age of subject.

**WILLIAMS SYNDROME SUBJECTS**

The number of trials in which the hypothesised object was selected in the first and second subtrials is as follows, for all subjects:
TABLE B.VII
PERFORMANCE OF WS YEAR OLD SUBJECTS

<table>
<thead>
<tr>
<th>Subject</th>
<th>1st subtrial</th>
<th>2nd subtrial</th>
<th>Chance probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>4</td>
<td>3</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>CC</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>EE</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>FF</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>HH</td>
<td>2</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>KK</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>MM</td>
<td>2</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>OO</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>PP</td>
<td>4</td>
<td>4</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>QQ</td>
<td>4</td>
<td>2</td>
<td>p&lt;0.05</td>
</tr>
</tbody>
</table>

All subjects in the WS group demonstrated fast-mapping ability, as the chance probability of their scores was less than 0.05. There is no difference between the WS experimental group and the two control groups in fast-mapping ability.

PRODUCTION TASK: NAMES GIVEN TO OBJECTS

The WS subjects were asked after each trial if they could remember what each of the previously unfamiliar objects was called. One of the subjects, II, could not satisfactorily do this, and was discarded from this analysis. Their responses were recorded.

The responses were scored as follows. For each correct repetition of the name given to the unfamiliar object, one point was scored. For each repetition of the name given to the unfamiliar object where the response repetition differed only by one consonant (eg "yek" instead of "lek"), half a point was scored. The points scored were summed over all trials (a maximum of 8 was possible).
TABLE B.VIII
PRODUCTION SCORES OF WS SUBJECTS

<table>
<thead>
<tr>
<th>subject</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>7.0</td>
</tr>
<tr>
<td>CC</td>
<td>3.5</td>
</tr>
<tr>
<td>FF</td>
<td>6.0</td>
</tr>
<tr>
<td>HH</td>
<td>3.0</td>
</tr>
<tr>
<td>KK</td>
<td>5.5</td>
</tr>
<tr>
<td>MM</td>
<td>1.5</td>
</tr>
<tr>
<td>OO</td>
<td>6.0</td>
</tr>
<tr>
<td>PP</td>
<td>3.5</td>
</tr>
<tr>
<td>QQ</td>
<td>4.0</td>
</tr>
</tbody>
</table>

These scores are significantly less than the scores for receptive fast-mapping for each subject (two-tailed t-test, df=9, t=5.9, p<0.0001). The expressive (production) fast-mapping ability therefore lags behind the receptive (comprehension) fast-mapping ability, although this would be expected as the production task is more taxing in processing demands.

There is a significant correlation between these scores, corresponding to the number of novel names that subjects were able to learn by the N3C principle (N.B. after only one exposure), and the test ages on the BPVS, corresponding to the vocabulary age of the subjects (linear regression, df=9, r=0.9, F=54.3, p<0.0001). There is no significant correlation with the non-word repetition test age of the subject, which would perhaps be expected for subjects asked for what are nonce words. This suggests that, for these WS subjects at least, use of the N3C principle does in fact help them learn new words.

DISCUSSION

Fast-mapping ability is possessed by every subject in each of the two normal control groups, the 3-year-olds and the 9-year-olds, and in the experimental WS group. The N3C principle is then present in WS subjects as it is in normal subjects. This replicates the findings of Mervis and Bertrand (1993). The linkage also found by Mervis and Bertrand between fast-mapping ability and ability in an exhaustive sorting task will be examined in section
B.3.6. There is no effect of age in the normal control groups on strength of expression of fast-mapping.

In the WS group, expressive fast-mapping ability, as measured by the reproduction of names for each object after each trial, lags behind the receptive fast-mapping ability, as measured by the number of times the unfamiliar hypothesised object is selected in response to the unfamiliar label. This is to be expected, as the former is more demanding of processing capacity than the latter.

However, there is no correlation between the scores for producing novel names and the non-word repetition test ages for each subject. These test ages are for a normative task - immediately repeating back nonce words said previously to the subject by the experimenter. As this task probably measures some of that extra processing demand on the phonological short-term memory of the subject, this is perhaps surprising. It indicates instead that WS subjects in the fast-mapping task are not simply repeating back the last phonological item that they heard, but are instead remembering a word that they have applied as a reference to an unfamiliar object. It indicates that they are 'learning' these novel words as labels. The scores for naming novel objects correlate with BPVS test age scores, itself a measure of vocabulary comprehension and a level of acquisition. This demonstrates that the N3C principle is implicated in acquisition of new vocabulary items by WS subjects.

Mervis and Bertrand (1993) demonstrated that onset of fast-mapping ability lags behind the onset of the vocabulary explosion in WS, whereas in both normal and DS populations these coincide. This could suggest that fast-mapping was not a useful mechanism for WS subjects in acquiring new words. However, the link demonstrated here between the score for production of fast-mapped labels and the test-age for BPVS, but not non-word repetition tasks, indicates that fast-mapping is an important mechanism in lexical acquisition in WS.
B.3.2. IS THE WHOLE OBJECT ASSUMPTION PRESENT IN WILLIAMS SYNDROME?

INTRODUCTION

The N3C constraint (Golinkoff et al., 1994), demonstrated by fast-mapping ability, can be divided into the whole object and mutual exclusivity assumptions of Markman's model (Markman, 1992). This experiment, based on the first part of study 2 in Markman and Wachtel (1988), examines whether the constraint of the whole object assumption is used by WS subjects, in an experimental situation where the choice is forced between a whole object and its salient part as the referent for a given word.

Subjects are presented with drawings of objects, together with a stimulus sentence of the form "This is a XXXX", where XXXX is the name of either the whole object or a salient part of that object. Objects in the drawings are either familiar or unfamiliar to subjects. Subjects must indicate what XXXX refers to, either the whole object or the part. Markman and Wachtel (1988) tested normal children up to 3 years old and demonstrated that as predicted, subjects would choose the unfamiliar object above the unfamiliar part in reference to the given word.

No previous research has examined whether children older than 3 years will demonstrate a whole object preference to the same degree in this type of procedure. Four groups of control subjects, of mean ages roughly 3, 5, 7 and 9 years, were used to cover approximately the range of verbal and performance mental ages of the WS population tested.

The experimental procedure is more artificial than that used in the previous study of fast-mapping. However, given that all WS subjects tested showed fast-mapping ability, it is predicted that they should also show the whole object assumption, and in the following study, the mutual exclusivity assumption. These two constraints acting in tandem would, in these experimental situations, replicate the action of the N3C constraint that possession of fast-mapping demonstrates.
METHOD

PRELIMINARY STUDIES

Preliminary study to assess familiarity of objects

A large pool of objects was chosen. These were pre-tested on 6 children around the age of 9. They were asked in a production task to name the objects depicted in drawings. Of the familiar objects, those were selected of which all the children could give a name and gave the same name (bar one exception where 'mouse' and 'rat' were given for the same item. Of the unfamiliar objects, those were selected of which none of the children could give a name. It was felt that if the (un)familiarity of the objects was certain for 9 year olds, then this would hold for the younger age groups.

Preliminary study to assess salience of parts

The items chosen by the previous study were assessed for the visual salience of the parts. Ten adults were presented with the drawings, and asked to rate the visual salience of the parts of the objects from 1 to 10 (10 being very prominent). These were indicated to the subjects. Those objects were chosen for final sets, in each condition of familiarity, that had no significant difference in the judgements of visual salience of parts (p<0.05).

The pool of items used in the experiments is as follows:

<table>
<thead>
<tr>
<th>TABLE B.IX</th>
<th>EXPERIMENTAL ITEMS USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDITION</td>
<td>OBJECT</td>
</tr>
<tr>
<td>FAMILY</td>
<td>mouse / rat</td>
</tr>
<tr>
<td></td>
<td>house</td>
</tr>
<tr>
<td></td>
<td>leg</td>
</tr>
<tr>
<td></td>
<td>car</td>
</tr>
<tr>
<td></td>
<td>camel</td>
</tr>
<tr>
<td></td>
<td>bottle</td>
</tr>
<tr>
<td></td>
<td>television</td>
</tr>
<tr>
<td></td>
<td>bird</td>
</tr>
</tbody>
</table>
Subjects of control groups and experimental groups were given a stimulus sentence "This is a XXXX", in conjunction with a drawing of an object with a salient part. XXXX referred to either the object or the part (3 for each, for each subject). The objects were either familiar or unfamiliar to the children (3 of each, for each subject). The subject was asked to indicate whether the object was the XXXX or the part was the XXXX. The design was within-groups for comparison of the effect of familiarity, between-groups for comparison of the effect of age.

SUBJECTS

For control subjects, 10 subjects of normal schoolchildren in each of four age groups were used. These age groups were 3 year old (range of ages 3;0 to 3;10; mean 3;4), 5 year old (range of ages 5;1 to 5;9; mean 5;3), 7 year old (range of ages 7;0 to 7;11; mean 7;6), and 9 year old (range of ages 9;1 to 9;9; mean 9;4). There were an equal number of males and females in each of the groups.

For experimental subjects, 19 WS subjects were tested. Results of 5 of those tested had to be discarded, as they used an alternative response strategy such as always choosing the response indicated first. Of the remaining 14 subjects, 6 were male and 8 female. The mean age was 20;1, ranging from 7;5 to 31;5 years;months.

MATERIALS

A set of drawings kept in a laminated book: Each drawing was labelled with a letter for easy identification by the experimenter. Two drawings of...
familiar objects were used for practice items, and six drawings of familiar objects and six of unfamiliar were used for the experimental items for each subject. These were taken from a larger pool of drawings, from which items were used for all subjects. The number of times any particular drawing was used was standardised for between age group of control subject. Examples of drawings are given on page 115.

FAMILIAR OBJECT / FAMILIAR PART

MOUSE / TAIL

UNFAMILIAR OBJECT / UNFAMILIAR PART

PORTICO / IONIC

PROCEDURE

Each subject was seen individually, sitting opposite the experimenter at a table in a quiet room. The subject was told: "Today we're going to play a game, to do with the whole of an object or with just a part of it". The subject was given real-object examples of objects with parts such as the table and leg, the (experimenter's) face and nose, the (subject's) hand and finger, and was encouraged to point out any other examples. The subject was then told: "I'm going to show you some things now, and I want you to tell me if it's the whole of an object (experimenter drew a large circle with his finger on the table) or just a part of it (experimenter drew a small circle with his finger on the table)."

Then the book of drawings was produced, and the child given two practice items. For each item, before it was shown, the experimenter would say "This is a XXXX", where XXXX was either the whole object in the drawing or just the part of it. The drawing was then shown to the child and the experimenter said "Which is the XXXX? Is this the XXXX, (experimenter drew a large circle with his finger around the whole object), the whole thing? Or is this the XXXX (experimenter drew a small circle with his finger around the part), this part?". The second practice item was either the part or whole object, depending on which was used first. The subject was encouraged to make a response using their finger to mimic the experimenter. If the subject made a
mistake during the practice items, the experimenter would explain why that response was wrong until the child made the correct response and appeared to understand why.

Then followed six familiar object experimental trials alternating with six unfamiliar object experimental trials. The procedure was exactly that of the practice items, except that no extra help was given if the subject made a mistake and the subject's first firm response was taken as the response. Whether the object or the part was indicated first by the experimenter was counter-balanced across trials.

At the end of the task, the subject was asked for each practice and experimental item in turn "Can you tell me what this thing is called? If you don't know, then either make a guess if you think you might be right, or otherwise just say you don't know", in the order of presentation during the experiment proper. The name given by the subject was recorded. The number of object responses made by each subject in each of the categories of familiar and unfamiliar objects was summed.

The experimental hypotheses are:

**CONTROL SUBJECTS HYPOTHESES**

*for effect of familiarity*

**H1:** hypothesis states that for the familiar objects and parts, the child will be able to select either object or part as referred to. For unfamiliar objects and parts however, the child will use the whole object assumption and select the object response exclusively.

**H1:** hypothesis states that for the familiar objects and parts, the child will be able to select either object or part as referred to. For unfamiliar objects and parts however, the child will select randomly or by some other heuristic either object or part with equal frequency.
Idealised results then, to support H1i:

<table>
<thead>
<tr>
<th>familiar : object / part</th>
<th>unfamiliar : object / part</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypothesis₁</td>
<td>3/3</td>
</tr>
<tr>
<td>hypothesis₀</td>
<td>3/3</td>
</tr>
</tbody>
</table>

for effect of age

H2: hypothesis₁ states that there will be no significant effect on the familiarity effect (object bias) by the age of the subjects.

H2: hypothesis₀ states that there will be a significant effect on the familiarity effect (object bias) by the age of the subjects.

EXPERIMENTAL (WILLIAMS SYNDROME) SUBJECTS HYPOTHESES

From the results of the previous study for fast-mapping, it is hypothesised that WS subjects will also show the whole object assumption for unfamiliar items.

H3: hypothesis₁ states that there will be a significant object bias in WS individuals, comparable to that in normal control subjects of the same verbal mental age.

H3: hypothesis₀ states that there will be no significant object bias in WS individuals.

H4: hypothesis₁ states that there will be no significant effect of age on the object bias in WS individuals.

H4: hypothesis₀ states that there will be a significant effect of age on the object bias in WS individuals.
RESULTS

The number of object responses by each subject made in the familiar and unfamiliar object categories were summed.

Control subjects

The number of object responses made by subjects in each age group for each category of familiarity of item is shown in Table B.X and Figure B.XI following.

TABLE B.X
NUMBER OF OBJECT RESPONSES MADE BY SUBJECTS IN EACH AGE GROUP IN BOTH CONDITIONS

<table>
<thead>
<tr>
<th>age group</th>
<th>mean number of object / part responses in familiar category</th>
<th>mean number of object / part responses in unfamiliar category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>predicted</td>
<td>actual</td>
</tr>
<tr>
<td>3 year</td>
<td>3.0/3.0</td>
<td>3.0/3.0</td>
</tr>
<tr>
<td>5 year</td>
<td>3.0/3.0</td>
<td>3.8/2.2</td>
</tr>
<tr>
<td>7 year</td>
<td>3.0/3.0</td>
<td>3.2/2.8</td>
</tr>
<tr>
<td>9 year</td>
<td>3.0/3.0</td>
<td>3.0/3.0</td>
</tr>
</tbody>
</table>

FIGURE B.XI:
MEAN NUMBER OF OBJECT RESPONSES FOR FAMILIAR AND UNFAMILIAR CATEGORIES ACROSS AGE GROUPS
FIGURE B.XII: FREQUENCY OF CONTROL SUBJECTS MAKING NUMBER OF OBJECT RESPONSES IN FAMILIAR AND UNFAMILIAR CATEGORIES

Figure B.XI indicates that there is an increase in the number of object responses made in the familiar category versus the unfamiliar category, and that there is no apparent effect of age. A two-way unrelated ANOVA was carried out to investigate the effects of familiarity of objects and age of subjects on the number of object response made by subjects. The effect of familiarity on the number of object responses made was significant ($F_{1,12}$ ratio = 5.73, $p < 0.025$). Neither the effect of age of subject nor the interaction between the two variables was significant ($F_{3,12}$ ratio = 0.35, $p > 0.05$; $F_{3,12}$ ratio = 0.35, $p > 0.05$).

Figure B.XII seems to indicate that for the familiar category at least, the distribution of object responses made by each subject in the familiar category is roughly normal. The distribution of object responses made by each subject in the unfamiliar category is very different.

Therefore the experimental hypotheses H1i and H2i were supported for the control groups. There was a significant increase in the number of whole object responses made in the unfamiliar condition as opposed to the
familiar condition. There was no interaction effect of the age of the subjects on this increase in number of whole object responses in the unfamiliar condition.

Follow-up paired t-tests were carried out to test for the significance of the effect of familiarity of stimuli on the number of object responses made in each age group. There is a significant ($p < 0.01$) increase in the number of object responses made in the unfamiliar objects category compared to the familiar category for the 3 year group. There is a significant ($p < 0.001$) increase in the number of object responses made in the unfamiliar objects category compared to the familiar category for the 5 year group. There is a significant ($p < 0.05$) increase in the number of object responses made in the unfamiliar objects category compared to the familiar category, for both the 7 year and 9 year groups.

Responses for unfamiliar items

For one of the unfamiliar items, lung, 90% of the responses were made for the part, bronchiole. That item was then replaced with another, amoeba, with salient part pseudopod, before WS subjects were tested.

WILLIAMS SYNDROME SUBJECTS

The mean number of object responses made in the familiar and unfamiliar categories was: 3.0/3.2. The mean number of object responses made in the familiar category, 3.0, is the same as that made by all age groups of normal controls. However, the mean number of object responses made in the unfamiliar category, 3.2, is considerably lower than the mean across all age groups of controls, 4.6. The frequency distribution of number of object responses in the unfamiliar category is as follows:
FIGURE B.XIII:
FREQUENCY OF WILLIAMS SYNDROME SUBJECTS MAKING A PARTICULAR NUMBER OF OBJECT RESPONSES FOR UNFAMILIAR ITEMS

ANALYSIS

A paired t-test on the number of object responses made in each category was carried out. No significant difference was found. A whole object assumption is not present in WS, unlike the normal controls of ages 3 to 9 years. The hypotheses are not supported.

There is no significant correlation between the chronological age of subjects and the number of unfamiliar object responses made (simple linear regression, R=0.1, df=11, F=0.1, p>0.05). Neither is there a significant correlation between the number of responses made and any measure of verbal intelligence, verbal IQ (WISC) (simple linear regression, R=0.2, df=11, F=0.3, p>0.05), BPVS (simple linear regression, R=0.2, df=11, F=0.3, p>0.05) or TROG (simple linear regression, R=0.3, df=11, F=0.6, p>0.05).

NAMES GIVEN TO OBJECTS
By control subjects

All the familiar objects were named by all ages of children with very few exceptions as would be expected. The unfamiliar objects were either met with 'don't know', some guess that usually corresponded to something
perceptually similar to the item (e.g. "gate" for "portico"), or by repetition of the word used during the experiment to refer to that item. This last response strategy was found particularly in the oldest age group of controls.

**By WS subjects**

Almost all of the familiar objects were named correctly by subjects. Of the unfamiliar objects, most were named incorrectly or no label was offered. Most subjects however, seemed to give at least one repetition of the names given to the object/part during the procedure. The only unfamiliar stimulus item which was recognised correctly, though not named correctly was the *cafetiere*. Six subjects identified it as something used to make coffee.

The labels offered that were incorrect were always for an object that perceptually resembled the stimulus item, such as *gate* for *portico* and *Leaning Tower of Pisa* for *pagoda*.

**DISCUSSION**

For all the normal control subjects, the experimental hypotheses have been supported. Thus significantly more object responses are made in the familiar condition than in the unfamiliar condition, across all age groups. There is also no significant effect of the age of subjects on the number of object responses made.

These results basically replicate those of Markman and Wachtel (1988), who only used subjects of mean age 3:4 years, over a much broader subject population. However, the difference in the number of object responses made in each condition is not as strong in this study as in their study. This is probably due to the anomalous effect of one of the unfamiliar stimuli used, the lung. Despite no difference in the adult rating for the visual salience of its part, the bronchiole, almost all responses made by all subjects for this item were part responses. Certainly, it does appear that for children the part is extremely salient, and is like the figure to the ground of the whole. This is borne out by the responses of several children asked to name it, who called it a "crocodile or log floating in a lake." However, if the results from this item are excluded, then the difference between the number of object responses
made in each condition is comparable to that found by Markman and Wachtel (1988).

A number of subjects in the younger control groups were generally either responding exclusively with only object or only part, or by responding with whichever of object or part was indicated first in the procedure for each item. Their results were removed from the analysis.

For WS subjects, the results do not support the hypotheses. There is no significant difference between the number of object responses made for familiar and unfamiliar items. This indicates that there is no whole object assumption for WS subjects present throughout development from 3 years onwards as there is in normal children. This is surprising, given that WS subjects do show fast-mapping ability. It may be that the experimental situation is too artificial for WS subjects to succeed in this task. In that case, they should not demonstrate a mutual exclusivity assumption tested in a very similar experimental procedure in the following study, B.3.3.
B.3.3 IS THE MUTUAL EXCLUSIVITY ASSUMPTION PRESENT IN WILLIAMS SYNDROME?

INTRODUCTION

Following from the previous study, this experiment, also based on the first part of study 2 in Markman and Wachtel (1988), examines whether the mutual exclusivity assumption is used by WS subjects in an experimental situation where choice is forced between the whole object and a salient part as referent to a given word.

Subjects are presented with drawings of objects, together with a stimulus sentence of the form "This is a XXXX", where XXXX is the name of either the whole object or a salient part of that object. Objects in the drawings are all familiar to subjects. The salient parts of those objects are either familiar or unfamiliar to subjects. Subjects must indicate what XXXX refers to, either the whole object or the part. Markman and Wachtel (1988) tested normal children up to 3 years old and demonstrated that, as predicted, subjects would choose the unfamiliar part above the familiar object in reference to the given unfamiliar (novel) word.

Normal children are used as control subjects. Given that the previous study showed no effect of age on performance of normal controls on a very similar experimental procedure, it was decided to use the top and bottom ends of the control groups: 9 years old; 3 years old. No previous research has examined whether children older than 3 years will demonstrate a mutual exclusivity assumption. These control groups will match to the top and bottom ends of the verbal mental ages of the WS subjects tested.

From the results of study B.3.1, where WS subjects all demonstrated fast-mapping, a mutual exclusivity assumption would be expected to be shown by all subjects. From the results of study B.3.2, however, a similar procedure to that used here did not demonstrate a whole object assumption. It is predicted therefore that WS subjects will also not show a mutual exclusivity assumption.
METHOD

PRELIMINARY STUDIES

Preliminary study to assess familiarity of objects

The same pool of familiar objects/familiar parts was used for this study as was used for the whole object assumption study of B.3.2. These were screened as in the previous study. Of the familiar objects and unfamiliar parts, those were selected of which all of the children could give a name for the familiar objects, but which none of the children could give a reliable name for the unfamiliar parts. It was felt that if the (un)familiarity of the objects/parts was certain for 9 year olds, then it would be so for younger age groups.

Preliminary study to assess salience of parts

The familiar object/unfamiliar part items were assessed for the visual salience of the parts. Ten adults were presented with the drawings, and asked to rate from 1 to 10 the visual salience of the parts relative to the whole objects (10 being very prominent). These were indicated to the subjects. Those objects were chosen for final sets, in each condition of familiarity, that had no significant difference in the judgements of visual salience of parts (p<0.05).

On preliminary testing with 9 year old subjects, one of the items used with the 3 year old subjects (fish/dorsal [fin]) was found to produce predominantly object responses (fish) when the part name (dorsal) was used. It was reasoned that this was because subjects had reliable names for both object and part already, fish and fin, and therefore were using the whole object bias for choosing dorsal as a second referent for the whole object, as they already had a referent for the part. This item was replaced by another (spanner/ratchet) for testing with 9 year old subjects and experimental WS subjects.

The pool of items used in the experiments is as follows:
### TABLE B.XIV
EXPERIMENTAL ITEMS USED
FOR YOUNGER CONTROL SUBJECTS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>OBJECT</th>
<th>PART</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAMILIAR</td>
<td>mouse</td>
<td>tail</td>
</tr>
<tr>
<td></td>
<td>house</td>
<td>chimney</td>
</tr>
<tr>
<td></td>
<td>leg</td>
<td>foot</td>
</tr>
<tr>
<td></td>
<td>car</td>
<td>wheel</td>
</tr>
<tr>
<td></td>
<td>camel</td>
<td>hump</td>
</tr>
<tr>
<td></td>
<td>bottle</td>
<td>top</td>
</tr>
<tr>
<td></td>
<td>television</td>
<td>screen</td>
</tr>
<tr>
<td></td>
<td>bird</td>
<td>beak</td>
</tr>
<tr>
<td>UNFAMILIAR</td>
<td>fish</td>
<td>dorsal fin</td>
</tr>
<tr>
<td></td>
<td>horse</td>
<td>fetlock</td>
</tr>
<tr>
<td></td>
<td>lightbulb</td>
<td>tungsten</td>
</tr>
<tr>
<td></td>
<td>door</td>
<td>lintel</td>
</tr>
<tr>
<td></td>
<td>camera</td>
<td>f-ring</td>
</tr>
<tr>
<td></td>
<td>eye</td>
<td>iris</td>
</tr>
</tbody>
</table>

FOR OLDER CONTROL SUBJECTS AND WS SUBJECTS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>OBJECT</th>
<th>PART</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAMILIAR</td>
<td>mouse</td>
<td>tail</td>
</tr>
<tr>
<td></td>
<td>house</td>
<td>chimney</td>
</tr>
<tr>
<td></td>
<td>leg</td>
<td>foot</td>
</tr>
<tr>
<td></td>
<td>car</td>
<td>wheel</td>
</tr>
<tr>
<td></td>
<td>camel</td>
<td>hump</td>
</tr>
<tr>
<td></td>
<td>bottle</td>
<td>top</td>
</tr>
<tr>
<td></td>
<td>television</td>
<td>screen</td>
</tr>
<tr>
<td></td>
<td>bird</td>
<td>beak</td>
</tr>
<tr>
<td>UNFAMILIAR</td>
<td>spanner</td>
<td>ratchet</td>
</tr>
<tr>
<td></td>
<td>horse</td>
<td>fetlock</td>
</tr>
<tr>
<td></td>
<td>lightbulb</td>
<td>tungsten</td>
</tr>
<tr>
<td></td>
<td>door</td>
<td>lintel</td>
</tr>
<tr>
<td></td>
<td>camera</td>
<td>f-ring</td>
</tr>
<tr>
<td></td>
<td>eye</td>
<td>iris</td>
</tr>
</tbody>
</table>

**DESIGN**

Subjects of control groups and experimental groups were given a stimulus sentence "This is a XXXX", in conjunction with a drawing of an object with a salient part. XXXX referred to either the object or the part (3 for
each, for each subject). The objects were either familiar or unfamiliar to the children (3 of each, for each subject). The subject was asked to indicate whether the object was the XXXX or the part was the XXXX. The design was within-groups for comparison of the effect of familiarity, between-groups for comparison of the effect of age.

SUBJECTS

For control subjects, two groups were tested, the younger the 3 year old group and the older the 9 year old group. In the younger group, 22 normal schoolchildren were screened to see if they could name the whole object for 2 or 3 out of the 3 items in the familiar objects / unfamiliar parts condition. Ten of these 3-year-olds could not yet do so and treated the familiar objects as if they were unfamiliar objects. The remaining 12 subjects were used for analysis. Their mean age was 3;5, ranging from 3;0 to 3;11. There were an equal number of males and females in the group. In the older group, 12 normal school children were tested. Their mean age was 9;6, ranging from 9;0 to 9;11.

For experimental subjects, 12 WS subjects were tested. Two of these subjects did not select reliably on the familiar object/familiar part condition, and their results were discarded from further analysis. The 10 remaining WS subjects formed the experimental group. Their mean age was 19;6, ranging from 8;0 to 30;5.

MATERIALS

A set of drawings kept in a laminated book: Each drawing was labelled with a letter for easy identification by the experimenter. Two drawings of familiar objects/familiar parts were used for practice items, and six drawings of familiar objects/familiar parts and six of familiar objects/unfamiliar parts were used for the experimental items for each subject. These were taken from a larger pool of drawings, from which items were used for all subjects. The number of times any particular drawing was used was standardised for between age group of control subject. Examples of drawings are given on the following page:
B.3.2 - WHOLE OBJECT ASSUMPTION STUDY
EXAMPLES OF STIMULI

Familiar Object: Bird
Familiar Part: Beak

Unfamiliar Object: Portico
Unfamiliar Part: Ionic

B.3.3 - MUTUAL EXCLUSIVITY ASSUMPTION STUDY
EXAMPLES OF STIMULI

Familiar Object: Mouse
Familiar Part: Tail

Familiar Object: Bulb
Unfamiliar Part: Tungsten
PROCEDURE

The procedure was the same as in the whole object assumption study, section B.3.2. Each subject was seen individually, sitting opposite the experimenter at a table in a quiet room. The subject was told: "Today we're going to play a game, to do with the whole of an object or with just a part of it". The subject was given real-object examples of objects with parts such as the table and leg, the (experimenter's) face and nose, the (subject's) hand and finger, and was encouraged to point out any other examples. The subject was then told: "I'm going to show you some things now, and I want you to tell me if it's the whole of an object (experimenter drew a large circle with his finger on the table) or just a part of it (experimenter drew a small circle with his finger on the table)."

Then the book of drawings was produced, and the child given two practice items. For each item, before it was shown, the experimenter would say "This is a XXXX", where XXXX was either the whole object in the drawing or just the part of it. The drawing was then shown to the child and the experimenter said "Which is the XXXX? Is this the XXXX, (experimenter drew a large circle with his finger around the whole object), the whole thing? Or is this the XXXX (experimenter drew a small circle with his finger around the part), this part?". The second practice item was either the part or whole object, depending on which was used first. The subject was encouraged to make a response using their finger to mimic the experimenter. If the subject made a mistake during the practice items, the experimenter would explain why that response was wrong until the child made the correct response and appeared to understand why.

Then followed six familiar object/familiar part experimental trials alternating with six familiar object/unfamiliar part experimental trials. The procedure was exactly that of the practice items, except that no extra help was given if the subject made a mistake. The subject's first firm response was taken as the response. Whether the object or the part was indicated first by the experimenter was counter-balanced across trials.

At the end of the task, the subject was asked to name the part and whole object of each practice and experimental item in turn "Can you tell me what this thing is called? If you don't know, then either make a guess if you
think you might be right, or otherwise just say you don't know", in the order of presentation during the experiment proper. The name given by the subject for part and whole object of each item was recorded.

The experimental hypotheses are:

CONTROL SUBJECTS HYPOTHESES

for effect of familiarity

H1: hypothesis states that for the familiar objects and familiar parts, the child will be able to select either object or part as referred to. For familiar objects and unfamiliar parts however, the child will select the object as referred to, but will select the part in response to an unfamiliar referent rather than labelling the object with a second referent, using the mutual exclusivity assumption.

H1: hypothesis states that for the familiar objects and parts, the child will be able to select either object or part as referred to. For familiar objects and unfamiliar parts however, the child will select the object as referred to, but will select randomly either object or part in response to the unfamiliar referent.

Idealised results then; to support H1:

<table>
<thead>
<tr>
<th></th>
<th>familiar : object / part</th>
<th>unfamiliar : object / part</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypothesis</td>
<td>3/3</td>
<td>3/3</td>
</tr>
<tr>
<td>hypothesis</td>
<td>3/3</td>
<td>6/0</td>
</tr>
</tbody>
</table>

for effect of age

H2: hypothesis states that there will be no significant effect on the mutual exclusivity effect by the age of the subjects.

H2: hypothesis states that there will be a significant effect on the mutual exclusivity effect by the age of the subjects.
EXPERIMENTAL (WILLIAMS SYNDROME) SUBJECTS HYPOTHESES

Given that WS subjects did not show a whole object assumption on a similar procedure in the previous study, B.3.2, it is hypothesised that they will show no mutual exclusivity assumption for unfamiliar items.

H3: hypothesis$_1$ states that there will be no significant mutual exclusivity bias in WS individuals.

H3: hypothesis$_0$ states that there will be a significant mutual exclusivity bias in WS individuals, comparable to that in normal control subjects of the same verbal mental age.

H4: hypothesis$_1$ states that there will be no significant effect of age on the mutual exclusivity bias in WS individuals.

H4: hypothesis$_0$ states that there will be a significant effect of age on the mutual exclusivity bias in WS individuals.

RESULTS

The number of object responses made by each subject in each of the categories of familiar objects/familiar parts and familiar objects/unfamiliar parts was summed.

Control subjects

The number of object/part responses made by subjects in each age group for each category of familiarity of item is shown in Table B.XV below.

<table>
<thead>
<tr>
<th>age group (n=12)</th>
<th>mean number of object responses in familiar objects / familiar parts category</th>
<th>mean number of object responses in familiar objects / unfamiliar parts category</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 YR</td>
<td>3.0/3.1</td>
<td>3.0/3.4</td>
</tr>
<tr>
<td>9 YR</td>
<td>3.0/3.0</td>
<td>3.0/3.2</td>
</tr>
</tbody>
</table>
The mean number of object responses made in both conditions for both age groups do not differ greatly from those hypothesised for both conditions, 3.0.

The frequency of subjects making a number of object responses in both conditions is shown in Figure B.XVI following.

**FIGURE B.XVI:**
**FREQUENCY OF CONTROL SUBJECTS MAKING NUMBER OF OBJECT RESPONSES IN THE TWO CONDITIONS**

fo/fp condition = familiar object / familiar part condition
mo/mp condition = familiar object / unfamiliar part condition

![Graph showing the frequency of control subjects making object responses in the two conditions.](image)

Figure B.XVI indicates that there is no increase in the number of object responses made in the familiar object/familiar part category versus the familiar object/unfamiliar part category, and that there is no apparent effect of age. A two-way mixed ANOVA was carried out to investigate the effects of familiarity of parts and age of subjects on the number of object response made by subjects. Neither the effect of part familiarity on the number of object responses made was significant ($F_{1,22}$ ratio = 0.881, $p > 0.05$), nor the effect of age of subject nor the interaction between the two variables was significant ($F_{1,22}$ ratio = 0.786, $p > 0.05$; $F_{1,22}$ ratio = 0.35, $p > 0.05$).
Therefore the experimental hypotheses H1i and H2i were supported for the control groups. There was no significant increase in the number of whole object responses made in the unfamiliar part condition as opposed to the familiar part condition, nor was there any effect of the age of the subject on this effect.

Follow-up one-tail paired t-tests were carried out to test for the significance of the effect of familiarity of part stimuli on the number of object responses made in each age group. There is no significant difference between the number of object responses made in the familiar objects/familiar parts condition and the familiar objects/unfamiliar parts condition (df=11, t=-0.9, p>0.05) for the 3 year old normal control group, nor is there for the older 9 year old normal control group (df=11, t=-0.5, p>0.05).

**WILLIAMS SYNDROME SUBJECTS**

The mean number of object responses made in the familiar and unfamiliar categories was: 3.0/3.2. The mean number of object responses made in the familiar object/familiar part category, 3.0, is the same as that made by both age groups of normal controls. The mean number of object responses made in the familiar object/unfamiliar part category, 3.2, is similar to the mean across all age groups of controls, 3.3. Of the 10 WS subjects, 9 made 3 object responses in the familiar object/unfamiliar part category, and 1 made 5 object responses in that category.

**ANALYSIS**

A paired t-test on the number of object responses made in each category was carried out. No significant difference was found. A mutual exclusivity bias does seem to be present in WS, just like the normal controls of ages 3 to 9 years.

**NAMES GIVEN TO OBJECTS**

*By control subjects*

Almost all the familiar whole objects and familiar parts were named reliably and correctly by all subjects in both age groups. The familiar whole objects (with unfamiliar parts) were named less reliably, but there were still
correct responses by a majority of subjects. The unfamiliar parts were not
terably. A majority of subjects in both age groups said 'Don't Know' as a response to these.

**By WS subjects**

Almost all the familiar whole objects and familiar parts were named reliably and correctly. The familiar whole objects (with unfamiliar parts) were named less reliably, but there were still correct responses by a majority of subjects. The unfamiliar parts were not named reliably. There was an even distribution of 'Don't Know' and roughly apt but inaccurate descriptions of the part as responses across all subjects.

**DISCUSSION**

For all the normal control subjects, the experimental hypotheses have been supported. Thus significantly more object responses are not made in the familiar part condition than in the unfamiliar part condition, across all age groups. There is also no significant effect of the age of subjects on the number of object responses made. These results basically replicate on a broader age range those of Markman and Wachtel (1988), who used subjects of mean age 3:4 years.

For WS subjects again, a mutual exclusivity assumption is present. For stimuli where the object was familiar but the salient part unfamiliar, then a novel label was mapped onto the part, not the object. Again, there was no effect of age of subject on the responses made.

Therefore, contrary to predictions, a mutual exclusivity assumption has been demonstrated to be present by a similar procedure as that which demonstrated no whole object assumption in the same group in the previous study. This indicates that the lack of a demonstrable whole object assumption cannot be due to some problem that subjects have with the procedure itself. Possible reasons for this difference will be discussed after investigating whether there is a confounding factor in a possible local (part) level bias in visuo-spatial processing of hierarchical stimuli by WS subjects. It may be that there is some relationship between visual processing of such stimuli in the part-whole study and the visual processing of hierarchical stimuli. If there
were such a relationship, one would expect those subjects with a bias towards the local parts level of the hierarchical stimuli to show an object response bias below chance, that is to choose parts. One would expect those subjects with a bias towards the global whole level of the hierarchical stimuli to show an object response bias above chance. The absence of a whole object assumption as shown in this experiment would then be due to a difference in processing of the visual information of the stimuli, and not due to a difference in default assumptions within the linguistic domain. This is examined in section B.3.4.
B.3.4. IS THERE A DISSOCIATION IN WILLIAMS SYNDROME BETWEEN GLOBAL AND LOCAL LEVELS IN VISUOSPATIAL PROCESSING OF HIERARCHICAL STIMULI?

