A STUDY OF DOMINANCE IN SPEECH PERCEPTION AND PRODUCTION BY GERMAN-ENGLISH BILINGUALS

by

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For Nick
ABSTRACT

The aim of this study was to characterise the concept of language dominance by a detailed analysis of patterns of cross-language influence in bilingual linguistic processing.

The material for this analysis was acquired by testing a group of bilinguals with heterogenous language-acquisition and language-usage patterns in both their languages across a variety of tasks accessing different levels of linguistic encoding and different modalities of language processing. Monolingual controls were also tested in each language.

The test battery included perception and production of vowel duration and vowel quality contrasts; a lexical decision and lexical-level metalinguistic judgment task; a test of global accent and a test of syntactic-semantic performance. In addition, detailed information was collected on the language background and language usage of the bilingual subjects, in order to permit an analysis of the interaction of individual variables with patterns of performance.

The results showed evidence of extensive cross-language effects in all subjects, regardless of the age or circumstances of bilingual acquisition. This interference was also found to be bidirectional rather than unidirectional, with the second language exerting a significant effect on the primary language as well as vice versa. Further findings were that the extent and nature of cross-language influence was variable across different linguistic levels, and that some subjects experienced greater levels of interference than others. It appears that a certain degree of dominance is protective against some aspects of cross-language influence, and that parameters of variation such as duration of residence in each language environment, educational experience in each language and current language usage patterns interact with subject variables in affecting individual performance.

The results are interpreted as contrary to models of bilingualism based on the maturational state hypothesis, but compatible with interference-based models.
ACKNOWLEDGMENTS

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<tr>
<td>AOL</td>
<td>Age of Learning</td>
</tr>
<tr>
<td>CVC</td>
<td>Consonant-Vowel-Consonant</td>
</tr>
<tr>
<td>dB</td>
<td>Decibels</td>
</tr>
<tr>
<td>df</td>
<td>Degrees of Freedom</td>
</tr>
<tr>
<td>F0</td>
<td>Fundamental frequency</td>
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<tr>
<td>F1</td>
<td>First formant</td>
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<td>F2</td>
<td>Second formant</td>
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<td>II</td>
<td>Phonotactically illegal nonword in both languages</td>
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<td>LBQ</td>
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<td>MLE</td>
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<td>VOT</td>
<td>Voice Onset Time</td>
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### Note on individual subject codes:

- Codes beginning 'b' denote bilingual subjects
- Codes beginning 'mel' denote English monolingual subjects
- Codes beginning 'mgs' denote German monolingual subjects

The remainder of the subject code is arbitrary.
### SYMBOLS USED FOR TRANSCRIPTION OF ENGLISH

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## SYMBOLS USED FOR TRANSCRIPTION OF GERMAN

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CHAPTER I
INTRODUCTION AND REVIEW

1.0 INTRODUCTION
The field of bilingualism is both a challenging and rewarding area of study because bilingual speech and language processing differs qualitatively as well as quantitatively from that of monolinguals. This difference affords the researcher the opportunity to investigate some fundamental questions about the nature of language representation and of language-processing systems. Issues of particular interest are:

- how two competing language systems might be organised in the same individual;
- to what extent the two languages form separate systems;
- what form any links between these systems might take;
- how the bilingual manages to effect a separation between the two languages when functioning in a monolingual speech mode;
- whether it is possible to attain native-like mastery of two languages simultaneously, or whether and in what ways each language is affected by the co-existence of the other.

Researchers in the field face numerous obstacles on the path to answering these questions. The very diversity of interest offered by the field of bilingual studies, the multiplicity of the contexts in which people become and remain bilingual and the many ways in which they use their two languages means that the principal difficulty confronting the researcher is how to control and characterise this immense body of variability sufficiently to reach conclusions which have any general validity.

Experimental studies of bilingualism have tended to fall into two main categories, depending on their focus. Some have concentrated on the individual, with his or her unique competence, acquisition history and patterns of language-use. One of the main aims of such approaches has been to develop a multi-faceted characterisation of the individual variability that is such a feature of second-language acquisition and usage. Older models of this type date back to Weinreich (1953) and Ervin and Osgood (1954). More recent experimental studies that have focussed on the
parameters of individual variability include Cutler et. al. (1992) and Hazan and Boulakia (1993).

Other studies (eg. Bohn & Flege, 1993; Flege, Munro & MacKay, 1995a) have focussed to a greater extent on task-based variables, investigating the performance of often large numbers of subjects across different test modalities. Such studies have tended to focus on at most one or two principal subject-based variables such as age of learning, using relatively homogeneous subject groups in whom other possible sources of variance were assumed to be at a minimum.

There has been little consideration of the interaction of the varying types of individual variability with the demands of different types of task, which means that the results from these studies cannot be generalised beyond the particular test-type or subject population used in each case. A study taking both types of variable into account would provide information about the extent to which processing strategies vary with or are constant across individual variability and across different types of task.

The aim of the present work was to develop a set of tests which will permit an overview of subjects' performance across a wide range of modalities and task types, while balancing this experimental data with detailed profiles of individual subjects' language backgrounds and language-use patterns. The information from such a test series, in combination with detailed background material on the language history and language usage of individual bilinguals, would make possible a detailed profile of how patterns of language processing may vary across different levels of encoding and different types of task, and how such variability may be conditioned by the multiple factors within an individual's language background and language-usage.

Several fundamental theoretical questions underlie this investigation. They are stated here in general terms, and will be refined and focussed as the review and discussion progress. The first question concerns the effect on each language system of two languages co-existing in the same individual: to what extent do bilingual speakers behave like monolingual speakers of each of their two languages, and in what ways do they differ? The second question concerns the relative balance of the two languages: if
bilinguals differ from monolinguals, do they do so in a consistent and predictable way, with the categories and standards of one language influencing the other across all levels of speech and language processing?

The thesis of this work is that an adequate characterisation of bilingual competence and performance requires a much more complex and flexible framework than many investigators have allowed for, and that this can be achieved only by a model of bilingualism that can give a coherent account of speaker and test variability to serve as a framework for the interpretation of experimental results.

Before such a task can be attempted it is necessary to undertake an examination of the terms of the discussion, starting with a review and evaluation of the different criteria which have been used to define bilingualism, and a description of the different theoretical models which have been proposed to explain the organisation of two languages in the individual bilingual. This is followed by an account of the dimensions of variation encountered in the field, and a discussion of how they can be taken into consideration in research work. The next two sections provide a review of experimental techniques for the measurement of bilingualism, and of previous investigations into bilingual performance across different levels of linguistic encoding. The final section returns to re-examine the theoretical questions posed above in the light of the body of work reviewed, and to provide a framework and rationale for the experimental studies that form the core of the present work.

I.1 DEFINITIONS
Perhaps one of the most fundamental sources of confusion in the field of bilingual studies is the fact that there is no universally accepted definition of what it means to say that someone is bilingual, nor is there an agreement over the criteria which might form the basis for such a judgment.

One reason for the failure of research to provide a simple definition is the multidimensionality of the field of bilingual studies. Bilingualism is not a purely linguistic phenomenon; its most obvious manifestation is on the linguistic plane, but its causes and effects, both individual and social,
extend into such areas as sociology, economics, politics, education, psychology and neurology, to name just the most obvious. Consequently, researchers from a wide range of disciplines have a direct interest in the bilingual phenomenon and have brought their own investigative interests and the preconceptions and methodology of their research traditions to bear on their descriptions and definitions. This plurality has both advantages and disadvantages: on the positive side, the heterogeneous research backgrounds of workers in the field has meant the accumulation of a vast body of data covering almost every area which could be considered even tangentially relevant to an account of bilingualism. In other words, there exists the potential for taking a view as broad and comprehensive as the subject requires. The disadvantage is that the large and diverse body of information available has in most cases been used only selectively, leading to great disparities in definitional systems and practical criteria used in different research studies. There has been little interchange between workers in different disciplines, and few have tested subjects across different levels of processing or compared results from different experimental techniques. This has in turn meant that the experimental results from such studies may not be directly comparable because of discrepancies in the control of variables.

A major definitional problem in the linguistic dimension has been the polarisation of definitions based on theoretical and operational criteria. Many theoretical distinctions are based on abstract criteria which take no account of language use in the communicative context; conversely, many authors who have engaged in experimental work describe the criteria they used for selection of subjects in terms of that particular study, but do not discuss the theoretical implications of their distinctions or attempt to relate their studies to a definitional system.

In assessing the relative merits of different attempts to define bilingualism it is therefore necessary to consider both theoretical consistency and the realities of communicative language use.

I.1.1 Exclusive definitions
Exclusive definitions of bilingualism have arisen from the recognition that mastery of a second language is a highly variable phenomenon and
that if discussions and studies are to be meaningful, the range of variation must be controlled as far as possible. This has usually meant that only those who meet very stringent performance standards in both languages are considered to be bilingual; for example, those who manifest "native-like control of two languages" (Bloomfield, 1933), or those whose abilities in both languages are considered to be equivalent when measured against each other.

Exclusive definitions of this type are problematic in several ways, for both theoretical and practical reasons. The immediate practical question raised by such stringent criteria is how it might be possible to test whether a subject's performance is equal to that of a monolingual speaker of the respective languages. Tests for determining language ability have been developed, and will be discussed later in more detail; but it is doubtful whether even an extensive battery of such tests could claim to give a reliable picture of an individual's entire language capacity. A truly rigorous assessment of linguistic ability must take into account performance across all modalities, namely speaking, listening, reading and writing, and in all language-use situations; it is hard to see how ability in each of these skills could be reliably compared either to each other or to the performance of other subjects on the same areas. A further difficulty with an assessment of this type is that monolingual speakers also manifest a wide range of performance in these modalities (Bates, Bretherton & Snyder, 1988), further clouding the issue of what constitutes a 'normal' degree of variation.

An additional problem with any definition that entails rigorous testing is the implicit equating of language performance with language competence: the assumption is made that a bilingual whose performance on a particular test item in a given language is not measurably different from the performance on that test item of a monolingual speaker of the same language can consequently be assumed to have the same competence as the monolingual speaker. This seems unlikely in view of the multiplicity of different conditions under which individuals become and remain bilingual; social and psychological dimensions of language acquisition and maintenance have a significance which a purely performance-based account of language cannot account for (Lambert, Havelka & Gardner, 1959; Mackey, 1968; Romaine, 1989). It is in fact highly doubtful whether
the state of perfect language balance posited by exclusive definitions of bilingualism can in fact ever be anything other than hypothetical. If conditions and contexts of actual language use are considered it becomes clear that an individual with exactly equal competence at any given time in all language situations, all subject areas and across all modalities would be a very rare animal; it is hard to imagine a life context in which such perfect balance would be necessary or even achievable. Even when the strong form of this definition is not explicitly adopted, the assumption that only speakers who appear to function as native speakers of both their languages are 'true' bilinguals is very pervasive.

1.1.2 Inclusive definitions
At the other end of the spectrum, inclusive definitions are those which recognise that perfect balance may be illusory, and that an individual's L2 capacity is not insignificant simply because it varies across modalities and topics and diverges in some form from the performance of a monolingual. A strong version of this theory leads to bilingualism being defined as "the ability to produce complete meaningful utterances in a second language" (Diebold, 1964).

Such a stance is also problematic in that it could be taken to include everyone who has the ability to produce a limited range of formulaic utterances in a second language. This would probably cover almost the entire adult population of the world including anyone who had ever learnt a second language at school, or had had personal contact with another language group, however limited their competence. An obvious objection to such an open definition is its use of a common label for the person with a repertoire of a few halting sentences of school French and for someone who has spent an entire working life in another language community and reached a high degree of communicative proficiency. In other words, the absence of any minimal fluency criteria and the concentration on output alone means that such a definition is remote from the primary purpose of language as a means of communication. It does not specify whether the subject has to have an equivalent comprehension ability, or whether the subject's utterance has to be comprehensible to a native speaker of the language; it could in principle
be stretched to include non-communication based linguistic accomplishments, such as knowledge of Latin or Ancient Greek.

I.1.3 Function-based definitions
On the basis of the pitfalls of these two extremes it is clear that the minimal requirements are to find a definitional base which is sufficiently sensitive and rigorous to allow for such distinctions as may be required by theoretical systems and practical expediency, but which also has a strong base in the functional descriptions of actual language behaviour and so can avoid the sort of *reductio ad absurdum* outlined above.

Mackey (1968), following Weinreich (1953) defines bilingualism as "the practice of alternately using two languages"; similarly, Grosjean (1989) defines bilinguals as "people who use two or more languages in their everyday lives". This operational approach has several advantages over other more abstract definitional systems. It implies a bilingualism arising from a communicative need to use both languages, and a corresponding ability to do so at a satisfactory level across the modalities necessary for communication to take place. For operational purposes it provides a loose but flexible framework within which other factors relevant to the acquisition, competence and use of language may be measured and evaluated.

In practice, the kind of criteria adopted in selecting 'bilingual' subjects for experimental study vary widely, depending as much on the locality in which the study was conducted and on the characteristics of available subject populations as on theoretical foundations. For example, US-based studies of Spanish-English bilinguals may include immigrants who became bilingual in adulthood, after their arrival in the US and/or the children of immigrants, growing up in the US who can be considered childhood bilinguals (Bohn & Flege, 1993). Studies of French-English Canadians are similarly influenced by the pattern of language acquisition of the subject population: Caramazza et. al. (1973) stipulated that their subjects should have begun to acquire the second language by the age of seven, which would include speakers who learnt the second language at school rather than through exposure at home. Some studies simply selected their subjects by a variety of diagnostic tests in both language,
without controlling for age or circumstances of acquisition, but usually with some stipulation that both languages should be in regular use (e.g. Mack, 1989; Williams, 1977).

There is also a tendency in more recent studies to use the term 'non-native' or 'L2 learner' for listeners or speakers for whom a single primary early language could be identified, regardless of the age at which the second language was introduced (Flege, 1995; Strange, 1994; but cp. Hazan and Boulakia, 1993). This terminology, while it shifts the emphasis from the state of being bilingual to the process of becoming bilingual, does not necessarily imply that the type of subject population being studied is significantly different. The subjects used by Flege (1995) included some who had immigrated to Canada from Italy at a very young age, and who identified English as their language of principal use at the time of testing; all had a functional use of both languages, and would have been classified as bilingual in the terms of many other studies. The advantage of terms such as 'L2 learner' is that they imply a dynamic process in which language-use and language-acquisition are productively linked, and that they allow for the possibility of a change in usage patterns in the course of an individual's language history. The principal disadvantage of this usage is that it implies that those childhood bilinguals for whom no primary early language can be identified are necessarily qualitatively different from those who acquire a second language at a later stage in their development. This is of course an important theoretical point, which is discussed in more detail later (Section 1.3 below).

For the purposes of the present study, bilinguals were defined in terms of their overall communicative competence and patterns of language use, rather than according to strict biographical or performance criteria. Precise details of the selection criteria and the subject population are given in Section III.2 below, but it included both childhood bilinguals as well as later learners who had reached a very high standard of fluency in the second language. Another important criterion, which is all too often ignored, was to include only those who at the time of testing were active bilinguals, in other words, were using both their languages to communicate with native speakers on a regular basis.
The adoption of these functional criteria served practical as well as theoretical purposes, since it avoids making the assumption that later learners are inherently and inevitably different from those subjects who acquired both languages in childhood, while enabling a practical distinction to be made between those subjects who regularly function in a monolingual environment in both languages and those who have learnt a second language in their native-language environment without being massively exposed to native-speaker input in the target language. Although translating these considerations into practical selection criteria is not always entirely clear-cut, it is hoped in this way to avoid the pitfalls of both extremes of inclusive and exclusive definitions.

I.2. MODELS OF BILINGUAL REPRESENTATION

The range of normal (i.e. non-pathological) patterns of language use among monolinguals is relatively homogenous in comparison with that of bilinguals (Larsen-Freeman & Long, 1991): children acquiring L1 in a monolingual community are generally subjected to similar patterns of language exposure and follow similar patterns of language development. They are exposed to language use across all modalities (comprehension, speaking, reading, writing) and acquire competence in the use of language in a full range of situations (domestic, social, professional etc.). In bilinguals, as described above, the range of variables is much greater, leading to more, and more complex, permutations of types of language behaviour.

This complexity has led to the problem of how to give a theoretical account of bilingualism, and in particular the issue of whether bilingual behaviour is qualitatively different from that of monolinguals or whether the difference is merely quantitative and bilingual competence can be regarded as the sum of two monolingual competences. There is a body of evidence which suggests the latter is not the case, and that some of the assumptions and distinctions made by linguistic theory with regard to the acquisition and use of one language may not be appropriate for discussing the case of the bilingual. In particular the traditional distinction between competence and performance may not be helpful. Bilingual (as monolingual) studies have tended to choose approaches based on one or other of these aspects, either the Chomskian attempt to account for
performance through knowledge and theory of competence, or the recently revived observation-based approach which accounts for competence by examining output speech (Romaine, 1989). However, for bilinguals the relationship between competence and performance is more complex than it is for monolinguals, if indeed the distinction is valid at all. Because of the great variety of factors influencing the processes of becoming and being bilingual, it is not safe to assume that two speakers whose performance on a particular measure seems to be equal have the same mental representation for this item or process (Kolers, 1968; Grosjean, 1989).

One model of bilingualism which does attempt to relate competence and performance is that of 'compound' and 'co-ordinate' bilingualism, which can be traced back through various versions to Weinreich (1953). The principle of this model is that bilinguals may be classified according to the mental representation of their two languages. Framed in the terms of Saussurean structuralism, the theory posits two principal kinds of bilingualism which are the mental correlates of different modes and circumstances of acquisition:

Type A (co-ordinate)
A bilingual of this type would have separate sets of signifier and signified for each of the two languages involved; ie. words which were translation equivalents in each language would have separate mental representations. Such a person would function as a monolingual speaker of either language. Typically co-ordinate bilingualism is the result of learning each language in a different country and/or circumstances.

Type B (compound)
A speaker of this type has a single semantic representation for equivalent lexical items. Such a speaker would not function exactly as a monolingual speaker, although the discrepancy might be apparent only under certain circumstances. (Paradis, 1977) gives an example of a situation in which compound and co-ordinate speakers with high levels of mastery of both languages would function differently: in response to the translation equivalent sentences 'Bring me all the books that are on my desk' and 'Apporte-moi tous les livres qui sont
sur mon bureau', a co-ordinate English-French bilingual would bring books, notebooks and exercise books in the first instance, and printed books (livres) only but not notebooks or exercise books (cahiers) in the second, thus demonstrating an awareness of the different referents of the English and French nouns. A compound bilingual would apply a fused or intermediate system which would be identical in both cases. Typically an individual who learns both languages in the same environment would become a compound bilingual.

The original theory also made provision for a third type of bilingualism, which was not considered to be 'true' bilingualism:

**Type C (subordinate)**
According to Weinreich, individuals in this category are those who access items in the second language through their representations in the first language. Such a speaker would not function in any way as a native speaker of the language.

The distinction proceeds from Weinreich's extensive analysis of 'interlingual identification', the process whereby a speaker superimposes the distinctions of the native language onto a second language and mistakenly identifies different signs as equivalent. In Weinreich's analysis this process operates at all levels: phonological, syntactic and semantic, and Weinreich recognises that a given speaker's system may contain a mixture of compound and co-ordinate elements distributed differently across levels of encoding. This state is however seen primarily as a transitional stage, towards 'true' bilingualism which is defined as a co-ordinate system.

Ervin & Osgood (1954) reinforced this tendency by conflating the categories of compound and subordinate, implying that only the co-ordinate is a 'true' bilingual. Moreover, they concentrate on the semantic level at the expense of the phonological, lexical or syntactic, and consequently ignore the possibility that different types of representation might exist simultaneously in one speaker at different levels of encoding and that these may even influence each other. However, they do make a closer link between mode of acquisition and type of representation, recognising that a compound-subordinate representation would be the typical result of
learning an L2 in a school environment where processes like memorising vocabulary lists encourage the speaker to equate signs from L2 with those from L1 or in the case of subordinate bilingualism, to access L2 through the lexicon and structures of L1.

The compound/co-ordinate distinction is open to numerous criticisms. The system fails to acknowledge the numerous and complex varieties of situation which may lead to bilingualism and which may prove a simple two-state model to be inadequate, especially for late learners or for childhood bilinguals with complex patterns of language-use. There is a lack of empirical evidence for a direct causal connection between mode of L2 acquisition and the representation of languages in the brain (Diller, 1974). Weinreich's original theory stressed that different levels of language encoding would vary in the degree of compoundedness or co-ordinateness, which was regarded as a continuum; some subsequent writers have taken a discrete view of the hypothesis. A unidimensional model would seem too simple to capture the complex varieties of language behaviour, while on the former model it is unclear how different speakers' varying compoundedness could be measured and placed on the continuum.

At the same time there has been increasing awareness that a full account of bilingual language processing requires a combination of different types operating at different levels, since a bilingual's ability to distinguish his or her two languages and use each one with at least the appearance of functional autonomy necessitates an account at some level of the separateness of the two systems, just as the variety of cross-language influence effects requires an account of their relatedness.

More recent models of bilingual acquisition and competence have tended to concentrate on characterising the nature of language cross-influence, usually focussing on the effects of L1 on L2. Perhaps the best-known of these models is the Interlanguage hypothesis (Selinker, 1972; 1992). Interlanguage is defined as the language system which the individual learner constructs as a result of the interaction of his or her native language with the L2 input to which he or she is exposed. Interlanguage is assumed to be systematic, and dependent on the particular characteristics of the native language and target language, which will be common to all
learners of a particular L2 who share a given language background, as well as on the specific learning experiences of the individual.

The interlanguage hypothesis is perhaps the most broadly-based of the models of second language learning, in that it is formulated to be applicable to all levels of linguistic encoding; however, in practice, the focus of interlanguage studies has tended to be on syntactic and lexical aspects of language acquisition. Studies of the phonological level within the second language acquisition framework have mainly been conducted using observational/judgment techniques rather than analysis of the acoustic dimensions of speech production and perception (Neufeld, 1979; Oyama, 1976; Major, 1987). Models which focus more closely on the phonetic-phonological level, such as Best's perceptual assimilation model (Best, 1994) and Flege's speech learning model (Flege, in press) share some of the fundamental premises of the interlanguage model in assuming that L2 acquisition is systematic, and that the respective characteristics of both languages will affect the ways in which non-native phonological units are perceived. These models are discussed in more detail in the relevant sections.

One common feature of most models of second language acquisition and the studies based on them is their primarily unidirectional focus. Despite occasional references to the possibility of L2 to L1 transfer (eg. Trudgill, 1986), language influence is equated with the influence of L1 on L2. in many studies, no attempt is made to investigate learners' performance in their L1; other studies with a more bilingual focus which do test subjects in both languages did not test control subjects in both languages as a basis for comparison (eg. Altenberg & Cairns, 1983).

This selective focus springs from and perpetuates the assumption that the primary early language provides the stable base on which all subsequent language experience is built and that, except perhaps in the particular case of childhood bilinguals, the first language will always remain the stronger, and will dominate any other language(s) which the speaker may acquire. The primary focus of the present study is the investigation of language cross-influences in both directions, including the possibility that the relative balance of the two languages might be subject to changes for some individuals and some levels of language encoding. Central to such an
investigation is an account of the dimensions of variability in the ways in which individuals become and remain bilingual.

1.3 Dimensions of Bilingual Acquisition

There are specific factors governing the ways in which individuals become and remain bilingual which, although they may not have obvious performance correlates, have nevertheless been shown to influence language processing, and which admit more variation in bilinguals than in monolinguals. Even if it is not possible to give as structured an account of such dimensions as was hoped by the behaviourists, much less suggest direct causation between circumstances and language performance, these aspects do need to be considered systematically as variables, or controlled in experimental work.

1.3.1 Age of Acquisition

One of the most commonly-cited factors governing the degree of bilingualism an individual will acquire is the age at which the second language is acquired.

Age of learning (=AOL) has been shown to be a significant factor in many aspects of bilingualism, and its effects are particularly pronounced at the phonological level, both in speech production, where interferences are manifested as 'foreign accent' (see, for example, Flege & Eefting, 1987; 1988; Flege 1991; Flege & Muromoto 1995b) and in speech perception (Werker & Tees, 1984). Indeed, it has been suggested that late learners (variously defined as post-puberty, though some studies cite an earlier cut-off age) may never acquire perfect mastery of all aspects of an L2 (Barry 1981; Flege & Hillenbrand 1984; Mack 1989).

Two main theories have been put forward to account for this phenomenon:

(i) Maturational State Hypothesis

This hypothesis states that there is a 'critical period' for language learning (Lenneberg 1967; Scovel 1969; 1988) during which a child's innate language-learning capacity is ready to be exploited, and that
successful language-acquisition (ie to native-like standards) cannot take place after the upper age-limit of the critical period has been passed.

A wide body of evidence exists which supports this theory by showing that infants possess an ability to discriminate certain non-native contrasts which has been lost in adults. Although the original exponents of the hypothesis thought that the loss might be due to neural atrophy of certain feature detectors in the brain, more recent research suggests that the disappearance of this sensitivity in older individuals appears not to be a sensory loss, since it seems to be possible to acquire non-native contrasts through training (Werker & Logan, 1985; Jamieson & Morosan, 1986; Logan, Lively & Pisoni, 1991; Lively, Logan & Pisoni, 1993), but rather represents a focusing on the categories of the native language to the exclusion of irrelevant non-native contrasts. However, opinions vary on the upper age after which such sensitivities are lost. Lenneberg's original (1967) suggestion was that puberty formed the upper limit of the critical period; however, several studies have shown that sensitivity to some non-native contrasts may be lost as early as 12 months (Werker & Tees, 1984). Flege et. al. (1995) found a continuous effect of AOL for production of English contrasts, with subjects whose AOL was as low as 9 years, and who had lived in an English-speaking country for at least 25 years, deviating significantly from monolingual standards in their output. However, these effects may be specific to the particular test used in each case, since there is conflicting evidence that for other non-native contrasts adults may manifest superior discrimination to infants (Polka & Werker 1994).

However, the importance of AOL as a factor in L2 acquisition does not necessarily imply support for the maturational state hypothesis, since an alternative analysis is also possible:

(ii) Interference Hypothesis
This hypothesis proposes that the capacity for language learning, rather than decaying irretrievably with age, is hampered in the later learner by the greater mastery of the L1. The implication is that acquisition of the L2 system presents difficulties because the new system must compete with the more established L1 system. The ultimate degree of
attainment in the L2 depends on the relative strength and characteristics of the two systems.

The most salient difference between the two theories lies in the implications for the co-existence in the individual of the two language systems. The maturational state hypothesis predicts that, for a later learner, the L1 will be unaffected by mastery of the L2, and will always remain the stronger and that L2 acquisition is ultimately limited, however extensive the degree of exposure to the second language. The interference hypothesis, with its co-existence model, implies that the initial disadvantages of the L2 may be overcome for some individuals and for some aspects of language competence given the right conditions; it also predicts that increasing mastery of L2 will be accompanied by a change in the way L1 is processed.

This last prediction is of particular importance for a model of language dominance, since it allows for the possibility of bi-directional cross-language influence, and hence for possible changes in the language competence and performance of the individual.

1.3.2 Mode of acquisition

In the particular case of childhood bilinguals, a dominance model of the latter type, which allows for the influence of both languages on each other, rather than a uni-directional model, in which L2 is only and necessarily affected by L1, is particularly appropriate.

Under the influence of older versions of the maturational state hypothesis, it was previously often assumed that, as long as a child had acquired both languages before the age of 12, competence in both would become equally established, and each system would be free from interference by the other. However, in the light of more recent evidence showing that a variety of AOL effects may apply from very early in the linguistic development of the individual, a closer look at the various ways in which children may become bilingual is warranted.

The two principal modes of childhood dual-language acquisition may be summarised as simultaneous or successive (McLaughlin, 1984). Each of
these modes is also likely to entail different environmental and social factors, which may also influence the types of competence ultimately achieved, and will be considered separately below.

(i) Simultaneous Acquisition

The most exhaustive studies of children acquiring two languages simultaneously are observational in nature, often carried out by linguists observing their own children's development, with all the concomitant problems of reliability and control entailed in one-off studies. Details of the language development of the individual children are therefore probably not suitable for generalisation, but there are general points of agreement which suggest that the acquisition process for the bilingual child is the same in its basic features and in developmental sequence as for the monolingual child. It is often the case that when a particular feature (whether phoneme or syntactic structure) is simpler in one of the languages than in the other, then the simpler form, was acquired first and used in both languages. However, this is a tendency not a rule and is heavily dependent on secondary factors like relative strength of the two languages at the time that particular feature was acquired.

It seems that the child initially employs a single set of rules and heuristics for items in both languages (Leopold, 1939) and that sounds, lexical items and formal structures gradually become more differentiated as the language capacity and general cognitive ability develops. Authors differ in their judgment of the age at which the child became aware of using more than one code: the lowest estimate is 1;6 (Ronjat, 1913) while the upper limit indicating the age by which all the children studied had achieved this awareness is 3;6 (Leopold, 1949; Ruke-Dravina, 1967). Differences in the criteria used to measure awareness may account for this variation. Once awareness of two codes is achieved, separating them seems to present much less difficulty for the child than for the adult learner, and a level of performance matching that of monolinguals in each of the languages can be achieved fairly quickly (McLaughlin, 1984).

However, the final degree of separation between the languages seems to be heavily environmentally determined. In other words, the young
learner has the potential to achieve high separability and concomitantly low levels of interlingual interference, at least at an observational level, but this potential will not necessarily be realised if the circumstances are unfavourable.

Successful separation seems to be heavily dependent on the 'who speaks what to whom' factor. With the reservations mentioned above about the observational nature of the material, it seems that separation will be maximised if (a) the respective spheres of use of each language are clearly defined and (b) both languages are used on a regular basis (Ronjat, 1913; Pavlovitch, 1920). In practice this means that children are most likely to achieve monolingual-like standards in both languages through consistent adherence to the one parent-one language principle. A situation in which one language is spoken in the home and another outside typically leads to a greater degree of interference (Ruke-Dravina, 1967). The greatest amount of interference occurs when mixed speech is the norm of the child's language environment (Burling, 1959).

(ii) **Successive Acquisition**

McLaughlin (1984) defines the cutoff point for simultaneous acquisition at 3 years, maintaining that a child who begins to acquire a second language after that age has such a head start in L1 that the two acquisition processes can no longer be said to be truly simultaneous. There are individual variations in the way in which learners acquire the structures of a second language (Hakuta, 1974). The amount of interference depends on similar factors to those that operate in simultaneous acquisition, principally the environment in which each language is used, the amount of contact with the L2 and whether or not the L2 is used in the home.

The key finding from both simultaneous and successive acquisition which has implications for models of language acquisition is that the relative balance of the two languages is not necessarily stable, so that even where apparently native-like mastery has been achieved in both languages the pattern of interference may change very quickly with a change in circumstances. It further shows that such interference is bi-directional and that the pattern of relative strengths and weaknesses may change several
times in the course of a child's acquisition, depending on environmental and social factors (Leopold, 1939; Ruke-Dravina, 1967; McLaughlin, 1984). This finding supports the reservations discussed above about the maturational state hypothesis, since it is clear that childhood acquisition does not necessarily result in lasting interference-free output in adulthood.

1.3.3 Experience

One important disadvantage of the maturational state hypothesis is that it is relatively inflexible in the explanations it allows to account for the varying degrees of success experienced by learners whose circumstances appear to be very similar. One factor which has a strong influence in adult as well as child learners on the successful mastery of L2 features is the degree and duration of exposure to the target language. For example, studies of /r/ and /l/ processing among Japanese learners of English have shown significant differences between experienced and inexperienced learners for both perception and production tasks (MacKain et. al., 1981; Nakauchi, 1993; Flege, Takagi & Mann, 1995), and similar findings are reported for a range of different contrasts and different language pairs (Bohn & Flege 1990; Flege 1995; Flege, Munro & MacKay, 1995a); however, Flege (1995) also showed that long exposure to L2 was less of a factor in determining performance than age of acquisition.

Intensive training may also facilitate the acquisition of new phonological contrasts: Tees & Werker (1984) found that after 5 years' Hindi language instruction English learners were able to discriminate place and voicing contrast in stops, whereas first-year learners discriminated only the voicing contrast. In addition it seems that even short-term training may produce an improvement in function which results in a long-term change in perception (Logan et. al., 1991).

1.3.4 Ultimate attainment

Variation in these dimensions is assumed to affect the final competence attained by the individual. Ultimate attainment is often described in terms of how native-like each of the language systems is (Larsen-Freeman & Long, 1991); however, as discussed above (Section 1.1.1) this is difficult or
impossible to measure for all modalities of speech, and may in any case not be the the most appropriate standard.

A more promising approach, in that it permits a consideration of the balance of the two languages relative to one another, as well as a comparison against monolingual norms where appropriate, is the concept of dominance. Central to the notion of dominance is the idea of an imbalance in the patterns of language cross-influence; an individual who is dominant in one of his or her languages shows a significantly greater influence of that stronger language on the weaker one.

Some authors have used the terms balanced and dominant to describe the intuitive categories of fluent and non-fluent respectively. To the extent that an individual's competence in L2 is not approaching native-like on any level or modality it is probably fair to describe that person as dominant in L1. However, with regard to bilinguals performing at a high (though not necessarily equal) level in both languages, the dominant/balanced distinction becomes more contentious, since patterns of language cross-influence may be highly complex, and performance on particular measured variables cannot be assumed to be representative or predictive of performance on other modalities.

One study has used the concept of dominance as a post-hoc criterion for subdividing a group of highly fluent bilingual subjects on the assumption that, however equal performance in both languages appears, one language is primary in determining which of two competing strategies will be applied to situations where processes differ across languages (Cutler et. al., 1992). In this instance, dominance was defined along a single feature, namely subjects' response to a forced-choice decision as to which of their two languages they would retain if they had to lose one. The results showed that dominance, as defined by these criteria, correlated with subjects' sensitivity to language-specific syllabification categories, and the authors concluded that some aspects of language processing were invariably monolingual in nature, with individual subjects' dominance determining their use of syllabification strategies in speech segmentation. However, further attempts to correlate this definition of dominance with other biographical features of the subjects' language acquisition and usage were unsuccessful, and it seems likely that a definition of dominance
along these lines admits too many uncontrollable variables to make it reliable.

A similar result was reported by Hazan & Boulakia (1993), who studied the perceptual weighting of spectral cues to the voicing contrast in French-English bilinguals, and showed that language dominance was correlated with individual subjects' sensitivity to vowel onset characteristics. However, the definition of dominance used in this study was far more comprehensive than that of Cutler et. al. (1992), taking into account factors such as AOL and experience, which have been shown to have a decisive influence on subjects' performance, as well as taking into account less objective measures such as subjects' self-assessment of the relative strength of their languages, and the languages used for certain highly automated functions such as counting and swearing. The use of this more objective definition of dominance, which takes into consideration variables in individual language-history profiles, is clearly preferable to the more nebulous criterion of Cutler et. al., which located dominance solely in the preferences of the individual.

A large-scale study of Italian learners of English found that the variable which most closely correlated with subjects' performance was AOL (Flege, Munro & MacKay, 1995a; Flege 1995), and concluded that a multidimensional dominance profile based on that of Hazan & Boulakia (1993) offered no advantages in terms of explaining and predicting the performance patterns of individuals. However, the subjects in this study were a relatively homogeneous group (Italian immigrants to Canada), among whom AOL was probably the most significant single variable. Among less homogeneous groups of subjects, manifesting a wider range of language-acquisition and language-usage patterns, other aspects of a dominance scale might assume more significant proportions.

The ultimate focus of the present work is to identify some of the correlates of dominance in order to test its validity in characterising the types of competence a bilingual may acquire within the framework of his or her language background and particular patterns of language use.
I.4 MEASUREMENT OF BILINGUALISM

I.4.1 Performance measurement
Early approaches to quantify and characterise subjects' performance in both languages were based on attempts to find measurable correlates of variations in fluency. Lambert, Havelka & Gardner used the term "automaticity" to describe the intuitively satisfying distinction between "the linguistic behaviour of those using a language with fluency in contrast to the hesitancy of others beginning the study of a second language" (Lambert, Havelka & Gardner, 1959). The principal correlate of automaticity used in assessment was reaction time across a range of language-based tasks, such as word-recognition, verbal response set to linguistically ambiguous items, and facility in translation. The combined results of such test series were collated to give a comprehensive picture of the individual's language ability (Mackey, 1968).

Although many of the tests used for building up these speaker-hearer profiles are still used, less extravagant claims are made about the ability of test batteries to give a complete picture of a subject's linguistic competence. There is an increasing awareness that performance on a given task may not be generalisable to other tasks. A cautious note was being sounded by Macnamara as long ago as 1969, when he observed that "before setting out to obtain measures of bilingual proficiency it is necessary to determine the purposes for which such measures are required. The reason is that proficiency in a language and a fortiori in two languages is not a single skill but a combination of numerous skills and therefore it is necessary to bear in mind clearly which skills one wants to evaluate" (Macnamara, 1969).

I.4.2 Measurement of indirect factors
An awareness of the shortcomings of performance tests was matched by increased interest in the measurement of other factors affecting language-use. Even in the heyday of behaviouristic research there was a suggestion that more complex acquisitional, cultural and social factors, which are not easily reduced to a set of test scores, might play an important role in determining and influencing language ability and language use. However,
a recurring problem has been how these more elusive factors can be captured and measured.

Weinreich recognised that what he calls "extra-linguistic factors" play a significant part in any account of language capacity and language use. Initially it was hoped that these factors could be easily quantified. The finding that such tests could distinguish "subjects whose language-histories suggested probable differences in their comparative linguistic skills" led to the conclusion that there was a close correlation between language performance and language history and that the relationship between them was so close that no separate account needed to be given (Lambert, Havelka & Gardner, 1959). Subsequently there have been many attempts to quantify these factors in the interests of better-controlled experiments (Macnamara, 1969) and of determining their influence on language ability (Mackey, 1968). The grouping of these factors varies between authors, and there are differences in terminology.

The measurement of background variables is clearly far more complicated than measurement of performance, since far more variability is involved with fewer obvious behavioural correlates, and there is more argument about which levels of each variable should be admitted. In Mackey's model, the uses to which the bilingual puts the languages are determined by the number of areas of language contact on the one hand, and the duration, frequency and pressure of these contacts on the other. Areas of contact are divided into the principal categories of 'home', 'community', 'school', 'mass media' and 'correspondence', each of which may be subdivided further. Subjects' responses in each of these categories are combined into a scoring system, which is intended to give a comprehensive view of the environmental, social and affective factors influencing the language-use of individuals.

The problem inevitably besetting this and similar measurement attempts is the accusation of arbitrariness. It is relatively easy to see how one might document the frequency and duration of language-contacts undergone by a subject over a limited period, but it is less certain how such a measure could be extended over the whole of the speaker's lifetime, nor how the relative importance of different periods of exposure in determining language competence could be assessed and weighted as it would need to
be if it were to have any meaning in explaining how the subject came to possess the competence that he or she has. Observational longitudinal studies of bilingual children acquiring language (e.g. Leopold, 1939 etc.) give some idea of the interplay of social, emotional and locational factors which play a part in governing the language behaviour of bilingual children, and underlines the difficulty of capturing the subtle interplay of influence and performance. Furthermore, it is questionable whether it is possible to represent a complex and abstract factor like linguistic behaviour in terms of numeric values for each of a number of discrete components. How far, for example, the cultural factors which make a language more prestigious than another can be distinguished from the economic, political and historical factors may be open to question. More recently the importance of these factors in predicting subjects’ performance on perception and production tasks has been questioned (Bohn, in press).

1.4.3 Individual variability
Many studies have also attempted to take account of those aspects of an individual’s language capacity which are deemed to proceed from internal factors rather than through the influence of external social and cultural factors. Factors shown to be of relevance here include intelligence, attitude (Gardner, 1980; Hermann, 1980), aptitude (Carroll, 1981) and motivation (Burstall, 1975). However, it seems likely that individuals may vary inherently and unpredictably in the way they make use of the information present within speech (Hazan & Rosen, 1991).

In general it is clear that the factors mentioned above are relevant to language capacity, but they are not of primary interest to the study of bilingualism, since individual characteristics affecting a given subject’s language capacity will affect all languages spoken by that individual, and will affect monolingual speakers of the language as well. Such factors do not therefore contribute to an account of differential language ability in one individual. However, the potential role of inherent variability must be borne in mind in any evaluation of bilinguals' processing abilities, since it implies that not all inter-subject variation will be attributable to external factors, and that some individuals may be inherently more likely to acquire new linguistic categories and patterns than others.
In summary it may be said that it seems there is a need to integrate a set of rigorous performance assessment criteria with a recognition that language cannot be analysed without due regard to the context in which it is used, and that a wide range of affective factors underlie output performance.

I.5 LEVELS OF LINGUISTIC ENCODING
The different encoding levels vary in their accessibility to linguistic, psychological and neurological experimentation. A wide range of techniques of differing degrees of abstraction have been used to extract information about processes at various points in the encoding hierarchy; thus, the results obtained are subject to the variability inherent in trying to measure different levels of a complex phenomenon using the methods appropriate to each.

I.5.1 The syntactic level
A great deal of research has been done in the field of syntactic-level second language acquisition (see, for example, Larsen-Freeman & Long, 1991; Selinker, 1992). However, much of it does not lend itself well to an investigation of bilingualism, since it focusses on the acquisition of particular structures in the target language rather than enabling a comparison of performance across languages.

One study which is more directly relevant to bilingualism is that of Patkowski (1980), in which transcripts were made of 5-minute extracts from the spontaneous speech of non-native speaker immigrants to the United States, as well as of a small number of native speakers. These transcripts were presented to native speaker judges for rating of the global syntactic proficiency of the subjects. The results showed a significant age of learning effect, with subjects who had arrived in the US before puberty being rated at the same level as the native speakers, while those who had immigrated after puberty performing at a lower level than the native speakers. The results are interpreted as evidence of the existence of a critical period for syntactic-level language acquisition.

However, this study is open to some criticisms, since the ratings were based on the opinions of only two judges; it seems likely that a larger
number would be needed to ensure that the judgments were reliable and representative. Another potential problem is the difficulty of separating the lexical and semantic features of the utterances from the strictly syntactic; it seems likely that the judgments were based at least partly on the lexico-semantic features of the transcripts as well as the grammatical.

1.5.2 The lexical level

There is a large body of research into lexical storage and retrieval, since this level is relatively accessible to experimental investigation of cross-language influence in all four language modes (speaking, listening, writing, reading) using several basic techniques. The experiments draw upon several aspects of lexical behaviour, principally:

- lexical access (how the speech stream is segmented into word units);
- denotative meanings and their storage;
- connotative meanings and storage of associations.

Early studies in this area used these tests as part of an attempt to determine whether two languages had joint or separate representation in the brain. Apart from the obvious objection that information about lexical level processing cannot necessarily be extrapolated to other levels, the experimental evidence suggests that, even at the lexical level, both extremes of independence and interdependence are untenable.