INTRODUCTION

Hierarchical visual stimuli have two levels, a global, whole object level and a local, part level. An example from advertising culture is the Halifax Building Society logo where people in different coloured suits move in synchrony so that from a distance, the blocks of colour form a gigantic X. The global level here is the X, whilst the local level is the individual people that form that X. Experimental hierarchical stimuli are thankfully simpler. A typical example would be a drawing of an X that is formed by a configuration of much smaller Os. The global level here is the X, the local level the Os.

Bihrlle et al. (1989) examined global versus local processing of hierarchical visual stimuli in different populations. In patients with unilateral focal damage, it has been demonstrated that those with left hemisphere damage have difficulty in drawing the local forms whereas those with right hemisphere damage have difficulty in the global forms. Bihrlle et al. examined WS and Down Syndrome populations, neither of whom have localised cerebral damage but rather a genetic disorder.

Four subjects from each group were presented with an hierarchical drawing of a form such as of:
They were either asked to copy the stimulus from memory or by copying it when presented. Typical responses for each of the subject groups in both conditions are:

\[ DS \text{ subject aged 16} \quad WS \text{ subject aged 16} \]

As can be seen from the examples of drawings above, the Down Syndrome group concentrated on the global form of the stimulus, ignoring the local components, whereas the WS group demonstrated the opposite effect. The Down Syndrome group show similar results to patients with left hemisphere focal damage, whilst the WS group show similar results to patients with right hemisphere focal damage.

Bellugi et al. (1988) also found that in copying hierarchical drawings, individuals with WS "represent only the local internal details, without organising them into the appropriate whole". They demonstrated this apparent dissociation between global and local levels of hierarchical stimuli in samples of WS and Down Syndrome subjects' spontaneous drawing as well. Rossen et al. (1994) found more 'fragmented' local-level visuospatial processing by WS subjects on the WISC-R Block Design Test.

There are various criticisms that can be made of this conclusion, and this study which attempts to replicate previous findings, will address these shortcomings. In all previous studies very small groups of subjects were used, and they were essentially therefore qualitative studies. It is possible though that not all subjects with WS will show this dissociation between global and local levels of processing at all, or show it to such a striking degree. It is essential to study a larger group of subjects.

A method of quantitative assessment of these stimuli was devised by Stiles (Stiles, in press). It involves independently assessing
the global accuracy and the local accuracy of each stimulus response. Each are marked out of 5.

**Scoring system used to evaluate hierarchical drawings**

**Measure of global level accuracy**
This is scored first. The content and accuracy of the local form are ignored for this measure.

**Score 0**
- nothing or scribble
- randomly placed local elements with no recognisable global configuration
- one single, non-configural, inaccurate form

**Score 1**
- recognisable but inaccurate configural form
- partial configuration: if target closed, give credit for closed configuration, if target open give credit for open configuration (line, arc, etc.)

**Score 2**
- accurate global form but not configural

**Score 3**
- form must be accurate
- must be attempt at configuration, but spacing may be distorted, non-uniform, or irregular
- overdrawing, where local elements are placed on top of a global but non-configural form
- orientation of global form off more than 20 degrees

**Score 4**
- must be accurate, configural form
- adequate, uniform spacing (no more than 4 forms may touch)
- orientation must be accurate within 10 degrees
- generally well drawn

**Score 5**
- accurate configural form
- accurate spacing between all elements
- accurate orientation
- good approximation to number of local elements (>70%)
Measures of local level accuracy
This is scored second. The content and accuracy of the global form are ignored for this measure.

Score 0
- nothing or scribble
- global form but no elements

Score 1
- recognisable but inaccurate elements (must be at least 2 of the same form)
- attempt to indicate elements but no real local level forms

Score 2
- less than 50% of the correct number of elements (they must be discrete and recognisable)
- at least one of the elements must be accurate

Score 3
- all elements must be recognisable
- more than 50% of correct number of elements present
- more than 50% of those elements are accurate
- may be orientation problems

Score 4
- all elements are accurate and adequately drawn
- adequate, uniform spacing between elements
- orientation correct within ten degrees

Score 5
- all elements accurate and well drawn
- all elements correctly oriented
- accurate number of elements
- accurate spacing

For the characteristic responses of a Down's Syndrome subject and a WS subject, the scores for each level in this assessment scale would be as follows. The Down Syndrome subject would score 2 for global level accuracy and 0 for local level accuracy. The WS subject would score 0 for global level accuracy and 4 for local level accuracy.

No comparison has been made in previous studies with mental-age-matched normal controls. The assumption presumably has been that as the Down Syndrome and WS subjects were mental-age-matched, there was no need for normal controls. The dissociation between the two syndromes can thus be demonstrated. It is not
possible, however, to claim that Williams syndrome alone shows a particular pattern, without first comparing against the results of mental-age-matched controls.

In fact, normal controls have been tested. Stiles tested normal children aged from 4- to 8-years-old, as well as normal adults, on their stimuli. The mean accuracy of the local level was in fact 0.2 greater than the global level for the youngest children, rising to 0.5 for the 5-year-old children, before the two levels equalled out at 8-years-old. This suggests the possibility that at least some of the difference between local and global levels in WS subjects may be caused by a factor related to the mental age of the subjects.

Somewhat different, stimuli were used in the present experiment to those used by Stiles. Normal children from age 3-years-old were therefore tested on these stimuli, to match to the developmental trajectory for this task derived from the results of Stiles.

It is not possible to conclude, as Bellugi et al. did, that the difference in drawings produced by Down Syndrome and WS subjects is necessarily due to a difference in visuospatial perception. The implication then is that WS subjects, for example, cannot perceive the global whole configuration of the hierarchical stimuli. If that were the case, then subjects should not be able to describe the stimuli verbally.

It is possible that rather than an outright inability to perceive the global configuration, there is a selective bias that arises in situations where there is greater demand on processing capacity. In that case, WS subjects would be able to perceive the global configuration but the demands of the task being such, would ignore it when drawing a reproduction. In that case, one would expect that stimuli which were more taxing to reproduce would be more likely to show a greater local level accuracy than a global level accuracy. Stimuli chosen for this study were varied according to the number of strokes that each global and local element required to be drawn. For an instance, an X requires 2 strokes to draw, whilst an O only requires 1 stroke.
Finally, it may be that the problem for WS subjects in reproducing the global configuration arises from a problem in planning and execution of the motor response of drawing. WS subjects typically do have problems in motor co-ordination such as that required in a drawing task (Udwin et al., 1987). To draw the global array of local elements requires planning and co-ordination for up to 60 seconds, a typical time for each subject to execute a response. To draw each local element, however, takes a much shorter time and the motor action is repeated for each element drawn. This makes it essentially easier in terms of the motor response for the local level above the global level. This factor may explain the slight increase in local level accuracy for younger subjects in the study by Stiles. The actual stages in executing the response will be monitored. If there is a greater difficulty in planning and execution of the motor response, one might expect that a WS subject might at least attempt the global array, and then give up. Although an apparently random configuration of local elements would be the end-result, this is not equivalent to the essentially random array of local elements with no conception of the global configuration, described by Bellugi et al.

The stimuli presented also include non-hierarchical stimuli of the same form as the global form of the hierarchical stimuli, so that the difficulty of drawing a particular global form, on the larger scale that requires, can be measured.

**METHOD**

**DESIGN**

Five hierarchical and five non-hierarchical stimuli were presented in alternating order to subjects for five seconds. Subjects were then asked to reproduce what they saw. The order of presentation was counterbalanced across subjects.

A roughly even distribution of curvilinear and rectilinear shapes and also a roughly even distribution of closed and open shapes were used in both global and local elements of stimuli.
The design was within-subjects for comparison of global and local level accuracy, and between-groups for comparison between normal and WS subjects.

MATERIALS

A set of drawings kept in a laminated book: Five hierarchical and five non-hierarchical stimuli were used. The non-hierarchical stimuli were of the same form as the global forms of the hierarchical stimuli. The drawings were kept in an order alternating between hierarchical and non-hierarchical stimuli. The stimuli used can be seen below:

EXPERIMENTAL ITEMS USED

NON-HIERARCHICAL
Global/Local Parts Closed/Open Curvilinear/Rectilinear

1 c c

1 c r

4 o r
HIERARCHICAL
Global/Local Parts Closed/Open Curvilinear/Rectilinear

1/3 c/o c/r

1/2 c/c r/r

4/1 o/c r/c
Subjects were given sheets of paper and a pen to make their drawings.

SUBJECTS

Three year old subjects (n=10, mean age = 3;7 ranging from 3;2 to 3;11) and 5 year old subjects (n=10, mean age = 5;7 ranging from 5;0 to 5;11) were used as normal controls. As their results tallied significantly with those for normal subjects on similar hierarchical stimuli used by Stiles, no older age groups were used.

WS subjects participated as the experimental group (n=13, mean age = 18;10 ranging from 7;5 to 31;6). These were all subjects tested in the Whole Object Assumption study, in section B.3.2. One further subject was tested but her results were discarded as she had great problems in the motor control necessary to complete successfully any drawing.

PROCEDURE

Each subject sat at a table, and was given a blank sheet of paper and a pen. The experimenter also sat at the table and produced the book of stimuli. The experimenter said "Now, we're going to do some
drawing. I'm going to show you a picture, and in each case I want you to draw exactly what you see." The first stimulus was shown, for five seconds, removed from sight and the subject then asked again "Draw exactly what you saw". When the subject finished that drawing, their sheet was removed and a new blank sheet given. The procedure was then repeated for the rest of the stimuli.

The drawings were then scored by the experimenter. Hierarchical stimuli drawings and non-hierarchical stimuli drawings were scored according to the relevant systems.

The experimental hypotheses are:

CONTROL SUBJECTS HYPOTHESES

for effect of global and local level

H1: hypothesis\textsubscript{i} states that the mean accuracy of reproduction of global and local elements will not significantly differ.

H1: hypothesis\textsubscript{o} states that the mean accuracy of reproduction of global and local elements will significantly differ.

for effect of age

H2: hypothesis\textsubscript{i} states that there will be a significant effect of age of subject on both the mean accuracies of both global and local levels, both increasing with age, and with the difference between local and global levels, the local level mean accuracy being greater with younger subjects.

H2: hypothesis\textsubscript{o} states that there will be no significant effect of age of subject on both the mean accuracies of both global and local levels, and the difference between local and global levels, the local level mean accuracy being equal to the global level for all ages of subject.
HYPOTHESES FOR WILLIAMS SYNDROME SUBJECTS

Assuming that the results of Bellugi et al. (1988) are replicated, the following predictions can be made:

**H3:** hypothesis\_i states that the mean accuracy of reproduction of global and local elements will significantly differ, with local level accuracy being greater than global level accuracy. In addition, the magnitude of this difference should be greater than that seen in any normal controls.

**H3:** hypothesis\_o states that the mean accuracy of reproduction of global and local elements will not significantly differ.

Assuming that there is a significant effect of age on both level accuracies in the normal control groups, then one may expect that the mean accuracies of both local and global levels in the WS group will be affected by their mental age. The best measure of this for this spatial task will be the Ravens Progressive Matrices task (Raven, 1986).

**H4:** hypothesis\_i states that there will be a significant correlation of both accuracy levels with the test age for the Ravens Progressive Matrices task.

**H4:** hypothesis\_o states that there will be no significant correlation of both accuracy levels with the test age for the Ravens Progressive Matrices task

**RESULTS**

Hierarchical drawings were rated for global level (whole) accuracy and local level (parts) accuracy according to the scoring system described in the introduction. Scores for each level of accuracy for each drawing ranged on a 6 point scale from 0 to 5, 5 being a perfect reproduction on that level.

Non-hierarchical drawings were rated for accuracy according to the scoring system below:
Scoring system for non-hierarchical stimuli

This is a 4 point scale, ranging from 0 to 3, 3 being a perfect reproduction.

Score 0
- nothing or scribble

Score 1
- Recognisable but inaccurate match. If target open, give credit for open. If target closed, give credit for closed.

Score 2
- Good approximate match. May be orientation problems. May be slight curving of what should be rectilinear shapes.

Score 3
- Excellent match.

Scores for each level of accuracy for each drawing ranged on a 4 point scale from 0 to 3, 3 being a perfect reproduction on that level.

NORMAL CONTROL SUBJECTS

Non-hierarchical stimuli

The mean scores for subjects in each age group are as follows:

TABLE B.XVII
SCORES FOR NORMAL CONTROL SUBJECTS WITH NON-HIERARCHICAL STIMULI

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 year olds</td>
<td>0.9/3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>5 year olds</td>
<td>2.6/3</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

There is a significant effect of age of subject on reproduction of non-hierarchical stimuli, with older subjects being more accurate.
Hierarchical stimuli

The mean scores for subjects in each age group are as follows:

**TABLE B.XVIII**
**MEAN SCORES NORMAL CONTROL SUBJECTS FOR REPRODUCTIONS OF HIERARCHICAL DRAWINGS ON EACH LEVEL, GLOBAL AND LOCAL**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Level/Local</th>
<th>Level Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 year olds</td>
<td>GLOBAL/LOCAL</td>
<td>GLOBAL</td>
<td>1.0/5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>LOCAL</td>
<td>0.4/5</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>5 year olds</td>
<td>GLOBAL/LOCAL</td>
<td>GLOBAL</td>
<td>2.4/5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>LOCAL</td>
<td>3/5</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

These means tally significantly with those obtained with similar hierarchical stimuli by Stiles for 4 year olds, 5 year olds, 6 year olds, 8 year olds and adults (global: simple linear regression, \( df=6, R=1, F=71.4, p<0.05 \); local: simple linear regression, \( df=6, R=0.9, F=19.8, p<0.05 \)). The means for each age group in that study were as follows:

**TABLE B.XIX**
**MEAN SCORES OF REPRODUCTION IN STILES' STUDY BY NORMAL CONTROL GROUPS**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Global Mean</th>
<th>Local Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Adult</td>
<td>4.7</td>
<td>4.7</td>
</tr>
</tbody>
</table>

For the 3 year old group in this study, the global level mean accuracy is significantly greater than the local level mean accuracy (Wilcoxon signed-ranks test, \( N=8, Z=-3, p<0.005 \)). For the 5 year old group however, the global level mean accuracy is significantly less
than the local level mean accuracy (Wilcoxon signed-ranks test, $N=7$, $Z=-2.8$, $p<0.01$). The local level biases (local level accuracy - global level accuracy) for each stimulus for each subject in each group were calculated; the local level bias for the 5 year old group was significantly greater than that for the 3 year old group (Wilcoxon signed-ranks test, $N=28$, $Z=-3.9$, $p<0.001$).

For normal subjects therefore, there is a tendency for subjects younger than 5 years to perform better in reproducing the local level elements of hierarchical stimuli as opposed to the global level elements.

**WILLIAMS SYNDROME SUBJECTS**

**Non-hierarchical stimuli**

The mean scores for subjects in each age group are as follows:

<table>
<thead>
<tr>
<th></th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9/3</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

There is no significant difference between the mean accuracies of non-hierarchical stimuli of WS subjects and of 5-year-old normal controls. Overall, the reproductions of these stimuli are good, and there does not appear to be any difficulty in reproducing non-hierarchical stimuli on the same scale as the hierarchical stimuli.

**Hierarchical stimuli**

The mean scores for all subjects for the two levels are as follows:
TABLE B.XXI
MEAN SCORES OF REPRODUCTION ON BOTH LEVELS, GLOBAL AND LOCAL, BY WS SUBJECTS

<table>
<thead>
<tr>
<th>subject</th>
<th>global mean</th>
<th>local mean</th>
<th>local bias (local mean - global mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>CC</td>
<td>1.6</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>DD</td>
<td>3</td>
<td>2.2</td>
<td>-0.8</td>
</tr>
<tr>
<td>EE</td>
<td>2.4</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>FF</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>HH</td>
<td>2.8</td>
<td>4.2</td>
<td>1.4</td>
</tr>
<tr>
<td>II</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>KK</td>
<td>3.8</td>
<td>3.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>MM</td>
<td>0.2</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>NN</td>
<td>3</td>
<td>4.2</td>
<td>1.2</td>
</tr>
<tr>
<td>OO</td>
<td>2.4</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>PP</td>
<td>4</td>
<td>3.8</td>
<td>-0.2</td>
</tr>
<tr>
<td>QQ</td>
<td>1.2</td>
<td>1.2</td>
<td>0</td>
</tr>
</tbody>
</table>

The overall means for the WS group are as follows:

<table>
<thead>
<tr>
<th>GLOBAL/LOCAL LEVEL</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL</td>
<td>2.4/5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>LOCAL</td>
<td>2.8/5</td>
<td>0</td>
<td>4.2</td>
</tr>
</tbody>
</table>

There is no significant difference between the scores for the global level and local level accuracies (Wilcoxon signed ranks test, N=51 (not including tied scores), Z=-1.4, p>0.05). This contradicts the findings of Bellugi et al. (1988), who found almost a complete lack of accuracy on the global level and good accuracy on the local level.

FURTHER ANALYSIS

There appears to be significant variation in the local biases (local level mean score - global level mean score) within the WS subjects. Some subjects do indeed show a much higher local level mean than global level mean, as one would predict from the findings of Bellugi et al. (1988). However, most subjects do not.
Before further analysis of these differences between subjects, it is essential to take some account of any difference that might be due to differing general spatial intelligences of subjects. All subjects were previously tested by Grant (Karmiloff-Smith et al., 1996) on the Raven's Progressive Matrices Test. This test gives a spatial intelligence mental age, based on extensive normal data.

There is no significant correlation between the test ages of subjects on the Raven's test and any of the global level mean accuracy, local level mean accuracy and local level bias. However, one may assume that there is a significant correlation between Raven's test age and global and local level mean accuracies for normal subjects, as there is a significant effect of chronological age. The Raven's test is a normative task, and test ages by definition are equivalent to chronological ages for the average normal subject.

The global level and local level means that one might predict for each subject from their Raven's Test Age can be extrapolated from graphs of Raven's Test Age versus global and local level means for normal control subjects. The graphs of chronological age versus global means and local means respectively, based on results with normal children in this study and that of Stiles (in press), are as follows.

**FIGURE B.XXII**
**GLOBAL MEAN VS AGE FOR WS SUBJECTS**
FIGURE B.XXIII
LOCAL MEAN VS AGE FOR WS SUBJECTS

These graphs were used to calculate predicted global and local level means from Raven's Test Ages for WS subjects. These are as follows:

TABLE B.XXIV
ACTUAL MEANS VERSUS MEANS PREDICTED FROM RAVEN'S TEST AGE SCORES FOR WS SUBJECTS

<table>
<thead>
<tr>
<th>subject</th>
<th>Raven's Test Age</th>
<th>global level mean actual</th>
<th>local level mean predicted</th>
<th>local level mean actual</th>
<th>local level mean predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>9</td>
<td>4</td>
<td>3.7</td>
<td>4</td>
<td>3.6</td>
</tr>
<tr>
<td>CC</td>
<td>5.25</td>
<td>1.6</td>
<td>2.8</td>
<td>4</td>
<td>2.2</td>
</tr>
<tr>
<td>DD</td>
<td>N/A</td>
<td>3</td>
<td>•</td>
<td>2.2</td>
<td>•</td>
</tr>
<tr>
<td>EE</td>
<td>7</td>
<td>2.4</td>
<td>3.4</td>
<td>2.4</td>
<td>3.4</td>
</tr>
<tr>
<td>FF</td>
<td>5.5</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3.2</td>
</tr>
<tr>
<td>HH</td>
<td>5.25</td>
<td>2.8</td>
<td>2.8</td>
<td>4.2</td>
<td>3.1</td>
</tr>
<tr>
<td>II</td>
<td>8</td>
<td>1</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>KK</td>
<td>9</td>
<td>3.8</td>
<td>3.7</td>
<td>3.4</td>
<td>3.6</td>
</tr>
<tr>
<td>MM</td>
<td>4</td>
<td>0.2</td>
<td>1.5</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>NN</td>
<td>6</td>
<td>3</td>
<td>3.2</td>
<td>4.2</td>
<td>3.3</td>
</tr>
<tr>
<td>OO</td>
<td>11</td>
<td>2.4</td>
<td>3.8</td>
<td>2.4</td>
<td>3.8</td>
</tr>
<tr>
<td>PP</td>
<td>9</td>
<td>4</td>
<td>3.7</td>
<td>3.8</td>
<td>3.6</td>
</tr>
<tr>
<td>QQ</td>
<td>5.25</td>
<td>1.2</td>
<td>2.8</td>
<td>1.2</td>
<td>3.1</td>
</tr>
</tbody>
</table>
There is no significant difference between the predicted and actual mean accuracies for both global and local levels (Wilcoxon signed-rank test - global: Z=-1.7, p>0.05; local: Z=-0.1, p>0.05). The subjects with positive local biases, that is those with local level means higher than global level means, are as follows. Whether their actual global and local level means are greater (>) or less (<) than their predicted global and local level means is also shown.

**TABLE B.XXV**

**DIFFERENCES BETWEEN ACTUAL AND PREDICTED MEANS FOR SUBJECTS SHOWING A POSITIVE LOCAL BIAS**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Local bias</th>
<th>Global diff.</th>
<th>Local diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>2.4</td>
<td>&lt;</td>
<td>&gt;</td>
</tr>
<tr>
<td>HH</td>
<td>1.4</td>
<td>=</td>
<td>&gt;</td>
</tr>
<tr>
<td>II</td>
<td>2.0</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>MM</td>
<td>0.8</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>NN</td>
<td>1.2</td>
<td>=</td>
<td>&gt;</td>
</tr>
</tbody>
</table>

For three subjects, CC, II and MM, the actual global level is less than that predicted, whilst for HH and NN the actual and predicted levels are equal. For three subjects, CC, HH, and NN, the actual local level is greater than that predicted, whilst for II and MM the actual and predicted levels are equal. There appears to be no uniform pattern in this subgroup as to differences between actual and predicted levels for global and local level means that might indicate a common mechanism behind these subjects' positive local biases. It is only these 5 subjects who support the predictions from the hypothesis of Bellugi et al made for all WS subjects.

The claim of Bellugi et al. (1988), that there is a dissociation in visuo-spatial perception of hierarchical stimuli in WS, is contradicted. However, there is great variation in the local biases of the subjects in this population group, not a uniform local level bias as Bellugi et al. (1988) would predict. It might be possible to claim then that these 5 subjects represent a subgroup of WS distinguished from others by their local level bias on this task. Even were this so, the local level bias on this task for the subgroup does not necessarily reflect a local level bias in visuo-spatial perception.
There is a possibility that the significant local level bias is rather caused by a difference in attention or planning the motor response in copying the stimulus. This is examined in the next section.

**DIFFICULTIES IN MOTOR RESPONSE**

**DESCRIPTIONS OF STIMULI**

In order to answer whether the local level bias in the 'subgroup' of WS subjects arises because of a dissociation in visuo-spatial perception of hierarchical stimuli, as Bellugi et al (1988) claim, or because of some other factor such as a problem in planning the motor response, the following post-hoc study was carried out.

Twelve subjects of the original 13 of the experimental WS group (subject NC was unavailable) participated, including all 5 who showed a positive local level bias. Subjects were asked to imagine that another person was sitting outside the room with pen and paper, and wanted to draw exact copies of the various hierarchical stimuli. The only way that this could be done was for the WS subject to describe exactly the stimulus, so that the imaginary researcher could follow their description.

If subjects had a perceptual bias for the local level of hierarchical stimuli then one of 2 descriptions should be given: a strong positive local level bias in visuo-spatial perception would result in the global level elements consistently not mentioned at all; a weak positive local level bias in visuo-spatial perception would result in the local level elements indicated consistently before the global level elements.

The descriptions given by each subject of the hierarchical stimuli follow.
Form of description:

SUBJECT NAME

(*) - did not show a positive local level bias

(*) - did show a positive local level bias

stimulus number: description (experimenter’s further question?)

SUBJECT AA

2: Draw a D in L letters - shape of a capital D with Ls all the way down and round it.

4: A capital N there, do it with the letter P all the way down and up again.

6: A tricky one, do an O, with capital Fs all around it in a sort of sq...circular shape...I was going to say a square for a minute.

8: Won't be too difficult, got a capital E there and do it in O letters.

10: A square there...I think it is...do it in the shape of triangles with all sides level with each other.

SUBJECT CC

(*)

2: D. (Anything else?). They're L-shaped letters aren't they?

4: Letter N. (Anything else?). P-shaped.

6: O shaped. (Anything else?). They're all F.

8: O's. That's a big letter E I can see. (Anything else?). They're all O-shaped aren't they?

10: Square-shaped triangles. They're all triangles.

SUBJECT DD

(*)

2: a D and you got to draw lots of Ls round it

4: Got to draw N, and then you got to draw loads of Ps around it

6: Got to draw O, and then you got to draw loads of Fs around it

8: Got to draw an E, and then you got to draw loads of dots around it

10: Got to draw a square, and then you got to draw loads of rectangles around it
SUBJECT EE *  
2: the letter D with Ls  
4: that's an N with Ps  
6: that's a circle with Ffers...Fs  
8: that's the letter E with circles  
10: that's a square with triangles round it  

SUBJECT FF *  
2: the letter D with all the Ls  
4: the letter N and its with all the Ps shaped, letter Ps  
6: that's a letter F all in circles and it's round  
8: that's a letter E with circles  
10: that's a square triangle  

SUBJECT HH *  
2: a D, got letters in it, Ls  
4: N for my name, Nelson, with Ps  
6: an O, F  
8: L, Os on it  
10: a square with triangles on it  

SUBJECT MM *  
2: L. (Anything else?). D.  
4: N and P. (Anything else?). No.  
6: F. O. (Anything else?). No.  
8: O and E. (Anything else?). No.  
10: Triangle. (Anything else?). Square.  

SUBJECT NN *  
2: D. (Anything else?). L....it's got Ls all over it.  
4: N. (Anything else?). Ps.  
6: O. (Anything else?). F.  
8: E. (Anything else?). Little circles.  
10: A square. (Anything else?). Triangles.
SUBJECT OO •
2: a D - that's all with Ls
4: a N, and Ps
6: an O, all with Fs
8: an E, with all Os
10: a square, with triangles

SUBJECT PP •
2: a D, got Ls on it
4: a N, Ps
6: an O, F
8: an E, E...Os
10: a square that's got triangles on it

SUBJECT QQ •
2: It's a D, it's got Ls on it
4: It's a N, it's got Ps on it
6: It's a O, it's got Fs on it
8: It's a E, it's got circles on it
10: A squared shape, it's got triangles on it

All subjects who did not show a positive local level bias (marked with •) described the stimuli taking account of both global and local levels, and indicating the global level first - although subject DD did describe the local level of stimulus 10 as rectangles rather than triangles.

The descriptions of the subjects who did show a positive local level bias (marked with *) are more varied. Subjects CC and NN described both global and local levels of all stimuli, with the global described first. Subject HH performed similarly on all stimuli bar stimulus 8, where the global level "E" was described rather as a "L". Subject MM on stimulus 10 described first the local level triangles, then the global level square. The only subject of those showing a positive local level bias consistently to indicate first the local level was subject II - the global level elements were, however, consistently noted, albeit after the local level elements.
This indicates that there is no dissociation in the visuo-spatial perception of these stimuli. Rather, it is a problem in the motor execution in drawing these stimuli. A further anecdotal indication of this is given by subject AA's comments about stimuli 6 and 8. AA describes stimulus 6 as "a tricky one" and stimulus 8 as not "too difficult". The mean accuracies for these stimuli in both global and local levels are shown in figure B.XXIV following:

**FIGURE B.XXVI**
GLOBAL AND LOCAL LEVEL MEANS FOR STIMULI 6 & 8

![Graph showing mean accuracy for stimuli 6 and 8](image)

The local level mean accuracy for Stimulus 8 (an E made out of O's) is much greater than its global level mean accuracy or those for both global and local level mean accuracies for Stimulus 6 (a circle made out of F's). Subject AA's comments seem to reflect the relative difficulty of drawing the local elements of the stimuli.

That all WS subjects asked to describe the stimuli were able to take account of both the global configuration and local elements indicates that there any dissociation between global and local levels does not lie in perception.
EXECUTION OF DRAWINGS

Anecdotal observation of the execution of drawings by subjects with WS gives further support to the hypothesis that the problem in reproduction of the global level elements lies in planning of the response. One subject, NN, drew for stimulus 8 (the E made out of Os): a vertical line of Os, followed by a horizontal lines of Os at the top of the vertical line - see Figure A below; this was followed by a second horizontal line of Os below the first but not in the middle of the vertical line as would be necessary for a perfect E - see figure B below. The subject then paused, and added 3 further horizontal lines spaced evenly with the gap between the first 2, so as to fill the entire space created by the vertical line. The result - see figure C below - can hardly be called a perfect E, but the impression is not of a subject who is unable to perceive any of the global configuration.

Some of the other WS subjects did not complete the closed configuration of the global elements such as the D of stimulus 2. The impression given was that they had grown bored of the task and felt they had done enough. One other subject, EE, indeed asked whether he really "needed to do all the Ls up to there" to complete the D.

This evidence is impressionistic, but indicates again that the problem for WS subjects in reproducing the global elements of hierarchical stimuli lies in planning and execution of the drawing, rather than a dissociation in visuo-spatial perception.
DISCUSSION

The experimental hypotheses for the control groups were supported. There is a significant effect of age on both the global and local levels mean accuracies, the older subjects being more accurate in their drawings, and on the difference between the global and local levels, the difference being greater for the 5-year-old subjects than for the 3-year-old subjects. In addition, the results very closely tally with those obtained by other age groups of children by Stiles (in press), although different stimuli were used in the two studies.

Although there is a difference between the local level and global level mean accuracies in the WS group, with the local level more accurate than the global level, this difference is not significant. Only 5 subjects within the group showed a positive local level bias. For the other 8, there was no significant difference between accuracies for the two levels. It is not possible to claim, as Bellugi et al. do, that all WS subjects are incapable of reproducing the global configuration of an hierarchical stimulus.

Younger normal controls also have a local level bias (local level mean accuracy greater than global level mean accuracy), but this is not a significant difference. The most appropriate measure for the mental age of WS subjects on this task is the test age for the Ravens Spatial matrices task. The chronological age of normal controls corresponds to their test age on the Ravens task. If the global and local level mean accuracies of the WS subjects are corrected according to predictions made from their Ravens test ages on the developmental trajectories of the level accuracies of normal subjects, they do not match. The local level bias shown by the 5 WS subjects' subgroup cannot therefore be explained by a similar mechanism of that shown in young normal controls.

The problem, however, does not seem to lie in visuo-spatial perception, as Bellugi et al. (1988) claim. 12 WS subjects, including all of the 5 showing a positive local level bias, were able to describe accurately verbally all the stimuli. Only 1 out of those 5, II, consistently indicated the local level elements first, whereby one can hypothesise a
weak bias towards the local elements that may be perceptual in basis. One other subject, QQ, spontaneously said whilst trying to draw stimulus D2, "I can't do a D made out of Ls". If subjects can describe the hierarchical stimuli accurately in words, then they cannot be said to be incapable of perceiving the global level. Rather, the problem must lie in planning and execution of the motor response. This is borne out by qualitative analysis on stages in the process of drawing.

This study does not bear out the view that WS subjects are incapable of perceiving the global configuration, the whole object, above the local elements, the parts of that object. Rather, for those subjects who do show a dissociation on this task, it appears to be a result of a problem in planning and execution of the motor response of drawing. As such, it is unlikely that the ability or inability of subjects on this task will be able to explain the lack of a demonstrable whole object assumption default constraint. This will be discussed in the conclusion, section B.4.
B.3.5 IS THE TAXONOMIC ASSUMPTION PRESENT IN WILLIAMS SYNDROME?

INTRODUCTION

This study investigates whether there is a taxonomic assumption in WS, that is whether novel words cause subjects to attend more to taxonomic relations between objects and to extend word reference accordingly.

The study used a version of the procedure common to all previous research with normal subjects, discussed in section B.1.10. In this, the subject is asked to select an object 'that goes with' a target object, making a choice between a taxonomically related object and a thematically related object. The same stimuli were used in different sessions in two conditions for each subject: no label present and novel label present.

Two factors that have been investigated in previous research were not examined here. The first is the order of acquisition of different hierarchical levels of category kind. In normal subjects, basic level object categories are the most primary (Mervis & Crisafi, 1982; Waxman & Hatch, 1992). It is essential to demonstrate first whether a taxonomic bias occurs with basic level object kinds in WS subjects.

The second is the developmental relationship between shape similarity and taxonomic relations between objects. Shape similarity is the most salient factor in perceptual similarity between objects for the taxonomic effect to occur in the presence of a novel label. It was argued in section B.1.10 that it may indeed be primary to the taxonomic effect, and that perceptual similarity between objects 'bootstraps' appreciation of taxonomic relations as the two co-occur for objects more often than not. However, it was felt that WS subjects might be distracted by a factor of perceptual similarity, colour similarity, that is less salient for normal subjects than shape similarity. As this might have a more significant effect on differences between normal and WS subjects on taxonomic bias, colour was tested instead.

The shape bias emerges in normal subjects before the taxonomic assumption. It was felt that this order of emergence would also hold for WS subjects, and that by a certain age, the two biases could not be separated.
Given the age of WS subjects in the study population, it was felt that they were probably too old for any possible dissociation between the two biases to be detectable. It is recommended, however, that this factor is investigated in further research with younger WS subjects.

In order to avoid a possible translation effect (Markman & Hutchison, 1984), artificial 'nonce' stimuli were used. The subject was taught the relevant taxonomic and thematic relations for each stimuli set before testing of each item. Although demonstration with actual objects rather than pictures has been shown to be the most effective for teaching relations between objects (Mervis & Mervis, 1988), it proved impossible to find actual object stimuli that were unfamiliar to the oldest subjects in both the normal control and WS groups. Pictures were therefore used.

There is an additional confounding factor that has not been always controlled for in previous research. The sentences used by the experimenter to introduce the novel label and no label conditions must be made as equivalent as possible in the syntactic and semantic structure used. For example, Imai et al. (1994) introduced the novel label condition with the sentence "This is a dax. Show me another dax." but the no label condition with the sentence "Find the one that goes with this one." In this experiment, the same sentence structure is used for both conditions, with a nonce noun used in the novel label condition in the positions where the word "one" was used in the no label condition, as done by Golinkoff et al. (1994).

Normal children are used as control subjects. Given that the range of mental ages, both general performance and verbal, of the WS experimental subjects may vary, it was decided to use two groups of control subjects, of mean ages roughly 3, and 9 years. The top and bottom ends of a developmental trajectory (Jones et al., 1994) can thus be traced for normal children against which WS children can be compared. As argued in section B.2.3, it was hypothesised that WS subjects would not show a taxonomic bias in the presence of a novel label for either basic level or superordinate level stimuli.
METHOD

DESIGN

Subjects of control groups and experimental groups were asked to select one of two pictures that corresponded to a target picture. The choices were related either taxonomically to the target or thematically to the target; this relation was previously demonstrated to each subject by showing them a picture involving target and thematically related objects.

There were two conditions, novel word and no word. Each subject was tested on the same stimuli in both conditions, with retest occurring at least a week later for all subjects. In the novel word condition, a novel word was selected for each item to correspond to the target item.

In addition there were four conditions of colour similarity between target and taxonomic and thematic choice pictures. Either, both, or neither of the choice pictures was coloured the same as the target picture. An example follows:

**TABLE B.XXVII**
**EXAMPLE OF COLOUR CONDITIONS**

<table>
<thead>
<tr>
<th>Target Object</th>
<th>Taxonomic Choice</th>
<th>Thematic Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 green 'ball'</td>
<td>red 'ball'</td>
<td>red 'footballer'</td>
</tr>
<tr>
<td>2 green 'ball'</td>
<td>red 'ball'</td>
<td>green 'footballer'</td>
</tr>
<tr>
<td>3 green 'ball'</td>
<td>green 'ball'</td>
<td>red 'footballer'</td>
</tr>
<tr>
<td>4 green 'ball'</td>
<td>green 'ball'</td>
<td>green 'footballer'</td>
</tr>
</tbody>
</table>

Colour level 1 has taxonomic and thematic coloured the same as each other, but both different from the target. Colour level 2 has thematic the same as the target, but the taxonomic different. Colour level 3 has taxonomic the same as the target, but thematic different. Colour level 4 has all, taxonomic, thematic and target, coloured the same.

3 of the stimuli used did, however, use superordinate level taxonomically related objects as the taxonomic choice to check whether a taxonomic bias was possible for such stimuli. Of the remaining 5 basic level stimuli, the 2 with most perceptual similarity between target and taxonomic choice were eliminated from this comparison, leaving a group of 3 basic level
stimuli for comparison with the 3 superordinate level stimuli. Two sets of 3 stimuli with taxonomic choices at basic level (items 1, 2 and 5) and taxonomic choices at superordinate level (items 6, 7, and 8) to target were compared for effect of level of category in taxonomic relation to target.

The order of presentation of stimuli was counterbalanced across subjects and conditions. The order of conditions was counterbalanced across subjects. The novel words used in the novel word condition was counterbalanced across subjects.

The design was within-groups for comparison of the effect of novel word versus no word, between-groups for comparison of the effect of age.

SUBJECTS

For control subjects, two age groups of normal school children participated. These age groups were 3 to 4 year old (n=32, range of ages 3;1 to 4;4; mean 3;10), and 9 year old (n=12, range of ages 8;11 to 9;10; mean 9;5). There were an equal number of males and females in each of the groups.

For experimental subjects, 12 WS subjects were tested. 5 were male and 7 female. The mean age was 19;9, ranging from 8;6 to 30;11 years;months.

MATERIALS

The materials consisted of: a set of 8 drawings kept in a laminated book; a set of 3 picture cards for each drawing kept in the laminated book, with the relevant drawing. One of these picture cards was the target, labelled with a 'T' on the back for easy identification by the experimenter. The other two were taxonomic and thematic choice response cards. The pictures and picture cards are shown below:

---

32 The research assistant testing the 3 year old group got carried away slightly, hence 32 children were tested...
Items used
Item 1
Colour Level 1
Picture:

'ball' in pink, Mr Carefree in green

Description:
'It's playing with this. And it could play with anything else, couldn't it?'
Target picture:

in green

Taxonomic choice picture:

in pink
Thematic choice picture:

*in green*
Item 2
Colour Level 2
Picture:

all in orange

Description:
'This fits on top of this, because it's shaped like this at the end. Anything else shaped like this would fit on top of this, wouldn't it?'
Target picture:

in orange

Taxonomic choice picture:

in green
Thematic choice picture:

*in orange*
Item 3
Colour Level 3
Picture:

'fish' in green, Mr Surprised in pink

Description:
Look, this is being taken for a ride by this. Anything else could lift it up into the air for a ride, couldn't it?
Target picture:

\[
\text{in green}
\]

Taxonomic choice picture:

\[
\text{in green}
\]

Thematic choice picture:

\[
\text{in pink}
\]
Item 4  
Colour Level 4  
Picture: 

![Image of a character gobbling up something]

all in orange

Description:
Look, this is gobbling up this. It could gobble up anything else, couldn't it?

Target picture:

![Image of orange objects]

in orange
Taxonomic choice picture:

in orange

Thematic choice picture:

in orange
Item 5
Colour Level 1
Picture:

'ball' in pink, 'slot' in orange

Description:
Look, this slots down into this. Anything else with the right shaped slot could slot into it as well, couldn't it?

Target picture:

in pink
Taxonomic choice picture:

in orange

Thematic choice picture:

in pink
Item 6
Colour Level 2
Picture:

*all in orange*

Description:
Look, this is eating this. And it could eat anything else, couldn’t it?

Target picture:

*in orange*

Taxonomic choice picture:

*in pink*
Thematic choice picture:

'chair' in green

Description:
Look, it's sitting on this. Or it could sit in something else to go for a ride, couldn't it?
Target picture:

in green

Taxonomic choice picture:

in green

Thematic choice picture:
Item 8
Colour level 4
Picture:

all in pink

Description:
Look, it's wearing this on its tail. Or it could wear something round its neck, or on its head, couldn't it?

Target picture:

in pink

Taxonomic choice picture:

in pink
Thematic choice picture:

in pink

The list of novel words used in the novel word condition is listed below:

**TABLE B.XXVIII**
**NOVEL WORDS USED**

<table>
<thead>
<tr>
<th>PRINK</th>
<th>SHAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRICKLE</td>
<td>ROPPER</td>
</tr>
<tr>
<td>CLUD</td>
<td>PRAST</td>
</tr>
<tr>
<td>VENICK</td>
<td>DREVER</td>
</tr>
<tr>
<td>YIVE</td>
<td>ZENK</td>
</tr>
<tr>
<td>CORSHTER</td>
<td>HOCKREE</td>
</tr>
<tr>
<td>LEK</td>
<td>BIV</td>
</tr>
<tr>
<td>PUGBAH</td>
<td>FELDER</td>
</tr>
</tbody>
</table>

**PROCEDURE**

Each subject was seen individually, sitting opposite the experimenter at a table in a quiet room. The subject was told: "Today we're going to play a game, looking at some pictures." The experimenter took the set of cards for the first picture out of the laminated pocket and placed them face down on the table. The experimenter then showed the picture to the subject, saying 'Look what's going on here', followed by a brief relevant description that identified the taxonomic and thematic relations for the target. The experimenter pointed at relevant parts of the picture during the description. These descriptions are listed with each item in the previous materials section. The experimenter then closed the picture book and picked up the target picture card.
In the no word condition, the experimenter then said 'Do you see this one here. Can you show me another one that goes with this one here', then turned over the two response cards, then repeated 'that goes with this one here'.

In the novel word condition, the experimenter then said 'Do you see this XXXX here. Can you show me another one that goes with this XXXX here', then turned over the two response cards, then repeated 'that goes with this one here'. XXXX was the novel noun used for that item.

In both conditions, the experimenter then waited until the subject picked either taxonomic or thematic choice responses, marked down that response, then said 'OK. Let's have a look at this' and repeated the procedure for the next item.

Subjects were tested for all items in one condition in one session, and repeated with all items in the other condition at least one week later.

The experimental hypotheses were as follows:

**CONTROL GROUPS:** **NORMAL CHILDREN**

**Experimental hypothesis 1: H1i**
There will be a significant increase in the number of taxonomic responses made in the novel word condition than in the non-word condition.

**Experimental hypothesis 1: H1o**
There will be no significant increase in the number of taxonomic responses made in the novel word condition than in the non-word condition.

**Experimental hypothesis 2: H2i**
There will be no significant effect of the colour similarity between target, taxonomic choice and thematic choice on the taxonomic responses made in both conditions.

**Experimental hypothesis 2: H2o**
There will be a significant effect of the colour similarity between target, taxonomic choice and thematic choice on the taxonomic responses made in both conditions.
Experimental hypothesis 3: H3i
There will be no significant difference between the older (9 year old) and younger (3 to 4 year old) control groups for the number of taxonomic responses made in both conditions.

Experimental hypothesis 3: H3o
There will be a significant difference between the older (9 year old) and younger (3 to 4 year old) control groups for the number of taxonomic responses made in both conditions.

Experimental hypothesis 4: H4i
There will be a significant difference between the older (9 year old) and younger (3 to 4 year old) control groups for the taxonomic bias demonstrated for basic level and superordinate stimuli. The younger group will show a greater taxonomic bias for basic level stimuli, whilst the older group will show no difference.

Experimental hypothesis 4: H4o
There will be no significant difference between the older (9 year old) and younger (3 to 4 year old) control groups for the taxonomic bias demonstrated for basic level and superordinate stimuli.

EXPERIMENTAL GROUP WILLIAMS SYNDROME SUBJECTS

Experimental hypothesis 1: H1i
There will be no significant increase in the number of taxonomic responses made in the novel word condition than in the non-word condition.

Experimental hypothesis 1: H1o
There will be a significant increase in the number of taxonomic responses made in the novel word condition than in the non-word condition.

Experimental hypothesis 2: H2i
There will be a significant effect of the colour similarity between target, taxonomic choice and thematic choice on the taxonomic responses made in both conditions, with fewer taxonomic responses made when the colour of the taxonomic choice is dissimilar to that of the target.
Experimental hypothesis 2: H2o
There will be a significant effect of the colour similarity between target, taxonomic choice and thematic choice on the taxonomic responses made in both conditions, with fewer taxonomic responses made when the colour of the taxonomic choice is dissimilar to that of the target.

RESULTS

CONTROL SUBJECTS

The number of taxonomic responses in each condition, no word and novel word, was summed across items for all subjects. The mean number of taxonomic responses in each condition for both age groups is shown in the table and figures below.

**TABLE B.XXIX**
**MEAN NUMBER OF TAXONOMIC RESPONSES PER SUBJECT FOR BOTH CONDITIONS**

<table>
<thead>
<tr>
<th></th>
<th>NON-WORD</th>
<th>NOVEL WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 TO 4 YEAR OLD</td>
<td>1.6</td>
<td>6.3</td>
</tr>
<tr>
<td>9 YEAR OLD</td>
<td>2.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>

**FIGURE B.XXX:**
**3 TO 4 YEAR OLD GROUP**
**MEAN NUMBER OF TAXONOMIC RESPONSES IN EACH CONDITION**

![Graph showing mean number of taxonomic responses for non-word and novel word conditions.]
For both age groups, there is a large increase in the number of taxonomic responses in the novel word condition compared to the no word condition. This difference is significant for both age groups (3 to 4 year old, Wilcoxon Signed Rank, N=30, W=-4.7, p<0.001; 9 year old, N=9, W=-1.3, p<0.001).

There is a small but non-significant difference between the number of taxonomic responses in each condition between the two age groups. The number of taxonomic responses in both conditions is greater in the older age group than in the younger age group.

**ITEM ANALYSIS**

For each item, the taxonomic bias was calculated for each subject. This was done by allotting 0 for a thematic response and 1 for a taxonomic response, in both of the conditions, non-word and novel word, then subtracting the no word response from the novel word response. Thus, according to the hypothesis, one would expect a taxonomic bias of 1 (1 in novel word condition - 0 in non-word condition for each item for each subject). The mean taxonomic bias for all subjects for each item is shown in the table below.
TABLE B.XXXII
MEAN TAXONOMIC BIAS ACROSS ALL SUBJECTS PER ITEM

<table>
<thead>
<tr>
<th>ITEM</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAX.</td>
<td>0.5</td>
<td>0.4</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

There is no significant difference in the mean taxonomic biases for all items for all subjects (df=7, Friedman's Chi$_r$-squared = 6.9 (corrected for ties), p>0.05).

ITEM COLOUR ANALYSIS

The colour similarity (perceptual similarity) between target, taxonomic response and thematic response has four levels, detailed in the design section. Item pairs 1 and 5, 2 and 6, 3 and 7, and 4 and 8, share the same relationship between colour of target, taxonomic response and thematic response, levels 1, 2, 3 and 4 respectively. The mean taxonomic bias for each level of the colour condition was calculated by summing those item pairs and dividing by 2. They are shown in the table below.

TABLE B.XXXIII
MEAN TAXONOMIC BIAS PER COLOUR LEVEL ACROSS ALL SUBJECTS

<table>
<thead>
<tr>
<th>COLOUR LEVEL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAX. BIAS</td>
<td>0.6</td>
<td>0.55</td>
<td>0.65</td>
<td>0.55</td>
</tr>
</tbody>
</table>

There is no significant difference between the mean taxonomic biases for the four colour levels (df=3, Chi$_r$-squared = 0.7 (corrected for ties), p>0.05).

VARIATION BETWEEN SUBJECTS

The taxonomic bias for each subject summed across all items was calculated. The number of subjects in the younger 3 to 4 year old group showing a particular taxonomic bias is shown in the figure following.
The vast majority of younger subjects show a taxonomic bias between 4 and 8; only 2/32, 6.3%, do not show a taxonomic bias at all.

The number of subjects in the older 9 year old group showing a particular taxonomic bias is shown in the figure following.
All subjects show a positive taxonomic bias, with most in the range 3 - 5.

**BASIC LEVEL VERSUS SUPERORDINATE LEVEL TAXONOMIC CATEGORIES**

The taxonomic biases for each subject for items in the basic level taxonomic set (items 1, 2, and 5) and those in the superordinate level taxonomic set (items 6, 7, and 8) were compared for both age groups of control subjects.

There was no significant difference between the taxonomic biases for the two stimuli sets for either age group (one-tailed t-test, 3-year-old group: df=95, t=-1.1, p>0.05; 9-year-old-group: df=35, t=-1, p>0.05). There is no difference then in the taxonomic bias shown for the two levels of categorisation by both age groups of subject, contrary to the experimental hypothesis.

**SUMMARY OF RESULTS FOR CONTROL SUBJECTS**

There is a significant taxonomic bias for both the older and younger age groups of normal children, with more taxonomic responses made in the novel-word condition than in the no word condition. There is a small but non-significant increase in the number of taxonomic responses for the older age group, in both the novel word and no word conditions.

There is no difference in the taxonomic bias shown by all subjects between individual items, nor between pairs of items in each level of colour similarity, nor is there any effect of the level of categorisation of taxonomic relation between target and taxonomic choice across both age groups.

**WILLIAMS SYNDROME SUBJECTS**

The number of taxonomic responses in each condition, no word and novel word, was summed across items for all subjects. The mean number of taxonomic responses in each condition for all WS subjects is shown in the table and figures following.
<table>
<thead>
<tr>
<th></th>
<th>NO WORD</th>
<th>NOVEL WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS group</td>
<td>2.8</td>
<td>4.8</td>
</tr>
</tbody>
</table>

There is no significant difference between the number of taxonomic responses in the no word condition and the novel word condition (Wilcoxon, N=11, W=-1.6, p>0.05).

The number of taxonomic responses made in the no word condition, 2.8, is close to that mean for the older 9 year old group of normal controls. The mean number made in the word condition, 4.8, is greatly reduced relative to the older normal controls. The lack of a significant difference is not then caused by a greater number of taxonomic responses made in both conditions, but by the lack of a taxonomic bias in WS subjects.

**ITEM ANALYSIS**

For each item, the taxonomic bias was calculated for each subject. This was done by allotting 0 for a thematic response and 1 for a taxonomic response, in both of the conditions, non-word and novel word, then subtracting the non-word response from the novel word response. Thus, according to the hypothesis, one would expect a taxonomic bias of 1 (1 in
novel word condition - 0 in non-word condition for each item for each subject). The mean taxonomic bias for all subjects for each item is shown in the table below.

**TABLE B.XXXVIII**
**MEAN TAXONOMIC BIAS ACROSS ALL SUBJECTS PER ITEM**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TAX. BIAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>7</td>
<td>0.2</td>
</tr>
<tr>
<td>8</td>
<td>0.3</td>
</tr>
</tbody>
</table>

There is no significant difference in the mean taxonomic biases for all items for all subjects (df=7, Friedman's Chi²=1.9 (corrected for ties), p>0.05).

**ITEM COLOUR ANALYSIS**

The colour similarity (perceptual similarity) between target, taxonomic response and thematic response has four levels, detailed in the design section. Item pairs 1 and 5, 2 and 6, 3 and 7, and 4 and 8, share the same relationship between colour of target, taxonomic response and thematic response, levels 1, 2, 3 and 4 respectively. The mean taxonomic bias for each level of the colour condition was calculated by summing those item pairs and dividing by 2. They are shown in the table below.

**TABLE B.XXXIX**
**MEAN TAXONOMIC BIAS PER COLOUR LEVEL ACROSS ALL SUBJECTS**

<table>
<thead>
<tr>
<th>COLOUR LEVEL</th>
<th>TAX. BIAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>0.25</td>
</tr>
</tbody>
</table>

There is no significant difference between the mean taxonomic biases for the four colour levels (df=3, Chi²=0.6 (corrected for ties), p>0.05).

**VARIATION BETWEEN SUBJECTS**

The taxonomic bias for each subject summed across all items was calculated. The number of subjects showing a particular taxonomic bias is shown in the figure following.
Whereas most WS subjects do not show a taxonomic bias higher than 2, 4 subjects do show such a high taxonomic bias. This is suggestive of a bimodal distribution in the group.

**BASIC LEVEL VERSUS SUPERORDINATE LEVEL TAXONOMIC CATEGORIES**

The taxonomic biases for each subject for items in the basic level taxonomic set (items 1, 2, and 5) and those in the superordinate level taxonomic set (items 6, 7, and 8) were compared for both age groups of control subjects.

There was no significant difference between the taxonomic biases for the two stimuli sets for the WS group (one-tailed t-test, df=35, t=-1, p>0.05). There is no difference then in the taxonomic bias shown for the two levels of categorisation by the WS group.

**SUMMARY OF RESULTS FOR WILLIAMS SYNDROME SUBJECTS**

There is no significant increase in the number of taxonomic responses made in the novel word condition compared to the no word condition. No taxonomic bias exists then in WS subjects, as appears in both age groups of
normal controls. There is no significant difference between the mean taxonomic biases for items, nor is there any significant effect on the taxonomic bias per item across all subjects by the colour level of the item stimulus triads, nor is there any effect of the level of categorisation of taxonomic relation between target and taxonomic choice.

COMPARISON BETWEEN GROUPS

The median 12 results of taxonomic biases for the younger group of normal controls were taken, and entered in a 1-way ANOVA with the 12 results of the older group of normal controls and the 12 results of the WS group. There was a significant difference between the taxonomic biases for the 3 groups (F(2,22)=6.5, p<0.01). Follow-up Scheffe F-tests showed that there was no significant difference between the taxonomic biases for the two normal control groups, but that there were significant differences between the younger group and the WS group (Scheffe F=5.4, p<0.05) and between the older group and the WS group (Scheffe F=4.3, p<0.05).

DISCUSSION

Both the normal control groups, the younger 3 to 4 year olds and the older 9 year olds show a significant taxonomic bias. Normal children of these ages, and one may assume between these ages, are more likely to choose a taxonomic response in the presence of a novel noun than they are in the presence of no noun. The first hypothesis for the control groups is therefore supported. The colour similarity between target, taxonomic response and thematic response, as a distracting variable, has no significant effect on the taxonomic bias.

Although there is an increase in the number of taxonomic responses in the older group in both the novel noun and no noun conditions, this difference is not significant. There is therefore no effect of the age of normal control on the taxonomic bias observed.

By contrast, the WS group show no overall taxonomic bias. There is no significant difference between the number of taxonomic responses made in the no word condition and in the novel word condition. There are also significant differences between the taxonomic biases of the WS group and
those of both the normal control groups. This demonstrates that the
taxonomic bias present in normal children is not present in WS subjects,
supporting the first hypothesis for the experimental group.

Again, the colour similarity between target, taxonomic response, and
thematic response, as a distracting variable, had no significant effect on the
number of taxonomic responses made in each condition. This does not
support the second hypothesis for the experimental group. WS subjects are
not more likely to be distracted by other factors unrelated to taxonomic
function when making their response than normal controls.

However, as can be seen from Figure B.XXXX, there is much more
variation in the taxonomic biases within the WS group than there is within
either of the normal control groups. There are two clusters of scores, one
around subjects showing no taxonomic bias, and one around subjects
showing a high positive taxonomic bias. Within the paradigm of this test, it
appears that there may be two subgroups of WS subjects, those that show no
taxonomic bias as those that do show a taxonomic bias. Although the
difference is not significant, those WS subjects showing a taxonomic bias have
higher test age scores for the BPVS than those that show no taxonomic bias.

Both normal control groups showed a similar taxonomic bias with
basic level object kinds and superordinate level object kinds. There is no
difference too for this factor in the taxonomic biases of WS subjects. This is
contrary to the experimental hypothesis for normal subjects. It is most likely
that the stimuli sets were too simplistic for any significant difference to
emerge.

One might expect those WS subjects who do show a taxonomic bias to
be more likely to show an organisation of lexical items semantically closer to
that of normal subjects than those WS subjects who do not show a taxonomic
bias. Correlations between the taxonomic biases of WS subjects and measures
of those subjects' semantic organisation investigated in Part C, will be
discussed in Part D. Section B.4. discusses whether this lack of a demonstrable
taxonomic bias in WS subjects is caused instead by a lack of categorisation
ability as measured by the Spontaneous Exhaustive Sorting Task examined in
the following study, B.3.6.
B.3.6 IS ABILITY IN SPONTANEOUS EXHAUSTIVE SORTING PRESENT IN WILLIAMS SYNDROME?

INTRODUCTION

The exhaustive-sorting procedure was devised by Gopnik and Meltzoff (1987) to map the development of categorisation skills in young children and infants. Their premise, supported by experimental data, is that children have a spontaneous ability and desire to sort objects into categories, in the absence of any specific cues from the experimenter on how to do so. This spontaneous ability co-occurs with the onset of the vocabulary explosion33.

Their procedure involved presenting the subject with a set of 8 objects in a random arrangement, that included 2 subsets of 4 objects of the same category. The subject was told to "Fix these up. Put them where they go", and permitted to manipulate the objects for up to 3 minutes. Three levels of categorisation skill were described. If the subject is scored as having made the highest level-3 categorisation in any set, or all 3 sets were administered, then the task was finished. Scoring is the highest level of categorisation that the subject makes in the task. Only if level-3 categorisation is reached is the child deemed to have gained spontaneous categorisation ability.

The criteria for levels of categorisation are listed below:

SCORING CATEGORISATION LEVELS

**level 1**

*single category grouping, in which the child groups the four objects from one category together. (a similarity judgement? I like this one, I’ll get all the others that look like this).*

**level 2**

*sequential manipulation. The child will touch the four objects from one category and then touches the four from the other.*

---

33 Note the caveat to the universality of the vocabulary explosion on p.66, in the work of Goldfield and Reznick (1990).
The child sorts the objects from each of the categories into two distinct piles, each pile corresponding to a category.

The child lines up the objects from each category so that there is a one-one correspondence between the members of the categories.

The child picks up the members of one category, puts them in a place away from the other category members. She then alternates gaze between the two piles three times.

Gopnik and Meltzoff demonstrated spontaneous exhaustive sorting in normal children just prior to the vocabulary explosion, from before 2 years of age. This is also confirmed for Down Syndrome children. For WS children, however, fast-mapping co-occurs with spontaneous exhaustive sorting. Neither, however, co-occur with the onset of the vocabulary explosion, but rather occur much later (Mervis & Bertrand, 1993).

Given that there is strong experimental evidence that spontaneous exhaustive sorting arise in normal children in conjunction with fast-mapping ability, normal controls will not be tested in this study. This study only sets out to check whether the WS subjects in this study population are capable of spontaneous sorting, whether the results of Mervis and Bertrand (1993) are replicated with this group. One cannot assume that WS is a homogeneous group with regards to this ability, although it is hypothesised that as all subjects in this population possess fast-mapping ability, they will also all possess spontaneous categorisation ability.

**METHOD**

**DESIGN**

Five sets of objects were used. One set consisted of two categories separated at the basic level, spoons and coins. One sets was two categories separated at the basic/superordinate level, one-pence-coins and two-pence-coins. These sets are similar to those used by Gopnik and Meltzoff, and Mervis and Bertrand. The remaining three sets could be divided in two ways. They each contained two sets of objects divided at the basic level, but each set of 4 contained 2 objects of 1 colour, and 2 objects of another colour. It was hypothesised, however, that as there was no effect of colour on the taxonomic
shift effect for WS subjects that this would also probably have no significant
effect on object-kind sorting, and that subjects would be able to sort to level 3
on both object and colour criteria.

Subjects were presented with a random arrangement of one set of 8
objects. 5 sets were presented to all subjects. Each set was divided into two
subsets of object-kind in all 5 sets, and each subset was further divided into
two subsets of colour-kind in 3 of the sets. The subjects' spontaneous sorting
of the set was scored according to the criteria presented previously, to one of
three levels.

SUBJECTS

Thirteen WS subjects were tested. Five were male and 8 female. The
mean age was 20;9, ranging from 8;8 to 31;2.

MATERIALS

Five sets of objects were used, as below:

set a
hoops/rods
object and colour
2 green rods
2 red rods
2 green hoops
2 red hoops

SET a

ROD HOOP
set b
wheels/bricks
object and colour
2 yellow wheels
2 red wheels
2 yellow bricks
2 red bricks

SET b

\[\begin{array}{cc}
\text{WHEEL} & \text{BRICK} \\
\end{array}\]

set c
bridges/rectangles
object and colour
2 blue bridges
2 red bridges
2 blue rectangles
2 red rectangles

SET c

\[\begin{array}{cc}
\text{BRIDGE} & \text{RECTANGLE} \\
\end{array}\]

set d
spoons/2pences
object
4 tea-spoons
4 two-pence-coins
PROCEDURE

Subjects were seen individually. Experimenter and subject sat together at a table. The experimenter produced one of the 5 sets of objects, placed all objects in that set on the table in front of the subject in a random arrangement, opened his hands and said "See these. Fix these up. Put them where they go."

The experimenter recorded the subject's response, listing objects touched, where they were moved and any relevant actions or glances of the subject. After the subject had indicated they had finished, or 3 minutes had elapsed (none of the subjects ever took close to 3 minutes). The final position of the objects was recorded.

This procedure was repeated with the remaining sets of objects. Order of presentation of sets was counterbalanced across subjects.

EXPERIMENTAL HYPOTHESES:

H1: hypothesisi states that as all subjects in the group possess fast-mapping ability, they will all be able to sort objects by both colour (if applicable) and object-kind to level 3 categorisation, on at least one of the sets.

H1: hypothesiso states that as even though all subjects in the group possess fast-mapping ability, not all will be able to sort objects by both colour (if applicable) and object-kind to level 3 categorisation, on at least one of the sets.

RESULTS

Sorting by colour and object kind were both scored separately, according to the criteria levels listed in the introduction. Two independent raters scored the responses of the subjects. Inter-rater reliability was 0.95. If subjects scored at level 3 in sorting of any of the sets divided by object-kind alone, they would possess spontaneous exhaustive-sorting ability. If they scored at level 3 for both object-kind and colour-kind in sorting of any of the
sets so divided, then they possessed spontaneous exhaustive sorting for both object-kind and colour-kind criteria.

**Object-kind and colour-kind sorting**

The ratings of subjects’ sorting of each set, a, b, and c, for object-kind and colour-kind, are listed below. Ratings range from 0 to 3. Level 3 has three equivalent sublevels, 3 i, 3ii, and 3 iii. Levels are described in the above introduction.

**TABLE B.XXXI:**
**RATINGS FOR ALL WS SUBJECTS OF SORTING OF OBJECT-KIND AND COLOUR-KIND STIMULI SETS**

<table>
<thead>
<tr>
<th>subject</th>
<th>set a</th>
<th></th>
<th>set b</th>
<th></th>
<th>set c</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>object</td>
<td>colour</td>
<td>object</td>
<td>colour</td>
<td>object</td>
<td>colour</td>
</tr>
<tr>
<td>AA</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
</tr>
<tr>
<td>CC</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
</tr>
<tr>
<td>DD</td>
<td>1</td>
<td>3 i</td>
<td>0</td>
<td>1</td>
<td>3 ii</td>
<td>3 i</td>
</tr>
<tr>
<td>EE</td>
<td>3 ii</td>
<td>0</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 ii</td>
<td>3 i</td>
</tr>
<tr>
<td>FF</td>
<td>3 i</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
</tr>
<tr>
<td>HH</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
</tr>
<tr>
<td>II</td>
<td>1</td>
<td>0</td>
<td>3 i</td>
<td>3 i</td>
<td>3 i</td>
<td>3 ii</td>
</tr>
<tr>
<td>KK</td>
<td>i</td>
<td>3 i</td>
<td>ii</td>
<td>3 i</td>
<td>3 i</td>
<td>3 i</td>
</tr>
<tr>
<td>MM</td>
<td>2</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 ii</td>
<td>2</td>
</tr>
<tr>
<td>NN</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 ii</td>
<td>3 ii</td>
</tr>
<tr>
<td>OO</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 ii</td>
<td>3 ii</td>
</tr>
<tr>
<td>PP</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 ii</td>
</tr>
<tr>
<td>QQ</td>
<td>3 ii</td>
<td>3 i</td>
<td>3 i</td>
<td>3 ii</td>
<td>3 ii</td>
<td>0</td>
</tr>
</tbody>
</table>

As can be seen from the table, all subjects show level 3 categorisation in both of the object-kind and colour-kind conditions for at least one of the 3 sets, and indeed most show it for all 3 sets. All subjects possess spontaneous exhaustive-sorting ability according to the marking criteria set for both object-kind and colour-kind, and the hypothesis is supported.

**Object-kind alone**

The ratings of subjects’ sorting of each set, d and e, for object-kind alone are listed below. Ratings range from 0 to 3. Level 3 has three equivalent sublevels, 3 i, 3ii, and 3 iii. Levels are described in the above sections.
As can be seen from the table, all subjects show level 3 categorisation in the object-kind condition alone for at least one of the 2 sets, and indeed most show it for both sets. All subjects possess spontaneous exhaustive-sorting ability according to the marking criteria set for object-kind alone, and the hypothesis is again supported.

**Variation between subjects**

Most subjects showed very strong spontaneous sorting ability, marked by level 3 categorisation for all conditions in all sets. Some did not show level 3 categorisation in all sets, however. The number of sets (out of 5) that each subject demonstrated level 3 categorisation for object-kind, and the number of sets (out of 3) that each subject demonstrated level 3 categorisation for colour-kind, were as follows:
**TABLE B.XXXXIII**
**NUMBER OF SETS SORTED TO LEVEL 3 CATEGORISATION PER WS SUBJECT**

<table>
<thead>
<tr>
<th>subject</th>
<th>no. of sets with level 3 categorisation object (max=5)</th>
<th>no. of sets with level 3 categorisation colour (max=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>CC</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>DD</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>EE</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>FF</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>HH</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>KK</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>MM</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>NN</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>OO</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>PP</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>QQ</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

It can be seen from this table that subjects DD, MM and II were the only ones in the group not to show level 3 categorisation for object-kind in all sets. It is arguable that they therefore have a weaker spontaneous sorting ability for object-kind than the rest of the WS group.

It can be seen from this table that subjects DD, EE, II, MM and QQ were the only ones in the group not to show level 3 categorisation for colour-kind in all sets. It is arguable that they therefore have a somewhat weaker spontaneous sorting ability for colour-kind than the rest of the WS group.

**DISCUSSION**

All subjects show level 3 categorisation in both object-kind and colour-kind in at least one of sets a-c, and in object-kind alone in at least one of sets d-e. As subjects only need to show level 3 categorisation in one set to be said to possess spontaneous exhaustive sorting ability, the experimental hypotheses are therefore supported. All subjects tested possess fast-mapping ability (demonstrated in study B.3.1) and also spontaneous exhaustive sorting ability. This is as predicted from the results of Mervis and Bertrand (1993), who found that the onset of fast-mapping ability coincided with the onset of spontaneous exhaustive sorting ability, for all subject groups. There may be a
quantitative link between the strength of spontaneous sorting and the strength of fast-mapping ability. This will be examined in section B.4.

It was argued that the lack of a taxonomic bias in the overall WS group in study B.3.5 might be caused by a lack of taxonomic categorisation ability. This is not so. There may, however, also be a quantitative link between both of the object-kind and colour-kind sorting abilities, and the taxonomic bias shown by subjects. This will also be examined in section B.4.

B.4. DISCUSSION OF ALL RESULTS

B.4.1 FAST-MAPPING & N3C PRINCIPLE/ WHOLE OBJECT AND MUTUAL EXCLUSIVITY ASSUMPTIONS

All WS subjects tested were shown to possess fast-mapping ability, and thus the N3C principle. The WS group were shown to possess the mutual exclusivity assumption, but not the whole object assumption, in the procedures of studies B.3.3 and B.3.2 respectively. Given that the N3C principle is arguably equivalent to the two latter default constraints operating in tandem within the procedures concerned, then one must examine whether there is any other factor that might have produced these apparently contradictory results.

B.4.1.1 Relationship with performance in reproduction of hierarchical stimuli

It was hypothesised that any dissociation between visuo-spatial perception of the global configuration and of the local elements of hierarchical visual stimuli, as Bellugi et al. (1988) discovered in a small number of WS subjects, would possibly significantly affect performance on the procedures testing the whole object and mutual exclusivity assumptions. These procedures forced a choice between two alternatives, the whole of an object and its salient part, thought to correspond to the global configuration and a local element.

However, as study B.3.4 shows, this dissociation in perception turns out to be non-existent. No significant local level bias (accuracy in
reproduction of local level elements greater than that of global configuration) was found in this experimental population. Subsequent verbal descriptions of the stimuli indicated that all WS subjects perceive the local and global level elements. For the 5 WS subjects (out of 13 subjects) who did show a local level bias, it is argued that their problems must therefore lie in planning and motor execution of the drawing.

There are no significant correlations for WS subjects between on the one hand any of the global level accuracy, local level accuracy, and local level bias, and on the other hand either of the number of object responses for unfamiliar objects / unfamiliar parts in the whole object assumption study and the number of object responses for familiar objects / unfamiliar parts in the mutual exclusivity assumption study.

Only 5 subjects showed a positive local level bias. In the whole object assumption study, one might expect them to show scores uniformly much less than the hypothesised 6 out of 6 for number of object responses for unfamiliar objects/unfamiliar parts. In the mutual exclusivity assumption study, one might expect them to show scores uniformly much less than the hypothesised 3 out of 6 for number of object responses for familiar objects/unfamiliar parts. Both these would demonstrate a bias towards selection rather of salient parts, that would correspond in this argument to a positive local level bias, a bias towards local elements in reproduction of hierarchical stimuli. The relevant scores for both studies are shown for these 5 subjects below:

TABLE B.XXXXIV
RELEVANT SCORES ON THE WHOLE OBJECT & MUTUAL EXCLUSIVITY ASSUMPTION STUDIES OF SUBJECTS SHOWING A POSITIVE LOCAL LEVEL BIAS ON HIERARCHICAL DRAWING TASK

<table>
<thead>
<tr>
<th>Subject</th>
<th>whole object</th>
<th>mutual exclusivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no. of object responses in relevant condition (max=6)</td>
<td>no. of object responses in relevant condition (max=6)</td>
</tr>
<tr>
<td>CC</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>HH</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>MM</td>
<td>did not complete</td>
<td>1</td>
</tr>
<tr>
<td>NN</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>hypothesised</td>
<td>&lt;&lt;6</td>
<td>&lt;3</td>
</tr>
</tbody>
</table>

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No dissociation in visuo-spatial perception exists that might explain why subjects did not demonstrate a whole object assumption in the procedure of study B.3.2. Instead one must look for possible pitfalls in the procedure of the whole object and mutual assumptions of the default constraints model (Markman, 1990).

A difference in the results of these two studies is better explained in the following way. When confronted by a novel label for a stimulus in the whole object assumption study, the subject has two possible references onto which to map this label, the object and the part, as both are previously unfamiliar and unlabelled. Both whole object and part have been given equal emphasis in the warm-up to the experimental session. The action of the experimenter in indicating both to the subject in each experimental trial also emphasises them equally. The subject therefore has two equivalent choices of referent. Accordingly, if the subject comes to the task with no constraint biases, the subject will probably choose object as referent for half of the stimuli, and part as referent for the other half, giving a mean 3 out of 6 whole object responses in this condition. The actual mean for the group was 3.2 out of 6.

This assumes that the equal emphasis placed for all subjects by the experimenter on whole object and part must override the whole object assumption (equivalent to principle of Object Scope in DLPF model). As this did not occur with normal control subjects, who had a significant whole object bias, but did with WS subjects, one must assume either that WS subjects are more sensitive to cues within the experimental situation, or that the bias is much weaker, or both. Given the reported and anecdotal sensitivity of WS subjects to socio-pragmatic factors within social situations, this heightened sensitivity to implicit experimental cues is likely. For this to have any effect though, the constraint biases will probably be weaker in WS subjects than in normal controls.

B.4.2 TAXONOMIC BIAS/SPONTANEOUS EXHAUSTIVE SORTING

No taxonomic bias was observed in the WS group, whereas a taxonomic bias was observed in both age groups of normal controls. There was no significant effect of interaction for all groups of perceptual similarity
between target and taxonomic and thematic choices, nor of hierarchical category levels of taxonomic relation between target and taxonomic choice.

One must attempt to eliminate the possibility that this lack of a taxonomic bias is caused by a lack of categorisation ability in the WS subjects, by comparing scores for individual WS subjects on the taxonomic bias task and the spontaneous exhaustive object sorting task.

There is no significant correlation between scores for individual subjects in the taxonomic bias task on any of the number of taxonomic responses in the no word condition, the number of taxonomic responses in the word condition, the taxonomic bias with any of the following measures derived from the spontaneous exhaustive object-sorting task: average level of categorisation of object-kind-only sets; average level of object-kind categorisation of the object-kind and colour-kind sets; average level of colour-kind categorisation of the object-kind and colour-kind sets; average level of shape bias (object-kind categorisation - colour-kind categorisation) of the object-kind and colour-kind sets. In addition, as most subjects were at ceiling on the spontaneous exhaustive object-sorting task, one cannot conclude that any lack of a taxonomic bias in WS subjects is due to a lack of categorisation ability.