The hypothesis of complete separateness is easily disproved by the bilingual's ability to translate from one language to another, an ability which presupposes some kind of cross-language connection. Experimental evidence has demonstrated an equivalence effect on short-term memory for lexical items and their translation equivalents (Kolers, 1966a, Lopez & Young, 1974); lexical decision tasks have shown that cross-language links exist at the lexical level (Soares & Grosjean, 1984). Further it appears that these links are at some level not under voluntary control and that the 'latent' language maintains a residual level of activation at all times, even when it is not appropriate to the current task (Hamers & Lambert, 1972; Hamers, 1973).
The hypothesis of joint representation for lexical items is contradicted by the mass of observational and experimental evidence showing that language-specificity does operate at various levels. It has been demonstrated that association patterns to common lexical items are different in each of the bilingual's languages (Kolers, 1968; Ruke-Dravina, 1971). In free recall and word association tasks, intra-language links have consistently been found to be stronger than inter-language associations (Kolers, 1963; Macnamara, 1966; Lambert et. al., 1968; Taylor, 1971).

Once seen outside the construct of a rigid independence-interdependence dichotomy, these ambiguous findings are not mutually contradictory, but point to the need for a comprehensive 'joint system' account of language processing. The 'extended system' regards separateness/jointness as varying continuously along different dimensions of levels and processing so that, for a particular part of a given task, the representation or process may be more or less separate.

There are several basic types of experiment which have been used to investigate the lexical level of storage and processing in bilinguals. The studies need to be viewed specifically in the light of a more complex model, to see which subprocess of which encoding levels are being examined and how they contribute to the overall pattern of activity, rather than being regarded as explanations of language behaviour in their own right.

(i) **Lexical Decision**

One technique which has been used to gain information about various aspects of lexical storage and processing in bilinguals is that of lexical decision or word-naming. Exact experimental protocol varies, but the basic process involves measuring the speed and efficiency with which subjects decide between words and non-words and using this information to make hypotheses about how words are stored in the brain. The assumption is that a longer decision time for bilinguals over monolinguals reflects joint storage as items from both languages are searched, while comparable reaction times for bilinguals and monolinguals implies separate storage, with only one lexicon being searched (Soares & Grosjean, 1984; Altenberg & Cairns, 1983).
There is evidence that bilingual lexical processing involves both types of search. Kirsner et al. (1984), in a series of experiments designed to compare monolingual and bilingual performance on tasks of this type found that where the bilingual nature of the exercise was not mentioned and translicative activity was not required there was no significant difference in performance that could be attributed to bilingualism; as in the word-association tasks, intra-language links were found to be stronger than inter-language links. However, in conditions where translicative activity was required, significant interlingual transfer did take place. These results are interpreted to mean that jointness of storage/processing may be a task-dependant variable. However, the relevance of these findings may be restricted to the circumstances in which they were elicited, namely the visual presentation of isolated nouns.

Another study (Soares & Grosjean, 1984) designed specifically to investigate the performance of bilinguals under various 'speech modes' used a lexical decision task in which the stimulus words were embedded in either same-language or different-language carrier sentences. It was found that in the monolingual (English) condition bilinguals were as fast as monolinguals in responding to English words but significantly slower in responding to non-words. The authors interpret these findings to mean that the latent language lexicon is not activated when confronted with a real word in the active language, but that the latent language lexicon is searched in response to a non-word. In a bilingual condition where a word from language B was inserted into a sentence in language A the bilinguals also took longer to reach a decision than they did in the monolingual condition, while the reaction time of bilingual subjects to non-words was identical across all conditions. This result was taken by the authors as confirmation of the hypothesis that the base-language lexicon is searched first.

Other research indicates that these two speech modes (bilingual and monolingual) for lexical access are not to be understood as discrete states, and provides some further suggestions about the type of factors which may influence heuristic processing strategies. The existence of states of dual-language activation intermediate to the monolingual and bilingual was shown by Hamers (1973) in a series of experiments using semantically ambiguous English and French homographs (eg. the lexical item PAIN
which occurs as a printed word in both English and French, with a
different meaning in each). Subjects were asked to give an associate to the
printed stimulus word, a task which entailed making a lexical decision
and assigning the word to one or the other language, in a variety of
conditions. Cross-language interference (defined as an associate mediated
by the latent language) was found to be greatest when the stimulus was
presented in isolation; instructing subjects to decode in one language only
or keeping them in ignorance of the bilingual nature of the test did not
reduce the number of associates mediated by the latent language. At the
other extreme, cross-language effects were almost totally eliminated when
the stimulus was accompanied by a verbal language-tag such as an article
(LE/LA or THE). This is in accordance with the findings described above,
that the base language lexicon is searched first and the search only
extended to the latent language if no matching word is found (Soares &
Grosjean, 1984). However, intermediate levels of cross-language
interference were elicited by using non-verbal cues to language of
presentation, such as colour-coding the print for a particular language.
This and similar non-verbal techniques were not as successful as a verbal
language-tag in eliminating semantic decoding through the latent
language, but they did reduce interference in comparison to the condition
where subjects received no cues as to which language to use for decoding
(Hamers, 1973).

In addition to the environmental factors which influence language-set,
several properties of the words themselves were found to influence the
likelihood of a word-search being extended to the latent language lexicon.
In particular there was a very powerful frequency of occurrence effect:
words occurring more frequently in the latent than in the manifest
language tended to prompt associations mediated through the latent
language. There was also a significant effect of grammatical category: when
faced with a semantically ambiguous word which was a noun in the latent
language and some other part of speech in the active language, subjects
tended to give associations mediated through the noun (Hamers, 1973).

Other factors of significance are: morphology (Kirsner, 1986); auditory or
visual presentation (Hamers, 1973); reading silently and reading aloud
(Kolers, 1968). The presence of these effects suggests that phonetic factors
may well influence other levels of processing.
(ii) **Translation tasks**

A possible framework for the testing of the translation facility is again measurement of response time to a task requiring subjects to give the translation equivalent of individual lexical items. Materials for this (matched for word-class, frequency of occurrence etc). exist, from the Bilingual Aphasia Test (Paradis, 1987). The assumption is that greater speed in translation reflects greater automaticity and a higher degree of fluency in the language (Lambert, Havelka & Gardner, 1959). However, it has also been suggested that translation is a very specialised facility, which is not dependent on fluency or performance on other language-testing modes, and may even interfere with them (Macnamara, 1967a).

(iii) **Language-Tagging**

Experiments of this type involve testing a subject's ability to recall the language of presentation of a particular lexical item or a particular piece of information. Their basis is in the finding that, at some level, subjects' stores for lexical items (and for other information) are linked, since information given in one language is accessible through the other language. In particular it has been found that repetition of exact translation equivalents has the same facilitating effect on short-term memory as repetition of identical lexical items in a monolingual list (Kolers, 1966a; Lopez & Young, 1974). Moreover, repetition of translation equivalents is more effective than using intralanguage synonyms in aiding short-term memory (Kolers & Gonzalez, 1980).

The assumption behind tests of language-tagging is that bilinguals will find it more difficult to remember the language of presentation, since information passes more easily between their two language stores. However, there are implications involving the function of short-term and long-term memory which may not be easily overlookable. In particular, tasks of this type are relatively artificial, since in real language situations items are presented in the context of particular information or in particular circumstances which would cue their language-tag.
(iv) List Recall

The technique of asking subjects to memorise a list of lexical items and later to recall the items presented has been used to extract two main types of information.

Firstly it has been used to investigate whether the retention of information is language-specific. In monolingual lists of unconnected words, the probability of a subject recalling any given word is directly dependent on the number of times that word was presented: a word presented four times in a list is twice as likely to be recalled after 6 months as a word presented twice (Kolers, 1966a). With bilingual subjects it has been found that this effect remains constant regardless of the language in which the items are presented: presentation of the same word twice or of a word and its translation equivalent in L2 have an identical effect on the likelihood of that item being retained in short-term memory (Kolers, 1966a, Kolers & Gonzalez, 1980). Moreover, it has been found that subjects presented with such bilingual lists were often unable to say in which language a given item was presented and often gave as a response a word which had not itself appeared in the list although its translation equivalent had (Liepmann & Saergert, 1974).

A number of different interpretations of these results are possible. It seems that, at least at the level of denotative meaning, a strong independence hypothesis which holds that items are stored specifically in the language in which they are encountered with separate memories for items in each language is not tenable. There is evidence that the relevance of these findings may be limited to the relatively simple case of short-term memory for lexical items and that more complex information may be less easily transferred to a language other than that in which it was acquired (Kolers, 1968).

The technique of list recall has also been used to investigate how lexical items are stored in short-term memory. Studies of monolingual subjects have shown that recall of words from a list is not random, but that they will make use of any organisational possibilities built into the list to produce the phenomenon known as 'clustering' in which groups of items which have a common connection will tend to be recalled together. Such a connection may be external -- for example grouping together items in the
list which belong to logical categories or which are commonly associated with each other -- or, in the absence of obvious external groupings, subjects may make use of internal, more idiosyncratic links to order the items in their memory (Lambert et al., 1968). This technique has been applied to bilingual subjects to determine what part cross-language links play in the overall scheme of lexical organisation. The results of various experiments of this type suggest that intra-language links are more powerful than interlanguage links as a factor in the organisation of short-term memory, but that both types of links exist, supplementing rather than conflicting with one another (Lambert et al., 1968). Greatest recall facilitation was found to occur when the lists were drawn up to have completely congruent language and category clusters, and that where both interlanguage and intralanguage links could be used, memory facilitation was greater than for either type of link working separately (Dalrymple-Alford & Aamiry, 1969).

These findings suggest that cross-language links may operate at the level of connotative and associative meaning in short-term memory as well as denotative meaning. Moreover, it confirms that many different types of link can co-exist and that they seem to be employed on a heuristic basis depending on the circumstances and the requirements of a particular task. However, a major problem with interpreting the results of the clustering experiments is the impossibility of determining for certain what categories the subjects were using in all cases and on what basis idiosyncratic associations had been formed. A further problem is that in experiments of this type there is little consistency in the modalities used both for the stimuli and the response. This has meant that the role of factors like phonetic or orthographic similarity or difference in mediating associations cannot be accounted for.

(v) Word Association
A technique used for investigating the patterning of items in memory is that of free association. Many variants exist, but the basic technique is for subjects to be presented with a list of words in one or more languages and to give the first word that comes to mind as an association. These responses are then examined to see which connections seem to be primary in the organisation of words in the memory.
One important result emerging from experiments of this type is that subjects tend to give different associations to words in each of their two languages even when the prompt words were translation equivalents (Kolers, 1963; 1968; Ruke-Dravina, 1971). This finding is interpreted as contradicting theories of joint memory representation for lexical items in which the cognitive referent of a word in both languages is a higher-order abstract representation which exists independently of the language used to encode it. However, this cross-language difference is strongly linked to factors such as frequency of occurrence of the word in question and in particular to the level of abstraction of the referent: common words denoting concrete objects tend to show a much higher level of cross-language similarity in associates given than words denoting more abstract concepts which are more dependent on individual experience (Kolers, 1963; 1968).

A variation on this technique is that of continuous word-association where subjects are required to give as many associations as possible in one or both languages to the original stimulus word. This technique introduces a further variable into the experiment, namely the number of associations given to a particular stimulus as well as the type of associations mediated by each stimulus word.

Such work has shown that the number of associations given by bilinguals in comparison to monolinguals is dependent on the relative fluency of the bilingual's two languages (Macnamara, 1967). Where subjects were free to switch languages in their output as they chose, they tended to cluster related words from one language and switch when the cluster was exhausted, suggesting that intra-language semantic categories links were stronger than inter-language cues, but confirming the finding for short-term memory that both kinds of links exist and play a complementary role where appropriate in organising the mental lexicon (Dalrymple-Alford & Aamiry, 1969; Taylor, 1971). The primacy of intra-language links is further supported by the finding that when subjects are forced to switch languages every \( n \) words, fluency is impaired and the number of associations given to a word reduced. This effect increases the more frequent the forced switches are (Macnamara, 1967).
I.5.3. The phonetic/phonological level
The phonological level is less immediately accessible to investigation than
the lexico-semantic, since comparable phonemic contrasts across languages
are less easy to find and manipulate than, for example, translation
equivalent lexical items.

However, non-linearities in speech perception and production at the
phonetic level are a particularly important part of any account of second
language learning, since the manifestations of interference at this level are
particularly widespread and tenacious. Phonological interference leads to
the phenomenon of accent, whereby speakers of a language which is not
their first or dominant language may produce certain phonetic features of
the target language in a way that is identifiably different from utterances by
native monolingual speakers. It seems that a native-like accent may be the
most difficult aspect of a foreign or second language to acquire, and it may
be the only L1 interference that persists in some L2 learners who are
otherwise functionally bilingual (McLaughlin, 1984). Further, it seems that
some bilingual speakers who do not have a perceptible accent may, for
some phonetic features and under some conditions, produce utterances
that deviate from those of a monolingual speaker, although this difference
may not be perceptible (see section I.5.2.2 below for discussion of non-
linearities in speech production).

The problem of 'accent' ie. phonological interference at the productive
level is inextricably linked with phonetic-phonological perception,
although the nature of the relationship between the two modalities is far
from clear (see Llisterrri, in press, for review).

I.5.3.1 Perception
A range of studies of different types have shown that adults have difficulty
discriminating and identifying stimulus pairs that represent a non-native
contrast, although the same stimuli are processed without difficulty by
native speakers: in other words, adults are language-specific perceivers of
speech (see, for example, Bohn, in press; Llisterrri, in press; Strange, 1994
for general reviews).

The precise nature of the difficulties experienced by an individual are
strongly related to the characteristics of that individual's primary early
language (L1). More specifically, there is a large body of evidence which suggests that perception of an L2 contrast will be highly accurate only for contrasts which are distinctive in the L1, and that contrasts which are not distinctive in the subject's L1, or which are realised differently, will present a perceptual problem, since the learner is faced with the problem of acquiring new phonetic categories, or of reorganising existing ones.

Best (1994) has proposed a model of 'perceptual assimilation' in an attempt to characterise and predict the relationship between native-language phonology and perception of non-native contrasts. This model assumes, firstly, that learners perceptually assimilate non-native contrasts to the categories of their native language where possible, and secondly, that the extent and nature of these assimilations is determined by the extent to which L2 categories correspond to those of L1.

Typically, good discrimination would be predicted for so-called two-category contrasts, where two L2 phones can be assimilated to two separate L1 categories, whereas poor discrimination would be expected for single-category contrasts, where two L2 phones are assimilated to a single L1 phone. Slightly better discrimination would be predicted for uncategorisable contrasts where neither L2 sound can be assimilated to any L1 category, and good to moderate discrimination is expected for sounds that are subject to a category goodness difference, where the two L2 sounds are matched to a single L1 category, but differ in their goodness of fit to that category. A fifth grouping is formed by those L2 sounds which are not heard as speech, and so cannot be assimilated to L1 at all.

Problems with this model include the fact that it is not always possible to tell how individuals have categorised stimuli. If an L2 phone occurs midway between two L1 categories, speakers may assimilate it with either of the two adjacent L1 categories. A further problem is that performance on discrimination tasks may differ from that on labelling tests. Labelling in particular may be a problem where sounds in a two-category contrast differ in their phonetic realisation. In such cases a learner may be able to discriminate the two L2 sounds, but may place the boundary in a different place to that of native speakers, so that, although the number of categories remains the same across the two languages, some intermediate stimuli may differ in the category to which they would be allocated.
The model of speech learning developed by Flege (Flege & Hillenbrand, 1984; Flege, in press; 1988) provides a framework for explaining how such identifications may change over time in individual learners. Flege's model predicts that, if an L2 phone differs substantially from an L1 phone, learners can eventually, with sufficient time and exposure to native output, overcome their original identification of the new phone with the L1 category, and develop a new perceptual category for the L2 sound. For phones that are very similar across the two languages incorrect identification may persist, leading to a fossilised perception of the L2 contrast, which may also ultimately affect perception of the L1.

However, the relative characteristics of the L1 and L2 are not the only factors which affect the perceptual difficulty presented by non-native contrasts. Apart from the subject variables described above (Sections 1.3 and 1.4), other factors of interest are those relating to the particular contrast which is selected for testing, and details of the test procedure used for the investigation.

(i) Contrast variables
Contrast variables have been shown to play a crucial part in determining the perception of L2. The characteristics of the contrast chosen for testing may affect the response pattern found in several different ways.

Firstly, there is evidence that consonantal contrasts may be perceived differently from vowel contrasts (Llisterrri, in press), and it has been hypothesised that the different acoustic properties of vowels and consonants may trigger different modes of perception (Repp, 1984; Studdert-Kennedy, 1993; Polka, 1995).

Within each sound class, perceptual patterns may also vary across particular pairs of contrasts. One contrast which has been extensively studied with bilinguals and L2 learners is the Voice Onset Time (VOT) cue to initial stop voicing. VOT is defined as the duration between the burst release and the onset of vocal fold vibration (Lisker & Abramson, 1964). In English, voiced stops are produced with a short voicing lag, while initial voiceless stops are produced with a long lag accompanied by aspiration. In languages such as French and Spanish, voiced stops are produced with a
long lead (or prevoicing), and voiceless stops are produced with a short lag. Typically, researchers have tested speakers of language pairs such as English and French, or English and Spanish, which differ in their use of VOT to mark the voiced-voiceless contrast in initial position. The procedure involves testing bilinguals twice, once in each language-set, and presenting, for labelling or discrimination, the same randomised stimulus continuum which spans the categories of both languages. The presence of a fixed phoneme boundary, either at one of the language boundaries or at an intermediate position, which does not vary across language-set is taken to mean that the listener is using the same perceptual categories in processing both languages; a shift in phoneme boundary is taken to indicate that the listener has established separate perceptual categories for his or her two languages (categories which may or may not correspond to those of native speakers of the languages concerned).

Studies of this type have shown that both patterns may occur. Some researchers have found that some bilinguals do possess separate perceptual categories in each language, and switch between them as appropriate in response to the language set of the task (Elman, Diehl & Buchwald, 1977). However, this study, with Spanish-English speakers, found that the degree of the perceptual switch was variable across individuals according to the strength of both languages: those subjects who were considered to have achieved a high degree of balance between their two languages manifested a substantial switch in each condition, while for other subjects the categories of one language were clearly dominant. However, one potential problem with the interpretation of these results is that only group results are presented, which means that an apparently intermediate result may be masking different patterns of behaviour by individual subjects.

Flege & Eefting (1987), in a similar test with speakers of English and Dutch, reported a small phoneme boundary shift for bilinguals between the two language conditions, and attributed the small magnitude of the shift to the fact that the (synthetic) stimuli were biased towards English. Hazan & Boulakia (1993), who tested English-French bilinguals using computer-edited natural stimuli, also reported a small but significant perceptual switch.
Other studies have found that perception does not change as a function of language set, but rather that the bilinguals studied appeared to operate a single set of perceptual categories intermediate to those of monolinguals in each of the languages (Caramazza et. al., 1973; 1974; Williams, 1977). However, the caveat about group results mentioned above applies here too: it is impossible to tell whether these findings result from a truly intermediate boundary across the whole subject population, or from an averaging of subjects with either an L1 or an L2 boundary.

Another consonantal feature which has been used in the investigation of bilingual perception is place of articulation, and there is evidence that this feature may present greater perceptual difficulties to learners than the voicing contrast. Tees & Werker (1984) showed that inexperienced listeners were less sensitive to place cues in natural tokens of Hindi stops than to the voicing contrast in the same stops. On the other hand, Best et. al. (1988) found that monolingual English speakers showed good performance on discrimination of place, voicing and aspiration contrasts in Zulu clicks, despite having no prior exposure to these sounds.

Several interpretations of these findings are possible. Firstly it may be that some contrasts are inherently easier to discriminate because they are in some way acoustically more salient or robust (Polka, 1991). It may also be that different acoustic parameters within the contrasts are weighted differently as cues depending on the learner's L1 experience: in this way listeners may focus on a particular dimension of a cue in the effort to discriminate the unfamiliar contrast (cf. discussion of vowel perception below). It is also possible that listeners may be making different use of speech or non-speech perceptual modes, depending on the extent to which the non-native sounds are identified (or misidentified) with L1 sounds (Polka, 1991).

Investigations into the perception of vowel contrasts confirms the suggestion that listeners may make differential use of the information available to them. Native-language categories were shown to exert a significant influence on the perception of unfamiliar German vowels by English listeners, with the vowel pairs that differed substantially from the L1 being better discriminated than those which were more similar to L1 categories (Polka, 1995).
However, not all subjects will respond to cues in the same way: a study of the acquisition of English /æ/ by German learners showed that, while some experienced learners were able to make use of the spectral cues on which the English monolinguals relied, others were unable to do so, relying instead on duration cues. Among inexperienced learners, most relied on duration cues, resulting in perceptual categories unlike native English listeners, although a few of the inexperienced subjects were able to use the spectral information, resulting in a more native-like identification function (Bohn & Flege, 1990). Similar findings are reported in a study of Chinese subjects' perception of the burst and closure voicing cues to the word-final English /t/-/d/ contrast (Flege, 1989). These findings confirm the suggestion made above that learners, when confronted with non-native contrast may make differential use of the acoustic information within the signal, relying more heavily on those parameters which are familiar from the L1. They also indicate the possibility that non-native listeners may, in time, become more sensitive to the unfamiliar aspects of the signal and acquire a more native-like functioning, but that their ability to achieve this may be subject to a large degree of individual variability.

(ii) Task-based variables
A number of studies have also shown the many ways in which task-based variables may interact with contrast features and individual characteristics.

- Synthetic or natural speech
Synthetic stimuli give the experimenter total control over the cues present in the stimulus material, and thus to be more certain about the features to which the subjects are responding; however, their lack of naturalness also means that subjects may not maintain a consistent language set, or may even switch into a non-speech mode of perception (Repp, 1982). However, Repp's results raise some doubts about the relative acceptability of synthetic and natural stimuli. It seems possible that the relative paucity of the synthetic stimuli as opposed to the natural may have been impairing subjects' maintenance of a consistent language set (Bohn & Flege, 1999). If computer-edited natural speech is used, further bias is possible since the stimulus words or syllables will have a bias towards the language in which they were originally
produced, and may contain additional, uncontrolled, cue information, which is likely to affect subjects' responses.

- **Phonetic context**
  Some contrasts may be easier to discriminate in certain phonetic environments than in others, and may be marked by different sets of acoustic cues in different contexts: Polka (1992) found that the velar-uvular contrast in voiced plosives was more easily discriminated than the same contrast in ejectives. A similar finding is reported for identification of /r/ and /l/ by Japanese speakers, whose performance on the labelling task was affected by the syllable position and vowel context in which the contrast was presented (Flege & Wang, 1989; Logan, Lively & Pisoni, 1991; Lively, Logan & Pisoni, 1993; Nakauchi, 1993).

- **Range effects**
  A change in the range of stimuli presented will tend to affect labelling of the continuum, with the perceptual boundary gravitating towards the centre of the continuum (Rosen, 1979). However, where the same continuum is presented to subjects in each language condition, range effects will not affect the validity of the results, since any shift in boundary can be attributed to the effect of language.

- **Real words or nonsense syllables**
  Subjects will be biased in favour of a percept which forms a real word rather than one which forms a nonsense syllable; among real words, frequency effects will also influence perception (Centmayer, 1973).

- **Language setting**
  Another important experimental variable is the degree to which the listener was set into a particular language mode for the test. Strategies used include the use of particular-language carrier sentences (Elman et. al., 1977) or, more stringently, interspersing the stimuli with language tasks that required the subjects actively to process material in the test language (Flege & Eefting, 1987; Bohn & Flege, 1993). The language in which the experimenter interacts with the subjects is also a consideration: ideally the experimenter(s) should be native speakers of the language in which the test is taking place (Flege & Eefting, 1987).
the other end of the spectrum, tests which are least likely to maintain the subject in a particular language set are those in which synthesised nonsense syllables are presented in isolation with no real-language context (Werker & Logan, 1985).

I.5.3.2 Production
The relationship between perception of L2 speech and learners' own production of L2 is far from straightforward, and the results of experimental studies are subject to a range of variables comparable to those affecting perception.

One well-documented finding is that the output of learners is likely to differ significantly on a range of features from the output of monolinguals, and that these production difficulties are related to the phonological categories and the phonetic realisation of sounds in the L1. Typically, learners' pronunciation of contrasts which had no equivalent categories in their native language (such as English /r/ and /l/ for Japanese learners), or of contrasts that differed in phonetic realisation from L1 sounds (such as VOT in stop voicing contrasts, or formant frequencies of vowels) falls short of native speaker targets (Flege & Hillenbrand, 1984; Flege, 1988; 1995).

However, although contrastive phonological analysis of language pairs can predict likely areas of difficulty, such cross-language effects may have different manifestations for perception and production. Several studies which tested cross-language perception and production of particular contrasts for the same subjects have found that, while the perceptual shift between the two language conditions was small or non-existent, the shift in production was much greater, and that subjects with a high level of fluency in both languages were able to match native-speaker performance in both languages. For example, Caramazza et. al. (1973; 1974) found that their bilingual subjects, (French-English Canadians) showed clear category switching for production of VOT in stop consonants, reaching or approaching monolingual targets in both languages, while their perceptual categories showed no such switch, occupying an intermediate position between French and English monolinguals. Williams (1977) reported the same finding for Spanish-English bilinguals on similar tests of VOT in stop consonants.
Other studies, which did find a significant perceptual switch across language conditions, found that the degree of shift in the production task was much greater (Flege & Eefting, 1987; Mack 1989; Hazan & Boulakia, 1993). Perhaps the most striking evidence for the non-linearity of performance between the perceptual and production modalities comes from a test in which Japanese speakers were able to produce reliably identifiable (though not necessarily native-standard) tokens of English /r/ and /l/, but were subsequently unable consistently to identify their own production (Goto, 1971). Another interesting finding was that perceptible elements of accent could be induced even in speakers who normally passed for monolinguals in both languages, if they were put under sufficient stress in an environment in which both languages were highly activated, in this case in a production task that required them to switch languages at regular intervals (Kolers, 1966). Clearly, although perception and production are inextricably linked at the phonetic-phonological level, the interaction between them is complex.

As with the perception tasks, these effects are highly variable across different contrasts and different parameters of particular contrasts (Mack, 1989; Flege, Munro & MacKay, 1995a). Subject variables are also likely to be influential: some studies have found a strong AOL effect on the nativeness of L2 production (Flege, Munro & MacKay, 1995a; Flege, 1995), while other influential variables must be sought in the finer details of the the language-background in which individual speakers became and remained bilingual. In particular, the exposure of learners to accented English is a considerable factor influencing the authenticity of their output (Flege & Eefting, 1988), and whether or not the learners continued to use their L1 with others (Flege, 1988).

1.6 SUMMARY
The various studies reviewed in the previous sections show us that the relationship between the two languages of the bilingual is far from straightforward, and that an over-simplified approach to research problems is likely to obscure rather than shed light on the complex reality.
It is clear that the question which informed much of the work done in the 1960s and 70s, namely whether two languages have joint or separate representation, is no longer appropriate, and has been superseded by the rather more modest aim of characterising the type and degree of cross-language influences for different levels and types of processing.

The disadvantage of this approach is that studies of different levels of processing are not united by a common theoretical underpinning. Too often the theoretical models which are proposed relate only to one level of language, leading to a fragmented view of bilingual language capacity. However, there is a common thread running through the numerous different approaches to the phenomenon of bilingualism, which may be found in the questions that were stated in general terms in section I.0 above.

Those questions can be reformulated here to focus on the concept of dominance. Common to all experimental studies of bilingualism, whether implicitly or explicitly, is the attempt to characterise the nature of and the relationship between the two languages of the bilingual. Typically, where such effects have been found they have been classified as 'interference', and used as proof of the bilingual's inability to keep his or her two languages separate, and dominance has been regarded as the sum total of the individual's interferences (see section I.3.4 above). The approach taken here differs in several important ways.

In keeping with the interlanguage hypothesis, and the models which developed from it, it recognises that the language systems of the bilingual may differ systematically from those of monolingual speakers of the same languages, and that such differences have their origins in the particular characteristics of both languages as well as in the language history and language-use patterns of the individual. The intention is of the present study is to focus on characterising bilingual behaviour in both languages in an attempt to explore the rarely-acknowledged, though often implicit, possibility of bi-directional language cross-influence, on the assumption that a complete account of bilingual competence requires an investigation of the ways in which both languages may be affected by their co-existence in the same individual.
By building up a picture of the pattern of cross-influences in different individuals and across different types of task, it is hoped to provide a characterisation of dominance that is more flexible and responsive to the complexity of individual language behaviour than has been possible until now. The development of a theoretically and empirically satisfactory concept of dominance would provide a framework for undertaking detailed theoretical research without losing sight of a wider perspective.

In attempting to test and formulate this concept, the following questions are addressed in detail:

- Can dominance be shown across different levels of processing, and are dominance patterns necessarily consistent across such levels?
- Can dominance be predicted from the individual's language history, by such factors as, for example, age of learning, length of residence etc.?
- Is dominance inevitable?
- Can dominance patterns change in the course of an individual's lifetime?

The following chapter describes in some detail the development and piloting of a range of tests which would enable these questions to be addressed. Chapter III reviews the final test battery, and details the procedures used for the main phase of the testing. It also gives the test results in the form of raw data. Chapter IV gives a more detailed analysis and discussion of the experimental results, both at group and individual levels. Chapter V undertakes a general discussion of the implications of the test data for a model of bilingual dominance, and explores the connections between individual variables and patterns of bilingual performance.
CHAPTER II
TEST DEVELOPMENT

II.0 INTRODUCTION
A study of the available research into bilingual processing and performance underlines the need for an assessment of the interaction of the different types of variation, both subject-related and task-related, that have been found to influence the ways in which bilinguals store and use their language capacity.

In the light of the many disparities which became apparent in the course of the literature survey, the aims underlying the development of the test battery were two-fold:

- to investigate the language performance of English and German bilinguals in comparison with that of monolingual speakers of the two languages, using a variety of tests extending across different levels of linguistic encoding. This information would permit the establishment of a detailed profile of individual and task-based variability in the subjects tested.

- the development of a detailed language-background and language-usage questionnaire, which could contribute to an interpretation of the result patterns found in the experimental data and might contribute to an understanding of the ways in which the individual's language history and patterns of language-use might determine or affect his or her performance for a given type of task.

Combining information of these two types would permit a detailed account of language dominance -- the influence on one another of two or more languages co-existing in the same individual -- and enable us to address the question of whether and to what extent the original dominance of a primary early language can be overcome. It would also make it possible to establish whether dominance can vary across different levels of language encoding and different types of task. Finally, this approach would also enable us to discover likely biographical correlates of particular dominance patterns.
The tests were designed with the intention of accessing different levels of subjects' language capacity as outlined below:

**Phonetic level**
- Perception and production of vowel duration
- Perception and production of vowel quality
- Production of accent-revealing sentences

**Lexical level**
- Processing of phonotactic constraints by measurement of reaction time in lexical decision task
- Metalinguistic judgments of nonwords

**Syntactic-semantic level**
- Production of free speech passages

**Background**
- Questionnaire

This chapter will describe in detail the pilot tests which were used in designing the final test battery. In some cases the tests were used in several different forms before the final version was developed. The results of these pilot studies are included here to provide a rationale for each experiment that was included in the main phase of testing. The results of the pilots do not form part of the main body of experimental data.

### II.1 PHONETIC TESTING

The initial aim of the pilot tests was to find workable cross-language phonetic contrasts which could be used in tests to investigate how subjects make use of the categories of their L1 and L2 in processing phonetic information.

#### II.1.1 Production of vowel duration

The initial pilot test involved two contrasts that are realised differently in English and German, namely vowel duration and final consonant voicing. Vowel duration alone (ie without an accompanying difference in
quality) can be distinctive in German, in a minimal pair such as 
\textit{Stadt/Staat (J\,\textipa{\textt umm}/\textipa{\textt umm})}; in English vowel duration is allophonic and 
depends on the voicing status of the following consonant. Final consonant 
voicing is distinctive in English as in a minimal pair such as \textit{beat/head} 
(\textipa{\textb e:t}/\textipa{\textb e:d}) (Klatt, 1976; Krause, 1982; Raphael, 1972), while in German 
final lenis obstruents are allophonically devoiced (Charles-Luce, 1985).

The initial hypothesis was that a vowel duration continuum in CVC 
context would be perceived more categorically by German speakers, for 
whom vowel duration is distinctive, than by English speakers, for whom 
it is not. If this proved to be the case, then the ability to label such a 
contrast categorically, as measured by the boundary placement and 
gradient of the identification function, might be a way of distinguishing 
between an English-dominant or a German-dominant language 
processing.

The first phase of testing was a preliminary pilot study to establish likely 
endpoints of vowel length continua in English and German, which could 
then form the basis of syntheses for subsequent perceptual testing. The 
study involved making duration measurements and acoustic analyses 
from recordings of both English and German monolinguals producing 
words containing phonemically and allophonically long and short vowels, 
and phonemically and allophonically voiced and voiceless final 
consonants. As well as establishing endpoints for future synthesis, the 
recordings also served to test the following assumptions:

- German allophonically devoiced final consonants are phonetically 
  identical to their phonemically voiceless counterparts;

- English vowels, whether phonologically long or short, are longer 
  before voiced final consonants than before voiceless ones.

\textbf{Test Material}
The test material consisted of common words in both languages which 
contained the contrasts of interest. The English material contained words 
illustrating with long and short vowels, before final fortis and lenis 
consonants (eg. \textit{but, bud, hard, heart}). The German material contained 
words with long and short vowels, as well as words with a phonologically
voiceless and allophonically devoiced plosive (eg. satt, Saat, bunt, Bund). It was not possible to assemble an adequate list of tokens all from the same word class, so the list contained nouns, verbs and function words. The final list of test words is given in Appendix III.

Subjects were presented with this material in the form of a randomised printed list in which each word occurred three times. Filler words were inserted at the beginning and end of the lists to eliminate beginning and end of list effects. All words were presented in carrier phrases: "Please repeat ______ again." (English condition), "Bitte das Wort ______ wiederholen." (German condition).

Subject Selection
For each language six speakers were chosen whose accents were judged representative of the standard variant of each language (Standard Southern British (SSB) for English; Hochdeutsch (High German) for German). All speakers were educated to university level and none had any known hearing or speech defects. Equal numbers of male and female subjects were recorded for each language. The German subjects were Erasmus students at the University of Westminster, who were not living permanently in London, but who had a functional knowledge of English. However, it would have been almost impossible to find German speakers in London without significant exposure to English, and since the task was essentially a monolingual one there was no reason to suppose that the speakers' knowledge of the other language would be activated to influence their production.

Test procedure
The recording sessions took place in a sound-proofed cubicle at UCL. Two-channel recordings were made onto DAT tape, with a simultaneous backup onto audio cassette tape. Channel 1 was used to record the speech waveform via microphone, and channel 2 was used to make a recording of glottal activity via laryngograph (Fourcin & Abberton, 1971).

Results
The test sentences were digitised in separate speech files using a sampling rate of 20 kHz and the test syllables cut and saved onto a Masscomp
computer. Duration measurements were then made using the following criteria:

- **Consonant duration** was measured from closure onset to the frame immediately before the onset of periodicity for the following segment.
- **Vowel duration** was measured from the first glottal pulse to the onset of closure for the following consonant. In the English condition the durations of vowels in environments preceding /t/ and /d/ were included in the data, so the English results represent an averaging of findings from the two different phonetic contexts.

### Table II.1
Mean durations (msecs) of final consonants in English and German

<table>
<thead>
<tr>
<th></th>
<th>/d/</th>
<th>/t/</th>
</tr>
</thead>
<tbody>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>57.33</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>12.16</td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>117.38</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>51.36</td>
</tr>
</tbody>
</table>

![Boxplots comparing English and German consonant durations](image)

### Figure II.1
Durations of final consonants in English and German†

† Boxplots are interpreted as follows: the midline represents the 50th percentile; the upper and lower edges of the box represent the 25th and 75th percentiles; the lines represent the 10th and 90th percentiles; the circles represent outlying values.
In the English condition, the duration of final voiceless /t/ was approximately twice as long as that of final voiced /d/; a t-test for all speakers showed that the difference in duration between the two consonant groups was significant at the level t=3.11, df=10, p<0.01. In German the mean duration of the final plosives in words like Tod and tot were very similar both to each other, and to the mean duration for English final /t/. None of the final plosives in each of these three categories differed significantly in duration from one another.

Both the graph and the table show that the degree of variation in consonant duration was much greater in German than in English: it seems likely that greater variance is permissible in German, since there is no voicing contrast for final plosives to which consonant duration might act as a cue.

Table II.2
Mean durations (msecs) of vowels in English and German†

<table>
<thead>
<tr>
<th></th>
<th>/at/</th>
<th>/ad/</th>
<th>/a:t/</th>
<th>/aːd/</th>
</tr>
</thead>
<tbody>
<tr>
<td>English condition</td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>112.56</td>
<td>164.39</td>
<td>176.88</td>
<td>210.33</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>28.90</td>
<td>36.20</td>
<td>24.20</td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>97.34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>11.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† The phonetic symbol /a/ is used here to denote both the English and German vowels, without and with the length mark for the short and long vowels respectively. See footnote on transcription in Section II.1.3 below for further discussion.
English phonologically long vowels have greater mean duration than short vowels. The duration difference between these two categories was significant at the level $t=2.53$, $df=10$, $p<0.05$. The amount of variation, both intra and (especially) interspeaker was relatively high. This is due at least in part to differences in the phonetic environment: English vowels of both classes are shorter before a final voiceless obstruent than before a voiced obstruent.

The difference between long and short vowels in German was greater than in English, and characterised by a much lower level of variation. The difference between the two classes in the German condition was significant at the higher level of $t=5.63$, $df=10$, $p<0.0005$.

**Discussion**

The clearest conclusion to emerge from this data is that there seems to be no difference in German between word-final phonologically voiceless and allophonically devoiced stops. This is supported by studies specifically of final voicing which have found no significant difference for possible parameters of variation (closure duration, preceding vowel duration, voicing into closure) between German underlyingly voiceless and devoiced stops in the contexts in which they were used here (Fourakis, 1984; Fourakis & Iverson, 1984; Charles-Luce, 1985).
The behaviour of vowels is much more complex, and a number of factors must be taken into account in the analysis. Overall, the results for German showed a much closer clustering of long and short vowel durations than for comparable English syllables, both across utterances and between speakers. In contrast, the vowels produced by the English speakers showed a much greater range of durations within each category, and far more inter- and intrasubject variation, and this is reflected in the lower level of significance for the feature of duration in English than in German.

It seems likely that the more complex role of vowel duration in English and its relation to the voicing status of the following consonant leads to a more variable patterning of long and short vowels than the two-way contrast found in German.

II.1.2 Perception of vowel duration
The aim of the set of tests described in this section was to examine English and German speakers' perception of a synthesised vowel continuum in CVC context, in order to investigate the perceptual categories used for long and short vowels in each language.

Test Material
The stimuli used in this test were CVC syllables. The vowel element was synthesised using the cascade branch of a Klatt synthesis system, using values appropriate to the German central vowel /a/, based on analysis of the natural utterances of a male speaker of German, one of the subjects who participated in the production tests described in the previous section. The formant values of the steady state of the vowel were F1 720 Hz; F2 1200 Hz; F3 2500 Hz; F4 4000 Hz. The fundamental frequency was 100 Hz, falling to 85 Hz, and the amplitude of voicing was 40 dB.

The duration of the shortest vowel was 50 msecs, and duration was increased in 10 increments of 20 msecs each, producing a vowel duration continuum ranging from 50-230 msecs, encompassing the maximum and minimum duration values for long and short vowels in both languages, as established in the production tests.
The initial and final consonants used were /m/ and /t/, excised from digitised natural utterances by the same speaker on whose speech the synthesised vowel was based. The three segments were then concatenated to form hybrid synthetic/natural syllables giving the German words matt and Maat with the short and long vowels respectively.

The stimulus syllables were randomised in 10 blocks of 10 stimuli each, giving a total of 100 stimuli in all, and were recorded onto audio cassette tape.

Subjects
Subjects for the experiment were 12 native German speakers in the age group 20-30 years, with equal numbers of male and female subjects. All were speakers of standard German, and were students at the Free University of Berlin. All were phonetically untrained, and reported normal speech and hearing.

Test Procedure
The tests took place in a quiet room at the Free University of Berlin over a period of several weeks in April-May 1992. The test tape was played to the subjects on an individual basis on a Marantz audio cassette recorder over Sannheiser HD 414 headphones. The test stimuli themselves were preceded by a practice block consisting of three repetitions of the endpoints of the duration continuum, to familiarise subjects with the shortest and longest stimuli. The instructions given to the subjects were to decide whether each test stimulus was more like the matt exemplar or like the initial Maat token, and they were asked to indicate their choice on a printed test sheet. It was emphasised that they must make a decision in each case, even when they were unsure which token the stimulus most resembled.

Results
The results for the labelling tests are given below. Each data point in the table represents 120 responses (12 subjects x 10 repetitions).
Table II.3
% of /a/ (short vowel) responses by German subjects

<table>
<thead>
<tr>
<th>Step</th>
<th>Duration (msecs)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>99.1</td>
<td>3.0</td>
</tr>
<tr>
<td>4</td>
<td>110</td>
<td>65.4</td>
<td>29.44</td>
</tr>
<tr>
<td>5</td>
<td>130</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>150</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>170</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>190</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>210</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>230</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure II.3
% of /a/ (short vowel) responses by German subjects

The responses show a remarkable degree of consistency. Syllables in which the vowel duration measured 100 msec or less were perceived in virtually all cases as short; syllables with a vowel duration of 140 msec or more were perceived as long. The only syllables which received a substantial proportion of ambiguous responses were those of 110 msecs.
It was decided to subject these highly consistent results to another, more finely-grained test by using shorter increments between the stimulus syllables.

**Test Material**
A new set of stimuli was synthesised and concatenated, using the same synthesis characteristics as previously. However, the vowel duration range was changed to 30-150 msecs, eliminating some of the redundancy at the long vowel end of the continuum used in the first experiment. In this test the duration of the vowel was increased in increments of 10msecs rather than 20, resulting in a total of 130 test syllables, randomised in ten blocks of thirteen syllables.

**Subjects and test procedure**
German subjects were taken from the same population as before; most of the subjects had in fact participated in the earlier experiment. The testing was conducted using the same procedure as before, over a period of several weeks in July 1992. The test was also repeated with English monolingual speakers in London. The English subjects were, like the German subjects, university students, native speakers in this case of English, and 20 - 30 years old. The test sessions took place under the same conditions as the German test, ie. in a quiet room, using the same equipment and test tapes.