Rather, the hypothesis is supported that there is no taxonomic bias effect in WS. WS subjects do not attend more to taxonomic kinds of objects in the presence of a novel label, nor can they therefore extend the reference of a novel word to kinds of objects. Whether this has any effect on the semantic organisation of the lexicon in WS subjects is examined in part C.

**B.4.3 FAST-MAPPING AND SPONTANEOUS EXHAUSTIVE SORTING**

There is a definite qualitative link between fast-mapping ability and spontaneous exhaustive sorting ability. All WS subjects tested were shown to possess both abilities. This replicates the finding of Mervis and Bertrand (1993). All subjects were older than those tested by Mervis and Bertrand, however, and were certainly beyond the phase of the vocabulary explosion. A longitudinal study of WS subjects from an early age would be necessary to demonstrate that the onset of both these abilities coincides, and do not co-occur with the naming explosion.
There are two quantitative measures for fast-mapping. One is a comprehension-type score, the number of objects selected as referent for the novel label by each subject (out of 8). The other is a production-type score, the score for the number of labels remembered by each subject (out of 8). There are two quantitative measures for spontaneous exhaustive sorting. One is the number of level-3 categorisations - the criterion for spontaneous exhaustive sorting to be possessed by a subject - made on the basis of object-kind alone (out of 5). The other is the number of such categorisations made on the basis of colour-kind alone (out of 3). Given the qualitative link between fast-mapping and spontaneous exhaustive sorting in WS subjects, one can hypothesise that there will be a quantitative link too. In that case, there should be significant correlations between the quantitative measures for spontaneous exhaustive sorting, and those for fast-mapping.

There is in fact a non-significant correlation between the number of novel names for objects in the fast-mapping procedure remembered by subjects, and the number of level-3 categorisations made for both object-kind and colour-kind (object-kind: R=0.6, df=9, F=3.8, P=0.09; colour-kind, R=0.6, df=9, F=4.1, p=0.08). Although these correlations are non-significant, it should be remembered that of these 4 quantitative measures, most subjects are at ceiling ability for 3 out of the 4, all except the production-type fast-mapping ability. These correlations, though non-significant, are suggestive that there is indeed a quantitative link between fast-mapping ability and spontaneous exhaustive sorting categorisation ability in WS subjects, as hypothesised from the results of Mervis and Bertrand (1993).

B.4.4 OVERALL SUMMARY OF RESULTS

In object-scope type constraint tasks, WS subjects show fast-mapping ability, demonstrating the N3C constraint of Golinkoff et al. (1994). They do not, however, show the whole object assumption of Markman's model (Markman, 1992) but do seem to show the mutual exclusivity assumption. This is not due to any bias in perception of whole and parts of objects; indeed, no such bias was found in WS reproduction of hierarchical stimuli contrary to previous research, rather a seeming problem in motor execution of drawings. It is argued that WS subjects possess weaker forms of the object-scope type constraints, wherein the more naturalistic experimental situations they show fast-mapping, but in more artificial experimental situations divorced of a
supportive context they cannot show the whole object assumption, but can 'rationalise' a response to the mutual exclusivity assumption stimuli. Normal children, tested in a greater age range than any previous studies, do show all 3 object-scope type constraints. There is a non-significant but suggestive correlation between productive fast-mapping ability and spontaneous exhaustive sorting ability for WS subjects as predicted from the results of Mervis and Bertrand (1993).

There is no overall taxonomic bias in the WS group tested, although some subjects do show a high taxonomic bias. In contrast, normal control subjects, again of a wider age range than previous studies, do show a taxonomic bias. The lack of a taxonomic bias in WS subjects is not caused by a lack of taxonomic categorisation ability, as all subjects tested do show spontaneous exhaustive sorting ability. Whether there is a relationship between the taxonomic bias for each WS subject and the semantic organisation of the lexicon will be examined in part C.
part C

SEMANTIC ORGANISATION
C.1. GENERAL INTRODUCTION

As argued in part A, the general claim of many researchers, such as Pinker (1994) and Bromberg (1994), is that access to the lexical representation or structure of the lexical representation is abnormal in people with WS. Their semantics are deemed deviant or bizarre, and their syntax deemed intact. It is not the scope of this thesis to explore the syntactic abilities of WS, but rather whether the semantic abilities of WS are indeed different from those of normal subjects. In my view, it is crucial to place WS semantic abilities relative to chronological-age matched and mental-age matched normal controls.

In part A, some previous findings on semantic abilities in WS were discussed. Some anecdotal evidence was reported for the use of normal words in novel contexts. Another type of 'interesting word use' is that of a novel or nonce word in a normal context. These nonces are almost always formed by apparent overextension of a prefix- or suffix- addition rule to a root word. For example, "I don't want to cause any botherance", or (when talking about stings that a jellyfish can cause) "the marks are jet red". From my own experience of occurrences in the spontaneous speech production of WS subjects, this second type of unusual word use is much commoner than using a normal word in a nonce context.

Rossen et al. (1994) detail further examples from the spontaneous speech of WS subjects. They hypothesise that these and other such word usages reveal a malspecificity in WS word choice - the sense of the word chosen does not exactly match the sense required by the context. In addition, these authors give further examples that demonstrate, they argue, a hyperspecificity in WS word choice - the sense of the word chosen is more specific than that required by the context. For example, "he cried his eyeballs out" (p.22), when the required contextual sense would be rather "he cried his eyes out".

Rossen et al. claim that WS language “deviance seems to involve dysfunction in forming principled combinations of words” (p.11), deviance here being different from normal output. This is not the case. There are many similar examples in corpuses of children's spontaneous speech. In certain circumstances of stress, normal adults may also produce similar 'bizarre'
word usage to those reported for WS. For example, I observed an actor in rehearsal struggling to remember his lines and improvising to cover; he meant to produce the phrase "altitudes and elevations" and instead produced the word "altivations". If a WS subject had produced this item, it would be used as further evidence of bizarre semantic choice!

As discussed in part A, a number of studies have reported that WS subjects often have unusually large vocabularies compared to normal children of a similar mental age, will often define words experientially according to personal anecdote, and are capable of explaining metaphor (Bellugi et al., 1988; Karmiloff-Smith et al., 1995; Karmiloff-Smith, 1992). The reported unusual word choice of WS individuals in tasks like the CELF (Bellugi et al., 1988), is discussed in section C.2.2 along with further studies using similar tasks (Rossen et al., 1994; Scott et al., 1994).

The last piece of experimental evidence for unusual semantics in WS comes from Rossen et al. (1994). They took a homonym set, i.e. words with multiple senses such as bank which can mean river bank or National Westminster Bank, and used them in 3 different tasks:

i) a free word-association task, where the subject is asked to produce a word in response to the homonym;

ii) a triad task, where the subject is read the homonym and a word relating to each of its different senses and asked to select the 2 that best go together;

iii) a definitions task, where the subject is asked to say everything they know about what that word means.

The Primary Bias, the degree to which the subject pays attention only to the primary sense of the homonym, decreased across tasks for all subjects: WS subjects; chronological-age matched DS subjects; and mental-age matched controls. It is highest in the word-association task and lowest in the definitions task. This is perhaps to be expected, as the latter task allows the subject more meta-task judgement, a sense of what the experimenter's purpose is in the task. However, the WS subjects show a greater decrease in the primary bias across tasks than do the other groups. Rossen et al. interpret this as a factor resulting from the differing processing demands that the task makes at an unconscious, automatic level. Their claim is, then, that there is an anomalous processing difference in WS that overrides the primacy of the chief sense of the homonym. Given, however, that WS subjects appear
excessively sensitive to different demands in social situations\textsuperscript{34}, including experimental situations, these results do not eliminate the possibility that the WS subjects are simply "giving the experimenters what they want" to a greater degree than are the other groups.

If there is indeed different semantic organisation or processing in WS, then how is it different? Semantic information can be organised taxonomically, based on categorical information, and/or thematically, based on functional or situational information. Given that WS subjects have good autobiographical memory for episodic information, one might expect that their thematic organisation or processing of the same will be intact. All previous research on WS semantics has focused on the taxonomic or categorical organisation. To claim that WS semantics is 'bizarre' implies that the taxonomic organisation or processing will be in some way anomalous in WS subjects. In addition, the lack of a taxonomic shift effect in WS subjects, as described in section B.3.5, may lead to an abnormal taxonomic organisation of semantic structure. Potential differences between taxonomic and thematic semantic organisation are measured on a variety of tasks off-line and on-line - these are described in section C.2.

A particular theoretical model of lexical representation is used to structure discussion of how semantic organisation in WS may differ to that in normals. The lexical entry of a word is taken to be a modality-independent core representation of its syntactic, semantic and phonological attributes. It is distinguished from the access to representations of a particular lexical item, which are modality-specific, and gives a perceptual target for lexical access. In terms of semantic organisation of the lexicon in English, the basic cognitive unit is taken to be the morpheme (Marslen-Wilson et al., 1994). One can consider that there will be a distributed representation of nodes - each representation congruent with a basic unit\textsuperscript{35}. There will be links between representations that correspond to the semantic relationships between morphemes or words; these links may be either excitatory or inhibitory. A spreading activation model (Quillian, 1967; Collins & Loftus, 1975; McNamara, 1992; McNamara, 1994) is invoked, where activation from one primed representation spreads along links to other secondary and related

\textsuperscript{34} At face value certainly more sensitive to these social demands than normal controls.

\textsuperscript{35} This is essentially a connectionist-flavoured model. It is not the remit of this thesis to discuss the theoretical debate between connectionist and symbolic models of cognition.
representations during processing. Residual activation at these related representations will facilitate their retrieval in any task.

How the semantic organisation differs in WS is the way in which representations are linked to each other, and the nature of those links, relative to those of normals. The cohort model (for reviews see Tyler, 1992; Marslen-Wilson, 1987; and also Marslen-Wilson, 1987; Marslen-Wilson & Tyler, 1980) focuses on processing of spoken language and considers that intermediate representations are built up from a variety of lexical and semantic cues during lexical processing. These intermediate representations are not available for conscious access, but the final representation implemented from these intermediates can be accessed consciously. The immediately preceding lexical and semantic context will affect the intermediate representations (and therefore final representation) of a given word. If the semantic organisation in WS differs from that in normals, then the intermediate representations constructed for a given word will also differ because of altered input from contextual information, lexical and semantic, compared to normals.
C.2 EXPERIMENTS

C.2.1 WORD MONITORING

INTRODUCTION

The implication in any claim that the semantics of WS are 'deviant' is either a problem of access or that the underlying organisation of lexical representations is in some way different from that in comparable normal subjects. However, all the experimental tasks used in previous research require the subject to make an explicit response. Such tasks necessarily involve processes that cannot tap the organisation of the underlying lexical representation.

In order to answer the question of whether anecdotal 'bizarre' productions are a result of a deviant or disorganised lexicon in WS - at the level of word representations intermediate before the speech act and interrelationships between these - or whether they are simply indicative of a problem of access to these representations through motivational or stress factors, a different type of experimental task is needed, which requires the subject to make an implicit response which taps only the underlying representations.

Off-line versus on-line tasks

'Off-line' tasks, such as the word fluency task commonly used with WS subjects, involve some conscious attention to the task. They are therefore susceptible to motivational and stress factors of the subject performing the experiment.

For example, a WS subject asked to name all the animals they can think of in a word fluency task, may decide that they want to impress the experimenter. The subject will then try as hard as possible to think of animals, producing more items through perseverance than a less motivated subject would. They may also concentrate on naming the most exotic-sounding animals they know, because they believe that will make them seem more intelligent in the eyes of the experimenter they are trying to impress. Consequently, in an off-line task like the word fluency task, our WS subject
may seem more verbally fluent and more 'unusual' in their semantic choice. Although off-line tasks are useful, they are possibly invalid for drawing conclusions about the properties of the underlying representation.

An 'on-line' task, where the subject is unaware of the nature of the experiment and its hypotheses, can bypass this problem. It can tap the underlying structure of the representation, and corresponding intermediate stages in language comprehension before production of the response. On-line experimental paradigms have been developed by Tyler and Marslen-Wilson, and their colleagues, and one of these, the primed-word monitoring task, is used in the present study. These paradigms are based on a theoretical model of spoken language comprehension known as the cohort model (Marslen-Wilson, 1975, 1987; Marslen-Wilson & Tyler, 1975, 1980; Tyler, 1992). These have been tested with brain-damaged patients (Tyler, 1992) and normal adults and children.

**Primed word-monitoring task**

In this task, the subject is required to listen for a target word, e.g. DOG, in a list of filler words and make a response when the target occurs. The response is to press a button which stops a timer started at the onset of the target. There are two conditions, a primed condition and a control condition. In the former, the word immediately preceding the target is related semantically to it, e.g. CAT, and primes the response to the target. In the latter, the immediately preceding word has no semantic relation to the target, e.g. POTATO, and there is no corresponding priming. According to the 'Spreading Activation' model of lexical representation (Collins & Loftus, 1975), priming will significantly reduce the subject's reaction time (RT) to the target.

The semantic relationship between prime and target has two variables: type of relationship and degree of association, each with two conditions. The type of relationship between prime and target can be either functional (thematic), e.g. DOG and BONE, or categorical (taxonomic), e.g. DOG and POODLE. Prime and target can be either highly associated normatively to each other, e.g. DOG and CAT, or non-associated normatively to each other, e.g. DOG and HORSE. Primes and targets are matched across conditions for
length, familiarity, concreteness and written frequency - all the main variables known to affect priming.

The materials used in this study was tested on normal subjects by Moss, Ostrin, Tyler and Marslen-Wilson (1995). Significant priming was found, causing a significant reduction of RT when the target was preceded by a semantically related prime as opposed to a control. There was no significant effect of either type of semantic relation or degree of normative association.

Moss et al. (1995) also tested a single patient, P.P., a subject whose case study is described in detail by Patterson, Graham and Hodges (1994). In brief, P.P. is a 68 year old who suffers from a selective deficit in semantic memory. She has a progressive loss of naming ability for people, places and things, although her autobiographical and episodic memories remain relatively intact. In short, there is damage to the underlying lexical representation in this patient. Despite this, significant priming was also found in P.P. There was, however, also a significant interaction between type of semantic relationship between prime and target, and the priming of the target. There was a significant reduction in RT to the target if the prime was functionally (thematically) related to the target, but not if it was categorically (taxonomically) related to the target.

If WS subjects also have some kind of damage or difference in the structure of their underlying representations, then there will be no or reduced priming of target for some or all of the experimental conditions. At the very least, a significant difference should be found between the amount of priming for all conditions in WS subjects and amount of priming for all conditions in normal subjects. Partially degraded semantic representations (Chertkow, Bub & Seidenberg, 1989), where only some links between units are damaged or missing, can also produce significant priming of target RT, but of a pattern very different from that of normal subjects. Instead, a pattern of hyper-priming is shown, where reaction time latencies are slower than normals for the control conditions, giving larger than normal control-prime differences (priming).
METHOD

Subjects

Twelve WS subjects were tested as the experimental group, with ages ranging from 14;3 to 30;5 (mean age 21;9). Five were male and 7 female. The control group were 20 native speakers of British English between the ages of 18 and 40, tested in the previous study on the same task by Moss et al. (1995). Comparison was also made with P.P. (Moss et al., 1995).

Moss et al. (1995) also used a group of controls matched by chronological age to P.P. As no significant differences in priming were found between this age-matched control group and the young control group, controls exactly matched by chronological age to the WS subjects in this study were thought unnecessary.

Materials and Design

The materials and design were the same as those used in the study by Moss et al. (1995). In brief, forty-eight prime-target word pairs were used to test priming for two main kinds of semantic relationship. Half the pairs had a category co-ordinate relation between prime and target, taken from familiar superordinate categories (e.g., dog-cat, coat-hat). The other half of the pairs instead shared a functional semantic relation: half of these were such that the prime referred to an object used to perform a familiar action on the object referred to by the target (e.g. broom-floor, where a broom is used to sweep a floor); the other half of the functional pairs had a target which referred to a typical component of a script evoked by the prime (e.g. party-music, where music is something you expect at a party). Since most of the words in the functional condition referred to man-made artefacts, as these have more clearly defined functions, the category-co-ordinate items were controlled for this variable. Due to constraints on the length of the test set, it was not possible to test all kinds of semantic relation on all targets. Rather, functional and category co-ordinate relations were tested over different sets of 24 words. Primes and targets were matched across conditions for length, familiarity, concreteness and written frequency - all the main variables known to affect

\[36\] This experimental data was very graciously made available to the author by Professor L. Tyler and her co-workers.
priming. Moss et al. (1995) carried out a pretest on 17 of the control subjects where participants were asked to rate the degree of relatedness between the pairs of words on a scale of 0 to 9. No significant differences between ratings were found across conditions.

The second major variable controlled across the material set was the degree of normative association between the prime and target items in each pair. If an item pair are highly normatively associated, the target item is probably the first item said when the prime is presented in a free association test. Previous studies have shown that a strong association may increase the amount of priming for a target, over non-associated but semantically related prime-target pairs (Moss et al., 1995). Possibly, associative priming may be maintained by a spread of activation at a pre-semantic level (Shelton & Martin, 1992). In order to ensure that any priming observed cannot be attributed to this system alone, the degree of association was also controlled. Therefore half of all the pairs in each condition were chosen so as to be strongly associated (M=39.5%) and half were not associated in either forward or backward direction. The associative data was taken from American English data from Postman and Keppel (1970) and association norms taken from 40 British English subjects (Moss & Older, in press).

Each target was paired with its related prime and also in a second version with a control word unrelated both semantically and phonologically. Materials from both conditions, the associated/non-associated condition and the functional/category-co-ordinated condition, were counterbalanced across the two versions.

**TASK**

The task used was a primed monitoring task devised by Moss et al. (1995). The subject presses a reaction time button as soon as she or he hears a target word prespecified by the experimenter. Each trial is a list of words spoken with a constant interval (ISI) between them, the list varying from 5 to 10 seconds long. The target word is always the penultimate word of its list, and is preceded in one version by the prime word and in the other version by the unrelated control word. The other filler words in the list were all semantically and phonologically unrelated to the prime and target words. The length of filler words was counterbalanced across trials. The target
appeared in two lists, one in each version of the experiment. In a list on one version, it would be preceded by the prime word, in the list on the other version it is preceded by the control word.

The ISI used was 1500 ms. Moss et al. (1995) also tested young controls on the same task with a shorter ISI of 200 ms. This was because it was hypothesised that the longer ISI might give subjects the time to develop a conscious responding strategy, and affect priming results. No significant differences in priming between groups using the longer ISI and the shorter ISI was found. As it was thought that WS subjects might have problems with the shorter ISI list, the longer ISI version of the experiment was used. As in Moss et al. (1995), a set of catch trials was also used in order to discourage use of conscious response strategies. These catch trials used a pseudoprime word (such as DUCK, when the target was BONE and the prime was DOG) in the list, related to the target but for which a number of unrelated filler words were interposed between pseudoprime and target. These trials were randomly distributed through the set. The same were used in both versions of the task.

Before the beginning of each list, the subject was told which target word to monitor for by the experimenter. A timing pulse at the onset of the target word was interrupted by the press of the reaction time button, thus giving a measurement of monitoring latency. If this time was faster for monitoring the target when it is preceded by the prime word than when it was preceded by the control word, then a priming effect equivalent to the difference between the two monitoring latencies was demonstrated.

PROCEDURE

All materials were spoken by a female British English speaker and digitised at a sampling rate of 20 Hz onto computer hard disc. They were then recorded onto one track of DAT (digital audio tape). The second track contained timing pulses synchronised with the onset of each target word. These materials were kindly lent to us by Professor Tyler's laboratory, so as to be identical to those used in the previous research.

*WS subjects.* Each subject was seen individually. Experimenter and subject each wore headphones connected to a DAT player. A line-out took the timed
pulse track into a timer (milliseconds) which restarted from zero on each pulse, and was stopped by the subject pressing a button in front of him or her. The subject was instructed before each list to keep their 'favourite' finger on the button at all times. As some of the subjects in the WS group had poor reading ability, the experimenter spoke the target word orally to the subjects. The subject was told the target word by the experimenter three times before each list, and repeated it back to the experimenter before the list commenced.

In all but one case, each subject was tested on the second version of the test at least one week after the first version. One subject, not available for testing in Britain for long, completed the second version one day after the first. In most cases, each version was completed in one testing session. For three subjects, as their attention and motivation waned visibly during the length of time required for one version, each version was split into two halves completed in separate testing sessions. In no case was material from one version presented in the same session as material from the other version.

Young controls. The young control group was tested by Moss et al. (1995), in subject groups of up to 4 at a time. Ten subjects completed each version of the experiment. The target words were presented to subjects on printed cards. Subjects were allowed 7 seconds between each trial to turn to the next card and read the target word. Spoken word lists were presented by a computer, which also recorded the reaction times directly.

P.P. P.P. was also tested by Moss et al. (1995). P.P. completed both versions of the experiment on the same day, with several hours separating the testing sessions. Target words were spoken by the experimenter, rather than P.P. reading it from a card as she suffered from surface alexia (Patterson, Graham & Hodges, 1994). The experiment was run from tape, with reaction times recorded in the same way as the WS subjects.
RESULTS

WS subject group

Anticipations and time-outs

Anticipations (pressing the button before hearing the target) and time-outs (no button response within 2s of the target) were recorded for each WS subject as follows in Table C.I below:

**TABLE C.I**
ANTICIPATIONS AND TIME-OUTS MADE BY WS SUBJECTS

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>NUMBER OF ANTICIPATIONS/TIME OUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>3/96</td>
</tr>
<tr>
<td>BB</td>
<td>2/96</td>
</tr>
<tr>
<td>CC</td>
<td>7/96</td>
</tr>
<tr>
<td>DD</td>
<td>4/96</td>
</tr>
<tr>
<td>HH</td>
<td>6/96</td>
</tr>
<tr>
<td>FF</td>
<td>5/96</td>
</tr>
<tr>
<td>KK</td>
<td>13/96</td>
</tr>
<tr>
<td>LL</td>
<td>3/96</td>
</tr>
<tr>
<td>NN</td>
<td>8/96</td>
</tr>
<tr>
<td>OO</td>
<td>2/96</td>
</tr>
<tr>
<td>PP</td>
<td>6/96</td>
</tr>
<tr>
<td>QQ</td>
<td>27/96</td>
</tr>
</tbody>
</table>

Only one of these mistakes was an anticipation: subject CC pressed on the prime word 'latin' before the target word 'greek'. Subject LL also pressed on the prime word 'blouse' before the target word 'dress', but recovered sufficiently to make a response to the target.

The rest of these were time-outs, usually caused by the subject either forgetting to press the button or forgetting what the target word was. The former was far more common than the latter.

In one instance, a time out was caused by the subject CC being upset by the mention of the word 'spider' in one list. She has a phobia of spiders. Subject KK also responded fearfully to the mention of the word 'balloon' in one list, but recovered to make a response to the target. She hates the squeaking sound of balloons being rubbed.
The total percentage of anticipation/time-out errors was 7.5%. This is significantly greater than the number of such errors made by the control group (one-group t-test, df=10, t=3.3, p<0.01). As one subject, QQ, made a total of 28% anticipations and time-outs, this subject's data were removed from further analysis. The total percentage of anticipation/time-out errors was then 5.6%. Values for remaining subjects for anticipations and time-outs were removed before further analysis, and replaced with the version condition mean.

**Smoothing out of data**

The mean and standard deviation for reaction times for each version condition for each subject was calculated. Any values either two standard deviations above or below the mean were removed, and replaced with the mean. The number of each of these replacements is shown in Table C.II below.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>NUMBER OF +/- 2 STD REPLACEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>4/96</td>
</tr>
<tr>
<td>BB</td>
<td>4/96</td>
</tr>
<tr>
<td>CC</td>
<td>3/96</td>
</tr>
<tr>
<td>DD</td>
<td>4/96</td>
</tr>
<tr>
<td>HH</td>
<td>4/96</td>
</tr>
<tr>
<td>FF</td>
<td>6/96</td>
</tr>
<tr>
<td>KK</td>
<td>8/96</td>
</tr>
<tr>
<td>LL</td>
<td>4/96</td>
</tr>
<tr>
<td>NN</td>
<td>2/96</td>
</tr>
<tr>
<td>OO</td>
<td>3/96</td>
</tr>
<tr>
<td>PP</td>
<td>2/96</td>
</tr>
</tbody>
</table>

The total percentage of these replacements is 4.2%. This value is not significantly greater than the number of such replacements made for the control group, 3.7% (one-group t-test, df=10, t=0.9, p>0.05).
ANALYSIS

Means were calculated over participant and item and entered into an analysis of variance (ANOVA) with the following factors: Version X Semantic Type (category or functional) X Association (associated or non-associated) X Prime type (related or control). There was a large and significant priming effect (related faster than control) for all conditions (66.4 ms): F1 (participant means) (1,10) = 28.679, p<0.0005; F2 (item means) (1,40) = 63.267, p<0.0001. There was a significant interaction between semantic type, associative type and priming for the participant means analysis (F1 (1,10)=13.526, p<0.005) but not for the item means analysis (F2 (1,40)=2.661, p>0.10). There were no other reliable main effects or interactions.

Results for the WS group, the young control group and for P.P. are shown in Table C.III, collapsed over the variable of association (There was no significant effect of degree of association on priming for both the young control group and for P.P.).

TABLE C.III
AMOUNTS OF PRIMING FOR GROUPS

<table>
<thead>
<tr>
<th>Group and semantic type</th>
<th>Related (R)</th>
<th>Control (C)</th>
<th>Priming (C-R)</th>
<th>% Priming (C-R)/R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Young controls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category co-ordinates</td>
<td>361</td>
<td>428</td>
<td>67*</td>
<td>18.6</td>
</tr>
<tr>
<td>Functionally related items</td>
<td>370</td>
<td>445</td>
<td>75*</td>
<td>20.3</td>
</tr>
<tr>
<td><strong>P.P.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category co-ordinates</td>
<td>403</td>
<td>392</td>
<td>-11</td>
<td>-2.7</td>
</tr>
<tr>
<td>Functionally related items</td>
<td>344</td>
<td>394</td>
<td>50*</td>
<td>14.5</td>
</tr>
<tr>
<td><strong>WS subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category co-ordinates</td>
<td>518.9</td>
<td>584.3</td>
<td>65.4*</td>
<td>12.6</td>
</tr>
<tr>
<td>Functionally related items</td>
<td>549.4</td>
<td>616.7</td>
<td>67.3*</td>
<td>12.2</td>
</tr>
</tbody>
</table>

* p<0.01 in both items and participants tests.
There is significant priming for both functionally (thematic) related items and categorically (taxonomically) related items in the WS group. The amount of priming, collapsed over both conditions, is 66.4 ms for the WS group, which compares favourably to the amount in the young controls, which is 71 ms. However, the amount of priming as a percentage of the overall RT is less than that in the normal control group. There is a significant interaction between the type of semantic relationship, the type of associative relationship, and the amount of priming, for the participant analysis but not the item analysis. The WS group mean priming for each of the four conditions is shown in figure C.IV:

**FIGURE C.IV**
**WS GROUP MEAN PRIMING FOR ALL CONDITIONS**

![Bar chart](image)

In the functional (thematic) condition, much greater priming is found in the associated condition than in the non-associated condition. There is, however, no significant difference between priming means for WS subjects in the 4 conditions (1-way related ANOVA, $F_{3,30}=2$, $p>0.05$).

**WS INDIVIDUAL SCORES**

For each WS subject, the following were calculated: overall mean amount of priming (priming); overall mean RT (RT); amount of priming in categorical condition ($f_1$ pri); amount of priming in functional condition ($f_2$ pri); difference in priming between categorical and functional conditions ($f_1-f_2$ pri); amount of priming in associative condition ($a_1$ pri); amount of priming in non-associative condition ($a_2$ pri); difference in priming between...
associative and non-associative conditions (a1-a2 pri). These are shown in the tables C.V, C.VI and C.VII:

**TABLE C.V OVERALL MEAN PRIMING AND MEAN RT PER SUBJECT**

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>PRIMING</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>40</td>
<td>423.7</td>
</tr>
<tr>
<td>BB</td>
<td>61.4</td>
<td>562.9</td>
</tr>
<tr>
<td>CC</td>
<td>23.9</td>
<td>784.3</td>
</tr>
<tr>
<td>DD</td>
<td>48.3</td>
<td>408.4</td>
</tr>
<tr>
<td>HH</td>
<td>66.5</td>
<td>672.6</td>
</tr>
<tr>
<td>FF</td>
<td>62.2</td>
<td>647</td>
</tr>
<tr>
<td>KK</td>
<td>85.8</td>
<td>693.5</td>
</tr>
<tr>
<td>LL</td>
<td>70.8</td>
<td>344.8</td>
</tr>
<tr>
<td>NN</td>
<td>14.4</td>
<td>719.9</td>
</tr>
<tr>
<td>OO</td>
<td>88.3</td>
<td>518.4</td>
</tr>
<tr>
<td>PP</td>
<td>168.7</td>
<td>464.9</td>
</tr>
</tbody>
</table>

**TABLE C.VI OVERALL MEAN PRIMING IN F1 PRI, F2 PRI, AND F1-F2 PRI CONDITIONS PER SUBJECT**

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>F1 PRI</th>
<th>F2 PRI</th>
<th>F1-F2 PRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>55</td>
<td>25.1</td>
<td>29.9</td>
</tr>
<tr>
<td>BB</td>
<td>49.9</td>
<td>73</td>
<td>-23.1</td>
</tr>
<tr>
<td>CC</td>
<td>41.4</td>
<td>6.4</td>
<td>35</td>
</tr>
<tr>
<td>DD</td>
<td>28.3</td>
<td>68.3</td>
<td>-39.9</td>
</tr>
<tr>
<td>HH</td>
<td>36.3</td>
<td>96.7</td>
<td>-60.4</td>
</tr>
<tr>
<td>FF</td>
<td>54.8</td>
<td>69.6</td>
<td>-14.8</td>
</tr>
<tr>
<td>KK</td>
<td>125.6</td>
<td>46</td>
<td>79.6</td>
</tr>
<tr>
<td>LL</td>
<td>63</td>
<td>78.5</td>
<td>-15.6</td>
</tr>
<tr>
<td>NN</td>
<td>-13.6</td>
<td>42.5</td>
<td>-56.1</td>
</tr>
<tr>
<td>OO</td>
<td>125.5</td>
<td>51</td>
<td>74.5</td>
</tr>
<tr>
<td>PP</td>
<td>153.4</td>
<td>184</td>
<td>-30.6</td>
</tr>
</tbody>
</table>

**TABLE C.VII OVERALL MEAN PRIMING IN A1 PRI, A2 PRI, AND A1-A2 PRI CONDITIONS PER SUBJECT**

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>A1 PRI</th>
<th>A2 PRI</th>
<th>A1-A2 PRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>63.9</td>
<td>16.2</td>
<td>47.7</td>
</tr>
<tr>
<td>BB</td>
<td>80.5</td>
<td>42.4</td>
<td>38.2</td>
</tr>
<tr>
<td>CC</td>
<td>57</td>
<td>-9.2</td>
<td>66.2</td>
</tr>
<tr>
<td>DD</td>
<td>45.5</td>
<td>51.1</td>
<td>-5.6</td>
</tr>
<tr>
<td>HH</td>
<td>48</td>
<td>84.9</td>
<td>-36.9</td>
</tr>
<tr>
<td>FF</td>
<td>73.7</td>
<td>50.6</td>
<td>23.1</td>
</tr>
<tr>
<td>KK</td>
<td>106.3</td>
<td>65.2</td>
<td>41.1</td>
</tr>
<tr>
<td>LL</td>
<td>111.8</td>
<td>29.7</td>
<td>82.1</td>
</tr>
<tr>
<td>NN</td>
<td>-35.5</td>
<td>64.4</td>
<td>-100</td>
</tr>
<tr>
<td>OO</td>
<td>85.4</td>
<td>91.2</td>
<td>-5.8</td>
</tr>
<tr>
<td>PP</td>
<td>187.6</td>
<td>149.7</td>
<td>37.9</td>
</tr>
</tbody>
</table>
CORRELATIONS OF INDIVIDUAL SCORES
WITH STANDARDISED DATA

There are no significant correlations of any of the above with any of the following standardised scores of WS individuals: chronological age; verbal IQ; performance IQ; BPVS standard score; BPVS test age; TROG test age; RAVENS test age; Inspection Time.

CORRELATIONS OF INDIVIDUAL SCORES
WITH PART B DATA

A relationship can be hypothesised between the difference in priming for categorical (taxonomic) and functional (thematic) conditions (f1-f2 pri) for each subject, and the taxonomic bias for each subject, discussed in section B.3.5, the taxonomic shift. The taxonomic bias was the difference between the number of taxonomic responses in the condition with a novel word, and the number in the condition with no word. This is an indicator of a degree to which novel words make subjects attend more to the categorical above functional relationships between objects. A significant correlation between the two would indicate that at the point of acquisition of new lexical items onwards, categorical links between the representation for that new item and other related items were being formed and strengthened.

Of the 11 WS subjects in this study, only 8 satisfactorily completed both conditions of the taxonomic shift experiment. There is no significant correlation between the taxonomic bias and the f1-f2 priming difference for these subjects (linear regression R=0.5, F=2.1, p>0.10). This is not as expected. As the taxonomic shift effect measures the degree to which a subject assimilates objects into object-kinds in response to a novel name as opposed to thematic information, the lack of such a bias should correlate with taxonomic organisation of such names with respect to object kind, as opposed to thematic organisation, as measured by the f1-f2 priming difference. The number of subjects who satisfactorily completed both experiments is small, even though a larger subject pool was tested for both. A larger number of subjects completing both experiments might yield a significant correlation between the taxonomic bias and f1-f2 priming difference, as hypothesised.
DISCUSSION

As a group, WS subjects show robust priming, of comparable magnitude to that of the control groups. This priming is shown for both strongly associated word-pairs and for non-associated pairs. More importantly, it is shown for both categorically (taxonomically) related word-pairs and for functionally (thematically) related word-pairs. This indicates that a range of kinds of semantic information is rapidly activated when a word is heard, and this information serves to prime subsequent words related in different ways.

In comparison, P.P. demonstrates priming for functionally related word-pairs, but not for categorically related pairs. P.P. has poor naming ability, and this coupled with the lack of priming for categorical pairs indicates that there is damage to the underlying lexical entries and their links involved in taxonomic relations between words. Certainly then, there is no impairment of semantic organisation in WS similar to that shown by P.P.

However, the percentage of priming, as compared to the overall reaction time latencies, is lower for WS across both conditions, as compared to the young controls. This is due to an increased average RT in WS, 567 ms, as compared to that in the young controls group, 401 ms. The most likely explanation is that the motor component of the reaction response is impaired in WS. WS subjects have great difficulty in many motor tasks, from drawing with a pencil, to climbing stairs. It is very possible, therefore, that the motor component of the RT is greater in WS than in normal controls, that they are simply generally slower in pressing response buttons, whatever the task.

Another factor that might affect the reaction time latencies of WS subjects is the fact that the task seems very laborious and tedious. Some of the subjects, particularly those who showed longer reaction time latencies, found it difficult to concentrate on the task and for these subjects each session had to be stopped at least once to give the subject a breather. Subjects might then be less motivated to press the button speedily. If this were so, then one would expect to find a positive correlation between the number of time-outs (where the subject didn’t press the button at all) and the overall mean RT for each subject. There is such a positive but just non-significant correlation (linear regression: df=11, R=0.6, F=4.1, p=0.07). This suggests that a possible (but
probably not only) factor in the longer reaction time latencies for WS subjects might be a lower motivation to complete a boring task.

A third possible factor for longer reaction time latencies in WS subjects might be the opposite of the partial degradation of the lexical representation that is found in Alzheimer’s patients, which results in hyperpriming (Chertkow et al., 1989). Instead, there might be a greater number of strong links between more lexical units. The effect of this would be that less activation would spread to the target as activation energy would be shared amongst more related unit representations. The target would therefore take longer to reach an activation threshold which would result in a reaction being triggered, leading to higher reaction time latencies in both primed and control conditions. Were this the case for WS subjects, then in a word-association task one would expect that they would give more different responses as a group than a normal adult control group, as there would be more representations strongly linked to any given target word. This is investigated in section C.2.3.