Both sets of subjects were trained using a practice block of 10 repetitions of the shortest and longest stimulus pairs to familiarise them with the tokens at the extreme ends of the continuum, and asked to categorise each test stimulus according to which token it most resembled. The English subjects were told that the stimuli were utterances of German words and, after hearing the practice block, were told to decide which of the demonstration syllables each stimulus most resembled. The answer sheets were identical for both groups of subjects, except that the instructions were translated into English for the English condition.

**Results**
Results for both English and German listeners are given below. Each data point represents 120 responses (12 subjects in each language condition x 10 repetitions).
Table II.4
% of /a/ (short vowel) responses by English and German subjects

<table>
<thead>
<tr>
<th>Steps</th>
<th>Duration (msecs)</th>
<th>English subjects</th>
<th>German subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean SD</td>
<td>mean SD</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>100 0</td>
<td>100 0</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>100 0</td>
<td>100 0</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>100 0</td>
<td>100 0</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>98.75 3.41</td>
<td>100 0</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>98.75 3.41</td>
<td>100 0</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
<td>86.37 21.51</td>
<td>81.25 9.91</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
<td>70 16.73</td>
<td>30 23.29</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>33.75 16.68</td>
<td>10 13.09</td>
</tr>
<tr>
<td>9</td>
<td>110</td>
<td>11.87 15.15</td>
<td>0 0</td>
</tr>
<tr>
<td>10</td>
<td>120</td>
<td>0.62 2.50</td>
<td>0 0</td>
</tr>
<tr>
<td>11</td>
<td>130</td>
<td>2.50 4.47</td>
<td>0 0</td>
</tr>
<tr>
<td>12</td>
<td>140</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>13</td>
<td>150</td>
<td>0.62 2.50</td>
<td>0 0</td>
</tr>
</tbody>
</table>

Figure II.4
% of /a/ (short vowel) responses by English subjects
A Maximum Likelihood Estimate (MLE) for the phoneme boundary and the slope of the identification function was calculated using the mean curve for each group of subjects.

The ability of the German subjects to label the vowel-length continuum into the two categories of long and short vowels occurring in their native language was good. There was a high degree of inter-subject consistency, with ambiguous responses confined to the range 80-100 msecs, reflected by the steep gradient of the identification function.

The most noticeable effect between the two sets of results for the German monolingual listeners is an apparent shift in the category boundaries of phonemically long and short vowels. For the first test, where the duration of stimulus vowels ranged from 50-230 msecs in 20 msec increments the category boundary occurred at 120 msecs; for the second test, which used a stimulus range from 30-150 msecs vowel duration with 10 msec increments, the boundary occurred at 86 msecs. Since the stimuli used were identical in acoustic characteristics, differing only in duration and range, and the same groups of subjects were used from each, it seems likely that the stimulus range presented was affecting the category labels used (Rosen, 1979).

The ability of the English control subjects to discriminate the same continuum into the two German categories was lower overall. There was
a greater degree of inter-subject variability: for some subjects ambiguous responses were confined to two or three of the stimulus levels, a performance comparable to that of the native German speakers, while other subjects were unable consistently to identify the stimuli over most of the stimulus range.

In the second test, where the categories of German and English listeners were compared, there was a small absolute boundary shift between the two groups of subjects: for English subjects the phoneme boundary occurred at 95 msecs, while for German subjects it occurred at about 86 msecs. The effect of phoneme boundary was significant at the level t=2.36, df=22, p<0.05.

The biggest difference between the two subject groups was found in the amount of variability present in the labelling behaviour. As can be seen from the graphs (Figures II.4 and II.5 above) the slope of the labelling function was much steeper for the German subjects than for the English, indicating that the German subjects' categorisation was sharper. There was also a much greater degree of inter-subject variability among the English listeners, with some individuals producing labelling curves which resembled those of the German listeners, while others showed great difficulty in forming categories with which to process the German vowel duration feature. The effect of slope was significant at the level t=3.42, df=22, p<0.01.

This variability suggests that the English subjects may have differed in the strategies they were using to process the stimuli.

Discussion
These findings support the prediction made from the analysis of subjects' production that English listeners would be less able reliably to divide the vowel duration continuum into two categories as the native German listeners were.

The multidimensional function of vowel length in English may be one source of the interspeaker variation found among English listeners, since it is possible that individual listeners were attending to different aspects of the stimuli. It has been shown that, if specific instructions are used to
predispose subjects to attend to particular dimensions of a complex multidimensional stimulus, detection of the unemphasised dimensions will decline relative to that of the emphasised characteristics (Werker & Tees, 1984). In this case, the English subjects were told that the stimuli were words in German, and were presented with the practice block containing the tokens at the extremes of the vowel length continuum. After this initial training, they were told that their task would be to divide the stimuli into two categories, according to which of the two tokens the individual test syllables resembled more. They were not told what the varying dimension was. It seems likely that some subjects were able to focus on a feature dimension to which they would not normally attend in the same way during English speech perception, and that this focus improved their ability to identify the non-native contrast. This suggestion is supported by studies on selective attention and language-set effects, which have found that, under normal circumstances, adults identify speech sounds according to the phoneme categories of their native language but that, if measures are taken to change their language-set or the focus of their attention, subjects may discriminate the same sounds according to phonetically relevant category boundaries used in another, but not their native language (Ellman et. al., 1977; Eilers et. al., 1989).

Another possible explanation for the inter-speaker variation may be found in the theory that different modes may be used for processing and interpreting different types of stimulus. In this case, individual subjects' experience of foreign languages or listening to synthetic speech might affect the triggering of the speech mode of perception (Repp, 1982). It should be noted, however, that in the present experiments, the English listeners' task was inherently more complex, since they were required to process foreign speech material, and that this imbalance between the German and English subjects may also have affected the results.

The English listeners may also have differed in their interpretation of the stimulus syllables. Although they were told that the stimuli were tokens of German lexical items, and despite the fact that the acoustic characteristics of the vowels were those of German vowels, it is possible that some subjects may have identified the stimuli with the English words mutt and mart, despite the phonetic differences. This identification may have affected their categorisation by triggering a different mode of
perception to that used by subjects who were processing the stimuli as non-native speech without relating them to potential English items.

It has been shown (Werker & Logan, 1985; Bohn & Flege, 1991) that listeners may process speech input using different modes, with mode selection dependent on a variety of factors. The 'default' mode used in everyday processing of native-language speech is the phonemic mode, in which sounds are classified according to the phoneme categories of the native language. At the other extreme is the auditory or acoustic mode, in which listeners discriminate sounds according to the acoustic events they contain. This is the mode that may be used for processing synthetic speech or nonspeech sounds. An intermediate mode has also been posited (Polka, 1991), which is sensitive to acoustic events that do not form part of the phoneme system of the listener's native language, but which are nonetheless speech specific. This is typically the mode that would be used for processing foreign-language speech material. In the light of such findings, it is possible that some subjects may have been treating the stimuli as English speech, some as non-English speech, and some as non-speech.

In the light of these possible sources of variation, an additional test of vowel duration processing was devised, which would complement the characteristics of the previous one. The test described above used language-ambiguous materials, which had potential real-word labels in both languages, although the stimuli were clearly biased towards German in their acoustic characteristics, and were much better examples of the German word pair mätt and Maat, which differ solely in vowel duration, than they were of the closest potential English labels mutt and mart, which differ in vowel quality as well as duration. However, the stimuli may have been sufficiently adequate as speech tokens to trigger subjects into a speech mode of perception, which may have affected their labelling of the continuum. The use of hybrid synthetic/natural stimuli may have reinforced this tendency.

It was also decided to include the existing test in the main test battery, but to make some changes to the test procedure in view of the results of the pilot. The principal change was to present the stimuli to subjects as real-word items in both languages, and to use response sheets which required
subjects to indicate which of the two real words they felt the stimuli most resembled, thus making the test overtly language ambiguous.

**Test material**

In designing the complementary test, the same vocalic elements were used, but they were placed in a synthetic consonantal frame /ʃ t _ t /. The use of this frame ensured that the stimuli could only be interpreted as the German words *Stadt* and *Staat*, with no possible English equivalents. The use of an initial consonant cluster which contravened English phonotactic constraints was a further feature which would prevent non-German subjects from interpreting the stimuli using a speech mode appropriate to English.

The consonant frame for the syllables was synthesised using Klatt synthesis software, so that the stimuli were fully synthetic rather than hybrid. The characteristics of the consonants were based on natural utterances from the same speaker on whose speech the vowel synthesis was based. The vowel element was the same as that used in the previous test, and was increased in 12 increments of 10 msecs, giving a stimulus continuum with a vowel element of 50-160 msecs. The program used to create the synthesis is reproduced in Appendix II.

The resulting stimuli were piloted by presenting them to native German speakers for open labelling; none experienced any difficulty in recognising the items as the German words *Stadt* and *Staat*.

**II.1.3 Perception of vowel quality**

In order to extend the range of information provided about subjects' processing of phonetic information, a set of tests was designed to investigate perception of vowel quality. This is an important area of investigation, since there are suggestions that information about accent may be carried primarily in the vowel (Barry, 1989; but cp. Flege, 1984).

The starting point for the test development is the fact that the front vowel space is divided in English into three categories, identified as the vowels
The vowels in the German word *hat* and the English word *but* are phonetically similar: both are classified as open central vowels (Kohler, 1977; Ladefoged, 1993) and have similar formant values (Kohler, 1977; Fry, 1979). For the purposes of this experiment, the English and the German phoneme were treated as equivalents. Similarly, the /æ/ vowel in English *bet* and German *Bett* may be considered equivalents (Bohn & Flege, 1990).

The location of these vowels in vowel space is shown on the diagram in Figure II.6 below.

---

Figure II.6
Vowel diagram for /e/, /æ/ and /a/

Observation suggests that many foreign learners find the English front open vowel particularly difficult to acquire, and its misproduction as /e/ or /a/ is a characteristic of foreign accent in learners of English. It has been demonstrated that on a productive level, /æ/ presents a difficulty to

---

† The open central vowel in English is usually transcribed /ʌ/; as described in the text, the phonetic similarities between this English vowel and the German open central vowel usually transcribed /a/ are substantial; in the present experiment they were treated as equivalent, and it was felt to be confusing to use two different phonemic symbols for the same phonetic entity. Hence the symbol /a/ is used throughout to denote the vowel in the English word *but* as well as the vowel in the German word *hat*. See also the accompanying vowel diagram.
German learners of English (Barry, 1974; 1981; Bohn & Flege, 1992), although there is considerable variation across speakers groups and different types of task.

Corresponding tests of learners' perception suggest that they may also have difficulty in developing a stable category for English /æ/, either identifying it with an adjacent German vowel (Barry, 1989) or using a category based on different acoustic dimensions to that of English natives (Bohn & Flege, 1990).

Because the front vowel continuum has clearly different divisions in English and German, it forms an ideal test of bilinguals' processing capacities and strategies.

**Test material**
The formant values for the vowels were based on acoustic measurements of similar syllables spoken by native English and native German speakers, and were tested for acceptability by native speakers of both languages. Three vowel elements were produced by copy synthesis of an utterance by a native German speaker using the cascade branch of a Klatt synthesis system, to produce vowels corresponding to English /e/, English /æ/, and English and German /a/. The acoustic characteristics of the stimulus vowels were consistent with with the findings from other studies of formant structure of these vowels (Kohler, 1977; Barry, 1981; 1989). The programs used to create the syntheses are reproduced in Appendix IV.

A continuum was then created by logarithmic interpolation of a further five values for F1, F2 and F3 between each of the three fixed points. Other characteristics were held constant. This resulted in a thirteen-point continuum of formant structure, ranging from /e/ through /æ/ to /a/.

The vowel tokens were inserted between two synthetic consonants, to produce CVC syllables. The consonant frame used for the English condition was /b_t/, giving the possible English words bet, bat and but; for German the context was /f_st/, giving the possible German words fest and fast. See Appendix IV for details of the syntheses.
The stimulus syllables of the fixed points (three in English; two in German) were piloted on both English and German native speakers by asking them to identify the words being spoken; in both languages all stimuli were identified correctly.

For testing in the main phase, the synthetic syllables were then randomised in ten blocks of thirteen stimuli each, and recorded onto audio cassette. A test block was also recorded consisting of an additional block of randomised stimuli, so that subjects could be familiarised with the material.

II.1.4 Global accent testing

A further part of the recording material consisted of five sentences in each language designed to reveal accent in L2 learners or bilinguals. They contained sounds which have no equivalent in the other language ([ς X θ ø w t e:\] for German); [ί θ β w t a z:\] for English), as well as sequences with different phonotactic status in each language ([t s J t kn] for German; [kw θ ] for English). It also included phonemes which have different allophonic realisations in English and German, such as final voiced vs devoiced obstruents and postvocalic clear vs dark /l/. Sentence structures were also varied, and included a question form, to test how the phrasing and intonation of learners might differ from that of native speakers. Similar use of accent-revealing sentences in a bilingual study is found in Hazan & Boulakia (1993).

Native speakers of both languages were asked to read these sentences out loud, without being told of their purpose. The subjects were those who participated in the recordings for the investigation of vowel duration contrasts. The sentence recordings were made at the same time using the same equipment. The sentences used were:

English condition:

1. Phil's first action was to sit down in the armchair and begin reading one of the magazines.
2. Last year more than three thousand victims of violence were entitled to compensation from the new fund.
3. Put those things down over there and then leave the room as quickly as possible.
4. Jill feels that she was cheated out of her chance to see the original film.
5. Have you seen the old pet shop which has dogs, cats and lots of birds in the front window?

German condition:

1. In München werden jeden Tag mindestens zehn Diebstähle angezeigt.
2. Martin zögerte noch einen Augenblick, bevor er in die Albrechtstraße einbog.
3. Hast du gesehen, wie der kleine Junge hinfiel und sich den Knöchel verstaucht hat?
4. Der Mann fuhr nach Berlin, weil ihm der Wald zu grün war.
5. Bei Vollmond hört man immer ein lautes Krachen wenn die Werwölfe unterwegs sind.

None of the subjects considered the sentences to be unusually difficult, or to present any particular obstacle to reading aloud.

II.2 LEXICAL TESTING

An experiment was designed to investigate cross-language influences at the lexical level of processing. The starting point was an experiment by Altenberg & Cairns (1983) designed to examine the use of phonotactic constraints in two different ways: firstly, during an on-line lexical decision task in which Reaction Time was measured, and secondly, using a metalinguistic acceptability judgment task. The pilot lexical task in the present set of investigations was designed with the same aims in mind, but attempting to correct some fundamental flaws in Altenberg & Cairns' design.

Altenberg & Cairns (1983) set out to address the question of whether the fluent bilingual has one unified language processing system, used for processing both languages, or two processing systems, one for each language, by conducting a series of experiments at the level of phonotactic
constraints. The test stimuli consisted of a corpus of monosyllabic non-words in which the initial consonant clusters were phonotactically legal in English and illegal in German, and vice versa. Two sets of control stimuli, one consisting of analogous words with initial clusters that were phonotactically legal in both languages, the other consisting of items that were illegal in both languages were also used.

Two types of test were run using this material, the first investigating metalinguistic judgments on the acceptability of nonword material, the second investigating on-line processing of the same material by measuring reaction time on a lexical decision task. For the first test, subjects were required to judge the acceptibility of all the four categories of non-word as hypothetical words in each of their languages.

The second test included an additional set of control material, consisting of real English words and real German words; each language category comprised two subsets: firstly, real words which were phonotactically legal in both languages, and secondly, real words which were phonotactically illegal in the other language. Subjects were required to make word-nonword decisions, and the time taken to reach a decision was recorded. In tests such as these the usual finding is that illegal nonwords are rejected faster than legal nonwords, since a string beginning with a cluster which is illegal in a particular language is blocked at an early stage of lexical retrieval.

Altenberg & Cairns found different patterns of interference in the two types of task. In the reaction-time test both the test and the latent language were activated, as shown by the different pattern of responses for bilinguals and monolinguals. In the metalinguistic task no cross-language influence was found: bilinguals performed like monolinguals in the English condition.

One of the flaws inherent in these tests is their unidirectional focus. Control subjects were tested in the English condition only, which means that no conclusions can be drawn about the performance of the bilinguals in the German condition relative to monolingual standards. A further problem is that group results only are provided for a very heterogenous subject population, consisting of childhood bilinguals and L2 learners with...
widely differing ages of acquisition. Additional problems with the stimulus material are described below. It was hoped that, if these flaws could be remedied, the techniques could provide useful information about patterns of lexical level processing in bilinguals.

Test material
There are several fundamental problems with the stimulus material used by Altenberg & Cairns, which needed to be remedied before the results could be considered reliable.

Altenberg & Cairns make the claim that "other than the initial consonant cluster, the rest of the word was always legal in both languages". Since we are dealing with written rather than auditory material here, the problem of phonetic differences between the two languages does not arise, but there is an analogous difficulty which arises from the failure of Altenberg & Cairns to make and maintain a clear distinction between phonemes (units of sound) and graphemes (units of writing). This omission leads to problems with a significant proportion of the material used in their experiment, and must cast doubt on the validity of the results.

The original material used is given in Table II.5 below. The material is categorised into four groups, with LL meaning items legal in both English and German; LI items legal in the test language but not the other language; IL items legal in the other language but not the test language; and II items illegal in both languages.
Several quite specific problems arise from the failure to distinguish between phonemes and graphemes, in addition to straightforward inaccuracies.

(i) Some of the initial clusters used are intrinsically problematic:

- The cluster PFR-, classified as II, is in fact legal in German, and occurs initially in words such as *Pfropfen* and *Pfriem*. It is certainly not a particularly high-frequency cluster, but the *Duden* gives five separate words starting with PFR-, which would put it on a par with the English cluster DW-, which also occurs in five separate lexical items in English, but is classified as legal in English.

- The initial grapheme sequence TW-, classified as illegal in German, does not occur in native German words, but it is very common in loanwords such as *twin*, *twen* etc., where it is realised as /t v -/. Its status as illegal in German is therefore slightly compromised.

- The same problem occurs in reverse with the initial sequence ZW-, classified as illegal in English. Again, this certainly does not occur in native English words, but it is not unfamiliar to English speakers.
through its use in proper names in America and to a lesser extent in England (for example, the bookshop Zwemmers, whose pronunciation is anglicised to /zV-/). Familiarity with basically non-native clusters such as these may cause subjects to judge them as relatively more acceptable than other 'illegal' clusters which are not so familiar.

- A further non-linearity occurs with the initial sequences SPR- and STR-. They are legal initial grapheme clusters in both languages, and they represent legal phoneme clusters in both languages; however, they are realised differently: as /ʃpr-/ and /ʃtr-/ respectively in German, and /spr-/ and /str-/ respectively in English.

(ii) The use of two graphemes for the medial vowel in the test items is also a source of inter-lingual ambiguity in grapheme-to-phoneme conversion. The graphemes used are shown below, together with their possible phonemic correlates in each language:

<table>
<thead>
<tr>
<th>Grapheme</th>
<th>English phonemes</th>
<th>German phonemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU</td>
<td>/ɔː/ cause</td>
<td>/au/ Haus</td>
</tr>
<tr>
<td></td>
<td>/ɑː/ aunt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/ʊ/ because</td>
<td></td>
</tr>
<tr>
<td>IE</td>
<td>/aɪ/ high</td>
<td>/iː/ Wien</td>
</tr>
<tr>
<td></td>
<td>/iː/ piece</td>
<td></td>
</tr>
<tr>
<td>OU</td>
<td>/ɔː/ bought</td>
<td>/au/ (loanwords only)</td>
</tr>
<tr>
<td></td>
<td>/ʊ/ cough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/ʌ/ country</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/ʊ/ could</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/uː/ soup</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/əu/ soul</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/au/ house</td>
<td></td>
</tr>
<tr>
<td>EI</td>
<td>/iː/ seize</td>
<td>/ai/ Zeit</td>
</tr>
<tr>
<td></td>
<td>/eɪ/ eight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/ai/ either</td>
<td></td>
</tr>
</tbody>
</table>
It is clear from Table II.6 above that the inconsistency of grapheme-to-phoneme conversion in English presents a problem for the use of such material in tests presented through the visual medium, since there is no way for the experimenter to ascertain whether subjects were responding to the stimuli as graphemes or as phonemes, and in the latter case, which of the possible phonemic implementations the subjects were using. In addition, there are inconsistencies between the two languages; again, the experimenter cannot know which version in which language bilingual subjects are using to form their judgments.

(iii) Final consonant grapheme to phoneme conversion presents some similar problems.

• -K is not a legal final grapheme in either English or German when preceded by a vowel. The phoneme /k/, however, is legal in both languages, but is usually represented word-finally by the grapheme sequence -CK in English as in German.

• Similarly, -Z when preceded by a vowel is not a legal final grapheme in either language, and is implemented as a different phoneme in each language. In English it occurs very rarely word-finally, but usually represents the phoneme /z/; in German the grapheme -Z usually represents the phoneme /t s/, which is not a single phoneme at all in English; however, German /t s/ would be represented by the grapheme sequence -TZ word-finally. -Z alone does not occur as a final grapheme.

• -B, -D and -G are problematic since, although both English and German permit them to occur as final graphemes, they will represent different phonemes word-finally: lenis plosives in English, and fortis plosives in German, which has a final devoicing rule. A further complication is that the final fortis plosives /p/ and /t/ are conventionally spelt -P and -T in English, but -PP and -TT in German. Either version could therefore be seen as a bias toward the language in which it occurs.

Several adaptations were made to remedy the most serious of the problems outlined above. Not all were easily soluble, and in some cases
problematic material was retained in the interests of keeping a reasonable body of stimulus material.

(i) Replacement of medial diphthongs (digraphs) with monophthongs. All test items containing digraphs were changed to single graphemes by omitting the second element; in cases where omitting the second element produced a real word, the first element was omitted instead.

(ii) Adjustment of the final consonant:

- Items ending in the illegal grapheme -K were changed to end in the digraph -CK, which is legal as a grapheme in that position, and is realised as the legal phoneme /k/ in both languages.

- Items ending in -X were also amended to end in -CK, since -X is an unusual ending in the orthography of both languages.

- Items ending in the grapheme -L were changed to end in -LL, which is a legal grapheme with the same phonological realisation in each language and, unlike -L in English, does not affect the length of the preceding vowel.

- Items ending in the phonemically ambiguous and graphemically illegal -Z were amended to end in -ST.

- Items ending in -R were amended to end in -RT.

(iii) Adjustments to initial clusters:

- In the II category, the legal German cluster PFR- was replaced by PFN-, which is unambiguously illegal in both languages, and FN- in the same category was replaced by FM- to avoid reduplication.

- In the category LI, the legal but uncommon cluster DW- was replaced by THR-.

- Other potentially problematic clusters, such as TW- and ZW- were retained to ensure a balanced corpus of material, but with the proviso
that they would need to receive special consideration at the data evaluation stage.

(iv) Some miscellaneous adjustments:

- Removal of any items which became real words through the adjustments above, and their replacement by analogous non-words.

- Adjustments to ensure equal distribution of vowel sounds and ending.

Adapted stimulus material
The adapted set of stimulus material used for the pilot set of tests is shown in Tables II.7-8 below.

Table II.7
Adapted stimulus material for lexical decision task

<table>
<thead>
<tr>
<th>Legal in both</th>
<th>Legal in English</th>
<th>Legal in German</th>
<th>Illegal in both</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLASS</td>
<td>THROG</td>
<td>ZWUCK</td>
<td>TLICK</td>
</tr>
<tr>
<td>FLID</td>
<td>THRAB</td>
<td>ZWAT</td>
<td>TLON</td>
</tr>
<tr>
<td>FLEG</td>
<td>THRESS</td>
<td>ZWUG</td>
<td>TLIST</td>
</tr>
<tr>
<td>BLUCK</td>
<td>TWACK</td>
<td>PFUD</td>
<td>SRAB</td>
</tr>
<tr>
<td>BLET</td>
<td>TWOT</td>
<td>PFOST</td>
<td>SRIM</td>
</tr>
<tr>
<td>BLAM</td>
<td>TWEST</td>
<td>PFEST</td>
<td>SREF</td>
</tr>
<tr>
<td>SPAP</td>
<td>SLEF</td>
<td>SCHNIM</td>
<td>PFNAD</td>
</tr>
<tr>
<td>SPEN</td>
<td>SLIN</td>
<td>SCHNOP</td>
<td>PFNECK</td>
</tr>
<tr>
<td>SPEB</td>
<td>SLECK</td>
<td>SCHNEB</td>
<td>PFNIP</td>
</tr>
<tr>
<td>FRAST</td>
<td>SMEST</td>
<td>SCHWOD</td>
<td>FMACK</td>
</tr>
<tr>
<td>FRUT</td>
<td>SMAT</td>
<td>SCHWAT</td>
<td>FMET</td>
</tr>
<tr>
<td>FRI P</td>
<td>SMOST</td>
<td>SCHWOST</td>
<td>FMOST</td>
</tr>
</tbody>
</table>
Two separate tests were performed using this stimulus material.

Subjects
The subjects for the pilot tests were monolingual first-year students: the English monolinguals were speech science students at University College London; the German monolinguals were students of the Institut für Kommunikationsforschung und Phonetik of the University of Bonn.

II.2.1 On-line processing
The online processing task was conducted first in all cases, so that subjects were not familiarised with the stimuli beforehand. The complete set of real word and nonword stimuli was randomised, and four training items (two nonwords, one real English word and one real German word) added at the beginning to give a set of 100 test items.

This corpus was used as input to a Reaction-Time measurement program, which displayed one item at a time to the screen. Subjects were told that their task was to decide as quickly as possible whether each item was or was not a real word in their language, and to respond as quickly as possible.
to each item by pressing the key on the computer keyboard labelled yes or no. In each condition the labels on the keys were appropriate to the language in which the test took place. They were told that the computer would measure the time taken to reach a decision.

Results
The results for the reaction time test consisted of two parts: the yes-no lexical decision, and the RT taken to reach that decision. Wrong decisions (false negatives and false positives) were excluded from further calculations. The remaining responses were processed to give a mean RT for each subject for each category. Different categories of stimulus are coded as follows:

<table>
<thead>
<tr>
<th>Code</th>
<th>Status</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>legal in both languages</td>
<td>FLID</td>
</tr>
<tr>
<td>LI</td>
<td>legal in test language</td>
<td>THRESS in English</td>
</tr>
<tr>
<td></td>
<td>illegal in other language</td>
<td>ZWUCK in German</td>
</tr>
<tr>
<td>IL</td>
<td>illegal in test language</td>
<td>ZWUCK in English</td>
</tr>
<tr>
<td></td>
<td>illegal in other language</td>
<td>THRESS in German</td>
</tr>
<tr>
<td>II</td>
<td>illegal in both languages</td>
<td>TLON</td>
</tr>
<tr>
<td>LO</td>
<td>legal in test language</td>
<td>FLUG in English</td>
</tr>
<tr>
<td></td>
<td>real word in other lang.</td>
<td>FLAT in German</td>
</tr>
<tr>
<td>IO</td>
<td>illegal in test language</td>
<td>ZWECK in English</td>
</tr>
<tr>
<td></td>
<td>real word in other lang.</td>
<td>THRIFT in German</td>
</tr>
</tbody>
</table>

Table II.9
Mean reaction times for different nonword categories in lexical decision task

<table>
<thead>
<tr>
<th></th>
<th>LL</th>
<th>LI</th>
<th>IL</th>
<th>II</th>
<th>LO</th>
<th>IO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.71</td>
<td>0.82</td>
<td>0.61</td>
<td>0.58</td>
<td>0.74</td>
<td>0.61</td>
</tr>
<tr>
<td>SD</td>
<td>0.08</td>
<td>0.17</td>
<td>0.09</td>
<td>0.05</td>
<td>0.13</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>German condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.76</td>
<td>0.78</td>
<td>0.66</td>
<td>0.61</td>
<td>0.81</td>
<td>0.77</td>
</tr>
<tr>
<td>SD</td>
<td>0.07</td>
<td>0.08</td>
<td>0.10</td>
<td>0.06</td>
<td>0.06</td>
<td>0.04</td>
</tr>
</tbody>
</table>
The basic finding is that, for monolingual speakers, phonotactic constraints play a significant role in the time taken to reach a lexical decision, as reflected by the clear cross-category differences in reaction time. Thus for English monolinguals nonwords which are phonotactically illegal (categories IL and II) are rejected faster than nonwords which are phonotactically legal in English (categories LL and LI). Similarly, German

\*\* For Figures II.6-10: shaded boxes represent phonotactically illegal stimulus categories.\*\*
words which are illegal in English (IO) are rejected faster than German words which do not violate the phonotactic constraints of English (LO); in other words, German words are treated like nonwords, according to phonotactic status.

The basic patterning of responses for the German monolinguals is similar. Phonotactically illegal nonwords (IL and II) are rejected significantly faster than legal ones. However, one unpredicted effect which was not apparent for English monolinguals is the relatively long time taken by the German subjects to reject English words that are in the IO category, ie. those which violate the phonotactic rules of German. Theoretically these should be treated like nonwords and rejected as fast as IL and LL nonwords; in practice the violation of German phonotactic rules by the real English words in this category does not seem to be sufficient to prevent a search of the lexicon, as reflected in the longer reaction time. A likely explanation is that almost all German subjects have some degree of familiarity with English and are exposed to it much more regularly in daily life than English speakers are to German. It seems likely that these 'foreign' words have become part of the lexicon even for monolingual speakers, and are causing some level of interference, a phenomenon normally associated with bilinguals.

II.2.2 Metalinguistic judgment
The non-words used in the lexical decision task were given to the same subjects for judgment of their acceptability as hypothetical words of either English or German.

The stimuli were presented to the subjects in the form of a randomised written list, and subjects were asked to indicate the acceptability of each item on a scale of 1-5, where a judgment of 1 meant that an item would be completely acceptable as a new English word and a judgment of 5 meant that it would be completely unacceptable under all circumstances.

Results
The mean ratings given by subjects to nonword items are given in Table II.6 below.
Table II.10
Acceptability judgments for nonword stimuli in different phonotactic classes

<table>
<thead>
<tr>
<th></th>
<th>LL</th>
<th>LI</th>
<th>IL</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.42</td>
<td>1.72</td>
<td>4.20</td>
<td>4.82</td>
</tr>
<tr>
<td>SD</td>
<td>0.42</td>
<td>0.69</td>
<td>0.66</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>German condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.51</td>
<td>1.18</td>
<td>4.31</td>
<td>4.86</td>
</tr>
<tr>
<td>SD</td>
<td>0.31</td>
<td>0.11</td>
<td>0.34</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**Figure II.9**
Acceptability judgments: English monolinguals

**Figure II.10**
Acceptability judgments: German monolinguals
The results show that subjects in both conditions operated a clear two-way distinction for nonword items on the basis of their phonotactic status in the test languages, with phonotactically legal items scoring consistently higher ratings than phonotactically illegal items. The phonotactic status of an item in the non-test language was, unsurprisingly, irrelevant for these monolingual subjects. However, there were differences in the amount of variance shown: the two legal categories in the English condition received more varied ratings than the illegal categories in English, or any of the categories in the German condition.

These metalinguistic judgments confirm the finding from the lexical decision task that subjects are able reliably to judge nonword items according to their phonotactic status, making such material a suitable test for investigation of bilingual processing.

II.3 SYNTACTIC-SEMANTIC TESTING

In order to obtain a sample of relatively free speech for recording, a map description task was adapted for use in both English and German (the maps are reproduced in Appendix VI). Subjects were asked to describe the journey from home to the station, describing the main features which they passed on the way, and this description was recorded. This task was conducted at the same time as the accent-revealing sentences (section II.1.4 above), using the same equipment and subjects. None of the monolingual subjects felt that the task presented any particular difficulties.

II.4 QUESTIONNAIRE

The purpose of gathering information on individual subjects' language history and patterns of language usage is to balance the detailed information on task-based variables from experimental results with comprehensive information on the individual differences which may underlie variations in subjects' performance.

The questionnaire was designed firstly to cover areas of general relevance to performance on speech and perception tests, such as health, region of origin, educational level and occupation. A second function was to gain
insight into different patterns of becoming and remaining bilingual. Key features of interest in this second category included:

- Country of birth
- Age of acquisition of second language
- Language(s) used with parents
- Language of education
- Length of residence in both countries

Because the test battery was designed to investigate performance at several different levels of linguistic encoding, the questionnaire aimed for a large amount of detail in numerous different areas, of which some may be only tangentially related to individuals' linguistic performance. An important source for the structure and content of the questionnaire was that questionnaire used for the Bilingual Aphasia Test (Paradis, 1987), but it was adapted with reference to other questionnaires of this type (Cutler et. al., 1992; Hazan & Boulakia, 1993). The questionnaire is reproduced in Appendix VII.
CHAPTER III: MAIN PHASE TESTING

III.1 SUMMARY OF TEST BATTERY
The final test battery contained the following experiments. Test procedures used are described in Section III.3 below.

III.1.1 Vowel duration perception
This test investigated the perception of distinctive vowel duration in two different contexts: firstly, using the hybrid synthetic/natural stimuli presenting a vowel duration continuum in the language-ambiguous context /m_t/, giving the English minimal pair *mutt* and *mart*, and the German minimal pair *matt* and *Maat*, and secondly using purely synthetic stimuli presenting the same vowel duration continuum in the German-language context /ʃt_t/, giving the minimal pair *Stadt* and *Staat*. The former test was taken by all subjects (monolingual and bilingual) in both language conditions (English and German); the latter was taken by monolinguals in both language conditions, but by the bilinguals in the German language-condition only. The stimuli were presented in isolation, and in both cases the test was run as a forced-choice identification task for the subjects, using language-appropriate response sheets.

The continuum presented in the first test contained thirteen steps, with vowels ranging from 30 to 150 msecs in increments of 10 msecs. The continuum in the second test contained twelve steps, ranging from 50 to 160 msecs in 10 msec increments. Details of the synthesis are given in section II.1.2 above. The stimuli were randomised in ten blocks of 13 stimuli each, plus a practice block (not included in the final data analysis) consisting of ten repetitions of the endpoints of the continuum.

III.1.2 Vowel duration production
This test was intended to investigate whether subjects' production of words containing distinctive vowel duration mirrored their perception of the same contrasts. The material consisted of a printed list of different words exemplifying the type of contrast used in the perception tests: for example, the German material contained examples such as *Stadt-Staat* and *satt-Saat*, while the English material contained similar pairs preceding
both fortis and lenis consonants, for example cut-cart, and cud-card. In the English condition two examples of each contrast were used, and each item was repeated three times. In the German condition three examples of each word type were used, and again each item was repeated three times. The English material contained a total of 24 randomised items, and the German material contained 18 (See Appendix III for full lists of the materials used). The bilinguals produced the appropriate stimuli in each of the language conditions, while the monolinguals produced the stimuli in their respective languages.

III.1.3 Vowel quality perception
This test examined the perception of a vowel quality continuum using an identification task. Three synthetic vowels produced to represent the English vowels in the triplet bet-bat-but, the endpoints of which correspond to the vowels in the German words Bett and Bad respectively. Logarithmic interpolation of the first three formant values was used to produce vowel continua between these three fixed points, giving a 13-point continuum spanning the English vowel range /e æ a/. For detailed descriptions of the syntheses, see section II.1.3 above.

The same continuum was presented to all subjects, using the synthesised speech frame /b_t/ for the English condition and the frame /f_st/ for the German condition. The entire continuum consisted of 13 steps, which were presented in 10 randomised blocks, giving a total of 130 stimuli, preceded by a practice block consisting of an additional 13 randomised steps to familiarise subjects with the material and the task. The test was presented as an open-labelling task.

III.1.4 Vowel quality production
As for the vowel duration tests, the perception test was accompanied by an equivalent test designed to investigate subjects' production of similar contrasts. The English material contained triplets exemplifying a three-way contrast such as beg-bag-bug; the German material consisted of pairs exemplifying the two-way German contrast fest-fast. In both conditions four examples of each word type were used, each repeated twice: the English material contained a total of 30 items, the German material a total
of 20 items. Again the individual stimuli were randomised and took the form of a printed list. See Appendix V for complete list of material used.

III.1.5 On-line phonotactic processing

This test consisted of a lexical decision task involving lexemes with varying phonotactic legality in English and German. There were 96 stimuli in all, of which 24 were real English words and 24 were real German words. Of the real words, 12 were legal in both languages, while the other 12 were illegal in the other language. The 48 nonsense words fell into four categories: 12 were legal in both languages; 12 were illegal in both languages; 12 were legal in English but not in German, and the remaining 12 were legal in German but not in English. See section II.2 above for complete lists of the material used.

These lexemes were presented individually via computer screen for lexical decision. Subjects were required to press a key labelled YES or NO (using labels appropriate to the test language) according to whether or not the item was a real word in the test language. The program used measured the time that elapsed between the appearance of the stimulus on the screen and the subject's key press response, and recorded both response and reaction time in a separate file.

The test was presented to all subjects in both conditions, so that bilinguals took the same test twice, once monitoring for English words, and once for German words. For exact details of the procedure used, refer to section III.3.5 below.

III.1.6 Metalinguistic judgments

In order to see whether subjects' on-line processing of phonotactic constraints accorded with judgments of the acceptability of the test items, the nonsense words used in the lexical decision task were presented in the form of a randomised printed list. Subjects were then asked to grade the acceptability of each item as a hypothetical word in the test language on a scale of 1-5. 1 was the maximum rating, meaning that the item would be entirely acceptable as a hypothetical word in the test language, while 5 was the minimum score, meaning that an item would be completely
unacceptable as a word in the test language. Again, this test was taken once by the monolinguals, and twice, once in each language set, by the bilingual subjects.

III.1.7 Global accent judgments
In order to obtain some data that would permit a more global assessment of the subjects' phonetic/phonological performance in each language, they were also recorded in each language condition reading aloud five sentences which were designed to detect foreign accent. See section II.1.4 above for details of the materials used. The sentences were presented in the form of a printed list, and each sentence was read once only. In addition, subjects provided a sample of relatively free speech in response to a task which required them to describe a journey between two points on a pictorial map. Two sets of accent-revealing sentences were used, one for each language; the map was identical for both language conditions, but verbal labels on it were appropriate to the language being tested (see Appendix VI for materials used).

III.1.8 Questionnaire
Subjects were also asked to provide a significant amount of background information in response to a questionnaire. The questions covered basic personal information such as age and place of birth, language and accent of the parents and information on health matters such as hearing, cerebral dominance (left- vs. right-handedness), dyslexia and speech problems. For the bilinguals, it also recorded detailed information on language acquisition history and patterns of language-usage in daily life, as well as a self-assessment of the relative strength of each language. The questionnaire is reproduced in Appendix VII.

III.2 Subjects
In selecting subjects for testing, theoretical as well as practical criterial were taken into account. Because of the need to test the validity of the concept of dominance across a range of competences and language acquisition patterns, the bilingual subject population was relatively heterogeneous.
12 bilingual subjects were tested in the main phase. As discussed in Chapter I, no rigid distinction was made between childhood bilinguals and those who had become bilingual later in life. The criteria for selection were: a high degree of fluency in both languages; that subjects should use both their languages on a regular, although not necessarily daily, basis; that they should have spent time living in both countries; that their English accent should fall within the range of Standard Southern British, and their German accent should be a standard northern German one (Hochdeutsch).

They were recruited from a range of sources: an advertisement in the library of the Goethe-Institut in London brought a considerable response; others were members of staff or students in German departments at institutions of Higher Education in and around London; some came through personal contacts. Preliminary screening in both languages took place on the telephone, in the course of which an individual's level of fluency could be assessed quite effectively. The mean age of the bilingual subjects was 39 years. Three were childhood bilinguals, who had acquired both languages before the age of five; the others had begun learning the second language at school and had attained a high level of fluency in adulthood. Most were living in London on a long-term basis; all but one were tested in London.

The bilingual subjects included in the main phase testing were matched for relative strength of their two languages using a language-dominance scoring system and subjects' own evaluation of their dominance (for further details see section III.4.9 below). On this basis, 6 subjects were judged to be stronger in English, 6 stronger in German. More detailed biographical information on individual subjects is given in section IV.9 below.

12 monolingual controls were tested, 6 English and 6 German. The English monolinguals were students and members of staff at the Phonetics Department, University College, and the German monolinguals were students and members of staff at the Fachbereich Computerlinguistik at the Universität des Saarlandes in Saarbrücken. All monolingual subjects had lived all their lives in their country of origin, and had parents who
were both native speakers of their language. All the monolingual subjects had basic phonetic training. None of the English monolinguals had any significant knowledge of German; inevitably it was not possible to find German monolinguals without some knowledge of English, but those who were accepted as subjects had a chiefly passive knowledge, and claimed to use their English very rarely. The English monolinguals had a mean age of 30 years; the German monolinguals a mean age of 26 years.

III.3 Test Procedure
Testing took place over one session for the monolingual subjects, and two sessions for the bilingual subjects, one in each language. Half the bilinguals were tested in English first, the other half in German first; in any case, the two sessions were conducted at least a fortnight apart.

Within the test battery, the order in which the tests were administered was held constant, in order to achieve an alternation of different types of task and maintain the subjects' attention; in addition, interspersing production with perception tasks was intended to help keep subjects in the appropriate language mode. All instructions/conversation took place in the language being tested. Testing and recording took place in soundproofed rooms at the Phonetics Department, University College London and in the Fachbereich Computerlinguistik at the University of Saarbrücken from April to July 1994. Subjects were paid for their participation, and reimbursed for travel expenses.

The protocol for the testing was as follows:

III.3.1 Questionnaire
This was conducted orally in the first session, in the appropriate language. Oral discussion was preferred to written presentation, since this made it possible to ensure that all the necessary information was given.

III.3.2 Language setting
All general conversation, administration and instructions took place in the language appropriate to the test. Before the testing began, subjects were
asked to read aloud a moderately difficult passage in the test language, to facilitate their setting into the appropriate language mode (the passages are reproduced in Appendix I). This passage was recorded, since this provided an opportunity to familiarise subjects with the recording equipment and protocol, and to check the recording levels.

III.3.3 Vowel duration perception
The first perceptual test to be administered was the vowel duration continuum in the /m_t/ context. The stimuli were played on a Marantz audio cassette recorder, and presented to the subject binaurally via Sennheiser HD 414 headphones. Initially the practice block alone was run, which demonstrated the endpoints of the continuum; an answer sheet for this practice block indicated clearly which word corresponded to which stimulus, so that subjects were familiar with the endpoints of the continuum before proceeding to the main test. Subjects were allowed to adjust the volume to a comfortable level. They were then told that during the test they would hear a series of words which were more like one or the other of the exemplars, and told that their task was to decide for each stimulus, which word it most resembled, and mark their choice on the response sheet. The response sheets were appropriate to the language being tested in each case, and offered the possible responses mutt and mart for the short and long stimuli respectively in the English condition, and the possible responses matt and Maat for the German condition. Subjects were asked to tick the response which they felt was more suitable in each case. The importance of making a choice even in the case of uncertainty was emphasised.

All monolinguals, and bilinguals in the German condition, were then presented with the duration perception task in the /ʃt_t/ context. This was essentially an identical task, and the same instructions and procedure were used.