In any case, the significant amount of priming that WS subjects show across all conditions indicates that there is no impairment in the underlying organisation of lexical representations. Semantic organisation, both taxonomically and thematically, is comparable to that of normal adult controls. The larger reaction time latencies for WS subjects may be as a result of overrepresentation of links between related units, but possible differences in motor response time and motivation to complete the task are likely to have a significant effect too in increasing latencies. This ‘on-line’ task has demonstrated that the semantic organisation of lexical representations in WS is similar to that of normals. In the following sections C.2.2 - C.2.4, explicit ‘off-line’ tasks that tap semantic representations are examined.
C.2.2 WORD FLUENCY

INTRODUCTION

The established view that the semantics of WS individuals is in some way deviant or bizarre is partly based on evidence from 'word fluency' tasks. These involve asking a subject to produce as many items as they can within a certain lexical category, most often in past research the category of animals, in a limited amount of time. The performance of WS individuals is typically reported thus:

*Ask a normal child to name some animals, and you will get the standard inventory of pet store and barnyard: dog, cat, horse, cow, pig. Ask a Williams Syndrome child, and you will get a more interesting menagerie: unicorn, pteranodon, yak, ibex, water buffalo, sea lion, saber-tooth tiger, vulture, koala, dragon, and one that should be especially interesting to paleontologists, "brontosaurus rex."* (Pinker, 1994, p.59).

This commonly repeated result is based on work by Bellugi et al. (1988), that uses too few subjects (n=4, at a guess), and no normal controls. The results might therefore be anecdotal. Rossen, Bihrl, Klima, Bellugi and Jones (1994) include a word fluency task within a battery of tasks performed with 7 WS subjects, with an average CA of 13;6, 7 MA and CA matched DS controls, and 9 normal controls matched for MA.

Rossen et al. used a standardised, normalised version of the task that is found as a subtest on the CELF (Clinical Evaluation of Language Functions; validated for non-normed population by Perez, Slate, Neeley & McDaniel, 1995). This test requires subjects to name as many exemplars as possible in 1 minute in each of 2 common semantic categories, animals and food. This particular version of the task was not used in the present study for 2 reasons: the standardised data are for American subjects, and a difference between American and British English speaker in items produced on this task is to be expected; pilot studies showed that the time limit of one minute is too short for younger control subjects to produce a reasonable number of items.

Three measures were calculated for all subjects by Rossen et al. The first measure was the total number of items produced, in both categories of animal and food. WS subjects performed at matched chronological age levels, in contrast to DS subjects who performed at matched mental age based on
WISC-R IQ scores. The second measure was the number of out-of-category responses (deemed 'intrusion') produced, in the animal category. Although DS subjects did produce more intrusions, there was no significant difference between WS and DS subjects for this measure. The third measure is the number of repetitions of previously named exemplars, in the animal category. Again, there was no significant difference between WS and DS subjects for this measure, although DS subjects did produce more repetitions.

In addition, Rossen et al. scored exemplars as being high-frequency or low-frequency, based on an arbitrary cut-off point of frequency of production in school text-books. Although there was no significant difference between the proportion of low-frequency exemplars produced over all the trial for all 3 groups, there was a significantly greater proportion of low-frequency exemplars produced later in the trial (defined by Rossen et al. as being after the first 7 exemplars) by WS subjects compared to the other 2 groups.

In addition, they note that some WS subjects produced in-category exemplars in high-speed bursts, with up to 10 produced at a rate of 3 a second. This phenomenon was not seen in DS subjects, and (according to their "informal observation") not even in the normal control group.

The explanation proffered by Rossen et al. for these effects is as follows:

"This is when the task is less automatic, and the subject has to invest more complex effort to arrive at additional exemplars. This mental effort must involve a complex interaction among excitatory effects stemming from the probe word and associated concepts and from response words (and associated concepts) just produced. The excitatory activation is responsible for causing appropriate in-category word forms to reach an activation level sufficient to allow a response. At the same time, inhibitory effects are also crucially involved in the mental effort. Inhibitory activation also stems from the activated representations of the probe and recent responses, but is more prominently involved in preventing out-of-category responses and repetitions." (p.14)

They argue that the gap between activation of high frequency words and that of low frequency words lessens as a trial continues, allowing more low frequency exemplars to emerge then.
Follow-up ERP work (after Neville, Mills & Bellugi, 1994) was done with WS subjects and normal controls (no indication as to whether controls were mental age or chronological age matched). WS subjects show a large positivity at 200 - 300 ms to any auditory word stimulus. This is linked by Rossen et al. to anomalous processing rather than any developmental delay, as the effect is not apparent in control subjects. Without testing DS subjects, however, this assumption cannot be made.

The authors further note that low-frequency exemplars produced late in the word frequency trial tend to be low-frequency because they are what they deem *hyperspecific*, subordinate levels to basic level exemplars, such as *pumpkin pie* as subordinate to the basic-level *pie*. These exemplars are low-frequency as much because of this effect as of any atypicality.

What is crucially missing from Rossen et al.'s account is any indication of the relationship between these low-frequency, hyperspecific exemplars and the exemplars produced immediately preceding. Any excitatory activation effect will, as they indeed state, be as much caused by activation from responses just said as it will from the probe itself. If, in fact, *pumpkin pie* is produced as one of a consecutive list of types of pie, rather than following an unrelated item such as *green pea soup*, then this is an indication of a strategy, unconscious or conscious, to move through taxonomic category. The relationship between items does not necessarily need to be taxonomic; if *ice-cream* is the item immediately preceding *pumpkin pie*, then there is a thematic relationship between items, and a thematic strategy used. It will be possible for subjects to switch between such strategies, taxonomic or thematic, within the task.

There is also no mention as to whether the items that WS subjects produced in high-speed bursts were closely related, either taxonomically or thematically. Pilot results from normal adult subjects indicate that any high-speed burst of items tends to be within a taxonomic or thematic subcategory, e.g. producing a list of breeds of dog.

One would expect in fact that items produced will tend to cluster according to taxonomic or thematic relationships between items - this kind of clustering is the easiest way to generate a long list of items, and pilot results indeed indicate that normal subjects of all ages use such strategies. One
would also expect that there will be a shorter time difference between items that are more closely related - according to the reasoning of Rossen et al., activation levels for items in a subcategory, taxonomic or thematic, will be raised as soon as any item that is within that subcategory is mentioned.

Rossen et al. used WS subjects with a mean chronological age of 13;6, and found a pattern of results for mean number of items produced that was more characteristic of chronological age controls than of mental age controls. A word fluency study in the animal category only, by Scott, Mervis, Bertrand, Klein, Armstrong and Ford (1994), used WS subjects of mean chronological age 10;2, with matched DS controls, and normal control groups, one matched for mental age, and one for chronological age. They, in contrast to the older WS subjects of Rossen et al., found that on mean number of items produced, the WS group were equivalent to the DS group and the MA matched normal group, all groups lagging behind the CA matched group.

In addition, they measured the standard frequency of items produced, the typicality of items according to ratings by adults, the mean low and high typicality of items produced, the proportion of items produced at the basic level and at the subordinate level, and the mean number of items produced that were mammals (the most common category of animal names produced by all subjects). For the mean low and high typicality of items, and for the proportion produced at the subordinate level, they found a similar pattern, with CA matched controls exceeding the other 3 groups, who were roughly similar. For all other measures, they found no significant differences between all 4 groups.

This suggests, that anomalous results by WS subjects may instead be caused by a developmental delay. Up to chronological age of 9 to 10, the age of the WS subjects of Scott et al., WS subjects produce results characteristic of mental age-matched controls. From chronological age of 13 (no range of ages for the sample used by Rossen et al. is given), WS subjects produce results characteristic of chronological age-matched controls. Several studies now suggest that language is different in young WS subjects and older subjects (Volterra, Sabbadini, Capirci, Pezzini & Ossella, 1994).

This study uses normal control groups of mean ages around 3 years, 5 years, 9 years and adult, to give an indication of developmental trajectories of
result patterns for this task. An older sample of 10 WS subjects, with a much higher chronological age than groups in either of the previous studies is used. In addition, a small group of 3 WS subjects with chronological age roughly equivalent to that sample in the study by Scott et al. is also tested.

The animal category is again used. In addition, there are two subcategories of animal used as probes for category production. One, pet, is a thematic subcategory. As all animals can possibly be pets, the out-of-category measure is rather whether items are animals, rather than whether they are pets. In addition, items are rated as to how frequently they occur within normal category production. The other, reptile, is a taxonomic subcategory. Both of these subcategories will increase the demands of the task, and probably decrease the number of items produced. Knowledge of what makes an animal a reptile is not likely to be found in the younger control groups. Johnson, Carey and Levine (1994) also demonstrate that there is a lack of conceptual understanding within the domain of intuitive biology for WS subjects, particularly for understanding involving conceptual change processes rather than enrichment processes. One would expect, then, that even older WS subjects will be weaker in this subcategory relative to chronological age-matched controls.

In addition, a second category is used. Rather than using the food category, which like the animal category may be taxonomically organised with a potentially limitless number of exemplars, the colour category is used, which has a rather different structure. There is a small number of frequent, basic-level colour exemplars, e.g. red. In addition, there are infrequent, subordinate level exemplars, e.g. burgundy, and infrequent compound exemplars, formed by adding a prefix, e.g. dark, to a basic-level exemplar to form e.g. dark red. The smaller number of exemplars available should increase the number of repetitions made by all groups. There may also be an interaction, with the WS groups producing more repetitions than the other groups.
METHOD

DESIGN

Subjects were asked to produce items in each of 2 categories. A stopwatch was started as soon as the experimenter gave the instructions, when time equalled zero. Responses were recorded together with the time after zero in seconds that the response was given. Categories were: animals; colours.

As stated above, in the animal category there were also further subcategories of: animals that are pets (thematic, based on where an animal might be most likely encountered); animals that are reptiles (taxonomic).

SUBJECTS

There were up to four normal control groups for each category: a 3 year old group; a 5 year old group; a 9 year old group; an adult group. Up to 16 WS subjects were tested on each category.

Animal Category

10 subjects of mean age 3;8, ranging from 3;6 to 4;2 were in the 3 year old group. There were 5 males and 5 females in the group. 10 subjects of mean age 5;2, ranging from 5;0 to 5;9 were in the 5 year old group. There were 5 males and 5 females in the group. 10 subjects of mean age 9;5, ranging from 8;11 to 10;2 were in the 9 year old group. There were 5 males and 5 females in the group. 10 subjects of mean age 23;1, ranging from 19;1 to 27;2 were in the adult group. There were 5 males and 5 females in the group.

In the WS group, 15 subjects were tested. Of these, two subjects could not complete the task and their results are not included in the analysis.

The remaining 13 subjects were divided into 2 groups. The first group, the younger WS group, had 3 subjects of mean age 8;9, ranging from 8;0 to 10;2. There were 1 male and 2 females in this group.
The second group, the older WS group, had 10 subjects of mean age 21;9, ranging from 14;2 to 30;5. There were 4 males and 6 females in the group. For purposes of comparisons with the normal control groups, only results from the older WS group were used.

**ANIMAL SUBCATEGORIES**

The same subject groups were used as in the animal category.

**COLOUR CATEGORY**

The same subject groups were used as in the animal category, except for the 5 year old group, which was not tested on this category.

**MATERIALS**

A stop-watch. Pen and paper. Shorthand skills.

**PROCEDURE**

Experimenter and subject sat at a table. The experimenter asked the subject to produce items in each of the categories, each category in turn. The precise requests for each category were as follows:

**Animal category:**
"Think about animals. Can you tell me all the animals you can think of?"

**Thematic subcategory: pet**
"Think about animals that are pets. Can you tell me all the animals that you, or anyone else, could have has a pet?"

**Taxonomic subcategory: reptile**
"Think about animals that are reptiles. Can you tell me all the animals that are reptiles that you can think of?"

**Colour category:**
"Think about colours. Can you tell me all the colours you can think of?"
As soon as the experimenter had finished their request, a stopwatch was set to time zero. Each response that the subject made was recorded, together with the time after zero to the nearest second that they began to say the response.

If a subject went for 30 seconds without giving a response at any point, they were asked "Can you think of any more XXXX", where XXXX is the name of the category. If they declined, then the test for that category was concluded. If they did not produce an item within 20 seconds after that, then the test for that category was concluded. After 120 seconds, the test for that category was stopped in any case.

RESULTS

ANIMAL CATEGORY

Means

In the following table C.VIII for the 3 year old group, in table C.IX for the 5 year old group, in table C.X for the 9 year old group, in table C.XI for the adult group and in table C.XII for the WS group, the mean, minimum and maximum of the 5 year old group is shown for each of the following categories: number of items produced by each subject; number of repetitions by each subject; number of out-of-category responses by each subject; number of plural responses by each subject; number of singular responses by each subject; number of false plural responses by each subject (e.g. sheeps); number of ambiguous as to whether singular or plural responses by each subject (e.g. fish); number of repetitions where subject acknowledged repetition by each subject.
### TABLE C.VIII
MEANS FOR 3 YEAR OLD GROUP

<table>
<thead>
<tr>
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<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
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<tr>
<td>Mean number produced</td>
<td>6.1</td>
<td>2</td>
<td>13</td>
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<tr>
<td>Repetitions</td>
<td>0.3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Out of category</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Plural</td>
<td>3.1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Singular</td>
<td>2.5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>False plural</td>
<td>0.2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ambiguous singular/plural</td>
<td>0.3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Acknowledged repetitions</td>
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<td>0</td>
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### TABLE C.IX
MEANS FOR 5 YEAR OLD GROUP

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</tr>
</thead>
<tbody>
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<td>6</td>
<td>28</td>
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<tr>
<td>Repetitions</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Out of category</td>
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<td>Plural</td>
<td>3.2</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Singular</td>
<td>9</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>False plural</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ambiguous singular/plural</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Acknowledged repetitions</td>
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<td>0</td>
<td>1</td>
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### TABLE C.X
**MEANS FOR 9 YEAR OLD GROUP**

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<td>Repetitions</td>
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<td>Out of category</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Plural</td>
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<td>Singular</td>
<td>13.7</td>
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<td>1</td>
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<td>Ambiguous singular/plural</td>
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### TABLE C.XI
**MEANS FOR ADULT GROUP**

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<tr>
<td>Repetitions</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Out of category</td>
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<td>0</td>
</tr>
<tr>
<td>Plural</td>
<td>5.2</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Singular</td>
<td>22</td>
<td>9</td>
<td>43</td>
</tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ambiguous singular/plural</td>
<td>1.3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledged repetitions</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TABLE C.XII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEANS FOR WS GROUP</td>
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<td></td>
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</table>

<table>
<thead>
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<th></th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number produced</td>
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<td>7</td>
<td>33</td>
</tr>
<tr>
<td>Repetitions</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Out of category</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Plural</td>
<td>8.2</td>
<td>0</td>
<td>18</td>
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<tr>
<td>Singular</td>
<td>11.1</td>
<td>0</td>
<td>29</td>
</tr>
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<td>False plural</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ambiguous singular/plural</td>
<td>1.1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledged repetitions</td>
<td>0.1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Forty different exemplars were produced by the 3 year old group. Appendix C.2.2a shows the exemplars produced in the animal category by 3 year old subjects and the number of each produced by the group. Sixty different exemplars were produced by the whole group. Appendix C.2.2b shows the exemplars produced in the animal category by 5 year old subjects and the number of each produced by the group. Seventy-four different animal exemplars were produced by the whole group. Appendix C.2.2c shows the exemplars produced in the animal category by 9 year old subjects and the number of each produced by the group. One hundred and twenty-five different animal exemplars were produced by the whole group. Appendix C.2.2d shows the exemplars produced in the animal category by adult subjects and the number of each produced by the group. Ninety-three different animal exemplars were produced by the whole group. Appendix C.2.2e shows the exemplars produced in the animal category by WS subjects and the number of each produced by the group.
COMPARISON BETWEEN GROUPS

Mean number of exemplars produced by subjects

The following figure C.XIII shows the mean number of exemplars produced by subjects in the animal category for each group.

FIGURE C.XIII
MEAN NUMBER OF EXEMPLARS PRODUCED IN ANIMAL CATEGORY PER GROUP

There is a significant difference in the mean scores per subject between the groups (1-way ANOVA, $F_{4,45}=12.9$, $p<0.0001$). Follow-up Scheffe F-tests show significant ($p<0.05$) differences between the 3 yr old group and the WS group ($F=4.7$), between the 3 yr old group and the adult group ($F=11.5$), between the 5 yr old group and the adult group ($F=1.4$), and between the 9 yr old group and the adult group ($F=3.6$). There were no other significant between-group differences. The WS group mean is higher than the 9 yr old group mean and lower than the adult group mean, but is not significantly different from either.

Total number of exemplars produced

The following figure C.XIV shows the total number of different exemplars in the animal category produced by each group.

227
The WS group total is higher than the 9 yr old group mean and lower than the adult group total. These results confirm our predictions. The WS group is comparable to mental age-equivalent normal subjects, but less than chronological age-equivalent normal subjects. There is a significant positive correlation between the mean number of exemplars per subject and the total number of exemplars produced in each group (linear regression, df=5, R=1, F=626.7, p<0.0001).

**Percentages of responses in singular and in plural forms**

The percentage of responses in singular and in plural forms, out of the total number of responses by each subject, was calculated for every subject in each group. The mean percentages per subject in each group are shown in figure C.XV following.
There is a significant difference between the groups for the percentage of responses in the singular form (1-way ANOVA, $F_{4,45}=3.1$, $p<0.05$) and for the percentage of responses in the plural form (1-way ANOVA, $F_{4,45}=3.0$, $p<0.05$). There are no significant results from Scheffe F-tests between the groups, however. The pattern of responses for the WS group for both response forms is closest to that of the 3 yr old group amongst the normal control groups.

**Other scores**

There are no other interesting and significant differences between the groups on any of the other scores.

**RATING OF RESPONSES IN ANIMAL CATEGORY**

**FREQUENCY IN NORMAL DATA**

The responses for all 4 normal control groups were pooled, and the frequency of each exemplar within this data-pool calculated. This would give a maximum score for each item of 40 (e.g. all 10 subjects in each of the 4 control groups all say *dog*, giving *dog* a score of 40). Each score was then divided by 4 to give a maximum score for each item of 10. This score is the *exemplar frequency score* for the animal category.
LIKELIHOOD RATING

Two adult subjects were asked to rate how likely they would be to say a particular animal exemplar if asked to say all the animals they could think of - as if they were following the same procedure of the experiment. The ratings were from 1 (very unlikely) to 10 (very likely). Thus *dog* might be given a rating of 10, whereas *bobtailed peewit* might be given a rating of 1.

There was a highly significant correlation between each rater's ratings for all exemplars (linear regression, $df=161$, $R=0.7$, $F=199.8$, $p<0.0001$). The ratings from both raters were averaged, giving the *exemplar likelihood rating score* for the animal category. There is a highly significant correlation between the frequency and the rating scores for each exemplar (linear regression, $df=161$, $R=0.7$, $F=140.5$, $p<0.0001$).

DIFFERENCES BETWEEN GROUP RATINGS

*Exemplar frequency score*

All responses by all subjects in all groups were scored, and the mean score for each subject was calculated. The mean of subjects' scores for each group was also calculated. These are shown in figure C.XVI below.

**FIGURE C.XVI**

MEAN EXEMPLAR FREQUENCY SCORE PER GROUP

![Bar chart showing mean exemplar frequency score per group.](image)
There is no significant difference between the subjects' means of all groups (1-way ANOVA, $F_{4,45}=2.3$, $p=0.07$). There is a significant negative correlation between the mean chronological ages for each group and the mean subject scores for each group ($df=5$, $R=1$, $F=71.2$, $p<0.005$).

In order to compare ratings between groups for individual responses by subjects, the scores for the middle 7 responses of each subject were analysed. Thus if a subject made 23 responses, responses numbered 9 - 16 were used. If a subject made an even number of responses, e.g. 24, the first possible middle 7 rather than the second possible middle 7 were used, e.g. 9 -16, rather than 10 - 17. As some of the subjects in the 3 year old group did not make as many as 7 responses, that group were excluded from analysis. There is no significant difference between the individual scores of subjects of each group (1-way ANOVA, $F_{3,276}=1.6$, $p>0.05$).

**Exemplar likelihood rating score**

All responses by all subjects in all groups were scored, and the mean score for each subject was calculated. The mean of subjects scores for each group was also calculated. These are shown in figure C.XVII below.

**FIGURE C.XVII**

**MEAN EXEMPLAR LIKELIHOOD RATING PER GROUP**

There is no significant difference between the subjects' means of all groups (1-way ANOVA, $F_{4,45}=2.0$, $p=0.11$). There is no significant correlation
between the mean ages for each group and the mean subject scores for each group (df=5, R=0.6, F=2.2, p>0.05). In order to compare ratings between groups for individual responses by subjects, the scores for the middle 7 responses of each subject were analysed. There is no significant difference between the individual scores of subjects of each group (1-way ANOVA, F3,276=1, p>0.05).

LATE-OCCURRING LOW-FREQUENCY EXEMPLARS

Rossen et al. took a cut-off point for high- and low-frequency exemplars at 10 occurrences per-million-tokens in school text books. In order to divide responses by subjects in this study into frequency categories, the occurrence of particular frequency and rating scores of all response items was calculated. Cut-off points were chosen that gave roughly 50% of responses in each of the high- and low- frequency exemplar categories.

The cut-off point for exemplar frequency score is 0.75 (3 occurrences) and below. 58.4% of exemplars fall into this low frequency exemplar category. The cut-off point for exemplar likelihood rating score is 4.00 and below. 50.9% of exemplars fall into this low frequency exemplar category. Following Rossen et al., the first seven words produced are considered as "early in the trial", and those thereafter as "late in the trial".

Exemplar frequency scores

The proportion of high- and low-frequency exemplars in the early and late stages of the trial was calculated for all subjects in the 5 year old group, the 9 year old group, the adult group, the older WS group and the younger WS group. The 3 year old group was not used, as too many subjects produced fewer than 7 responses.

Table C.XVIII following shows the mean proportion for all groups of low-frequency exemplars in early and late stages of the trial.
The difference between proportions of low-frequency exemplars in early and late stages was calculated for all groups. There is no significant difference between these differences for all groups (1-way ANOVA, $F_{2,27}=0.01, p>0.05$).

**Exemplar likelihood rating scores**

The proportion of high- and low-frequency exemplars in the early and late stages of the trial was calculated for all subjects in the 5 year old group, the 9 year old group, the adult group, the older WS group and the younger WS group. The 3 year old group was not used, as too many subjects produced fewer than 7 responses.

Table C.XIX shows the mean proportion for all groups of low-frequency exemplars in early and late stages of the trial.

**TABLE C.XIX**

**MEAN PROPORTION OF LOW-FREQUENCY EXEMPLARS IN EARLY AND LATE STAGES OF TRIAL, PER GROUP**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>EARLY STAGE %</th>
<th>LATE STAGE %</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 year old</td>
<td>11.4</td>
<td>22.3</td>
</tr>
<tr>
<td>adult</td>
<td>20.1</td>
<td>31.8</td>
</tr>
<tr>
<td>old WS</td>
<td>21.5</td>
<td>33.9</td>
</tr>
<tr>
<td>young WS</td>
<td>14.3</td>
<td>23.8</td>
</tr>
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</table>

The difference between proportions of low-frequency exemplars in early and late stages was calculated for all groups. There is no significant difference between these differences for all groups (1-way ANOVA, $F_{2,27}=0.3, p>0.05$).
For both exemplar frequency scores and exemplar likelihood rating scores, there is no difference in the proportion of low-frequency exemplars between the early stage of the trial and the late stage of the trial, for all subjects and for all groups. This is contrary to the findings of Rossen et al., who found over 20% more low-frequency exemplars in the late stage of the trial for WS subjects. The average difference between the stages for the WS group in this study is closer to 9%, and much less than all other groups.

**ANALYSIS OF CONSECUTIVE ITEMS**

The response lists produced by all subjects were next analysed as to the type of relationship between consecutive items produced. These relationship types were as follows.

**Taxonomic relationship**

If two consecutive items are in the same genus (e.g. dog and chimpanzee are mammals) then they score 1. If two consecutive items are in the same family (e.g. chimpanzee and gorilla are apes) then they score 2. If two consecutive items are in the same species (e.g. African elephant and Indian elephant are elephants) then they score 3.

**Thematic relationship**

Scores from the following two subcategories of thematic relationship were summed to give an overall thematic relationship score between consecutive items.

1. **Place encountered**

   There are four types of subcategory in this category: pets; animal found in Britain; animal not found in Britain (most likely seen in zoo by subjects); extinct animal. If two consecutive items share the same subcategory (e.g. gerbil and hamster are pets) then they score 1.
2. Natural habitat

There are three types of subcategory in this category: water; land; air. If two consecutive items share the same subcategory (e.g. bird and bat are both found in the air) then they score 1.

SCORES FOR EACH SUBJECT

The number of consecutive items that shared a taxonomic relationship for each of the values from 0 to 3 was counted for each subject. The number of consecutive items that shared a thematic relationship for each of the values from 0 to 2 was also counted for each subject.

DIFFERENCES IN TIME OF RESPONSE BETWEEN CONSECUTIVE ITEMS

The difference in time of response between consecutive items for all responses for all subjects was calculated. These time differences were transformed by calculating the natural logarithm of each (as the natural logarithm of 0 is infinity, 0 was substituted). This transformation was done in order to derive instead of the actual difference between times, a sense of whether the time between consecutive items was in a fast group, a medium group, or a slow group. The transformed time differences between items are hereafter referred to as corrected differences.

GROUP SCORES

The mean percentage of consecutive item-pairs for all subjects in the group that shared a taxonomic relationship score of each of the values of 0 to 3, that shared a thematic relationship score of each of the values of 0 to 2, that shared any taxonomic relationship and that shared any thematic relationship, is shown in table C.XX for the 3 year old group, in table C.XXI for the 5 year old group, in table C.XXII for the 9 year old group, in table C.XXIII for the adult group, and in table C.XXIV for the WS group.
### TABLE C.XX
**Scores for 3 Year Old Group**

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<th>relationship score</th>
<th>mean percentage</th>
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<td>NO RELATIONSHIP</td>
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### TABLE C.XXI
**Scores for 5 Year Old Group**

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<td>them</td>
<td>0</td>
<td>18.9</td>
</tr>
<tr>
<td>them</td>
<td>1</td>
<td>16.5</td>
</tr>
<tr>
<td>them</td>
<td>2</td>
<td>64.7</td>
</tr>
<tr>
<td>them</td>
<td>TOTAL</td>
<td>81.1</td>
</tr>
<tr>
<td>NO RELATIONSHIP</td>
<td>TOTAL</td>
<td>7.0</td>
</tr>
</tbody>
</table>

### TABLE C.XXII
**Scores for 9 Year Old Group**

<table>
<thead>
<tr>
<th>taxonomic/thematic</th>
<th>relationship score</th>
<th>mean percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>tax</td>
<td>0</td>
<td>33.7</td>
</tr>
<tr>
<td>tax</td>
<td>1</td>
<td>57.1</td>
</tr>
<tr>
<td>tax</td>
<td>2</td>
<td>9.2</td>
</tr>
<tr>
<td>tax</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>tax</td>
<td>TOTAL</td>
<td>66.3</td>
</tr>
<tr>
<td>them</td>
<td>0</td>
<td>21.4</td>
</tr>
<tr>
<td>them</td>
<td>1</td>
<td>24.3</td>
</tr>
<tr>
<td>them</td>
<td>2</td>
<td>54.2</td>
</tr>
<tr>
<td>them</td>
<td>TOTAL</td>
<td>78.6</td>
</tr>
<tr>
<td>NO RELATIONSHIP</td>
<td>TOTAL</td>
<td>11.2</td>
</tr>
</tbody>
</table>
### TABLE C.XXIII
**SCORES FOR ADULT GROUP**

<table>
<thead>
<tr>
<th>taxonomic/thematic</th>
<th>relationship score</th>
<th>mean percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>tax</td>
<td>0</td>
<td>26.6</td>
</tr>
<tr>
<td>tax</td>
<td>1</td>
<td>45.9</td>
</tr>
<tr>
<td>tax</td>
<td>2</td>
<td>24.9</td>
</tr>
<tr>
<td>tax</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>tax</td>
<td>TOTAL</td>
<td>73.3</td>
</tr>
<tr>
<td>them</td>
<td>0</td>
<td>19.5</td>
</tr>
<tr>
<td>them</td>
<td>1</td>
<td>26.5</td>
</tr>
<tr>
<td>them</td>
<td>2</td>
<td>54.1</td>
</tr>
<tr>
<td>them</td>
<td>TOTAL</td>
<td>80.5</td>
</tr>
<tr>
<td>NO RELATIONSHIP</td>
<td>TOTAL</td>
<td>8.2</td>
</tr>
</tbody>
</table>

### TABLE C.XXIV
**SCORES FOR WS GROUP**

<table>
<thead>
<tr>
<th>taxonomic/thematic</th>
<th>relationship score</th>
<th>mean percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>tax</td>
<td>0</td>
<td>33.8</td>
</tr>
<tr>
<td>tax</td>
<td>1</td>
<td>45.1</td>
</tr>
<tr>
<td>tax</td>
<td>2</td>
<td>19.5</td>
</tr>
<tr>
<td>tax</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>tax</td>
<td>TOTAL</td>
<td>66.2</td>
</tr>
<tr>
<td>them</td>
<td>0</td>
<td>22.6</td>
</tr>
<tr>
<td>them</td>
<td>1</td>
<td>28.7</td>
</tr>
<tr>
<td>them</td>
<td>2</td>
<td>48.7</td>
</tr>
<tr>
<td>them</td>
<td>TOTAL</td>
<td>77.3</td>
</tr>
<tr>
<td>NO RELATIONSHIP</td>
<td>TOTAL</td>
<td>14.2</td>
</tr>
</tbody>
</table>

**Correlation with corrected time differences: 3 year old group**

There are no significant negative correlations between the corrected time differences and any of the relationships that consecutive items share. Thus for 3 year old subjects, the more closely related an item is to the one that precedes it, whether the relation is taxonomic or thematic, makes no difference as to how fast the subject is likely to produce it after that preceding.

**Correlation with corrected time differences: 5 year old group**

There are significant negative correlations between the corrected time differences and the taxonomic relationship score the consecutive items share (linear regression, df=118, R=0.3, F=11.8, p<0.001), between the corrected time
differences and the thematic relationship score the consecutive items share (linear regression, df=118, R=0.2, F=4.8, p<0.05), but not between the corrected time differences and the taxonomic plus thematic relationship score the consecutive items share (linear regression, df=118, R=0.2, F=3.6, p>0.05). Thus for 5 year old subjects, the more closely related an item is to the one that precedes it, whether the relation is taxonomic or thematic, the faster the subject is likely to produce it after that preceding.

**Correlation with corrected time differences: 9 year old group**

There are significant negative correlations between the corrected time differences and the taxonomic relationship score the consecutive items share (linear regression, df=160, R=0.3, F=11.3, p<0.001), between the corrected time differences and the thematic relationship score the consecutive items share (linear regression, df=160, R=0.2, F=6.9, p<0.01), and between the corrected time differences and the taxonomic plus thematic relationship score the consecutive items share (linear regression, df=160, R=0.3, F=13, p<0.005). Thus for 9 year old subjects, the more closely related an item is to the one that precedes it, whether the relation is taxonomic or thematic, the faster the subject is likely to produce it after that preceding.

**Correlation with corrected time differences: adult group**

There are significant negative correlations between the corrected time differences and the taxonomic relationship score the consecutive items share (linear regression, df=275, R=0.2, F=8.3, p<0.005), between the corrected time differences and the thematic relationship score the consecutive items share (linear regression, df=275, R=0.2, F=16.1, p<0.005), and between the corrected time differences and the taxonomic plus thematic relationship score the consecutive items share (linear regression, df=275, R=0.2, F=17.9, p<0.005). Thus for adult subjects, the more closely related an item is to the one that precedes it, whether the relation is taxonomic or thematic, the faster the subject is likely to produce it after that preceding.

**Correlation with corrected time differences: WS group**

There are significant negative correlations between the corrected time differences and the taxonomic relationship score the consecutive items share
(linear regression, df=195, R=0.3, F=17.9, p<0.0001), between the corrected
time differences and the thematic relationship score the consecutive items
share (linear regression, df=195, R=0.2, F=10.5, p<0.005), and between the
corrected time differences and the taxonomic plus thematic relationship score
the consecutive items share (linear regression, df=195, R=0.3, F=20 p<0.0001).
Thus for WS subjects, the more closely related an item is to the one that
precedes it, whether the relation is taxonomic or thematic, the faster the
subject is likely to produce the item after that preceding item.

COMPARISON BETWEEN GROUPS

For each subject in all groups, the percentage of consecutive items that
shared a particular type of relationship, taxonomic (0 to 3) or thematic (0 to 2),
were calculated. For each relationship category, the percentages of responses
of subjects were entered into a 1-way ANOVA between groups. There is no
significant difference between groups for percentage of consecutive items
sharing any of the scores of taxonomic relationship (tax0: F4,45=0.3, tax1:
F4,45=0.9, tax2: F4,45=2.2, tax3: F4,45=0.5, tax total: F4,45=0.3) or for any of
the scores of thematic relationship (them0: F4,45=0.7; all p>0.05, them1:
F4,45=0.7, them2: F4,45=0.8, them total: F4,45=0.7; all p>0.05), or for the
percentage of consecutive items that share no taxonomic or thematic
relationship (F4,45=0.8, p>0.05).

SUMMARY

With the exception of the 3 year old group, every group shows a
significant correlation between the time difference between consecutive items
and the relationship, taxonomic and thematic, that those items share. In
addition, there is no significant difference between the groups for the
percentages of consecutive items showing each types of relationship, and no
significant difference between the groups for the percentage of consecutive
items showing no relationship, taxonomic or thematic.

If individuals in the WS group did indeed show different semantic
organisation, then one would expect to find differences between this group
and all other groups for all of the above. As there are no such differences,
such an hypothesis is not supported.
**ANIMAL SUBCATEGORIES**
**THEMATIC SUBCATEGORY: PET**

**Mean number of responses**

The mean number of in-animal category responses made in each group by all subjects are shown in table C.XXV and figure C.XXVI below:

**TABLE C.XXV**
**MEAN NUMBER OF IN-ANIMAL CATEGORY RESPONSES PER GROUP**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN NUMBER RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 year old</td>
<td>3.8</td>
</tr>
<tr>
<td>5 year old</td>
<td>6.8</td>
</tr>
<tr>
<td>9 year old</td>
<td>6.7</td>
</tr>
<tr>
<td>adult</td>
<td>19</td>
</tr>
<tr>
<td>older WS</td>
<td>11.7</td>
</tr>
<tr>
<td>younger WS</td>
<td>6.0</td>
</tr>
</tbody>
</table>

**FIGURE C.XXVI**
**MEAN NUMBER OF IN-ANIMAL CATEGORY RESPONSES PER GROUP**

There is a significant difference between the groups, excluding the young WS group, for the mean number of responses made by subjects (1-way ANOVA, $F_{4,45}=11.6$, $p<0.0001$). Follow-up Scheffe F-tests show a significant ($p<0.05$) difference between the 3 year old group and the adult group ($F=9.4$),
between the 5 year old group and the adult group (F=6) and between the 9 year old group and the adult group (F=6.1).

**Exemplar frequency score analysis**

The responses for all 4 normal control groups were pooled, and the frequency of each exemplar within this data-pool calculated. This would give a maximum score for each item of 40 (e.g. all 10 subjects in each of the 4 control groups all say dog, giving dog a score of 40). Each score was then divided by 4 to give a maximum score for each item of 10. This score is the exemplar frequency score for the thematic subcategory of pet. The mean exemplar frequency score of each group by all subjects are shown in table C.XXVII and figure C.XXVIII below:

**TABLE C.XXVII**
**MEAN EXEMPLAR FREQUENCY SCORE PER GROUP**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN EXEMPLAR FREQUENCY SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 year old</td>
<td>2.7</td>
</tr>
<tr>
<td>5 year old</td>
<td>2.8</td>
</tr>
<tr>
<td>9 year old</td>
<td>3.9</td>
</tr>
<tr>
<td>adult</td>
<td>2.6</td>
</tr>
<tr>
<td>older WS</td>
<td>3.3</td>
</tr>
<tr>
<td>younger WS</td>
<td>3.6</td>
</tr>
</tbody>
</table>

**FIGURE C.XXVIII**
**MEAN EXEMPLAR FREQUENCY SCORE PER GROUP**

![Bar chart showing mean exemplar frequency scores for different groups](chart.png)
The lower mean frequency score for the adult group is caused by a greater number of subordinate level items, usually generated in taxonomic clustering from each applicable basic-level exemplar. There is no significant difference between the groups, excluding the young WS group, for the mean exemplar frequency scores for all subjects (1-way ANOVA, F_{4,45}=1.2, p>0.05).

SUMMARY

For both analyses of responses in this thematic subcategory, the WS groups show pattern of responses similar to their chronological age group equivalents. Differences for both analyses between the older WS group and the CA equivalent adult group appear to be caused by the latter's ability to generate taxonomic subordinates within the thematic category.

TAXONOMIC SUBCATEGORY: REPTILE

Mean number of in-category responses, out-of-category responses and repetitions

In table C.XXIX and figures C.XXX, C.XXXI and C.XXXII, the mean number of in-category responses, out-of-category responses and repetitions made by all subjects in each group are shown:

TABLE C.XXIX
MEAN SCORES PER GROUP

<table>
<thead>
<tr>
<th>GROUP</th>
<th>IN-CATEGORY</th>
<th>OUT-OF-CATEGORY</th>
<th>REPETITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 yr old</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5 yr old</td>
<td>0.2</td>
<td>1.5</td>
<td>0</td>
</tr>
<tr>
<td>9 yr old</td>
<td>1</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td>adult</td>
<td>8.3</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>old WS</td>
<td>2</td>
<td>3.2</td>
<td>0.1</td>
</tr>
<tr>
<td>young WS</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
There is a significant difference between the groups, excluding the young WS group, for the number of in-category responses made (1-way ANOVA, $F_{4,45}=15.8$, $p<0.0001$). Follow-up Scheffe F-tests show a significant ($p<0.05$) difference between the adult group, and each of the 3 year old group ($F=11.5$), 5 year old group ($F=10.9$), 9 year old group ($F=8.9$), and older WS group ($F=6.6$). It must be remembered that none of the 3 year old subjects made any response to this category.
There is a significant difference between the groups, excluding the young WS group, for the number of out-of-category responses made (1-way ANOVA, $F_{4,45}=3$, $p<0.05$). Follow-up Scheffe F-tests show a significant ($p<0.05$) difference between the 3 year old group and the older WS group ($F=2.7$). It must be remembered that none of the 3 year old subjects made any response to this category.

**FIGURE C.XXXII - REPETITIONS**

There is no significant difference between the groups, excluding the young WS group, for the number of repetitions made (1-way ANOVA, $F_{4,45}=0.8$, $p>0.05$). It must be remembered that none of the 3 year old subjects made any response to this category.

**SUMMARY**

The older WS group made equivalently more in-category responses to the 9 year old group, and the younger WS group made equivalently more in-category responses to the 3 year old and 5 year old groups. Both are roughly equivalent to their mental age controls. Both groups made a considerably greater mean number of out-of-category responses than any of the control groups.
COLOUR CATEGORY

3 year old group

In table C.XXXIII below, the mean of the 3 year old group is shown for each of the following scores: total number of items produced by each subject; total number of items not repetitions produced by each subject; number of repetitions by each subject; number of repetitions where subject acknowledged repetition by each subject; number of out-of-category responses by each subject. In table C.XXXIV these are shown for the 9 year old group, in table C.XXXV for the adult group, in table C.XXXVI for the older WS group, and in table C.XXXVII for the younger WS group.

TABLE C.XXXIII
MEANS FOR 3 YEAR OLD GROUP

<table>
<thead>
<tr>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Total non-repetitions</td>
</tr>
<tr>
<td>Total repetitions</td>
</tr>
<tr>
<td>Total repetitions acknowledged</td>
</tr>
<tr>
<td>Out-of-category</td>
</tr>
</tbody>
</table>

TABLE C.XXXIV
MEANS FOR 9 YEAR OLD GROUP

<table>
<thead>
<tr>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Total non-repetitions</td>
</tr>
<tr>
<td>Total repetitions</td>
</tr>
<tr>
<td>Total repetitions acknowledged</td>
</tr>
<tr>
<td>Out-of-category</td>
</tr>
</tbody>
</table>

TABLE C.XXXV
MEANS FOR ADULT GROUP

<table>
<thead>
<tr>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Total non-repetitions</td>
</tr>
<tr>
<td>Total repetitions</td>
</tr>
<tr>
<td>Total repetitions acknowledged</td>
</tr>
<tr>
<td>Out-of-category</td>
</tr>
</tbody>
</table>
TABLE C.XXXVI
MEANS FOR OLDER WS GROUP

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>18.6</td>
</tr>
<tr>
<td>Total non-repetitions</td>
<td>15.6</td>
</tr>
<tr>
<td>Total repetitions</td>
<td>2.9</td>
</tr>
<tr>
<td>Total repetitions acknowledged</td>
<td>0.1</td>
</tr>
<tr>
<td>Out-of-category</td>
<td>0.3</td>
</tr>
</tbody>
</table>

TABLE C.XXXVII
MEANS FOR YOUNGER WS GROUP

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>17.8</td>
</tr>
<tr>
<td>Total non-repetitions</td>
<td>9.1</td>
</tr>
<tr>
<td>Total repetitions</td>
<td>8.7</td>
</tr>
<tr>
<td>Total repetitions acknowledged</td>
<td>0</td>
</tr>
<tr>
<td>Out-of-category</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Sixteen different exemplars were produced by the 3 year old group. Appendix C.2.2f shows the exemplars produced by the group, and the number of each produced. Twenty-nine different exemplars were produced by the 9 year old group. Appendix C.2.2g shows the exemplars produced by the group, and the number of each produced. Sixty different exemplars were produced by the adult group. Appendix C.2.2h shows the exemplars produced by the group, and the number of each produced. Fifty-nine different exemplars were produced by the older WS group. Appendix C.2.2i shows the exemplars produced by the group, and the number of each produced. Twenty-six different exemplars were produced by the younger WS group (only 3 subjects in the group). Appendix C.2.2j shows the exemplars produced by the WS group, and the number of each produced.

COMPARISON BETWEEN GROUPS

Mean total of items produced by subjects

Figure C.XXXVIII shows the mean number of items produced in the colour category by all subjects in each group:
Excluding results from the younger WS group (as there were only 3 subjects in the group), there is a significant difference between the groups for totals produced by subjects (1-way ANOVA, $F_{3,36}=5.4$, $p<0.005$). Follow up Scheffe F-tests show a significant ($p<0.05$) difference between the 3 year old group and the adult group ($F=4.7$), but between no other groups.

**TOTAL NUMBER OF EXEMPLARS PRODUCED**

Figure C.XXXIX shows the total number of different exemplars produced by all groups, excluding the younger WS group:
There is a significant correlation between the mean age of the groups and the total number of different exemplars produced by each group (linear regression, df=1, R=1, F=1288.5, p<0.001).

**MEAN NUMBER OF REPETITIONS (TOTAL)**

The mean total number of repetitions for all groups, summing non-acknowledged and acknowledged (where the subject recognises that they have said that exemplar previously), is shown in figure C.XL below:

**FIGURE C.XL**

**MEAN NUMBER OF REPETITIONS PER GROUP**

Excluding the younger WS group (as there were only 3 subjects in the group), there is no significant difference between the groups for the number of repetitions made by subjects (1-way ANOVA, F3,36=0.7, p>0.05).

**MEAN NUMBER OF OUT-OF-CATEGORY RESPONSES**

The mean number of out-of-category responses made by subjects in all groups is shown in figure C.XLI following:
Excluding the younger WS group (as there were only 3 subjects in the group), there is no significant difference between the groups for the number of out-of-category responses made by subjects (1-way ANOVA, F3,36=1.0, p>0.05).

**SUMMARY**

The older WS group shows a pattern similar to that expected for their chronological age, equivalent to the adult control group, for all the above analyses of results. The younger WS group show a pattern similar to that expected for their chronological age, equivalent to the 9 year old control group, for the mean total of items produced, but show a much higher number of repetitions and of out-of-category responses than any of the other groups.

**FREQUENCY OF EXEMPLARS IN NORMAL GROUPS**

The responses for all 3 normal control groups were pooled, and the frequency of each exemplar within this data-pool calculated. This would give a maximum score for each item of 30, excluding repetitions (e.g. all 30 subjects in each of the 3 control groups all say red, giving red a score of 30). Each score was then divided by 3 to give a maximum score for each item of 10, excluding repetitions. This score is the exemplar frequency score for the colour category.
Those exemplars with an exemplar frequency score greater than 1 (i.e. more than 3 mentions by all control subjects pooled) are listed in table C.XLII following.

**TABLE C.XLII**
**HIGH FREQUENCY SCORING EXEMPLARS**

<table>
<thead>
<tr>
<th>EXEMPLAR</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>red</td>
<td>13.67</td>
</tr>
<tr>
<td>yellow</td>
<td>12.67</td>
</tr>
<tr>
<td>blue</td>
<td>12.33</td>
</tr>
<tr>
<td>green</td>
<td>11</td>
</tr>
<tr>
<td>black</td>
<td>10.67</td>
</tr>
<tr>
<td>purple</td>
<td>10.67</td>
</tr>
<tr>
<td>orange</td>
<td>10</td>
</tr>
<tr>
<td>white</td>
<td>8.67</td>
</tr>
<tr>
<td>brown</td>
<td>8</td>
</tr>
<tr>
<td>pink</td>
<td>8</td>
</tr>
<tr>
<td>gold</td>
<td>4.33</td>
</tr>
<tr>
<td>grey</td>
<td>4.33</td>
</tr>
<tr>
<td>silver</td>
<td>4.33</td>
</tr>
<tr>
<td>turquoise</td>
<td>3</td>
</tr>
<tr>
<td>violet</td>
<td>2.33</td>
</tr>
<tr>
<td>indigo</td>
<td>2.33</td>
</tr>
<tr>
<td>mauve</td>
<td>2.33</td>
</tr>
<tr>
<td>bronze</td>
<td>1.67</td>
</tr>
<tr>
<td>ochre</td>
<td>1.67</td>
</tr>
<tr>
<td>dark blue</td>
<td>1.33</td>
</tr>
<tr>
<td>beige</td>
<td>1.33</td>
</tr>
</tbody>
</table>

It should be noted that most of these exemplars are primary, basic-level colours, such as **red** or **blue**. Those exemplars with a frequency score less than 1 were all either secondary colours, such as **burgundy** or **crimson**, or compound colours, such as **light blue** or **dark yellow**.

**DIFFERENCES BETWEEN GROUP RATINGS**

**Exemplar frequency score**

All responses by all subjects in all groups were scored, and the mean score for each subject was calculated. The mean of subjects' scores for each group was also calculated. These are shown in figure C.XLIII following.
There is a significant difference between the groups for the subjects' mean item rating, excluding the younger WS group (1-way ANOVA, \(F_{3,36}=12.8, p<0.0001\)). There is a significant negative correlation between the mean chronological ages for all groups, including the young WS group, and the mean subject scores for each group (df=1, R=1, F=31.8, p<0.05).

**Unrated Responses Made by Older WS Subjects**

Table C.XLIV following shows the responses made by WS subjects that were not made by any of the control subjects. Out of these, 3 are out-of-category responses, 1 is a combination of 2 colours, 10 are secondary colours, 7 are compound colours made by adding any prefixes of *dark*, *light*, *bright* and *clear* to basic-level colours (not all of these, e.g. *clear white*, are typical colour names), and 5 are simply those prefixes or expressions of the compound-prefix rule. There appears to be more of a tendency for WS subjects to produce colour names by extension of a compound-prefix rule.
TABLE C.XLIV
RESPONSES PECULIAR TO WS GROUP

<table>
<thead>
<tr>
<th>Biscuit box</th>
<th>Black and green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackcurrant</td>
<td>Both blacks</td>
</tr>
<tr>
<td>Bright orange</td>
<td>Bright red</td>
</tr>
<tr>
<td>Bright yellow</td>
<td>Burgundy</td>
</tr>
<tr>
<td>Clear white</td>
<td>Coloured paper</td>
</tr>
<tr>
<td>Coloured pens</td>
<td>Dark</td>
</tr>
<tr>
<td>Dark brown</td>
<td>Dark red</td>
</tr>
<tr>
<td>Darkish</td>
<td>Light</td>
</tr>
<tr>
<td>Light and dark</td>
<td>Light brown</td>
</tr>
<tr>
<td>Light pink</td>
<td>Multicolour</td>
</tr>
<tr>
<td>Mushy pea green</td>
<td>Pastel green</td>
</tr>
<tr>
<td>Royal blue</td>
<td>Sapphire</td>
</tr>
<tr>
<td>Sapphire grey</td>
<td>Strawberry</td>
</tr>
<tr>
<td>Terracotta red</td>
<td>Think of a light colour</td>
</tr>
<tr>
<td>Tropical</td>
<td>Velvet</td>
</tr>
</tbody>
</table>

DISCUSSION

In both animal and colour categories, for the mean number of in-category responses produced, the mean number of out-of-category responses, and the total number of exemplars produced, both older and younger WS groups show a pattern close to that expected for their chronological age. In the pet (thematic) subcategory, but not the reptile (taxonomic) subcategory, this pattern was also shown. Instead, in the reptile subcategory, a pattern closer to that of mental age equivalents is shown. This is probably because of a lack of conceptual understanding (Johnson, Carey & Levine, 1994) as to what makes an animal a reptile; subjects asked afterwards as to this ranged in their explanations from "they eat meat" to "they live in water".

The mean number of repetitions was greater for the WS groups, particularly in the colour category where there are fewer basic-level items to select than in the animal category, where there are more basic-level exemplars than any one person could possibly know. A greater number of repetitions could, as Rossen et al. suggest, be caused by reduced inhibitory dynamics affecting lexical choice. This would also imply, however, that a greater number of intrusions, out-of-category exemplars would be produced - which is not found.

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All the same, these findings so far concur more with those of Rossen et al. who found a response pattern consistent with chronological age controls in WS subjects aged around 13 years, than with those of Scott et al., who found a response pattern consistent with mental age controls in WS subjects aged around 9 years.

The most striking difference between this study and that of Rossen et al. is that no propensity for low-frequency exemplars is found in WS subjects, compared to controls. This is true whether low-frequency is judged on the frequency of occurrence of exemplars in normal data, or on ratings of goodness of example by adults. In particular, Rossen et al. found a greater proportion of low-frequency exemplars in the late stage of a trial, compared to the early stage of the same. This finding was not replicated.

In fact, for the categories of animal and colour, and the subcategory of pet, mean frequency ratings of exemplars were found to significantly decrease with increasing chronological age for all groups, including both WS groups.

Low-frequency exemplars, as Rossen et al. indicate, tend to be subordinate-level (or hyperspecific) items. These are most often produced by all subjects as the result of taxonomic clustering, drawing on a relationship with immediately preceding items of the exemplar produced. Subjects in all groups show a similar propensity to draw on taxonomic or thematic relationships between items to generate further items, as there are no significant differences between groups for the strength of both taxonomic or thematic relationships of an item with the immediately preceding item. The adult group does show a greater proportion of high-strength taxonomic relationships between consecutive items, which would demonstrate a greater ability to taxonomically cluster; this difference with other groups is not significant, however.

For all groups, except the 3 year old group, there is a significant correlation between the corrected time difference between consecutive items and the strength of both taxonomic and thematic relationships between those items. The more closely related an item is to that immediately preceding, the faster a subject is likely to generate it. This reflects a similar excitatory dynamics in lexical choice for all groups. The non-significant correlation for
the 3 year old group is probably caused by the smaller number of items produced.

It is not true that all low-frequency or unusual items generated by WS subjects appear to be generated by taxonomic or thematic clustering. That is also not true of subjects in all the normal groups too. Such clustering can, however, sometimes produce low-frequency exemplars - this is a sample sequence produced in the late stage of a trial by one WS subject: sea urchin, spider, daddy-long-legs, locust, bee, wasp, hornet, blue-bottle, fly, dragon-fly. The first 3 items in this sequence are related by appearance, then the subject generates from the insect subcategory.

Contrast this with the standard quote as to the typical response of a WS subject on this very same task: unicorn, pteranodon, yak, ibex, water buffalo, sea lion, saber-tooth tiger, vulture, koala, dragon. It is not clear as to whether these items were produced in sequence, but even so, this is a list of far more unusual items than seen produced by any WS subjects in the present study. Certainly, there is variation between WS subjects’ performances tested here, but this does not seem sufficient to explain the great difference between the very unusual exemplars reported by other researchers, and those generated by subjects in the present study.

One possible partial explanation follows from the fact that most previous studies that cite such unusual examples have been based on work by Bellugi, whose lab is in La Jolla just outside San Diego. Any WS subject brought to the lab from out of San Diego will probably stay for a couple of days due to the distances, and almost certainly be taken to the Zoo which is a prize attraction of San Diego. This very exciting experience may bias WS subjects to concentrate more on the kinds of unusual and novel animals that this Zoo contains (the CDU cannot really compete, London Zoo being what it is!)

It is also not found that if you "ask a normal child to name some animals, and you will get the standard inventory of pet store and barnyard: dog, cat, horse, cow, pig" (Pinker, 1994). Compare this sequence from the late stage of a trial by a normal 9 year old subject: mole, wombat, turtle, octopus, owl, bird, whale, fish, jellyfish. There is no "interesting menagerie" (Pinker, 1994) to
be found in the minds of WS subjects that cannot be found in the mind of any normal child.

Finally, WS subjects tend to produce in the animal category more responses in the plural form than any normal group except the 3 year old group. This is in response to the implicit cue that is given in the experimenter's instructions to subject: "Can you tell me all the animals you can think of?". The best explanation for this is that the WS subjects are probably concentrating on the extension rather than the intension of a concept, as do young normal children (Karmiloff-Smith, 1979). The intension is the generic root of a concept (e.g. the kangaroo) whereas the extension is an elaborated form of the same (e.g. all the kangaroos). The experimenter cues an extensive plural response in the request "...can you tell me all the animals you can think of". No extensions are found in the responses of WS subjects in the colour category; unless one is a painter ordering for example "all the reds", such an extension never exists for colours. They are only heard in the intensive form.

An overextension of a particular form is found in WS subjects' productions in the colour category. WS subjects produce as many compound prefix colour exemplars, such as dark red, as do normal adults. Occasionally, they will overextend this (but not significantly) to produce nonce compound colours, such as clear white. As discussed in section C.1, overextension of prefix or suffix addition to roots is one of the most typical ways in which WS subjects will occasionally produce nonce words in spontaneous speech. In the next section C.2.3., a free word-association task is used in an attempt to elicit further such nonce compounds from WS subjects.
### APPENDIX C.2.2a
Exemplars produced by 3 year old group in animal category, and frequency of group production

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### C.2.2b
Exemplars produced by 5 year old group in animal category, and frequency of group production

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puppy  1  
rat     1  
reindeer 1  
rhinoceros 1  
sea dragon 1  
shark  1  
sheep   4  
snail   1  
snake   1  
tadpole 2  
tiger  5  
tiger cat 1  
tiger dog 1  
tortoise 3  
turtle  1  
whale   2  
zebra   2  

fly     1  
fox     2  
giraffe 1  
goat    2  
gorilla 1  
hamster 1  
hedgehog 1  
hippopotamus 1  
horse   6  
jaguar  1  
jellyfish 2  
kangaroo 2  
kitten  1  
koala   2  
leopard 1  
lion    7  
lobster 1  
mole    3  
monkey  4  
mouse   5  
octopus 2  
owl     2  
panther 1  
penguin 1  
pig     5  
pigeon  1  
polar bear 1  
pony    2  
puppy  1  
rabbit  4  
rat     2  
rhinocerous 2  
seahorse 1  
seal    3  
shark   2  
sheep   2  
snake   3  
snake  1  
spider  1  
squirrel 1  
snorke  1  
tortoise 2  
turtle  2  
wallaby 1  
whale   2  
wolf    1  
wombat  1  
worm    1  
zebra   2  

C.2.2c  
Exemplars produced by 9 year old group in animal category, and frequency of group production

animal exemplar | number  
ant         | 3  
bear        | 3  
beaver      | 1  
bee         | 1  
beetle      | 2  
bird        | 4  
budgie      | 1  
butterfly   | 1  
camel       | 1  
cat         | 6  
ceehah      | 1  
chicken     | 1  
chimpanzee  | 1  
cow         | 5  
crab        | 1  
crocodile   | 2  
deer        | 1  
dog         | 7  
dolphin     | 2  
donkey      | 3  
dragon      | 2  
dragonfly   | 1  
eagle       | 1  
elephant    | 5  
fish        | 2  

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C.2.2d

**Exemplars produced by adult group in animal category, and frequency of group production**

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C.2.e

**Exemplars produced by WS group in animal category, and frequency of group production**

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C.2.2g

**Exemplars produced by 9 year old group in colour category, and frequency of group production**

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C.2.2f

**Exemplars produced by 3 year old group in colour category, and frequency of group production**

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shades of those 1
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peach 1
ecrur 1
pale blue 1
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C.2.2i
Exemplars produced by older WS group in colour category, and frequency of group production

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Exemplars produced by younger WS group in colour category, and frequency of group production

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C.2.3 WORD-ASSOCIATION

INTRODUCTION

This study uses a free word association task to measure off-line the type, (taxonomic or thematic), and strength of links between lexical representations of items in WS subjects compared to other groups. It is a further off-line task that can give indications of the semantic organisation of the lexicon of WS subjects, if responses are compared to normal control groups.

As pilot studies demonstrated that young normal subjects have difficulty with this task, the youngest control group used was of 9 year old children, roughly equivalent to the maximum mental age of the WS subjects tested. In addition, normal adult controls of approximately the same mean chronological age as the WS group were tested.

This task also offers a way of eliciting nonce word comprehension and production, that proved too difficult to elicit in WS subjects with more direct, explicit, off-line tasks in pilot studies. If a nonce item is included at the end of a list of conventional words for which an associative response is requested, then a subject will be more likely to produce some kind of response. The implicit understanding is that if the experimenter regards it as a conventional word, then so will the subject.

Nonce words of 2 kinds were included, together with controls. The first kind were formed by adding the un-prefix to roots that do not normally accept this prefix, such as unbreak, actually produced in spontaneous speech by one of the WS subjects in an earlier experimental session. Similar compounds have been reported to be produced by some young normals (Bowerman, 1981). The control for this kind is an un-compound word, such as uncouple, that is conventional and roughly antonymous in meaning to the test item.

The second kind of nonce was formed by taking two control words, such as bothersome and nuisance, and swapping the suffixes to produce two test items nuisome and botherance (again, actually produced in spontaneous speech by one of the WS subjects in an earlier experimental session).
As well as recording the nonce type responses that WS subjects give in response to these, it is important to measure whether they give more No Responses to these nonce items than to control items. Were this the case, it would indicate that they were 'aware', consciously or unconsciously, that these are not conventional words.

Homonyms were included also as a test item. These are words with multiple senses e.g. *star* can refer to *Alpha Centauri* or *Michael Jackson*, Each was included twice in the task, in a separate half of the same session.

Rossen et al. (1994) performed a free-association task with 22 homonyms, with WS subjects, DS subjects and matched MA controls. All subjects showed a strong bias for primary word meaning above any other meanings, and there was no significant difference between groups for this. One would expect WS subjects in this study to be similarly able.

All responses are coded as to their taxonomic or thematic relationship to the stimulus item. Any bias towards taxonomic or thematic can reveal the access to and/or structure of the underlying lexical representation. Subjects will not necessarily be aware of the kind of relationship between their response and the stimulus item, and so the task is considered partly on-line. Remaining stimulus item types were chosen so as to give a likely spread of responses that were both taxonomically and thematically related to the stimulus.

Within each group, the most consistent response to each stimulus item will be noted, and the frequency of its response calculated. A high frequency of consistent response in any group would imply that most subjects in that group made that same response. A high frequency of consistent response could imply either fewer links between lexical units (not enough other items that could be potential responses), or a stronger link developed between units for target item and response - a more developed lexicon. A low frequency of consistent responses could imply either overrepresented links between items in the lexicon (too many potential other responses) or weaker links developed between representations of item and response. These differences can reflect either lexical organisation or access dynamics.
One would expect the adult group to show higher frequency of consistent response scores than the 9 year old group, from a more developed lexicon. The WS group may be likely to have a lower frequency of consistent response.

**METHOD**

**DESIGN**

Nine groups of 12 items were used, making 108 in total. The first test group was of words with multiple common senses. This group was repeated twice in the test, with the second occurrence of each being in the second half of the test. The second test group was of nonce words. Half of these were formed by taking two words and swapping their suffixes, e.g. *bothersome* and *nuisance* become *botherance* and *nuisome*. The controls for these were the original words with correct suffixes. The other half of the test group were formed by adding the prefix *un-* to words that do not take that prefix to become negative, e.g. *unopen*. The controls for these were opposite in meaning to their test counterparts, all with the *un-* prefix, e.g. *unlock*.

The remaining 5 groups were control fillers. The first group was of words, e.g. *rolling* with a common continuation in an associative phrase, e.g. *stone*. The complementary group for this test group was of words semantically close in meaning to the test words, e.g. *sliding*, without such a common associative continuation. The next group and its complement was of word-pairs that are associated together in a common phrase, e.g. *salt* and *pepper*. The last group was of words relating to emotions or social situations.

The order of presentation of items within each test was counterbalanced across item-groups. Presentation direction of items was counterbalanced across subjects in all groups.

Over all items, the most common response to each item in each group was marked, and the frequency of that response calculated. It was hypothesised that the WS group would show a response pattern more similar to the 9 year old group than to the adult group, which would show stronger agreement (higher frequency of most common response within-group) for responses to items than the other groups.
Over all items, the responses to all items were coded for each subject according to the type of relationship between stimulus item and response item. The categories of relationship were as follows: taxonomic; thematic; synonymous; antonymous; continuation in phrase; rhyme or other phonological type; subjective emotional description of item; other uncategorisable; missing. Examples of these relationships between response and stimulus are given in the results section. It was hypothesised that the WS group would show a response pattern more similar to the 9 year old group than to the adult group.

For the first test group, of words with multiple senses, it was hypothesised, following Bellugi, that the WS group would show in their responses less of a bias to one sense than would the other two groups. For the second test group, of nonces and their controls, it was hypothesised that the WS group would give more nonce-type responses than would the control groups. It was hypothesised that the WS group would give fewer no responses to these items than would the control groups, demonstrating that they are less 'aware' that these are nonce items. The items used are listed in Appendix C.2.3a.

SUBJECTS

Two normal control groups were used. The first was the 9 year old group, 10 children of mean age 9;8 (range from 9;2 to 9;11). The second was the adult group, 10 adults of mean age 20;2 (range from 19;0 to 27;0). There were 5 males and 5 females in each of the normal control groups.

The experimental group was 10 WS subjects, of mean age 20;9 (range from 9;0 to 31;5). There were 5 males and 5 females in the group.

PROCEDURE

Experimenter and subject sat at a table. The experimenter told the subject "I'm going to say a word, and I want you to say the first thing you think of when I say that word, whatever it might be." In all cases, the subject understood the instructions. The experimenter then said each stimulus item in turn, and noted down the first thing that subject said in response.
In addition, subjects in the adult normal control group were reassured that the test was not a psychoanalytic-type word-association test, as some subjects in a pilot word-association task were concerned about what a word-association might 'reveal' about them.

RESULTS

GROUP RESPONSES

The responses of individuals in each group to each item were collated. The most frequent response by individuals in each group was taken, ignoring no responses, and the number of individuals that gave that response totalled. This gives for each item a measure of the strength of associative link between the item and the most frequent response, in each of the 3 groups. The range of this score is from 1 (10 individuals give 10 different responses) to 10 (10 individuals give 1 same response). The mean associative link strength over all items for the 3 groups is shown in figure C.XLV below.

FIGURE C.XLV
MEAN ASSOCIATIVE LINK STRENGTH PER GROUP

The mean score for the adult group is greater than that for the 9 year old group, in turn greater than that for the WS group. There is a significant difference between the mean associative link strengths over all items for the 3 groups (1-way ANOVA, $F_{2,321}=9.5$, $p<0.0001$). Scheffe F-tests show that there is a significant ($p<0.05$) difference between the score for the adult group and the 9 year old group ($F=4.5$) and between the adult group and the WS group.
(F=9) but no significant difference between the WS group and the 9 year old group (F=0.8).

The adult group therefore shows more consistency in its responses as a group to the items than do the 9 year old group and the WS group. There appears to be a stronger association to one particular response for each item for the adult group than exists for the other 2 groups. This is as hypothesised. There is no difference between the 9 year old group and the WS group.

INDIVIDUAL RESPONSES

Coding of responses:

The responses of each individual to each item were coded into one of 8 categories. These are as follows, with the mean number of such responses for each individual in each of the two control groups and the experimental group shown in the figures.

Taxonomic only responses

A taxonomic only response is where the response item is in the same taxonomic category as the stimulus item, but is not synonymous or antonymous to it. For example, to the stimulus tea the response could be coffee. The mean number of such responses in each of the three groups is shown in figure C.XLVI below.

FIGURE C.XLVI
MEAN NUMBER OF TAXONOMIC ONLY RESPONSES
The mean number of taxonomic responses is roughly the same for the 3 groups. There is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=0$, $p>0.05$).

**Thematic only responses**

A *thematic only* response is where the response item could be in the same functional situation as the stimulus item, but is not a continuation common to a familiar phrase. For example, to the stimulus *tea* the response could be *toast*. The mean number of such responses in each of the three groups is shown in figure C.XLVII below.

**FIGURE C.XLVII**
**MEAN NUMBER OF THEMATIC ONLY RESPONSES**

The mean number of thematic responses is roughly the same for all 3 groups. There is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=0.1$, $p>0.05$).

**Synonymous responses**

A *synonymous* response is where the response item shares one of the same references as the stimulus item. For example, to the stimulus *come*, the response could be *arrive*. The mean number of such responses in each of the three groups is shown in figure C.XLVIII following.

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37 It may seem archaic, or quaint, to associate tea and toast together, but I can assure the reader that for the author and, it seems, a very good many of the subjects tested, this is quite a natural association to make.
The mean number of responses for the adult group is greater than those for the 9 year old and WS groups. There is a significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=10.2$, $p<0.0005$). Follow-up Scheffe F-tests show significant differences between the responses for the adult group and the other two groups (adult vs 9 year old, $F=8.1$; adult vs WS, $F=7.1$; 9 year old vs WS, $F=0$).

**Antonymous responses**

An antonymous response is where the response item shares one of the opposite references as the stimulus item. For example, to the stimulus *come* the response could be *go*. The mean number of such responses in each of the three groups is shown in figure C.II below.
The mean number of responses for the 9 year old group is greater than those for the other 2 groups, which are similar. However, this difference is not significant (1-way Unrelated ANOVA, $F_{2,27}=1.5$, $p>0.05$).

Continuation responses

A *continuation* response is where the response item can follow the stimulus item in a common phrase or expression. For example, to the stimulus *come* the response could be *here*. The mean number of such responses in each of the three groups is shown in figure C.1 following.
FIGURE C.L
MEAN NUMBER OF CONTINUATION RESPONSES

The mean number of responses for the adult group is greater than that for the WS group, in turn greater than that for the 9 year old group, but there is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, F_{2,27}=2.9, p<0.10).

**Rhyme responses**

A *rhyme* response is where the response item either rhymes with the stimulus item, or has a similar phonological structure, without falling into any of the previous categories. For example, to the stimulus *tea* the response could be *bee*. The mean number of such responses in each of the three groups is shown in figure C.LI following.
The mean number of responses for the 9 year old group is roughly the same as that for the WS group; both are greater than the adult group. There is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, \( F_{2,27} = 0.9, p > 0.05 \)).

**Other responses**

An *other* response is where the response item is not obviously related either semantically or phonologically to the stimulus item. For example, to the stimulus *tea* the response could be *Catch-22*. The mean number of such responses in each of the three groups is shown in figure C.LII below.
The mean number of responses for the 9 year old group is greater than that for the WS group, in turn greater than that for the adult group. There is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=1.8$, $p>0.05$).

**Missing responses**

A *missing* response is where no response is given to the stimulus item. The mean number of such responses in each of the three groups is shown in figure C.LIII below.

**FIGURE C.LIII**

**MEAN NUMBER OF MISSING RESPONSES**

The mean number of responses for the WS group is greater than that for the 9 year old group, in turn greater than that for the adult group. There is a significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=3.8$, $p<0.05$). Follow-up Scheffe F-tests show a significant difference between the WS group and the adult group only (Scheffe $F=3.8$).

**Nonce responses**

A *nonce* response is where the response item is a novel and unconventional word. For example, to the stimulus *tea* the response could be *untea*. The mean number of such responses in each of the three groups is shown in figure C.LIV following.
The mean number of responses for the WS group is roughly similar to that of the 9 year old group; both are greater than the adult group. There is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=1.8$, $p>0.05$).

**Subjective emotional descriptive responses**

A *subjective emotional descriptive* response is where the response item is an emotional response of the subject to the stimulus item. For example, to the stimulus *tea* the response could be *yuck*. The mean number of such responses in each of the three groups is shown in figure C.LV following.
The mean number of such responses for the WS group is greater than both the adult and the 9 year old groups. There is no significant difference between the mean responses for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=0$, $p<0.10$).

**Taxonomic total**

[Taxonomic only + Synonymous + Antonymous]

The taxonomic total is the sum of the taxonomic only, synonymous and antonymous response categories, as for all the response item will be taxonomically related to the stimulus item. The mean number of such responses for each of the 3 groups is shown in figure C.LVI following.
FIGURE C.LVI
MEAN TAXONOMIC TOTAL RESPONSES

The mean total for the adult group is greater than that of the 9 year old group, in turn greater than that of the WS group. There is no significant difference between the mean totals for the 3 groups (1-way Unrelated ANOVA, F_{2,27}=1.2, p>0.05).

Thematic total
[Thematic only + Continuation]

The thematic total is the sum of the thematic only, and continuation response categories, as for all the response item will be thematically related to the stimulus item. The mean number of such responses for each of the 3 groups is shown in figure C.LVII following.
The mean total for the adult group is greater than that of the WS group, in turn greater than that of the 9 year old group. There is no significant difference between the mean totals for the 3 groups (1-way Unrelated ANOVA, F2,27=1.4, p>0.05).

**Non-related total**

[Other + Missing]

The *non-related total* is the sum of the other and missing response categories, as for all the response item will not be related to the stimulus item. The mean number of such responses for each of the 3 groups is shown in figure C.LVIII following.
The mean total for the WS group is roughly similar to that of the 9 year old group; both are greater than that for the adult group. There is a significant difference between the mean totals for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=4.7$, $p<0.05$). Follow-up Scheffe F-tests show significant differences between the totals for each of the 9 year old and WS groups with the adult group (Scheffe $F=3.4$; Scheffe $F=3.6$).

**Taxonomic / Thematic difference**

[**Taxonomic total - Thematic total**]

The *Taxonomic / Thematic difference* is the difference between the taxonomic total and thematic total for each subject. The mean difference for the subjects in each of the 3 groups is shown in figure C.LIX following.
The mean total for the 9 year old group is greater than that of the adult group, in turn greater than that of the WS group. There is no significant difference between the mean totals for the 3 groups (1-way Unrelated ANOVA, $F_{2,27}=1.2$, $p>0.05$).

**WS GROUP**

*Comparison of scores with other test results*

**Age**

There is a significant negative correlation between age of subject and number of *other* type responses (linear regression, $R=0.7$, $F=6.4$, $p<0.05$). The older the subject, the more likely they are to be able to produce a response. There is a non-significant positive correlation trend between age and number of *taxonomic* type responses (linear regression, $R=0.6$, $F=4.7$, $p=0.06$) with more such produced with age, and a non-significant negative correlation trend between age and number of *rhyme* type responses (linear regression, $R=0.6$, $F=4.9$, $p=0.06$).

**verbal IQ**

There is a significant positive correlation between vIQ of subject and number of *taxonomic* type responses (linear regression, $R=0.7$, $F=6.2$, $p<0.05$). There is a significant positive correlation between vIQ of subject and number...
of thematic only type responses (linear regression, $R=0.7$, $F=8$, $p<0.05$). There is a significant negative correlation between vIQ of subject and number of emotional descriptive type responses (linear regression, $R=0.7$, $F=6.8$, $p<0.05$).

There is a non-significant positive correlation trend between vIQ and number of nonce type responses (linear regression, $R=0.6$, $F=4.8$, $p=0.06$), and a non-significant negative correlation trend between age and number of non-type responses (linear regression, $R=0.6$, $F=4.5$, $p=0.07$).

**Performance IQ**

There is a significant positive correlation between pIQ of subject and number of taxonomic only type responses (linear regression, $R=0.8$, $F=13.3$, $p<0.01$). There is a significant positive correlation between pIQ of subject and number of synonymous type responses (linear regression, $R=0.6$, $F=5.6$, $p<0.05$). There is a significant negative correlation between pIQ of subject and number of other type responses (linear regression, $R=0.8$, $F=17.2$, $p<0.005$). There is a significant positive correlation between pIQ of subject and number of taxonomic type responses (linear regression, $R=0.9$, $F=51.1$, $p<0.0001$).