III.3.4 Vowel duration production
For this task, subjects were presented with a printed list of the test items, randomised and presented in the carrier sentence "Please repeat ____ again" for the English condition, and "Bitte das Wort ____ wiederholen"
for the German condition. They were instructed to read the sentences out loud for recording, and to repeat any sentence in which they stumbled or made an error. Recordings were made using an AKG D190 E microphone, and a Sony DTC55 ES DAT recorder.

III.3.5 Lexical decision
For this task, subjects were seated in front of a computer screen, and told that they would see individual word-like items come up on the screen, including real words in the test language, nonsense words, and real words in the other language. They were instructed to press the key labelled YES if the item was a real word in the test language, and NO if it was not a real word in the test language, regardless of the item's status in any other language (the labels on the response keys were appropriate to the language being tested). They were told that the program would measure the time taken to reach a decision. A short training session with dummy items was then run to familiarise them with the type of material and the task, before they proceeded to the test itself. There were 96 items in all.

III.3.6 Acceptability judgments
For this test, subjects were given a printed test sheet, containing all the nonsense items that appeared in the previous test. They were told that none of the items were real words in the test language, but that some would be more hypothetically acceptable than others, and asked to grade the items from 1-5 on the basis of their acceptability as potential words in the test language (1=most acceptable, 5=least acceptable).

III.3.7 Vowel quality perception
This test was administered in a similar way to the previous perception tasks except that, instead of being a forced-choice decision, subjects were asked to write down the word in the test language which most resembled each stimulus heard. They were warned that some were clearer examples than others, but that all could be identified as real words. A training session was run using a sample of the real test items, to ensure that subjects had understood the nature of the task, before proceeding to the test itself.
III.3.8 Vowel quality production
This test was run in the same way as the previous production task, using the same techniques, equipment and carrier sentences.

III.3.9 Accent-revealing sentences
Subjects were asked to read the five sentences from a printed sheet in as natural a manner as possible, repeating the entire sentence if they made any errors during the reading. The reading was recorded as previously.

III.3.10 Map description task
Subjects were presented with the picture map and asked to describe the journey from the house in the bottom left-hand corner to the station in the top right-hand corner, taking in the main landmarks on the way. They were told not to be concerned about hesitations or errors, but simply to continue the description in as natural a manner as possible.

III.4 RESULTS: RAW DATA

III.4.0 Introduction
This section presents raw data from the test battery for the three groups of subjects: English monolinguals, German monolinguals, and bilinguals. The purpose of these group results is to establish values for the performance of the monolingual groups, against which the performance of the bilinguals may be measured.

The group results for the bilingual subjects do not provide a clear impression of performance, since the bilinguals were not a homogenous group, and the mixing within the group of subjects with different dominance patterns and different degrees of bilingualism means that potentially significant effects may cancel each other out.

However, the group results do give an idea of the range of performance among the bilinguals, and of the amount of variance present in
comparison with the monolingual controls. Closer analysis of the results of the bilingual subjects in terms of their dominance groupings and of individual performance across a range of tests is undertaken in subsequent chapters.

III.4.1 Vowel duration perception
A Maximum Likelihood Estimate procedure (Bock & Jones, 1968) was used to fit a cumulative normal function (probit analysis) for each subject's set of data. This analysis was performed on the identification function for individual subjects, and mean results for each groups were established. Two parameters were extracted to characterise each identification function:

(a) the phoneme boundary (PB) between /a/ and /a:/ calculated at the 50% point of the fitted identification function;
(b) the gradient of the fitted curve (slope), expressed as probit units divided by the number of stimuli in the continuum.

The phoneme boundary is an indication of subjects' categorisation of the stimuli, while the function gradient may be used as an indication of labelling consistency and of the degree of categorical labelling. The mean values of both these parameters for each of the four groups of subject in the two vowel duration tests are shown in Tables III.1 and III.2 below. Three groups of data only are presented in the /ʃt̩/ context, since this test was taken by bilinguals in the German condition only.

Table III.1
Vowel duration perception in /m̩t/ context

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>PB 7.045 (90.45 ms)</td>
<td>0.227</td>
</tr>
<tr>
<td></td>
<td>Slope -1.068</td>
<td>0.240</td>
</tr>
<tr>
<td>German condition</td>
<td>PB 7.331 (93.31 ms)</td>
<td>0.700</td>
</tr>
<tr>
<td></td>
<td>Slope -1.688</td>
<td>0.968</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>PB 7.369 (93.68 ms)</td>
<td>0.986</td>
</tr>
<tr>
<td></td>
<td>Slope -1.086</td>
<td>0.332</td>
</tr>
<tr>
<td>German condition</td>
<td>PB 7.056 (90.56 ms)</td>
<td>0.765</td>
</tr>
<tr>
<td></td>
<td>Slope -1.035</td>
<td>0.401</td>
</tr>
</tbody>
</table>
Table III.2
Vowel duration perception in /ft_t/ context

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>English condition</strong></td>
<td>PB</td>
<td>6.889 (108.88 ms)</td>
</tr>
<tr>
<td></td>
<td>Slope</td>
<td>1.198</td>
</tr>
<tr>
<td><strong>Monolinguals</strong></td>
<td>PB</td>
<td>5.904 (99.03 ms)</td>
</tr>
<tr>
<td><strong>German condition</strong></td>
<td>Slope</td>
<td>1.769</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td>PB</td>
<td>6.135 (101.35 ms)</td>
</tr>
<tr>
<td><strong>German condition</strong></td>
<td>Slope</td>
<td>1.426</td>
</tr>
</tbody>
</table>

Figures III.1-9 below show the individual labelling curves for subjects in each of the groups in both the vowel duration perception tests.

![Figure III.1](image)

Figure III.1
% /a/ responses in /m_t/ context: English monolinguals
Figure III.2
% /a/ responses in /m_t/ context: German monolinguals

Figure III.3
% /a/ responses in /m_t/ context: bilinguals English condition
Figure III.4
% /a/ responses in /m_t/ context: bilinguals German condition

Figure III.5
% /a/ responses in /f_t_t/ context: English monolinguals
III.4.2 Vowel duration production

The material used for measuring subjects' productions of words illustrating vowel duration contrasts analogous to those used in the perception material (e.g. card, cart, cud and cut for the English condition, Stadt, Staat for the German condition) were the recordings made during the testing sessions.
Vowel duration measurements of the digitised utterances were made from spectrographic displays on a real-time Kay spectrograph, from the first to the last periodic cycle of the vowel. Table III.3 below shows the mean and standard deviation for the duration of vowels produced in each of the contexts for the four groups of subjects. Each mean is based on six repetitions of each contrast per subject.

**Table III.3**  
**Mean durations (msecs) for vowels spoken by subjects**

<table>
<thead>
<tr>
<th></th>
<th>/aːd/</th>
<th>/aːt/</th>
<th>/ad/</th>
<th>/at/</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>273.9</td>
<td>198.6</td>
<td>132.9</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>51</td>
<td>49</td>
<td>42</td>
</tr>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>204.6</td>
<td>94.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>45</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>276.9</td>
<td>192.7</td>
<td>130.8</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>42</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>235.8</td>
<td>96.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>43</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

Figures III.10-13 below illustrate the data in the form of separate box plots showing the median as well as the amount of variation and the range produced by each of the four groups of subject.

**Figure III.8**  
*Durations of spoken vowels in English: monolinguals and bilinguals*  

† Figures III.8-9: vertically hatched boxes represent data from bilingual subjects
III.4.3 Vowel quality perception

As for the vowel duration data (section III.4.1 above), a Maximum Likelihood Estimate was used to obtain measurements of phoneme boundary (PB) and function gradient (slope).

In the English condition of this open labelling task, listeners consistently divided the continuum into three categories, corresponding to the English vowels in *bet, bat* and *but*; in the German condition, listeners divided the continuum into two categories, corresponding to the first vowels in the German words *fest* and *fas*. The results below are tabulated separately for the two language conditions, to characterise the two boundaries operated by listeners in the English condition (/*e_æ*/ and /*æ_a*/; Tables III.4 and III.6 respectively) and the single boundary operated by listeners in the German condition (/e_a/, Table III.5)

### Table III.4
Perception of /e-æ/ boundary (English condition)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>4.128</td>
<td>0.247</td>
</tr>
<tr>
<td>Slope</td>
<td>-2.303</td>
<td>0.595</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>3.949</td>
<td>0.839</td>
</tr>
<tr>
<td>Slope</td>
<td>-1.748</td>
<td>1.324</td>
</tr>
</tbody>
</table>
Figure III.10
% of /e/ responses: English monolinguals

Table III.5
Perception of /e - a/ boundary (German condition)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monolinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>6.469</td>
<td>0.986</td>
</tr>
<tr>
<td>Slope</td>
<td>-1.383</td>
<td>0.659</td>
</tr>
<tr>
<td>Bilinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>5.725</td>
<td>0.743</td>
</tr>
<tr>
<td>Slope</td>
<td>-2.620</td>
<td>1.147</td>
</tr>
</tbody>
</table>
Figure III.12
% of /e/ responses: German monolinguals

Figure III.13
% of /e/ responses: bilinguals German condition

Table III.6
Perception of /æ - a/ boundary (English condition)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>8.110</td>
<td>0.220</td>
</tr>
<tr>
<td>Slope</td>
<td>-2.650</td>
<td>0.412</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>8.306</td>
<td>0.505</td>
</tr>
<tr>
<td>Slope</td>
<td>-2.349</td>
<td>0.705</td>
</tr>
</tbody>
</table>
III.4.4 Vowel quality production

Subjects' own production of vowel contrasts analogous to those used in the perception tests were digitised from the recorded material obtained during the testing session. The words spoken illustrated the three-way contrast operated by English listeners (e.g. *bet, bat, but*) and the two-way contrast operated by German listeners (e.g. *fest, fast*). Measurements of F1
and F2 values for the steady state of the vowel were made using spectral and spectrographic displays on a Kay real-time spectrograph.

The mean values for the first two formants of the different vowels are given below. Separate means are calculated for male and female speakers; the values for male speakers are based on two monolingual and two bilingual speakers, and the values for female speakers on four monolingual and ten bilingual speakers. The graphical displays of F1 by F2 plots in Figures III.16-19 below represent the values for female speakers only, since they represented the bulk of the data.

**Table III.7**  
Vowel quality production: formant values (Hz) for vowels (male speakers)

<table>
<thead>
<tr>
<th></th>
<th>/e/</th>
<th>/æ/</th>
<th>/a/</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>F1</td>
<td>590</td>
<td>760</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1650</td>
<td>1380</td>
</tr>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>F1</td>
<td>590</td>
<td>712</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1690</td>
<td></td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>F1</td>
<td>475</td>
<td>690</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1710</td>
<td>1430</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>F1</td>
<td>490</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1760</td>
<td></td>
</tr>
</tbody>
</table>

**Table III.8**  
Vowel quality production: formant values (Hz) for vowels (female speakers)

<table>
<thead>
<tr>
<th></th>
<th>/e/</th>
<th>/æ/</th>
<th>/a/</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>F1</td>
<td>640</td>
<td>805</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>2120</td>
<td>1900</td>
</tr>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>F1</td>
<td>570</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1970</td>
<td></td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>F1</td>
<td>652</td>
<td>783</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>2002</td>
<td>1853</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>F1</td>
<td>598</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>2084</td>
<td></td>
</tr>
</tbody>
</table>
Figure III.16
F1 by F2 plots for German and English monolingual female speakers

Figure III.17
F1 by F2 plots for bilingual female speakers in German & English conditions
III.4.5 Lexical decision

Individual reaction time scores were assembled and collated to give mean RTs per subject group in each of the different stimulus categories (Table III.8 below). Only the RTs for correct responses were included in these calculations.
Table III.9
Mean reaction times (secs) for nonword stimulus categories in lexical decision task

<table>
<thead>
<tr>
<th></th>
<th>LL</th>
<th>LI</th>
<th>II</th>
<th>LO</th>
<th>IO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>0.77</td>
<td>0.78</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.14</td>
<td>0.16</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>0.69</td>
<td>0.67</td>
<td>0.55</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>1.14</td>
<td>1.23</td>
<td>0.85</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.49</td>
<td>0.66</td>
<td>0.23</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>0.78</td>
<td>0.96</td>
<td>0.72</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.18</td>
<td>0.32</td>
<td>0.12</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Figure III.20
Box plot of RT for legal categories: monolinguals and bilinguals English condition

+ Figures III.20-27: vertically hatched boxes represent data from bilingual subjects
Figure III.21
Box plot of RT for illegal categories: monolinguals and bilinguals English condition

Figure III.22
Box plot of RT for legal categories: monolinguals and bilinguals German condition
III.4.6 Acceptability judgments

The values below represent the mean scores given to items in each category, where 1 was the maximum (ie. entirely acceptable as a hypothetical word in the language) and 5 was the minimum (ie. completely unacceptable as a potential word).

Table III.10 Acceptability judgments for nonword stimuli in different phonotactic classes

<table>
<thead>
<tr>
<th></th>
<th>LL</th>
<th>LI</th>
<th>IL</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monolinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>1.88</td>
<td>1.88</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.636</td>
<td>0.633</td>
<td>0.629</td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>1.85</td>
<td>1.58</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.450</td>
<td>0.598</td>
<td>0.334</td>
</tr>
<tr>
<td><strong>Bilinguals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean</td>
<td>2.49</td>
<td>2.41</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.705</td>
<td>0.723</td>
<td>0.295</td>
</tr>
<tr>
<td>German condition</td>
<td>Mean</td>
<td>2.76</td>
<td>2.35</td>
<td>4.31</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.824</td>
<td>0.779</td>
<td>0.352</td>
</tr>
</tbody>
</table>

The following four figures illustrate the judgments for the various conditions across the different subject groups.
Figure III.24
Acceptability judgments for legal categories: monolinguals and bilinguals
English condition

Figure III.25
Acceptability judgments for illegal categories: monolinguals and bilinguals
English condition
III.4.7 Global accent judgments

Each subject's rendering of three of the accent-revealing sentences and the first 10 seconds of the free speech passages were digitised and saved on a Sun SPARC workstation, and the entire set of recordings for each language mode were randomised and recorded onto DAT tape. This material was
then played to groups of ten native speakers of the appropriate language so that they could evaluate the accents of the speakers. These native subjects were first-year students of the Phonetics Department, University College London (English utterances) and final-year school students from 3 Hamburg secondary schools (German utterances). None of these subjects were experienced in phonetic transcription or judgment, and none were familiar with any of the test battery subjects who featured in the recordings. They were asked to mark each utterance using a scale of 1-10 (1=least native-like; 10=most native-like) to indicate how native-like they felt it was.

The scores from each listener were combined to give a mean score per utterance per speaker; subsequently the mean score for the four utterances was obtained to give an overall accent score for each speaker. Table III.11 below gives the mean and standard deviation of all the speakers in each group; Tables III.12-15 give each a more detailed breakdown of each subject's score for each of the three sentences (s. 1-3) and the extract from the map description passage (pas.); the final column gives the overall mean rating for that subject's accent†.

Table III.11
Mean accent ratings for different subject groups

<table>
<thead>
<tr>
<th></th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monolinguals</td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean 9.43</td>
</tr>
<tr>
<td></td>
<td>SD 0.24</td>
</tr>
<tr>
<td>Monolinguals</td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>Mean 9.40</td>
</tr>
<tr>
<td></td>
<td>SD 0.21</td>
</tr>
<tr>
<td>Bilinguals</td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>Mean 5.39</td>
</tr>
<tr>
<td></td>
<td>SD 2.91</td>
</tr>
<tr>
<td>Bilinguals</td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>Mean 7.39</td>
</tr>
<tr>
<td></td>
<td>SD 1.49</td>
</tr>
</tbody>
</table>

† Subject codes beginning 'mel' denote English monolinguals; subject codes beginning 'mgs' denote German monolinguals; subject codes beginning 'b' denote bilinguals. The remainder of the code is arbitrary.
### Table III.12
Accent scores for monolinguals: English condition

<table>
<thead>
<tr>
<th>subject</th>
<th>s. 1</th>
<th>s. 2</th>
<th>s. 3</th>
<th>pas.</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>mel17</td>
<td>9.9</td>
<td>9.3</td>
<td>8.6</td>
<td>9.1</td>
<td>9.22</td>
</tr>
<tr>
<td>mel18</td>
<td>8.9</td>
<td>8.2</td>
<td>9.4</td>
<td>9.7</td>
<td>9.05</td>
</tr>
<tr>
<td>mel19</td>
<td>9.7</td>
<td>9.7</td>
<td>9.3</td>
<td>10.0</td>
<td>9.67</td>
</tr>
<tr>
<td>mel20</td>
<td>10.0</td>
<td>9.7</td>
<td>9.6</td>
<td>9.1</td>
<td>9.60</td>
</tr>
<tr>
<td>mel21</td>
<td>9.6</td>
<td>9.0</td>
<td>9.9</td>
<td>9.7</td>
<td>9.55</td>
</tr>
<tr>
<td>mel22</td>
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<td>9.8</td>
<td>9.4</td>
<td>9.3</td>
<td>9.50</td>
</tr>
</tbody>
</table>

### Table III.13
Accent scores for monolinguals: German condition

<table>
<thead>
<tr>
<th>subject</th>
<th>s. 1</th>
<th>s. 2</th>
<th>s. 3</th>
<th>pas.</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>mgs01</td>
<td>9.3</td>
<td>9.8</td>
<td>9.2</td>
<td>10.0</td>
<td>9.57</td>
</tr>
<tr>
<td>mgs02</td>
<td>9.1</td>
<td>9.2</td>
<td>9.7</td>
<td>9.5</td>
<td>9.37</td>
</tr>
<tr>
<td>mgs03</td>
<td>10.0</td>
<td>9.3</td>
<td>8.9</td>
<td>9.6</td>
<td>9.45</td>
</tr>
<tr>
<td>mgs04</td>
<td>9.7</td>
<td>9.9</td>
<td>9.0</td>
<td>9.6</td>
<td>9.40</td>
</tr>
<tr>
<td>mgs05</td>
<td>8.6</td>
<td>9.3</td>
<td>8.7</td>
<td>9.5</td>
<td>9.02</td>
</tr>
<tr>
<td>mgs06</td>
<td>9.6</td>
<td>9.2</td>
<td>10.0</td>
<td>9.7</td>
<td>9.62</td>
</tr>
</tbody>
</table>

### Table III.14
Accent scores for bilinguals: English condition

<table>
<thead>
<tr>
<th>subject</th>
<th>s. 1</th>
<th>s. 2</th>
<th>s. 3</th>
<th>pas.</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>bgl03</td>
<td>8.3</td>
<td>7.3</td>
<td>7.4</td>
<td>9.3</td>
<td>8.07</td>
</tr>
<tr>
<td>bgl04</td>
<td>1.7</td>
<td>2.1</td>
<td>1.3</td>
<td>3.2</td>
<td>2.07</td>
</tr>
<tr>
<td>bgl05</td>
<td>1.2</td>
<td>1.1</td>
<td>1.7</td>
<td>1.3</td>
<td>1.32</td>
</tr>
<tr>
<td>bgl06</td>
<td>3.0</td>
<td>3.1</td>
<td>3.0</td>
<td>5.2</td>
<td>3.57</td>
</tr>
<tr>
<td>bgl08</td>
<td>4.1</td>
<td>1.9</td>
<td>2.5</td>
<td>2.8</td>
<td>2.83</td>
</tr>
<tr>
<td>bgl09</td>
<td>2.4</td>
<td>2.2</td>
<td>2.3</td>
<td>2.6</td>
<td>2.37</td>
</tr>
<tr>
<td>bgl10</td>
<td>4.2</td>
<td>4.8</td>
<td>4.0</td>
<td>5.7</td>
<td>4.67</td>
</tr>
<tr>
<td>bgl11</td>
<td>8.0</td>
<td>7.8</td>
<td>5.8</td>
<td>6.3</td>
<td>6.97</td>
</tr>
<tr>
<td>bgl13</td>
<td>7.8</td>
<td>4.7</td>
<td>7.7</td>
<td>5.4</td>
<td>6.40</td>
</tr>
<tr>
<td>bel02</td>
<td>9.7</td>
<td>8.4</td>
<td>9.1</td>
<td>8.4</td>
<td>8.90</td>
</tr>
<tr>
<td>bel03</td>
<td>8.7</td>
<td>9.1</td>
<td>8.6</td>
<td>8.4</td>
<td>8.70</td>
</tr>
<tr>
<td>bes03</td>
<td>8.6</td>
<td>9.2</td>
<td>9.3</td>
<td>8.6</td>
<td>8.82</td>
</tr>
</tbody>
</table>
Table III.15
Accent scores for bilinguals: German condition

<table>
<thead>
<tr>
<th>subject</th>
<th>s. 1</th>
<th>s. 2</th>
<th>s. 3</th>
<th>pas.</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>bgl03</td>
<td>6.9</td>
<td>7.5</td>
<td>7.0</td>
<td>6.0</td>
<td>6.85</td>
</tr>
<tr>
<td>bgl04</td>
<td>9.4</td>
<td>8.2</td>
<td>8.9</td>
<td>9.1</td>
<td>8.90</td>
</tr>
<tr>
<td>bgl05</td>
<td>9.7</td>
<td>9.4</td>
<td>8.8</td>
<td>9.0</td>
<td>9.22</td>
</tr>
<tr>
<td>bgl06</td>
<td>7.4</td>
<td>7.9</td>
<td>7.6</td>
<td>7.0</td>
<td>7.47</td>
</tr>
<tr>
<td>bgl08</td>
<td>5.2</td>
<td>5.8</td>
<td>6.0</td>
<td>4.2</td>
<td>5.30</td>
</tr>
<tr>
<td>bgl09</td>
<td>8.9</td>
<td>8.6</td>
<td>9.1</td>
<td>9.1</td>
<td>8.92</td>
</tr>
<tr>
<td>bgl10</td>
<td>8.0</td>
<td>7.6</td>
<td>7.2</td>
<td>8.4</td>
<td>7.80</td>
</tr>
<tr>
<td>bgl11</td>
<td>7.3</td>
<td>8.2</td>
<td>6.9</td>
<td>8.0</td>
<td>7.60</td>
</tr>
<tr>
<td>bgl13</td>
<td>8.4</td>
<td>8.9</td>
<td>9.0</td>
<td>9.1</td>
<td>8.85</td>
</tr>
<tr>
<td>bel02</td>
<td>7.4</td>
<td>8.2</td>
<td>6.9</td>
<td>6.8</td>
<td>7.32</td>
</tr>
<tr>
<td>bel03</td>
<td>6.4</td>
<td>5.6</td>
<td>5.2</td>
<td>4.3</td>
<td>5.37</td>
</tr>
<tr>
<td>bes03</td>
<td>5.1</td>
<td>4.6</td>
<td>6.4</td>
<td>4.2</td>
<td>5.07</td>
</tr>
</tbody>
</table>

III.4.8 Syntactic/semantic judgments
An orthographic transcription was made of the map description recording for each subject. In each language condition, the passages from monolinguals and bilinguals were randomised together. These transcriptions were then given to the same subjects who made the accent judgments for grading on a scale of 1 to 10 according to nativeness. The mean ratings for each subject are given in the tables below. The orthographic transcriptions of the descriptions are reproduced in Appendix VI.