**BPVS Test Age (TA)**

There is a significant positive correlation between BPVS TA of subject and number of synonymous type responses (linear regression, $R=0.8$, $F=17.7$, $p<0.05$). There is a significant negative correlation between BPVS TA of subject and number of other type responses (linear regression, $R=0.8$, $F=17$, $p<0.05$). There is a significant positive correlation between BPVS TA of subject and number of taxonomic only type responses (linear regression, $R=0.8$, $F=10.8$, $p<0.05$).

**TROG Test Age (TA)**

There is a significant positive correlation between TROG TA of subject and number of antonymous type responses (linear regression, $R=0.8$, $F=9.7$, $p<0.05$). This may appear surprising, but is probably based on the fact that a good number of the antonymous responses involve adding a negative prefix to the stimulus item. This taps morphological ability, which is measured by the TROG.
There is a non-significant positive correlation trend between TROG TA of subject and number of *taxonomic only* type responses (linear regression, R=0.7, F=5.5, p=0.05).

**Number of taxonomic responses in word condition in taxonomic shift experiment of B.3.5 ("word condition score" or WCS)**

There is a significant negative correlation between WCS of the subject and the number of *thematic* type responses (linear regression, R=0.7, F=7.7, p<0.05). There is a significant correlation between WCS of the subject and the number of *antonymous* type responses (linear regression, R=0.6, F=5.8, p<0.05).

**Difference in priming between f1 (categorical/taxonomic) and f2 (functional/thematic) conditions in word monitoring task (f1-f2 pri)**

There is a significant positive correlation between f1-f2 pri of subject and number of *antonymous* type responses (linear regression, R=0.9, F=30.2, p<0.005). There is a significant positive correlation between f1-f2 pri of subject and number of *taxonomic* type responses (linear regression, R=0.9, F=18.6, p<0.01). There is a significant negative correlation between f1-f2 pri of subject and number of *thematic* type responses (linear regression, R=0.8, F=7.2, p<0.05). There is a significant positive correlation between f1-f2 pri of subject and number of *taxonomic* type responses minus number of *thematic* type responses (linear regression, R=0.9, F=13.3, p<0.05).

Given that the f1-f2 pri difference measures the bias towards stronger taxonomic (categorical) links than thematic (functional) links in the lexical representations, the above correlations are to be expected.

**TAXONOMIC VS THEMATIC DIFFERENCE AND TAXONOMIC BIAS**

All ten WS subjects in this study completed the taxonomic bias study described in section B.3.5. If the taxonomic bias mechanism, which helps constrain the meaning of new words, is helping shape the semantic organisation in WS subjects, then one can hypothesise a significant correlation between the taxonomic bias of each subject and the taxonomic - thematic difference in this word-association study. There is in fact a real trend,
although non-significant, between the two (linear regression, N=10, R=0.5, 
F_{1,8}=3.2, p=0.11). This is suggestive, but no more so, that the taxonomic bias 
may be helping shape the semantic organisation (taxonomic vs thematic) of 
WS subjects.

STIMULUS ITEMS BY CATEGORY

Multiple senses

These stimulus items have more than one common lexical sense or 
meaning. For example, *star* can be either a heavenly body or a pop singer. 
These items were given as stimuli twice each to subjects in all groups. The 
number of times that a subject responded to a different sense for the second 
stimulus than that for the first stimulus was recorded for each item. The 
number of subjects (out of 10) in each group that produced responses relating 
to 2 lexical senses of the stimulus item over the 2 trials was summed per item 
and is shown in figure C.LX following.

FIGURE C.LX

NUMBER OF SUBJECTS GIVING MULTIPLE SENSE RESPONSES

The mean number of subjects over all items responding to different 
lexical senses of the stimulus item was calculated and is shown in figure 
C.LXI following.
The adult group mean is greater than both the 9 year old group and WS group means, which are roughly the same. There is a significant difference between the means for all groups (1-way unrelated ANOVA, $F_{2,33}=4.1$, $p<0.05$). Scheffe F-tests show a significant ($p<0.05$) difference between the adult group and the 9 year old group ($F=2.9$) and between the adult group and the WS group ($F=3.5$), but not between the 9 year old group and the WS group ($F=0.1$). The adult group is therefore more likely to respond to different lexical senses of a word than either the 9 year old group or the WS group, which are more strongly tied to one of the senses.

**NONCE WORDS**

The nonce word items and their controls are divided into 2 categories: those with an un- prefix; nonces formed by swapping suffixes of two control words.

**Un- prefix nonces and controls**

The responses to un- prefix nonces and their controls were coded according to the following table, using *unfalse* as an example:
TABLE C.LXII
CODING OF RESPONSES USING UNFALSE AS EXAMPLE

<table>
<thead>
<tr>
<th>CODING NO</th>
<th>CODING CATEGORY</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>rhyme with item</td>
<td>waltz</td>
</tr>
<tr>
<td>2</td>
<td>un- prefix + unrelated root</td>
<td>unhappy</td>
</tr>
<tr>
<td>3</td>
<td>un- prefix + antonymous root</td>
<td>untrue</td>
</tr>
<tr>
<td>4</td>
<td>un- prefix + synonymous root</td>
<td>unforged</td>
</tr>
<tr>
<td>5</td>
<td>unprefixed antonym</td>
<td>wrong</td>
</tr>
<tr>
<td>6</td>
<td>unprefixed synonym</td>
<td>true</td>
</tr>
<tr>
<td>7</td>
<td>unprefixed root</td>
<td>false</td>
</tr>
<tr>
<td>8</td>
<td>nonce type synonym</td>
<td>unwrong</td>
</tr>
<tr>
<td>9</td>
<td>thematically related</td>
<td>courtroom</td>
</tr>
<tr>
<td>10</td>
<td>no response</td>
<td>PASS</td>
</tr>
<tr>
<td>11</td>
<td>other negative prefix + root</td>
<td>nonfalse</td>
</tr>
<tr>
<td>12</td>
<td>unrelated</td>
<td>apple</td>
</tr>
<tr>
<td>13</td>
<td>repetition</td>
<td>untrue</td>
</tr>
<tr>
<td>14</td>
<td>un- nonce, unrelated</td>
<td>unquiet</td>
</tr>
<tr>
<td>15</td>
<td>nonce rhyme</td>
<td>gunfalse</td>
</tr>
</tbody>
</table>

The responses for both nonces and controls were pooled, and coded according to the above.

The most common response types for each of the groups were as follows: 9 year old - unprefixed root (code 7); adult - unprefixed synonym/antonym (code 6/5); WS - no response (code 10).

Unprefixed Synonym/Antonym responses

Assuming an unprefixed synonym or antonym response to be the most likely adult response to either nonce or controls, the number of such responses for all items was summed for each subject in the 9 year old and WS groups. The mean number of such responses per subject is 2.4 (out of 10) for the 9 year old group and 2.2 for the WS group. There is no significant difference between the groups on this measure (unpaired t-test, df=18, t=0.3, p>0.05).
**Nonce responses**

Nonce response types are coded as 8, 11, 14 and 15. The number of such responses was summed for each subject in all groups. The mean number of nonce responses for each group is shown in table C.LXIII following:

**TABLE C.LXIII**  
**MEAN NUMBER OF NONCE RESPONSES PER GROUP**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN NUMBER OF NONCE RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 year old</td>
<td>0.2</td>
</tr>
<tr>
<td>adult</td>
<td>0.1</td>
</tr>
<tr>
<td>WS</td>
<td>0.8</td>
</tr>
</tbody>
</table>

There is a significant difference between the groups (1-way ANOVA, $F_{2,27}=4.8$, $p<0.05$). The WS group give significantly more nonce responses than both control groups, confirming the hypothesis.

**No responses**

No response types are coded as 10. The number of such responses was summed for each subject in all groups. The mean number of no responses for each group is shown in table C.LXIV following.

**TABLE C.LXIV**  
**MEAN NUMBER OF NO RESPONSES PER GROUP**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN NUMBER OF NO RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 year old</td>
<td>1.1</td>
</tr>
<tr>
<td>adult</td>
<td>0.1</td>
</tr>
<tr>
<td>WS</td>
<td>3.0</td>
</tr>
</tbody>
</table>

There is a significant difference between the groups (1-way ANOVA, $F_{2,27}=8.4$, $p<0.005$). Follow-up Scheffe F-tests show a significant ($p<0.05$) difference between the 9 year old group and the WS group ($F=3.5$) and between the adult group and the WS group ($F=8.1$), but not between the 9 year old group and the adult group ($F=1$). The WS group give significantly more no responses than do both control groups. This is contrary to the hypothesis, and seems to indicate that WS subjects are at the very least, no

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38 The use of ANOVA here is admittedly slightly problematic because a fair number of subjects in all groups have the same score or score zero; ANOVA ideally demands a normal distribution of scores.
less 'aware' than are both normal groups that these nonce responses are unconventional.

**Suffix swapped nonces**

Responses by all subjects in each group to the suffix-swapped nonces and their controls were coded according to the following, using *botherance* as an example:

**TABLE C.LXV**
CODING OF RESPONSES USING *BOtherance* AS EXAMPLE

<table>
<thead>
<tr>
<th>CODING NO.</th>
<th>CODING CATEGORY</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not related to root</td>
<td>apple</td>
</tr>
<tr>
<td>2</td>
<td>Related to root in meaning</td>
<td>trouble</td>
</tr>
<tr>
<td>3</td>
<td>Related to root in meaning and structure</td>
<td>annoyance</td>
</tr>
<tr>
<td>4</td>
<td>Once response</td>
<td>botheration</td>
</tr>
<tr>
<td>5</td>
<td>No response</td>
<td>PASS</td>
</tr>
</tbody>
</table>

The number of subjects in each group who gave a particular response type to each stimulus item was calculated.

**Nonce responses**

The mean number of subjects in each group who gave nonce responses to each item, averaged over all items, is shown in table C.LXVII following:

**TABLE C.LXVI**
MEAN NUMBER OF NONCE RESPONSES OVER ALL ITEMS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 year old</td>
<td>1.2</td>
</tr>
<tr>
<td>adult</td>
<td>0</td>
</tr>
<tr>
<td>WS</td>
<td>0.9</td>
</tr>
</tbody>
</table>

There is a significant difference between the groups for the mean number of subjects giving nonce responses (1-way ANOVA, $F_{2,33}=17.4$, $p<0.0001$). Follow-up Scheffe F-tests show significant ($p<0.05$) differences between the 9 year old group and the adult group ($F=15.7$), between the WS
group and the adult group (F=9.7), but not between the 9 year old group and the WS group (F=0.7).

**No response**

The mean number of subjects in each group who gave no responses to each item, averaged over all items, is shown in table C.LXVII following.

**TABLE C.LXVII**

**MEAN NO. OF SUBJECTS IN EACH GROUP GIVING NO RESPONSE**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 year old</td>
<td>2.1</td>
</tr>
<tr>
<td>adult</td>
<td>2.0</td>
</tr>
<tr>
<td>WS</td>
<td>3.7</td>
</tr>
</tbody>
</table>

There is no significant difference between the groups for the mean number of subjects giving no responses to the nonce items (1-way ANOVA, F2,33=2.6, p<0.05).

**WS GROUP: NO RESPONSES FOR NONCES VS CONTROLS**

The number of subjects giving a No Response to each of the nonce items and to its control was counted in each of the categories of nonce item, prefix and suffix. For the suffix group, there is no difference between the mean number of No Responses for nonces and controls (mean=2.3 in each case). For the prefix group, there are more subjects giving No Responses for nonces (mean=4.3) than there are for controls (mean=2.8). This difference is, however, not significant (unpaired t-test, df=10, t=1.1, p>0.05).
DISCUSSION

The mean associative link, the frequency of the most consistent response within a group over all items, is significantly higher for the adult group than both the 9 year old group and WS group, which are roughly equivalent. This is as predicted, and suggests either more developed links in the representation structure or differences in the dynamics of access to the lexical representation: more inhibition or less excitation of other possible items in the lexical representation that could be responses.

This result must be squared with results from the multiple sense (homonym) items. The adult group showed a greater tendency to respond to a multiple senses of an item than did the other two groups, which were roughly equivalent on this measure, as was found by Rossen et al. This again suggests that the adult representation has more developed links between more senses of an item than do the other two groups.

For the nonce word items and their controls, WS subjects give more nonce type responses to the prefix group than do the other groups. They also give more No Responses to the prefix group items than do the other groups. There is no significant difference between groups on these measures for the suffix group, however. This suggests that WS subjects in forming nonces using the un-prefix are overextending the 'rule' (whether 'implicit rule' within network or 'explicit rule' is not relevant to the present enquiry) that makes a negative by adding un-. Subjects are as likely to give nonces in response to control items as they do to test items - both sets are in this case merely cueing the use of the un-prefix. The rule that allows suffix extension to root is much harder to extract, and this perhaps explains why there is no significant increase in the WS group giving nonces to these items.

For the prefix group, there is a higher number of No Responses by WS subjects to the nonce test items than there is to each item's respective control. Due perhaps to small numbers of items, this difference is not, however, significant. Were this difference significant, it would imply that WS subjects are 'aware', consciously or as a result of an unconscious word-judgement mechanism, that nonce words are not conventional words. An ERP study comparing brain responses for conventional and nonce words in similar contexts, after that with language-impaired children by Neville, Coffey,
Holcomb and Tallal (1993), might elucidate whether there is an 'awareness' in WS subjects that nonce words are in fact nonce and unconventional.

There are very few significant differences between the groups for the response types to items. The first significant difference shows that the adult group is greater than both 9 year old group and WS group for the number of synonymous type responses. The second significant difference shows that both 9 year old group and WS group give more non-related responses to items than do the adult group. These both imply a more developed lexical representation for the adult group. Correlations between chronological age of WS subjects and the various taxonomic type responses shows that chronological age is the most crucial factor for these subjects in determining access to the structure of the lexical representation. However, there are no significant differences in taxonomic and thematic response types between the 9 year old group and the WS group. This suggests that the structure of the adult WS lexicon as accessed by this task has not developed beyond the level of a normal 9 year old.

The correlation for WS subjects between the difference between taxonomic and thematic responses, and the difference in the primed word monitoring task between taxonomic and thematic priming, indicate that this task is tapping the underlying organisation of the lexical representation. The real trend, although non-significant, between the difference between taxonomic and thematic responses and the taxonomic bias from section B.3.5 is at least suggestive that this taxonomic bias lexical constraint is helping shape the structure of the WS lexicon.
APPENDIX C.2.3a

ITEM GROUPS

association
non-taxonomic phrase

each item is followed in brackets by an example of a possible continuation in an associative phrase.

come (e.g. clean)
turkish (e.g. delight)
helping (e.g. hand)
rolling (e.g. stone)
holy (e.g. ghost)
question (e.g. mark)
short (e.g. circuit)
river (e.g. bank)
bat (e.g. man)
dust (e.g. pan)
long (e.g. jump)
top (e.g. of the pops)

fillers
arrive
greek
assisting
sliding
sacred
query
small
stream
club
dirt
lengthy
peak

association taxonomic phrase

salt
cats
table
rules
sun
doctor
peace
magazine
film
knife
shoes
tea

association taxonomic phrase 2

pepper
dogs
chair
regulations
moon
nurse
quiet
newspaper
television
fork
socks
coffee

multiple senses

bank
arm
swear
beat
cap
draw
fair
iron
bear
staff
strike
star
emotional/social
pleased
cheerful
miserable
angry
polite
rude
friendly
proud
humble
irritated
jealous
satisfied

nonce words
botherance
nuisome
unbreak
unfalse
unsweet
unnormal
unopen
unstraiten
retiriness
loneliment
congratulent
complimate

fillers
bothersome
nuisance
loneliness
retirement
congratulate
compliment
uncouple
untrue
unsavoury
unnatural
unlock
uncoil

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C.2.4 WORD-CHAINS

INTRODUCTION

The word-chains task is similar to the word association task, in that the subject must give a word response to stimulus words. However, the stimulus in this case is a word pair, that are related together either taxonomically or thematically. The subject must try and observe that relationship between the stimulus pair, and respect it when making a response. Similarly to the word-association task too, it is an off-line task that may reveal something of the nature of semantic organisation of the lexicon of WS subjects.

The task is also a comprehension analogue to the word fluency category production task. Section C.2.2 shows that in category production, subjects of all groups are best able to generate long lists of in-category items by generating within subcategories, taxonomic or thematic. In this task, the subject is required to produce a third item that in effect could follow the first two in an in-category list. The subject must, however, either consciously or unconsciously extract the underlying relationship between the stimulus item-pair. Subjects were allowed little time (2 seconds) for each item, in an attempt to reduce conscious judgement as to what the stimulus category relationship might be.

As pilot studies demonstrated that very young normal subjects have difficulty with this task, the youngest control group used was 9 year old children, roughly equivalent to the maximum mental age of the WS subjects tested. In addition, normal adult controls of roughly the same mean chronological age as the WS group were tested.

Stimulus word-pairs either taxonomic or thematically related to each other are used. Responses were rated according as to whether the taxonomic or thematic relationship is respected. For taxonomic items, the relative hierarchical level of the response to item-pair is rated. This task, by nature of presenting subjects with 2 words of differing or equal hierarchical categorical level, cues subjects to produce a response of hierarchical level appropriate to those of the stimulus pair. Following the principle of hyperspecificity that Rossen et al. (1994) hypothesise that WS subjects are guided by, one would
expect that the WS group will produce responses that are at a categorical hierarchical level subordinate to the item-pair.

METHOD

DESIGN

Fifty-four item-pairs were selected. The members of 36 of these item-pairs were taxonomically related items, of the remaining 18 item-pairs, the members were thematically but not taxonomically related.

Of the 36 taxonomically related item-pairs, for 16 the members of the item-pair were at the same ('equal') hierarchical level of the category, for 10 the first item was of a higher hierarchical level of the category than the second ('high-low'), and for the remaining 10, the second item was of a higher hierarchical level of the category than the first ('low-high').

The item-pairs are listed in Appendix C.2.4a.

Each subject gave a response to each of the item-pairs. These responses were coded according to their type of relation to the item-pair, whether taxonomic or thematic. It was hypothesised that the WS group would show a similar pattern to the 9 year old group, but that both would differ from the adult group.

For the taxonomically related item-pairs only, the taxonomic responses were coded according to the hierarchical level of the taxonomic category in relation to the item-pair. It was hypothesised, following the principle of hyperspecificity in WS (Rossen et al., 1994), that the WS group would show more responses that were at a more specific, lower hierarchical level than both the 9 year old group and the adult group.

SUBJECTS

Two normal control groups were used. The first was the 9 year old group, 10 children of mean age 9;8 (range from 9;2 to 9;11). The second was the adult group, 10 adults of mean age 20;2 (range from 19;0 to 27;0). There were 5 males and 5 females in each of the normal control groups.
The experimental group was 10 WS subjects, of mean age 20;9 (range from 9;0 to 31;5). There were 5 males and 5 females in the group.

The same subjects in both control groups and the experimental group were used as in the word-association study.

PROCEDURE

Experimenter and subject sat at a table. The experimenter told the subject, "I'm going to tell you 2 words, and I want you to tell me quickly a word that goes with the 2 that I say." The experimenter then said the first item-pair, in a slow and even tone. The subject was allowed up to 10 seconds to respond, otherwise no response was recorded. Their first response was recorded on the experimentation sheet by the experimenter. This was then repeated for the remaining item-pairs.

RESULTS

TAXONOMIC VERSUS THEMATIC RESPONSES

The responses to each item by all subjects in all groups were coded into one of the following categories:

**Taxonomic**
The response is taxonomically related to both members of the item-pair, e.g. *carrot* to *potato-cabbage*.

**Thematic**
The response is thematically related to both members of the item-pair, e.g. *plate* to *potato-cabbage*.

**Association**
The response is taxonomically or thematically related to one but not both of the members of the item-pair, e.g. *mash* to *potato* but not *cabbage*.

**Other**
The response is not taxonomically or thematically related to either of the members of the item-pair, e.g. *Catch-22* to *potato-cabbage*.
No response
No response is given to the item-pair.

The latter two response types were summed to make a non-related response type.

The mean number of responses per subject in each response type in all groups is shown in table C.LXVIII and figure C.LXIX below.

**TABLE C.LXVIII**
**MEAN NUMBER OF RESPONSES OF EACH TYPE PER GROUP**

<table>
<thead>
<tr>
<th>response type</th>
<th>9 yr old</th>
<th>adult</th>
<th>WS</th>
</tr>
</thead>
<tbody>
<tr>
<td>taxonomic</td>
<td>21.7</td>
<td>16.5</td>
<td>22</td>
</tr>
<tr>
<td>thematic</td>
<td>21.8</td>
<td>26.6</td>
<td>18.3</td>
</tr>
<tr>
<td>associated</td>
<td>5.3</td>
<td>6.6</td>
<td>6.1</td>
</tr>
<tr>
<td>non-related</td>
<td>4.5</td>
<td>1.9</td>
<td>6.0</td>
</tr>
</tbody>
</table>

**FIGURE C.LXIX**
**MEAN NUMBER OF RESPONSES OF EACH TYPE PER GROUP**

There is a significant increase in the number of thematic responses made by the adult group compared to the 9 year old group and the WS group.
(1-way ANOVA, F_{2,27}=10.1, p<0.0005, Scheffe F-tests (adult vs 9 yr old, F=3.4, p<0.05; adult vs WS, F=10, p<0.05)). There are no significant differences between the 3 groups in the number of any of the other response types: taxonomic responses, associated responses and non-related responses.

The response patterns of the WS group are more similar to those of the 9 year old group than the adult group, which are significantly different to the other two.

**WS GROUP**

**CORRELATIONS WITH OTHER DATA**

**Word Association**

There is a significant positive correlation between the number of thematic responses made by WS subjects in the word chains task, and the number of thematic-total responses made by WS subjects in the word association task (df=10, R=0.6, F=4.9, p<0.05).

There is a significant negative correlation between the number of taxonomic responses made by WS subjects in the word chains task, and the number of thematic-total responses made by WS subjects in the word association task (df=10, R=-0.8, F=14.9, p<0.0005).

There is a significant negative correlation between the number of taxonomic responses made by WS subjects in the word chains task, and the number of emotional descriptive responses made by WS subjects in the word association task (df=10, R=-0.7, F=8.8, p<0.05).

There is a significant positive correlation between the number of associated responses made by WS subjects in the word chains task, and the number of emotional descriptive responses made by WS subjects in the word association task (df=10, R=0.9, F=32.1, p<0.0005).

There is a significant positive correlation between the number of associated responses made by WS subjects in the word chains task, and the
number of taxonomic total responses made by WS subjects in the word association task (df=10, R=0.7, F=7.1, p<0.05).

There is a significant positive correlation between the number of non-responses made by WS subjects in the word chains task, and the number of non-responses made by WS subjects in the word association task (df=10, R=0.7, F=10.1, p<0.05).

All these correlations are as to be expected.

**CORRELATIONS WITH STANDARDISED DATA**

**Chronological age of subject**

There is a significant positive correlation between the number of thematic responses made by WS subjects, and the chronological age of the subject (df=10, R=0.6, F=5.6, p<0.05).

There is a significant negative correlation between the number of non-responses made by WS subjects, and the chronological age of the subject (df=10, R=-0.7, F=6.0, p<0.05).

**Verbal IQ of subject**

There is a significant negative correlation between the number of associated responses made by WS subjects, and the vIQ of the subject (df=10, R=-0.7, F=6.2, p<0.05).

**Raven's Test Age of subject**

There is a significant negative correlation between the number of associated responses made by WS subjects, and the Raven's Test Age of the subject (df=10, R=-0.7, F=5.9, p<0.05).

**Taxonomically related item-pairs**

The types of taxonomic responses to taxonomically related item-pairs are now considered. The item-pairs fall into 3 categories:
HIGH-LOW: The first item is higher up in the taxonomic hierarchy than the second item, e.g. superordinate-basic, animal-dog, or basic-subordinate, dog-poodle.

LOW-HIGH: The second item is higher up in the taxonomic hierarchy than the first item, e.g. basic-superordinate, cat-animal, or subordinate-basic, tabby-cat.

EQUAL: Both items are at the same hierarchical level in the same taxonomic category, e.g. superordinate-superordinate, animal-plant, basic-basic, dog-cat, or subordinate-subordinate, poodle-terrier.

The responses by all subjects were coded as follows for each of the 3 item-pair categories.

**HIGH-LOW/LOW-HIGH**

The coding of responses was the same for both of the HIGH-LOW and LOW-HIGH item pair categories. The coding is best explained using an example, vegetable-potato for the former category, potato-vegetable for the latter.

In figure C.LXX following, the item-pair is shown in grey lower case. Examples of possible responses are shown in bold lower case, and coding of those responses shown in upper case. The symbol '>' represents 'at a higher hierarchical level than', the symbol '=' represents 'at the same hierarchical level as', and the symbol '<' represents 'at a lower hierarchical level than'.

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FIGURE C.LXX
EXAMPLES OF HIGH-LOW AND LOW-HIGH ITEM PAIR RESPONSE CODES

HIGH-LOW ITEM-PAIR RESULTS

The taxonomically related responses for all item-pairs in this category were coded according to the notation above. The number of responses for each type of taxonomic response were summed across item-pairs across subjects for each group. These are shown in table C.LXXI following - in italics is the percentage of the total number of taxonomic responses (ignoring non-taxonomic responses) for each of the types of taxonomic responses:
The percentage of the total number of taxonomic responses (ignoring non-taxonomic responses) for each of the types of taxonomic responses for each subject in each group was entered into a 2-way mixed ANOVA. There is no significant difference between the taxonomic response types for the 3 groups. The second hypothesis is not met.

### LOW-HIGH ITEM-PAIR RESULTS

The taxonomically related responses for all item-pairs in this category were coded according to the notation above. The number of responses for each type of taxonomic response were summed across item-pairs across subjects for each group. These are shown in table C.LXXII following - in italics is the percentage of the total number of taxonomic responses (ignoring non-taxonomic responses) for each of the types of taxonomic responses:
### TABLE C.LXXII
MEAN NUMBER AND % OF RESPONSES TYPES PER GROUP

<table>
<thead>
<tr>
<th>response type</th>
<th>9 year</th>
<th>adult</th>
<th>WS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;HIGHER</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3.6%</td>
<td>2.3%</td>
<td>1.7%</td>
</tr>
<tr>
<td>=HIGHER</td>
<td>19</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>33.9%</td>
<td>27.9%</td>
<td>41.7%</td>
</tr>
<tr>
<td>INTERMED.</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.8%</td>
<td>4.4%</td>
<td></td>
</tr>
<tr>
<td>=LOWER</td>
<td>23</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>41.1%</td>
<td>51.2%</td>
<td>28.3%</td>
</tr>
<tr>
<td>&lt;=HIGHER</td>
<td>10</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>17.9%</td>
<td>14.0%</td>
<td>28.3%</td>
</tr>
<tr>
<td>&lt;LOWER</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NON-TAX RESP</td>
<td>44</td>
<td>57</td>
<td>40</td>
</tr>
</tbody>
</table>

The percentage of the total number of taxonomic responses (ignoring non-taxonomic responses) for each of the types of taxonomic responses for each subject in each group was entered into a 2-way mixed ANOVA. There is no significant difference between the taxonomic response types for the 3 groups. The second hypothesis is therefore again not met.

**EQUAL**

The coding for the EQUAL item-pair category is best explained using an example, *potato-cabbage*.

In figure C.LXXIII following, the item-pair is shown in grey lower case. Examples of possible responses are shown in bold lower case, and coding of those responses shown in upper case. The symbol '>' represents 'at a higher hierarchical level than', the symbol '=' represents 'at the same hierarchical level as', and the symbol '<' represents 'at a lower hierarchical level than'.
FIGURE C.LXXIII
EXAMPLE OF CODING RESPONSES FOR EQUAL ITEM-PAIR CATEGORY

EQUAL ITEM-PAIR RESULTS

The taxonomically related responses for all item-pairs in this category were coded according to the notation above. The number of responses for each type of taxonomic response were summed across item-pairs across subjects for each group. These are shown in table C.LXXIV following - in italics is the percentage of the total number of taxonomic responses (ignoring non-taxonomic responses) for each of the types of taxonomic responses:
TABLE C.LXXIV
MEAN NUMBER AND % OF RESPONSES TYPES PER GROUP

<table>
<thead>
<tr>
<th>response type</th>
<th>9 year</th>
<th>adult</th>
<th>WS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;&gt;</td>
<td>25</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>21.2%</td>
<td>25%</td>
<td>12.3%</td>
</tr>
<tr>
<td>=&gt;&gt;</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2.5%</td>
<td>1.0%</td>
<td>2.6%</td>
</tr>
<tr>
<td>=</td>
<td>81</td>
<td>64</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>62.6%</td>
<td>66.7%</td>
<td>72.8%</td>
</tr>
<tr>
<td>&lt;==&gt;</td>
<td>5</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4.2%</td>
<td>5.2%</td>
<td>10.5%</td>
</tr>
<tr>
<td>&lt; 1ST</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 2ND</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3.4%</td>
<td>2.1%</td>
<td>1.8%</td>
</tr>
<tr>
<td>NON-TAX RESP</td>
<td>42</td>
<td>64</td>
<td>46</td>
</tr>
</tbody>
</table>

The percentage of the total number of taxonomic responses (ignoring non-taxonomic responses) for each of the types of taxonomic responses for each subject in each group was entered into a 2-way mixed ANOVA. There is no significant difference between the taxonomic response types for the 3 groups. The second hypothesis is again not met.

DISCUSSION

For the types of response made, the adult group differs from both 9 year old group and WS group in making significantly more thematic responses than the other 2 groups. The positive correlation between chronological age of WS subjects and the number of thematic responses made suggests that for this task, thematic agreement of response with item-pair is a product of developing experience. Given that thematic information is closely tied to episodic information, experience of objects being in certain functional
situations with each other, this is perhaps unsurprising. This thematic difference between adults and other groups holds for taxonomic item-pairs as well; most taxonomic pairs will also probably share thematic, functional situations, for example lion and leopard will both eat babies.

There is, however, no difference between the number of taxonomic responses for all groups. For this task at least, taxonomic agreement of response with item-pair is possible for all groups. The taxonomic organisation of WS subjects, as measured by this task, is not significantly different from either chronological age equivalent or 9 year old (approximate mental age equivalent for most of the WS group) normal control groups.

The proportions of different levels of categorical hierarchical level of responses, relative to that of the taxonomic item-pairs, does not differ between all groups. Based on the principle of hyperspecificity that Rossen et al. (1994) hypothesise to influence WS subjects, one would expect that the WS group would show a greater level of subordinate-level responses relative to the item-pair, compared to the other groups. This is not the case.

The processing demands of this task are quite difficult; the subject must remember 2 words, and find a third word in response that in some sense matches the stimulus item-pair. These demands are somewhat greater than those accounted in spontaneous speech, where Rossen et al. took evidence for hyperspecificity in WS subjects. Yet, according to their processing account, one would expect more hyperspecific, subordinate examples in this task where demands of the task are greater. As this did not occur, their theory of hyperspecificity cannot be supported.
APPENDIX C.2.4a

Word chain item-pairs

taxonomic
zebra, donkey
blackbird, eagle
tiger, cat
python, snake
marsupial, koala
fly, blue-bottle
red, crimson
purple, violet
cream, white
turquoise, blue
yellow, brown
orange, green
meat, beef
vegetable, potato
apple, fruit
milk, drink
walnut, hazelnut
branflakes, weetabix
gerbil, hamster
lion, leopard
shark, fish
poodle, dog
bird, sparrow
reptile, lizard
ferry, hovercraft
helicopter, aeroplane
bus, minibus
steam-engine, train
paddle-steamer, ship
kitchen, bathroom
bath, sink
bowl, plate
chair, sofa
lamp, candle
blouse, shirt

thematic
cage, rat
shark, lighthouse
reindeer, Santa
pirate, parrot
farm, sheep
camel, zoo
bedroom, wardrobe
drawer, socks
papers, desk
television, lounge
grass, ball
dust, spider
coffee, toast
crisps, beer
car, garage
river, canoe
toothbrush, soap
cooker, tin-opener
C.3 GENERAL DISCUSSION

The impression given by most previous research on the semantic organisation of the lexicon in WS subjects is that it is deviant, bizarre, abnormal, and yet in scope very nearly equivalent to normal subjects of a comparable chronological age. The overwhelming impression given by all 4 studies in this section is quite the contrary - the semantic organisation of WS subjects is like that of normal children of a comparable mental age. To be sure, there are still some crucial differences in at least access to the underlying organisation of the semantic representation of WS compared to normal subjects. But there are fewer differences than would be predicted from the conclusions of previous research.

In the on-line word-monitoring task, semantic priming was found in WS subjects across all conditions, strongly associated and non-associated prime-target item pairs, and functionally (thematically) and categorically (taxonomically) related prime-target item pairs. On the other hand, P.P., the case-study tested by Moss et al. (1995) on the same task was found to have no priming for categorical prime-target item pairs, whereas priming for functional pairs was intact. This demonstrates that in WS there is no damage to the underlying semantic representation as there is for P.P., who suffers a selective loss of semantic memory.

Although the actual amount of priming averaged across all conditions for WS subjects is only slightly below that for normal control subjects, priming as a percentage of total reaction time is much lower. Two main hypotheses were advanced to explain this difference. The first is that the motor component of the RT is much larger in WS. Given the reported difficulties that WS subjects have in a great variety of motor acts, both fine and large-scale action, this must be at least partly true. The second is that the representation may be less developed in WS than it is in normal adults, that there are too many other possible targets that are activated when the prime word is heard, and that the priming to the target is thus diminished.

A measure on the word-association task which can tap the development of the underlying representation is the mean associative link of responses to a particular item within a subject group. The adult group were found to have a much stronger associative link than either the 9 year old
group or the WS group, which were equivalent. Thus there were fewer different responses to a particular item by all adult subjects than by subjects in either of the other groups. The link between response and stimulus item is therefore more developed. Were a word-monitoring task to be performed using the word-association stimulus item as the prime, and the word-association most frequent response item as the target, one could hypothesise again that there would be greater priming in the adult group than in either the 9 year old group or the WS group. This would be due to a more developed (pruned) lexical representation in the adults.

For the multiple sense items on the word association task (e.g. staff meaning teachers or stick) there were more consistent responses to both senses by adult subjects than by either the 9 year old group or the WS group. This again suggests that the adult representation is more developed than that in either of the other 2 groups.

The on-line word-monitoring and partially on-line word-association tasks, which tap the underlying structure of the representation, together indicate that the WS lexical representation has a developed structure more similar to that of the 9 year old normal controls than the adult normal controls. It would be desirable to run the word-monitoring task on a 9 year old normal group (or roughly equivalent to WS subjects in verbal mental age) on the word-monitoring task. One can hypothesise that the actual amount of priming should be similar to the WS group, although the priming as a percentage of RT would be less due to increased RTs in the WS group due to difficulties with the motor component.

In the word-association, word-fluency and word-chains tasks, there are measures of the degree to which taxonomic or thematic strategies (conscious or unconscious) are used in responding. For all 3 tasks, the WS group was more equivalent to the 9 year old group than either were to the adult group according to this measure.

In the word-fluency task, the adult subjects were more likely to use taxonomic-based strategies to generate items than either of the other 2 groups. Both taxonomic and thematic clustering of items was used by all subjects to generate new items. For all groups, the strength of relationship, taxonomic or thematic, between each item and that immediately preceding
was inversely proportional to the time between uttering those items. For example, *robin* would more quickly follow *thrush* than would *killer whale*.

More taxonomic responses as opposed to thematic responses also characterised the adult group in the word-association task. The largest increase seen in the adult group compared to the other 2 groups was in the number of synonymous-type responses (e.g. *quick* and *fast*), which became the largest subtype of taxonomic responses. Crucially, the chronological age of WS subjects was significantly correlated with the degree to which taxonomic responses were given in this task. If the WS group is most nearly equivalent to the younger 9 year old group, but becomes more like the adult group with increasing chronological age, it indicates that there is a slower trajectory of development of ability on this task for the WS group.

The taxonomic bias for each WS subject measured in section B.3.5 correlates non-significantly with the difference between taxonomic and thematic type responses on the word-association task. The taxonomic bias is not significantly present in the WS group, whereas it is overwhelmingly so for normal 9 year olds. The (very) tentative conclusion that can be drawn is that it is the lack of a taxonomic bias lexical constraint that is slowing development of WS on this particular task. The difference between taxonomic and thematic responses on the word-association task correlates significantly with the difference between priming for categorical (taxonomic) and functional (thematic) on the word-monitoring task. Again very tentatively, it may be possible with a larger WS sample to implicate the relative presence of a taxonomic bias constraint with the development of the structure of the underlying lexical representation.

Conversely, on the word-chains task, the adult group tends to produce more thematic type responses than either of the 9 year old or WS groups. The latter two are equivalent. Again, there is a significant correlation between chronological age and degree of thematic (adult-like) response for WS subjects. That this task produces an adult response of more thematic responses, compared to the word-association and word-fluency more taxonomic responses with the adult group, is most likely caused by differences in the implicit protocols of the tasks. In the word-chains task, the experimenter asks the subject to produce a word that "goes with" the stimulus pair. For many of the taxonomic stimulus pairs, there was also an
unavoidable thematic link between the two items. These two factors may bias towards a thematic response.

On the word-fluency task, the WS subjects tended to produce a total number of exemplars in the animal, pet and colour categories that was most nearly equivalent to chronological age-matched controls than any other control group. This was not true in the reptile category, a taxonomic subcategory of the animal category. As discussed in C.2.2, this is probably because of the lack of conceptual knowledge as to what makes an animal a reptile (Johnson et al., 1994).

Still, the WS group produced a total number of responses more like those of chronological age equivalents, the adult group, on this word-fluency task. For this task however, the most off-line of all the studies in this section, the subject is explicitly pushed to retrieve as many of the exemplars within a semantic category as they can. For this, the chronological age of the subject, which will obviously correlate with the amount of linguistic experience they have - the number of animals that they have heard of in their life - will be the most crucial factor.

Contrary to the claims of Bellugi et al. (1988, 1992), Rossen et al. (1994) and Pinker (1994), WS subjects do not produce any more unusual or low-frequency exemplars than do their mental age equivalent controls, whether measured across the whole of the trial or in the latter stages of the trial. Rossen et al. (1994) hypothesised a mechanism of hyperspecificity to account for their subjects producing low-frequency exemplars - those exemplars tend to be in more subordinate categories, more specific exemplars. Were this characteristic of WS subjects, then one would predict that in the word-chains tasks the responses of the WS group would tend to be at a more subordinate level than the stimulus word pairs. This was also not found.

To explain the difference between the findings of this word-fluency study and previous research, one must remember that for many previous studies, relatively few WS subjects were tested. Different situational factors, whether a greater desire to "impress the doc" or a possible previous trip to San Diego Zoo, might be invoked to explain why these subjects in previous studies produced more unusual exemplars within the animal category.
WS subjects tended to produce more extensions than intensions of the root exemplar, e.g. *all the kangaroos* as opposed to just *kangaroo*, which is most like the very youngest normal controls. Within this micro-domain of language production, development in WS is only comparable to that of 3 to 5 year old children.

In the colour category of the word-fluency task, WS subjects did produce more nonce-type items that were formed by overextending a prefix onto a colour root to form an unconventional compound, e.g. *clear white*. In the word-association task, the WS group also produced more nonce-type responses of a similar form, overextension of a prefix *un-* onto a basic root. WS subjects, however, did produce more *No Responses* to nonce stimuli in the word association task, which suggests that they may be 'aware' that these lexical items are unconventional. An ERP study might demonstrate whether awareness of the nonce as being unconventional is present in WS.

Were this to be the case, then the increase in nonce-type responses may be due to similar situational factors of wanting to impress the experimenter. It must be remembered also that WS subjects are often conscious of their relative ability in conversational language. Such nonce over-extensions are not just characteristic of younger normal children in a scientific sense, they are also in themselves linguistically creative and playful.

The overall conclusions to be drawn from the studies in this section allow us to paint a picture in broad brush-strokes of the semantic abilities and organisation in WS subjects. WS subjects can be characterised as developing the same underlying semantic organisation as normal subjects. This development is, however, much slower than in normals, and lags behind the actual linguistic experience that any WS person has. Further research with a larger population may establish the lack of a taxonomic bias lexical constraint as at least one crucial factor in slowing the development of semantic organisation along taxonomic lines.
part D

GENERAL DISCUSSION
D.1 INTRODUCTION

If this thesis has any one target for attack, the dartboard of choice is surely the quotation from Pinker's 'The Language Instinct', with which I opened:

>a rare form of retardation called Williams Syndrome. The syndrome appears to be associated with a defective gene on chromosome 11 involved in the regulation of calcium, and it acts in complex ways on the brain, skull, and internal organs during development, though no one knows why it has the effects it does. The children have an unusual appearance: they are short and slight, with narrow faces and broad foreheads, flat nasal bridges, sharp chins, star-shaped patterns in their irises, and full lips. They are sometimes called "elfin-faced" or "pixie people," but to me they look more like Mick Jagger. They are significantly retarded, with an IQ of about 50, and are incompetent at ordinary tasks like tying their shoes, finding their way, retrieving items from a cupboard, telling left from right, adding two numbers, drawing a bicycle, and suppressing their natural tendency to hug strangers. But... they are fluent, if somewhat prim, conversationalists...

Language tests confirm the impression of competence at grammar; the children understand complex sentences, and fix up ungrammatical sentences, at normal levels. And they have an especially charming quirk: they are fond of unusual words. Ask a normal child to name some animals, and you will get the standard inventory of pet-store and barnyard: dog, cat, horse, cow, pig. Ask a Williams Syndrome child, and you get a more interesting menagerie: unicorn, pteranodon, yak, ibex, water-buffalo, sealion, saber-tooth tiger, vulture, koala, dragon, and one that should be especially interesting to palaeontologists, "brontosaurus rex." One eleven year-old poured a glass of milk into the sink and said, "I'll have to evacuate it;" another handed Bellugi a drawing and announced, "Here Doc this is in remembrance of you..."

Complex grammar is displayed across the full range of human habitats... you can possess all these advantages and still not be a competent language user, if you lack just the right genes or just the right bits of brain. (Pinker, 1994, p.58).

Pinker essentially characterises the following major school of opinion on the abilities of WS: in WS, language is seen as spared relative to the rest of cognition; within the language domain, syntax or morphosyntax is seen as relatively intact and semantics 'deviant' or 'bizarre'. In considering the aetiology of the syndrome, whatever gene locus is implicated as abnormal in WS will be viewed as one possible locus in the set of genes that control the
semantic abilities of the WS individual. The agenda is then to establish the gene or set of genes that may control semantics in everyone, using WS as a guinea-pig in an experiment set up by Mother Nature.

Drawing on the work of the previous sections, this discussion demonstrates that such a view of WS abilities and its accompanying agenda are grossly inadequate. In section D.2 in this final chapter, the semantic abilities of WS individuals are discussed with reference to previous research described in parts A and C. It becomes apparent that any characterisation of WS semantic ability as 'bizarre' is extremely limited.

Section D.3 examines whether the characteristics of WS semantics may be explained by possible differences in development of the operation of lexical acquisition constraints described in section B. In section D.4, other possible explanations for differences in WS semantics are discussed - in particular, the impairment in conceptual development described by Johnson et al. (1994) is identified as a possibly important factor.

In section D.5, final conclusions, suggestions for future research, and relevant predictions are made for testing WS and other subject group populations.

D.2 SEMANTIC ABILITY AND SEMANTIC ORGANISATION IN WS

Part C set out to explore using a variety of experimental tasks, off-line and on-line, whether the semantic organisation in WS is actually deviant or delayed. If delayed, it would be pegged to equivalent milestones in comparable normally developing children or adults of younger chronological age than the WS individuals tested. If deviant, it would be of an entirely different character to that of normally developing individuals.

The overwhelming experimental evidence indicates a semantic organisation in WS that lags behind normal development, and slows at a level that is comparable to normal 9 years old. None the less, whether the organisation of semantics in a WS adult is comparable to that of a normal 9 year old, the linguistic experience of WS individuals is somewhat closer to that of a chronological age-matched normal adult. The vocabulary that they
will have experienced as linguistic input is not radically different from that experienced by anyone of the same chronological age. Any differences in vocabulary will result from differences in upbringing and educational experiences, as a WS individual will probably have spent more time under close supervision of a carer.

In sum, development of semantic organisation in WS is delayed, and slows to reach a level comparable to that of a normal 9 year old. Semantic experience, in terms of vocabulary, appears closer to that of chronological age equivalents. The following section discusses the findings of part C in more detail.

**D.2.1 SUMMARY OF FINDINGS ON SEMANTIC ORGANISATION**

**D.2.1.1 Structure of the representation**

In the on-line word-monitoring experiment in section C.2.1, the priming of reaction time (RT) to a target word, by a preceding semantically related word-prime, is measured. Priming was found in WS subjects in all conditions of relation between prime and target, whether strongly or weakly associated, or whether a functional (thematic) or categorical (taxonomic) relation.

The amount of priming in all conditions for WS subjects was comparable to that seen in normal adults. However, the percentage of priming compared to overall RT was much less in WS. This is probably due to motor problems in WS leading to a greater delay in any RT-based task. However, a component of this lower percentage of priming could result from a semantic representation with too many links between a target lexical item and any number of related items, however, tenuous the link. In general terms, the neural development of a representation follows a pattern of earlier growth and subsequent pruning and trimming. In this case, an overdeveloped lexical representation in WS might lack the pruning and be comparable to that shown by younger normally developing children.

Additional evidence for this position comes from the off-line word-association task. The strength of the mean associative link between stimulus item and the most frequent response by all subjects in each group was higher for the adult group than for the WS and 9 year old groups, which were
equivalent. To any particular lexical item, there is more likely to be one or a few strong associative links to other lexical items for the adult group than for the 9 year old group or the WS group. The 9 year old group and the WS group were equivalent on this measure. This supports the notion that, in the normal adult semantic representation of the lexicon, there are fewer but stronger links between lexical items. It is essential to follow up the word-monitoring study with testing of verbal mental age equivalents to the WS group (9 year olds) and to compare the patterns of priming with the WS and normal adult groups. According to this hypothesis, that normal adults have a more developed lexical representation by virtue of fewer and stronger links between items, the 9 year old group and the WS group should show a similar level of development of the lexicon, with over-representation of links compared to the adult group. The 9 year old group should then show a smaller amount of priming as a percentage of the RT to the adult group, but equivalent to the WS group. The actual amount of priming may be smaller in the 9 year old group than in the other 2 groups. The WS priming might then be as high as the adult group only because of longer overall RTs. In ERP studies by Neville et al. (1994) that involved semantic priming tasks, WS individuals showed a larger LPC component than normal controls for items presented orally but not visually. This component was implicated by Neville as indexing greater semantic priming. This is consistent with normal or enhanced lexical representations for auditory stimuli in WS, but not for visual stimuli.

Neville's result appears inconsistent with the results of section C.2. However, the task used by Neville et al. gave a semantic context via a sentence, whereas in the word-monitoring study the context was given only by the immediately preceding 'prime word'. If the lexical representation is 'overdeveloped' in WS, then the more contextual cues given, the more parts of the representation will be activated which are actually contextually salient to the target, giving greater priming. Where contextual cues are at a minimum in this study, then more parts of the representation not necessarily salient to the target will be activated, and the effect of priming will be lessened. If this study were repeated measuring ERPs, then one would expect that the LPC component would be similar to that in normals.

Neville herself argues that the evidence suggests that there are more links, and more excitability between links in the semantic representations in
WS, but only in the auditory mode. This may be related to hyperacusis, the auditory hypersensitivity shown by younger WS individuals. Hypersensitivity might lead to more representational space dedicated to auditory language, and more links between lexical items through over-dedication to orally presented language. In the word-monitoring task in this study, target words were presented orally to the WS subjects, but visually to the normal controls. This was because several of the WS group had problems in reading that would confound the task. As there should be no difference between priming for auditory and visual presentation for normal subjects, this should not affect comparisons for this study between groups. It would be interesting to compare priming in the auditory and visual capacities for WS, using subjects who were relatively skilled in reading. If, as Neville suggests, the auditory hypersensitivity of WS individuals is pushing linguistic processing and representations into different systems than in normals, then one would hypothesise much less priming for visual presentation in WS individuals.

In sum, the evidence from the experiment suggests that in WS the semantic representation is over-represented in the number of lexical items linked to any particular item. In this, they may have a comparable level of development to that in 9 year old normal controls, but with possible differences between modalities compared to normals. In WS, this may be caused by over-dedication to complex linguistic representations through early auditory hypersensitivity.

D.2.1.2 Taxonomic versus thematic access

In the word-fluency and word-association tasks, the WS group is again most like the 9 year old group. Both groups lag behind adults in terms of the proportion of taxonomic responses. In the word-chains task, the typical adult response is thematic; but again, both 9 year olds and WS groups lag behind adults in the proportion of this type of response. The chronological age of WS subjects correlates strongly with the degree of taxonomic (in the word-fluency and word-association tasks), or thematic response (in the word-chains task). This suggests a slower rate of development in the WS group for the adult type of response in each task, which may reflect a slower rate of development of aspects of semantic organisation.
That different tasks elicit different types of response indicates that the
tasks cannot be tapping organisation of the representation. Instead, they tap
access by subjects to certain aspects of the representation. The WS group
show both taxonomic and thematic responses on all tasks, however. The
predominaence of one type of response does not preclude another type of
response. In the WS group, then, access to both taxonomic and thematic links
is possible in all tasks, and equivalent to that shown by 9 year old controls.
The adult group shows a more developed predominant task-dependent
response-type, i.e. taxonomic or thematic.

This finding is not inconsistent with the hypothesis that in WS the
lexical representation is 'over-developed'. If, in WS, there are more linked
items to any target item than in the adult representation, with links being
either taxonomic or thematic, then one would expect that for any target item
more possible responses might be accessed, either taxonomic and thematic,
than in an adult control group. In this control group fewer links would be
accessed, of the task-dependent type, taxonomic or thematic.

In sum, these tasks probably tap access to the representation, rather
than directly mapping the organisation of the representation. The WS group
is equivalent to the 9 year old group in showing a more even distribution of
response types (taxonomic or thematic) than the adult group. The semantic
representation may therefore be over-developed in the WS and the 9 year old
groups, in comparison with the adult group.

**D.2.1.3 No evidence for preference for unusual words**

According to researchers such as Pinker, Bellugi and Rossen, the most
characteristic feature of WS semantics is that there is at least a *preference*, at
most a *predominance* for unusual word choice. There is no evidence for this in
any of the word-fluency, word-association or word-chains tasks in this study,
whether over the whole trial, or in the latter stages of the trial. Rossen et al.
(1994) characterised their WS group as showing 'hyperspecificity', a tendency
to select items that are more subordinate in their position in categorical
hierarchies; the more subordinate items also tend to be more unusual. The 3
tasks discussed here show no evidence for hyperspecificity in WS. On all
measures, the WS group seem roughly comparable to verbal mental age
equivalents; for the older WS group, this is the 9 year old normal group.
The contradiction between these results and previous findings is difficult to explain. One possible explanation is that previous studies have used far fewer subjects than in this study. Indeed, of all the previous word-fluency studies, Scott et al. (1994) stands alone in using a larger sample and finding similar results to those reported here. But no subjects in this WS group demonstrated a preference for unusual words, any more than that shown by younger normal controls. Certainly no such preference was found for unusual words comparable to that quoted by Pinker as being the typical "interesting menagerie" found in WS. An unlikely explanation is that the few subjects cited as demonstrating unusual word choice were an atypical subgroup of the syndrome. Another possible but unlikely explanation invokes situational factors. Rossen et al. (1994) argued that unusual word choice was most likely to happen in 'stress' situations, like that of a difficult context. This argument can perhaps be applied to a different sort of stress, the stress of the experimental situation. One must assume this to be greater for a WS individual travelling large distances away from home for testing in the San Diego labs of Bellugi, rather than being tested at home or travelling shorter distances to the CDU lab in London for study here. The sense of occasion, and resulting stress to perform well, would then be greater in Bellugi's lab studies, and perhaps result in more unusual word choice. None the less, this explanation remains relatively weak as a full account of the discrepant findings, although it may be a partial account. Different subject population sizes between studies is a more likely explanation.

In sum, the WS group tested here on the word-fluency task show no preference for unusual exemplars as would be predicted from the majority of previous results. Instead, my results concur with those of Scott et al. (1994) in finding a frequency of unusual items for category productions similar to that of normal 9 year olds.

D.2.1.4 Over-extensions

WS individuals occasionally produced nonce-type responses in the colour category of the word-fluency task, and for those items in the word-association task that were designed to elicit such responses. These nonce productions follow particular rules of overextension, where use of a prefix such as "clear" in the colour category or "un-" in the word-association task is over-extended inappropriately, e.g. "clear white" or "unfalse". It is interesting to compare this type of over-extension to that reported for WS individuals by
Pinker (1991) and Bromberg et al. (1994) in plural and past-tense formation. In these studies, with procedures that explicitly elicit formation of the past-tense of verbs and noun plurals, WS subjects typically are weaker at producing irregular forms. They instead over-extend the rule for regular formation of the past-tense '-ed' and the noun plural '-s' morphological markers, producing such items as 'goed' and 'mouses'. Anecdotal reflections on the prevalence of such productions in spontaneous speech of WS individuals indicate that over-extensions are much more common in experiments that are designed to elicit them than they are in everyday use. Both the studies of Pinker and Bromberg, and the studies here are off-line: for the plural formation, past-tense formation and word-association tasks, the procedure is deliberately designed to test those very aspects of production. For the word-fluency task, where the implicit goal is for the subject to produce as many exemplars as possible, prefix extension is one useful way to easily produce many items. The implication, then, is not that WS individuals over-extend in all situations, as Pinker and Bromberg suggest, with theoretical consequences for a dual-route model of rule extension. Rather, WS individuals in experimental situations may over-extend if necessary to help them complete the experimental task. Their awareness that over-extension may help them in the task arises from the explicitness of the experimental procedures.

This explanation is supported by two further pieces of evidence from the word-association task. Firstly, WS subjects gave more 'No Responses' to nonce forms than did 9 year old controls, suggesting that they may be aware that these forms are unconventional. Secondly, WS subjects did not over-extend suffixes to form nonces in the manner in which they did with prefixes. The suffix extension rule is much harder to consciously extract than the prefix extension rule in this task. The prefix used in every such stimulus item was 'un-', and the subjects were therefore primed to be aware of this. Control items also using this prefix were used. Adding this prefix to any adjective makes a negative form of that adjective; nonces are such because they are unconventional, not because it is morphologically impossible to use the 'un-' prefix. In contrast, each suffix was used only twice in the task, once in a nonce form e.g. 'botherance' and once in a conventional form, e.g. 'tolerance'. It was therefore much harder for subjects to be aware of the suffix-extension rule.

On the word-fluency task, too, WS individuals were like the youngest controls in their tendency in production to concentrate on the extension
(lions) rather than the intension (the lion) of any lexical item. More plurals were produced than in any other group apart from the 3 year old controls. To some extent, the extensive form may be elicited by the procedure for WS subjects. For example, in the animal category, the experimenter asks for "all the animals you can think of". For the WS group, with a tendency to over-extend, this may encourage focus on the extension rather than the intension of the concept. In sum, WS individuals show a tendency to over-extend morphological forms that are elicited by the experimental procedures, where the rules of morphological formation for over-extension are easily extracted from the stimuli.

D.2.1.5 Vocabulary size

The most 'off-line' measure in section C is the number of exemplars produced in the word-fluency task. This is also the task where for the majority of categories, WS individuals are most like chronological age equivalent controls in their responses.

The receptive vocabularies of WS individuals can be measured by the BPVS. For one subject in this pool, the BPVS test age is as high as 16 years. The number of exemplars produced by WS subjects does correlate strongly with BPVS test ages, suggesting that this measure is tied to overall vocabulary size. In sum, relative to what one might expect from other measures of semantic organisation, WS individuals demonstrate quite large vocabularies that are not that far behind those of chronological age matched controls.

D.2.1.6 Relationship to conceptual knowledge

The exception in number of items produced in the word-fluency task was the taxonomic subcategory of reptile, where although the number of responses still correlated with the BPVS test age of the subject, very few were produced by the WS group. This was probably due to a lack of knowledge as to what made an animal a reptile. Johnson et al. (1994) demonstrated that in the knowledge domain of intuitive biology, WS individuals were only comparable to very young controls due to a lack of conceptual development. Production of exemplars in a category can therefore be impaired by a lack of the relevant conceptual knowledge.
D.2.2 SUMMARY

Overall, the semantic organisation of WS is relatively similar to normal development, although delayed, with over-representation of links between items that in normal development are pruned away by adulthood. WS semantic representation is organised both taxonomically and thematically, but access to both sorts of links in certain tasks gives patterns of response more like that of 9 year old controls than adults. This may again be caused by over-representation or over-excitability of the links between items.

The vocabulary size of some of the WS individuals tested is greater than in 9 year old controls, but less than in adult controls. Vocabulary can only be accessed in certain knowledge domains where conceptual knowledge exists regarding an item’s category membership. The categories where WS individuals give a large number of exemplars in the word-fluency task (animal, colour and pet), all rely on very basic conceptual knowledge that can be gained through experience associatively, as measured by the Enrichment Battery in the studies by Johnson et al. (1994) rather than those requiring more advanced conceptual knowledge, such as reptile. It is possible that the large vocabularies of WS individuals can lead to conceptual development, in certain domains only. The knowledge that is implicit in the meaning of words will lead development of conceptual knowledge as vocabulary items are structured and linked through experience. In that case, conceptual knowledge should be delayed in acquisition, and be more advanced in conceptual domains that only require experiential knowledge, in which WS individuals are strong.

WS individuals show no predilection, predominance or preference for unusual words. Nor do they show hyperspecificity in vocabulary choice of the kind hypothesised by Rossen et al. (1994). However, there is a tendency for morphosyntactic over-extension in a variety of forms where the rule for extension is easily accessible. Another contrasting area of morphosyntax is the agreement of noun, adjective and article for grammatical gender in French. Karmiloff-Smith et al. (1997) examined the acquisition of grammatical gender in French-speaking WS individuals, which is poor. They argue that the complexity of the system cues, the greater number of elements that must be conjoined for gender agreement and the very arbitrariness of the system make grammatical gender very difficult for WS individuals to acquire, compared to
normal 4 year olds. Instead, systems like English past tense or plural markings, and indeed the extensive systems described here are much simpler, more regular, based on only one morphological marker, and with bootstrapping assistance from a semantic component.

In sum, WS individuals have a tendency to over-extend marker formation in morphosyntactic areas when the rule is both simple and extractable, with help from semantic boot-strapping e.g. past-tense formation and plural formation, and where such marker formation is elicited by the experimental procedure. Where the system is more complex and arbitrary, e.g. grammatical gender, then WS have problems. WS manifest dissociations within the domain of morphosyntax. It is fruitless to attempt to claim from this evidence that the syntax or semantics of WS is intact or deviant, as Pinker does to justify the target quotation.

**MAIN POINTS**

• WS vocabulary is greater than that of verbal mental-age matched controls, but less than chronological age-matched controls, in both production and comprehension. The only exceptions are where conceptual knowledge is required to construct a semantic domain, knowledge beyond that of a normal 3 to 4 year-old (as measured by the Enrichment Battery in the work of Johnson & Carey, 1996).

• WS semantic organisation is more delayed than deviant. It is comparable to verbal mental age-matched controls, but lags behind chronological age-matched controls.

• WS have no predilection, predominance or preference for unusual words beyond that of any normal verbal mental age-matched child.

• WS will over-extend morphosyntactic marker formation when the extension rule is easily extractable, and where it is elicited explicitly or implicitly by the experimental procedure.
D.3 IS THERE AN ABSENCE OF LEXICAL CONSTRAINTS IN WORD-LEARNING IN WS?

Section B set out to examine possible constraints on word-learning in WS. If indeed the semantics of WS were 'bizarre', then one might expect some differences in the operation or possession of mechanisms that in normally developing children have been demonstrated to constrain the learning of novel words. Since this also constrains the meaning of words, it would probably affect semantic organisation, which may then be related to differences in the operation of lexical constraints.

D.3.1 SUMMARY OF FINDINGS ON LEXICAL ACQUISITION

Two theories of lexical acquisition constraints were examined: the Developmental Lexical Principles Framework (DLPF) of Golinkoff et al. (1994); and the default acquisition constraints of Markman (1992). The relevant principles investigated can be divided into two categories. The first are those that limit a novel word to a whole object referent: the N3C principle in the DLPF framework, and the whole object and mutual exclusivity assumptions in Markman's framework. The second kind of principle are those that limit novel words to the category of object-kind: the principle of categorical scope in the DLPF framework and the taxonomic assumption in Markman's framework.

Of the first object scope constraints, the N3C principle as measured by fast-mapping ability was demonstrated to be present in WS individuals, replicating results of Mervis and Bertrand (1993), with a much broader age range of controls. The production measure of the N3C principle, i.e. whether a subject has learned a novel word to produce it as a referent for a novel object, also correlated with BPVS test age scores, implicating this principle in the acquisition of new words by WS individuals. Of Markman's two principles - whole object and mutual exclusivity assumptions - the former was not demonstrated in the WS group whereas the latter was. It was argued in part B that this may reflect the differing experimental demands of the tasks. In any case, it demonstrates weaker operation of this set of lexical constraints in WS than in normal subjects. It also implies, contrary to the presumption of Markman, that in WS at least, these principles are not hard-wired but acquired through development. This acquisition is likely to be delayed relative to normal development.
The lack of a whole object assumption in WS was shown not to be dependent on a focus towards the parts of an object, i.e. the local level of a hierarchically organised object. As a group, WS subjects showed no dissociation between global and local levels in reproducing a hierarchical drawing, contrary to Bihrle et al. (1989). Those subjects who did show a local level bias in drawing could describe the stimuli accurately verbally, making reference to both global and local levels. Previously reported dissociations must be a result of problems in the motor execution of drawings.

For the categorical scope principles, no taxonomic assumption was demonstrated in the WS group. Whereas for normal subjects the presence of a novel word biases them to make taxonomic links to extend the reference of that word, this was not the case in WS. WS were not distracted by other perceptual factors in the stimuli, nor was a difference shown between basic- and superordinate-level stimuli. Within the WS group, some subjects did show a positive taxonomic bias, some did not. The relationship between the presence or absence of this taxonomic bias and the 'bias' towards taxonomic responses in the studies in part C accessing semantic organisation will be discussed in D.3.2.

Lack of a taxonomic bias was not caused by a lack of awareness of categorical information. All WS subjects could to some degree spontaneously and exhaustively sort objects into categories. There was also a real but non-significant trend between ability on the Spontaneous Exhaustive Categorisation task and the production measure of the fast-mapping experiment. This trend is predicted from the work of Mervis and Bertrand (1993).

In sum, lexical constraints seem to be possessed by WS individuals to a weaker degree than in any normally developing controls. In particular, the taxonomic assumption is not shown by the WS group, although some individuals did show a positive bias. The effect that this lack of a taxonomic assumption may have on semantic organisation is examined in the next section.
D.3.2 INTERACTION BETWEEN TAXONOMIC BIAS AND SEMANTIC ORGANISATION

There were two measures in the studies in part C concerning the differences between taxonomic and thematic organisation of the lexicon and access to these aspects of the representation. The difference between the amount of priming in the word-monitoring experiment between taxonomic and thematic relations is a measure of the underlying organisation. The difference between taxonomic and thematic type responses in the word-association experiment is a measure of access to that organisation. In the WS group, there are real but non-significant trends between the taxonomic bias shown by subjects and these 2 measures. Future research should extend the subject pool for both experiments, and also increase the number of test-items in the taxonomic assumption experiment.

D.3.3 SUMMARY

Lexical acquisition principles do operate in WS, but in a much weaker form than in normal subjects. Significant correlations and real but non-significant trends with BPVS test age scores do suggest that lexical principles are implicated in acquisition of new vocabulary items. Evidence remains inconclusive as to whether the weaker operation of the categorical-scope type principles affects semantic organisation.

According to the developmental framework of Golinkoff et al. (1994), the categorical-scope principles are acquired later in development than are the object-scope principles. This pattern of development is also seen in WS from the relative strengths of operation of the principles, albeit with a much slower acquisition path than in normal development.

Lexical constraints can also possibly be acquired more slowly via assimilation of the meaning of words learned from other pre-vocabulary explosion associative principles, in a reverse of the normal learning mechanism. Mervis and Bertrand (1993) demonstrated that the fast-mapping ability does not necessarily coincide with the onset of the vocabulary burst in WS as it does in normals. It is possible that the weaker and later acquisition of lexical constraints in WS is due to this reverse learning mechanism. If constraints are assimilated through development, their operation will not
necessarily correlate with the chronological age of a subject, as other factors, such as verbal IQ and linguistic experience, will have a crucial effect. For the taxonomic bias, which as one of the weakest expressed in the WS group is a likely candidate to develop through this reverse learning mechanism, there is a significant correlation with the verbal IQ of subjects.

Neville et al. (1994) demonstrated that for auditorially presented stimuli different ERP components are evoked in WS than in normal controls. The implication is that functionally and possibly morphologically distinct neural systems could be involved in the linguistic development of WS individuals than in normals. The reason for this distinction could be the auditory hypersensitivity seen in younger WS subjects. Were language systems in WS functionally distinct from those in normal controls, this could explain both the relative preservation and slower development of language ability. The neural systems that underlie the operation of lexical constraints may be damaged and/or disconnected from other important systems in WS, resulting in weaker and later operation.

One can hypothesise therefore that in a longitudinal study of linguistic development in WS, one would find lexical acquisition constraints being expressed to some degree in the same order that Golinkoff et al. (1994) predict, but much later in development and certainly not coincident with other relevant linguistic milestones such as the onset of the vocabulary explosion.

**MAIN POINTS**

- Lexical acquisition principles do operate in WS, but in a much weaker form and with a much slower rate of acquisition than they do in normals.

- Of object-scope type principles, WS show the N3C principle, the mutual exclusivity assumption, but not the whole object assumption. All these principles were demonstrated in normal young children and in much older children than used in previous research.

- Of categorical-scope type principles, WS do not show the taxonomic assumption. This is not due to any difficulty in categorisation, as WS subjects were able to sort objects spontaneously. Both these principles were
demonstrated in normal young children and in much older children than used in previous research.

- There is an indication that the operation of lexical acquisition constraints may have a significant effect on the development of semantic organisation and the acquisition of lexical items in WS.

- There is no evidence that WS individuals show a local-level perceptual bias in reproducing hierarchical stimuli, nor that they "concentrate on the parts rather than the whole." Rather, any problems encountered in this task are due to difficulties in planning and motor control of drawing.

**D.4 OTHER EXPLANATIONS FOR SEMANTIC DIFFERENCES**

It was argued in D.3. that a weaker and later operation of lexical acquisition principles may be implicated in differences in semantic ability and organisation in WS. In the next section, other factors that can account for any differences from normal semantic organisation are discussed. In addition, task-based factors may explain differences between these results and those of previous research. It is essential to note that all explanations are not necessarily mutually exclusive. The interaction of several or all may be relevant to our understanding of WS.

**D.4.1 SOCIAL HYPERSENSITIVITY**

The social hypersensitivity and social anxiety displayed by WS subjects may lead them to attempt to 'over-perform' in the social situation of an experiment. The motivation here would be "I want to impress the Doc". Anecdotal evidence suggests that WS subjects are indeed anxious about their performance on experimental tests. It also indicates that WS individuals are aware that they are relatively skilful in conversation and language related tasks. It would be unsurprising therefore that 'over-performance' is concentrated in their areas of relative ability, such as language.
D.4.2 FACE FIXATION: PROBLEMS IN REGULATION OF JOINT ATTENTION

The fixation for faces that WS individuals demonstrate (Bertrand et al., 1993) may interfere with performance on an experimental task. Again, anecdotal experience suggests that on some tasks it is very difficult to make the WS individual attend to the experimental materials rather than to the experimenters themselves. More importantly, this may also have an adverse effect in development in the regulation of joint attention. As discussed in A.16.4, WS individuals lag in their development in this area (Bertrand et al., 1993). As it is essential that the child attend to an object that is being named in order to acquire that name as a referent for the object, their attentional problems may affect vocabulary development, possibly explaining the early delay in vocabulary acquisition. In addition, auditory hypersensitivity may force WS individuals to attend to the source of the spoken word as well as to that of other sounds, rather than to any relevant visually-presented object. The spoken word is of course seen on the face.

D.4.3 LARGE VOCABULARY SIZE WITH DELAYED LINGUISTIC DEVELOPMENT

Whatever the capabilities of the linguistic systems of WS individuals, it is important to recall that they have been exposed to an amount and quality of linguistic data that is at least roughly equivalent to that experienced by anyone of the same chronological age. Vocabulary size is generally greater than one would expect for IQ-matched controls. The relatively large vocabulary in WS may be a part cause and/or effect of the delay in other features of the semantic development. It gives WS individuals the linguistic capacity to be creative and playful in the words that they choose.

D.5 CONCLUSIONS AND PREDICTIONS

In section D.2, it was seen that the semantic organisation of individuals with WS is normal but delayed, and appears to settle at a level comparable to normal 9 year olds - with two exceptions. For older WS subjects, vocabulary size is closer to that of chronological age controls. For all WS subjects, there is a tendency to over-extend morphological formations where the rule of formation is easily extractable and supported by semantic knowledge; in this, they are like younger normally developing children. No preference was found for unusual words, contrary to that predicted from previous research.
(Rossen et al., 1994). In sum, WS do not show 'bizarre' semantics in the way that the Pinker quotation leads us to expect. Nor, it is argued, do they show intact ability in morphosyntax (Karmiloff-Smith et al., 1997).

In section D.3, it was seen that expression of lexical constraints is much weaker in WS than in normally developing children. Acquisition of the constraint principles is probably much later than in normals. One can predict that in a longitudinal study of acquisition, the constraints will be expressed in the order characterised by Golinkoff et al. (1994), with categorical-scope principles following object-scope principles. Acquisition in WS will be delayed, and not tied to other relevant developmental milestones. Correlations between the production measure of the fast-mapping (object-scope) task and BPVS test ages of WS subjects implicates these constraints in aiding acquisition of new vocabulary items. Real but non-significant trends between the taxonomic bias (categorical scope) and measures of taxonomic organisation of the semantic representation implicates these constraints in possibly helping organise the properties of the semantic representation in WS.

It was argued in section D.2 that the central hyperacusis shown by younger WS subjects may lead to over-dedication of representational space to auditorially presented language. This space may be functionally and possibly morphologically distinct from that dedicated to language systems in normal children. What would the properties of such an over-dedicated space be? Karmiloff-Smith et al. (1997) hint at the possibility of a connectionist account of properties of the linguistic system in WS. They argue that WS individuals are good rote learners, which leads them to have relatively large vocabularies, but much weaker in extracting any underlying rule system to language. In domains of conceptual knowledge too, WS individuals are better at associative learning than they are in extracting underlying systems of rules and building theories from these (Johnson et al. 1994; Johnson & Carey, 1996). Interestingly, this is a property of computational models where a relatively large amount of representational space ("hidden unit layers") is devoted to a particular task (Elman et al., 1996). The implication then is that the properties of the semantic organisation of WS may result from over-dedication of a larger (and possibly functionally distinct from normals) representational space for language, resulting from auditory hyperacusis in early stages of development. As yet, there is no quantitative measure of hyperacusis developed (Marriage, in progress), although one may arise indirectly through
ERP work such as that of Neville. If such a measure is developed, then one may predict that it will correlate with later properties of the semantic system in WS.

Karmiloff-Smith et al. (1997) also note that "WS language follows a different path to normal acquisition and may be more like second language learning". This observation is based on common difficulties that L2 learners and WS individuals share in acquiring systems such as grammatical gender. The syntactic structures that L2 learners have most difficulty with (Romaine, 1992) are also often those on which, on tests such as the TROG, WS individuals are weak (Karmiloff-Smith et al., 1997). The delay that WS individuals show in development of semantic organisation and general language acquisition is significant too. If L2 acquisition is delayed beyond a critical period, then it is not native-like (Johnson & Newport, 1988). One can therefore predict that the properties of the semantic system in late L2 learners will be similar to those shown by WS individuals. Running matched late L2 controls on the experiments in part C may lead to similar results to those shown by WS subjects.

This thesis opposes the view of WS language characterised by the Pinker quotation that opened part A, that WS shows intact morphosyntax and 'bizarre' semantics. The semantic organisation of WS individuals is not 'bizarre'. It is relatively similar to that shown by normal verbal mental age-matched controls, and is delayed in acquisition. Rather than blindly following the gross definition of Pinker, future research should focus on teasing apart the subtle differences that WS individuals do show from normal controls.

**MAIN FINDINGS FROM EACH EXPERIMENTAL SECTION**

- Lexical acquisition principles do operate in WS, but in a much weaker form and with a much slower rate of acquisition than they do in normals. Object-scope type principles precede categorical-scope type principles, as they do in normals.

- WS vocabulary size is greater than that of normal verbal mental age-matched controls, but WS semantic organisation is delayed in development and comparable to those same controls. Semantic organisation is not generally "deviant" or "bizarre", but there are subtle differences from that in normals.
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