Table III.16
Mean syntactic ratings for different subject groups

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monolinguals</td>
<td>English condition</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>Monolinguals</td>
<td>German condition</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>Bilinguals</td>
<td>English condition</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
</tr>
<tr>
<td>Bilinguals</td>
<td>German condition</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
</tr>
</tbody>
</table>
Table III.17
Syntactic-semantic scores for monolinguals: English condition

<table>
<thead>
<tr>
<th>subject</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>mel17</td>
<td>7.54</td>
</tr>
<tr>
<td>mel18</td>
<td>9.45</td>
</tr>
<tr>
<td>mel19</td>
<td>8.09</td>
</tr>
<tr>
<td>mel20</td>
<td>9.18</td>
</tr>
<tr>
<td>mel21</td>
<td>8.72</td>
</tr>
<tr>
<td>mel22</td>
<td>8.83</td>
</tr>
</tbody>
</table>

Table III.18
Syntactic-semantic scores for monolinguals: German condition

<table>
<thead>
<tr>
<th>subject</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>mgs01</td>
<td>9.08</td>
</tr>
<tr>
<td>mgs02</td>
<td>9.45</td>
</tr>
<tr>
<td>mgs03</td>
<td>8.34</td>
</tr>
<tr>
<td>mgs04</td>
<td>8.26</td>
</tr>
<tr>
<td>mgs05</td>
<td>8.03</td>
</tr>
<tr>
<td>mgs06</td>
<td>8.80</td>
</tr>
</tbody>
</table>

Table III.19
Syntactic-semantic scores for bilinguals: English and German conditions

<table>
<thead>
<tr>
<th>subject</th>
<th>English</th>
<th>German</th>
</tr>
</thead>
<tbody>
<tr>
<td>bgl03</td>
<td>6.36</td>
<td>5.72</td>
</tr>
<tr>
<td>bgl04</td>
<td>6.91</td>
<td>8.62</td>
</tr>
<tr>
<td>bgl05</td>
<td>4.82</td>
<td>8.00</td>
</tr>
<tr>
<td>bgl06</td>
<td>8.00</td>
<td>6.93</td>
</tr>
<tr>
<td>bgl08</td>
<td>7.09</td>
<td>6.72</td>
</tr>
<tr>
<td>bgl09</td>
<td>4.72</td>
<td>8.62</td>
</tr>
<tr>
<td>bgl10</td>
<td>7.27</td>
<td>5.83</td>
</tr>
<tr>
<td>bgl11</td>
<td>8.54</td>
<td>7.09</td>
</tr>
<tr>
<td>bgl13</td>
<td>6.63</td>
<td>8.42</td>
</tr>
<tr>
<td>bel02</td>
<td>8.54</td>
<td>5.91</td>
</tr>
<tr>
<td>bel03</td>
<td>8.65</td>
<td>3.79</td>
</tr>
<tr>
<td>bes03</td>
<td>8.36</td>
<td>6.0</td>
</tr>
</tbody>
</table>
III.4.9 Questionnaire

A brief background outline of the subjects, both monolingual and bilingual, who participated in the main phase of the testing was given in section III.2 above. This section describes a language-dominance scoring system, based on the information given in response to the questionnaires, designed to identify the relative strength of the two languages for the bilingual subjects.

The scoring system used was based on Hazan and Boulakia (1993), and measured the following aspects of language-background and current language-use:

- country of birth
- language-use with parents
- language-use at school/university
- current language-use (at home and at work)
- country of current residence
- length of residence in each country
- self-assessment of dominance

One point was given to the language that featured in each of the above categories. If both languages featured in response to a particular category, then half a point was given to each language. Length of residence in the country of current residence was calculated by adding up the number of years (not necessarily consecutive) spent living in each country, and expressing these figures as a fraction of the subject's age. A point was given to the language of the country in which the subject had spent more than half of his or her life. If this fraction was between 0.45 and 0.55, then half a point was given to each language. Table III.18 below shows the number of points scored by each subject in each of their languages. The maximum total score was seven, so a score of four or more in one language implies that that language was the stronger. The final column gives the subject's self-assessment of their own dominance, for comparison with the results of the questionnaire scoring. The response 'both' in this column indicates that the subject felt himself or herself to be equally dominant in both languages.
Table III.20
Evaluation of subjects' language dominance

<table>
<thead>
<tr>
<th>subject</th>
<th>English</th>
<th>German</th>
<th>Self-assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>bgl03</td>
<td>3</td>
<td>4</td>
<td>both</td>
</tr>
<tr>
<td>bgl04</td>
<td>2</td>
<td>5</td>
<td>German</td>
</tr>
<tr>
<td>bgl05</td>
<td>1.5</td>
<td>5.5</td>
<td>German</td>
</tr>
<tr>
<td>bgl06</td>
<td>3</td>
<td>4</td>
<td>both</td>
</tr>
<tr>
<td>bgl08</td>
<td>4</td>
<td>3</td>
<td>both</td>
</tr>
<tr>
<td>bgl09</td>
<td>2.5</td>
<td>4.5</td>
<td>German</td>
</tr>
<tr>
<td>bgl10</td>
<td>4</td>
<td>3</td>
<td>English</td>
</tr>
<tr>
<td>bgl11</td>
<td>4</td>
<td>3</td>
<td>English</td>
</tr>
<tr>
<td>bgl13</td>
<td>1.5</td>
<td>5.5</td>
<td>German</td>
</tr>
<tr>
<td>bel02</td>
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<td>English</td>
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<tr>
<td>bel03</td>
<td>6.5</td>
<td>0.5</td>
<td>English</td>
</tr>
<tr>
<td>bes03</td>
<td>5.5</td>
<td>1.5</td>
<td>English</td>
</tr>
</tbody>
</table>

Profiles of individual subjects
This section gives a summary for each subject of the information given in response to the questionnaire. Included are those parameters which were used in the initial assessment of relative language-strength (Section III.4.9 above) as well as some additional relevant detail about each subject's language background and current patterns of language-use. "Age of L2 learning" is given as the first exposure to the second language; "Language of education" includes experience at school and at university, where applicable; "Length of residence" corresponds to the number of years (not necessarily consecutive) spent in the country which was not the country of birth.

bgl03
Age at testing: 55
Place of birth: Germany (Sudetenland)
Parents' country/region of origin: Berlin
Age of L2 learning: 11 (school)
Language of education: German
Country of current residence: England
Length of residence in UK: 28 years
Current language of principal use: English  
Self-assessment of dominance: equal  

This subject acquired English at school, and became fluent after moving to England permanently at age 27. She is married to an Englishman, and teaches German at secondary school level.

**bg104**

<table>
<thead>
<tr>
<th>Age at testing:</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of birth:</td>
<td>Germany (Stuttgart)</td>
</tr>
<tr>
<td>Parents' country/region of origin:</td>
<td>Stuttgart</td>
</tr>
<tr>
<td>Age of L2 learning:</td>
<td>11 (school)</td>
</tr>
<tr>
<td>Language of education:</td>
<td>German</td>
</tr>
<tr>
<td>Country of current residence:</td>
<td>England</td>
</tr>
<tr>
<td>Length of residence in UK:</td>
<td>8 years</td>
</tr>
<tr>
<td>Current language of principal use:</td>
<td>English</td>
</tr>
<tr>
<td>Self-assessment of dominance:</td>
<td>German</td>
</tr>
</tbody>
</table>

This subject acquired English at school, and became fluent after moving to London at age 22. He works as an assistant director with an opera company, using both languages, and lives with English-speaking flatmates.

**bg105**

<table>
<thead>
<tr>
<th>Age at testing:</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of birth:</td>
<td>Northern Germany</td>
</tr>
<tr>
<td>Parents' country/region of origin:</td>
<td>Northern Germany</td>
</tr>
<tr>
<td>Age of L2 learning:</td>
<td>11 (school)</td>
</tr>
<tr>
<td>Language of education:</td>
<td>German</td>
</tr>
<tr>
<td>Country of current residence:</td>
<td>England</td>
</tr>
<tr>
<td>Length of residence in UK:</td>
<td>6 months</td>
</tr>
<tr>
<td>Current language of principal use:</td>
<td>Both</td>
</tr>
<tr>
<td>Self-assessment of dominance:</td>
<td>German</td>
</tr>
</tbody>
</table>

This subject had the least experience with English out of all the bilinguals, having lived in the UK for only 6 months. She works as a social worker with a local authority in London, and lives in a mixed-language flat. She
had previously lived in Thailand for two years in her twenties, where she spoke only English.

**bgl06**
- **Age at testing:** 57
- **Place of birth:** Germany (Sudetenland)
- **Parents' country/region of origin:** Southern Germany/Sudetenland
- **Age of L2 learning:** 11 (school)
- **Language of education:** both
- **Country of current residence:** England
- **Length of residence in UK:** 27 years
- **Current language of principal use:** English
- **Self-assessment of dominance:** equal

This subject has lived in various regions of northern and central German, as well as in French-speaking Switzerland. She had originally acquired English at school, but took a diploma in TEFL in the UK. She currently works as a language teacher (both German and EFL) and is married to an Englishman. She speaks German on a regular basis with her daughters.

**bgl08**
- **Age at testing:** 41
- **Place of birth:** South Africa
- **Parents' country/region of origin:** North Germany/UK
- **Age of L2 learning:** infancy
- **Language of education:** both
- **Country of current residence:** England
- **Length of residence:** approximately equal periods in both countries in total
- **Current language of principal use:** English
- **Self-assessment of dominance:** equal

This subject had a more complex language-background than the other bilinguals. She was a childhood bilingual, speaking German with her father and English with her mother; her parents communicated in both languages, and she used both with her siblings. She moved between the two countries at regular intervals, both as a child and an adult, and her education took place in the language of the country in which she was
living at the time. She is currently living in London, and speaks English with her partner. She works as a teacher of both EFL and German.

**bgl09**

<table>
<thead>
<tr>
<th>Age at testing:</th>
<th>43</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of birth:</td>
<td>France</td>
</tr>
<tr>
<td>Parents' country/region of origin:</td>
<td>Silesia/Sudetenland</td>
</tr>
<tr>
<td>Age of L2 learning:</td>
<td>11 (school)</td>
</tr>
<tr>
<td>Language of education:</td>
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</tr>
<tr>
<td>Country of current residence:</td>
<td>England</td>
</tr>
<tr>
<td>Length of residence in UK:</td>
<td>20 years</td>
</tr>
<tr>
<td>Current language of principal use:</td>
<td>English</td>
</tr>
<tr>
<td>Self-assessment of dominance:</td>
<td>German</td>
</tr>
</tbody>
</table>

This subject grew up in northern Germany, and became fluent in English after moving to the UK at age 18. She is married to an Englishman, and works as a medical secretary in the health service. She also works for a translation agency, translating English into German.

**bgl10**

<table>
<thead>
<tr>
<th>Age at testing:</th>
<th>46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of birth:</td>
<td>Germany (Ruhrgebiet)</td>
</tr>
<tr>
<td>Parents' country/region of origin:</td>
<td>Ruhrgebiet</td>
</tr>
<tr>
<td>Age of L2 learning:</td>
<td>11 (school)</td>
</tr>
<tr>
<td>Language of education:</td>
<td>both</td>
</tr>
<tr>
<td>Country of current residence:</td>
<td>England</td>
</tr>
<tr>
<td>Length of residence in UK:</td>
<td>25 years</td>
</tr>
<tr>
<td>Current language of principal use:</td>
<td>English</td>
</tr>
<tr>
<td>Self-assessment of dominance:</td>
<td>English</td>
</tr>
</tbody>
</table>

This subject lived in a German-speaking environment until moving to England at age 20 to take a degree (degree subject German). She currently works as a lecturer in a university department of German, using German for teaching and communicating with German-speaking colleagues. Her husband is a native speaker of Tamil: they communicate in English, but she uses German occasionally with her children.
This subject has a similar profile to bgl10, having lived in a German-speaking environment before coming to England at age 21 to study for a degree (subject: German and history). She also works as a lecturer in a university German department, using both languages in the course of her work. She lives with an English-speaking partner.

This subject acquired fluent English when she came to England age 19 to study for a degree in Fashion Design. She currently works as a secretary, using mainly English in the course of her work. She lives with German-speaking flatmates.

This subject has a similar profile to bgl10, having lived in a German-speaking environment before coming to England at age 21 to study for a degree (subject: German and history). She also works as a lecturer in a university German department, using both languages in the course of her work. She lives with an English-speaking partner.

This subject acquired fluent English when she came to England age 19 to study for a degree in Fashion Design. She currently works as a secretary, using mainly English in the course of her work. She lives with German-speaking flatmates.
Age of L2 learning: infancy
Language of education: both
Country of current residence: England
Length of residence in UK: 8 years
Current language of principal use: English
Self-assessment of dominance: English

This subject was a childhood bilingual who grew up in Germany, but spoke English at home, the language in which her parents communicated. She attended an English-medium primary school in Germany, followed by a German-speaking secondary school. She moved to England at age 22 to study for a degree in Speech Science, and is a qualified Speech and Language Therapist.

bel03
Age at testing: 23
Place of birth: England (East Anglia)
Parents' country/region of origin: England (Southwest)/Germany (Berlin)
Age of L2 learning: infancy
Language of education: English
Country of current residence: England
Length of residence in UK: lived in Germany for short periods
Current language of principal use: English
Self-assessment of dominance: English

This subject was the least experienced in German, and the only one who had not lived in both countries for an extended period. She was a childhood bilingual, speaking English with her father and both languages with her mother (her parents communicated in English). She is currently a university student in the UK, studying English literature.

bes03
Age at testing: 51
Place of birth: England (North)
Parents' country/region of origin: Ireland
Age of L2 learning: 14 (school)
Language of education: both
Country of current residence: Germany
Length of residence in Germany: 25
Current language of principal use: both
Self-assessment of dominance: English

This subject had first learnt German at school, and spent long periods in adulthood studying and working in Germany. He is presently working in Germany, where he is a university professor, but also spends periods of time in England, with his English-speaking wife.
CHAPTER IV
DATA ANALYSIS

IV.0 INTRODUCTION
This chapter presents detailed analyses of the results of the individual components of the test battery. The tests are analysed in the same sequence as that in which they were presented in the previous chapter.

For each test, the analyses of the monolingual results are presented first, to establish monolingual norms against which the behaviour of the bilingual subjects may be compared. The results of the bilinguals are then presented in several ways, firstly by comparing the results from bilinguals in each language condition, to investigate potential cross-language effects, and secondly by comparing the results from bilinguals with the values established for monolinguals, to investigate to what extent the bilingual subjects matched monolingual norms.

A third level of analysis involved breaking down the group results for bilinguals by establishing which individual subjects were performing outside the expected range for monolinguals (in most cases defined as performances more than one standard deviation from the monolingual mean). The reason for the individual analyses was that in the group results the different dominance patterns of individual bilinguals might produce different speech processing behaviours that did not emerge in the results because they cancelled each other out. A detailed profile of each of the bilingual subjects is given in Section III.4 above, which can be read in conjunction with the analyses of individual result patterns.

IV.1 PERCEPTION OF VOWEL DURATION

IV.1.0 Introduction
The features of phoneme boundary and slope extracted from the MLE procedure, and presented in section III.4.1 above, were used as the basis for comparing the performance of different groups of subjects. For vowel duration perception in the language-ambiguous condition (using the test syllable /m_t/) the tables and the graphical displays (Table III.1 and Figures III.1-4) show that the results are similar for the two groups of
monolinguals: in fact, variability appears higher for the German monolinguals than for the English. The displays for the bilingual results show the same pattern: neither the location of the boundary nor the shape of the slope or the amount of variability appear to differ substantially between groups of subject or language condition.

In contrast, perception of the same contrast in the German-language environment (using the test syllable /ʃt_t/) shows greater between-group differences. The results for this test show phoneme boundary shift of 9.85 msecs between the two groups of monolinguals (Table III.2), with the boundary for the English monolinguals occurring close to the middle of the continuum range, while that of the German monolinguals is skewed to the left. The shape of the function gradient is also much steeper for the German than for the English monolingual subjects (Fig. III.5-7). The mean phoneme boundary for the bilingual subjects lies between that for the two groups of monolinguals, but is closer to the German than the English monolingual boundary; similarly, the shape of the curve resembles that of the German monolinguals more closely than that of the English controls.

IV.1.1 Statistical analysis
The statistical analyses confirm these impressions. An initial statistical analysis in the form of a t-test on the values for phoneme boundary and slope extracted from the MLE was performed for the two sets of monolingual subjects, in order to set benchmarks for monolingual performance against which the bilingual results could be compared.

For perception of vowel duration in the /m_t/ context, neither the effect of phoneme boundary nor of function gradient were statistically different across the two groups of monolinguals (t=0.95, df=10, p>0.1 for PB, and t=1.52, df=10, p>0.1 for slope). This is in contrast to the findings of the pilot test (section II.1.2 above) where English monolinguals showed a significantly shallower function gradient and therefore a poorer ability to categorise the same continuum.

For perception of vowel duration in the /ʃt_t/ context, the phoneme boundary shift between the two groups of monolinguals was significant
The results for the bilingual subjects show a similar pattern to that of the monolinguals. In the /m_t/ context there was no significant switch in phoneme boundary between the English and the German conditions (t=0.86, df=22, p>0.1), and the effect of slope was also not significant (t=-0.34, df=22, p>0.5). Since there was no significant difference between the two monolingual conditions, it is not surprising that the bilinguals did not show any significant difference between the two language conditions. A comparison of the results of bilingual and monolingual subjects confirms that there was no significant effect of subject group in either language, with the effect of phoneme boundary and gradient well below the level of significance (t=0.78, df=16, p>0.1; t=-0.12, df=16, p>0.5 respectively in English condition; t=-0.73, df=16, p>0.1; t=2.05, df=16, p>0.05 respectively in German condition).

In the /ʃtʃ_t/ context, the bilingual phoneme boundary and gradient were not significantly different from those of the German monolinguals (t=0.88, df=16, p>0.1 and t=1.21, df=16, p>0.1 respectively), but did differ significantly from the English monolinguals (t=2.67, df=16, p<0.05 and t=2.34, df=16, p<0.05 respectively).

A further analysis involved identifying those individual subjects within the bilingual group whose performance in either language condition on any of the tests fell outside the monolingual range. This was defined as ±1 standard deviation from the mean result for monolingual subjects.

This analysis was particularly productive for the vowel duration perception in /m_t/ context in the English condition. Four subjects were outside the monolingual range for both phoneme boundary and slope (bgl04, bg105, bg108, bg110). Two subjects were outside the range on phoneme boundary alone (bgl03, bg109) and one subject (bel02) was outside the range on slope alone. For the same test in the German condition two subjects were outside the monolingual range on PB alone (bel02, bel03). All bilingual subjects performed within the monolingual range for gradient. However, no firm conclusions can be drawn from these findings,
since the two groups of monolinguals did not differ from one another on this test.

For vowel duration perception in /ʃ t_ t/ context, tested in the German condition only, two subjects performed outside the monolingual range on PB (bg106, bel03); all subjects were within the monolingual range for slope.

IV.1.2 Discussion

The most immediately striking finding to emerge from this set of results is the different labelling behaviour of the English monolinguals for the vowel duration continuum in the two different consonant environments. The explanation for this difference must lie in the instructions given to subjects and the format of the response sheet. In the pilot test, with the /m_t/ stimuli, monolingual English subjects were told that the stimuli were German words, and asked to categorise the continuum on the basis of a short training session to familiarise them with the endpoint stimuli; in the first of the present tests, English subjects were told that the stimuli were tokens of the English words mutt and mart; it is particularly interesting that this successful categorisation was performance was achieved despite the fact that the spectral cues which would be expected to mark the long-short vowel distinction in English were absent, so that the subjects had to rely on vowel duration alone, which is not in itself distinctive in English. This means that although the task (categorisation of a duration continuum) was the same, the subjects' identification of the stimuli with real English words clearly affected their perception of the continuum. However, since the differential between the English and German monolinguals was not significant, and the within-group variability was considerable, it seems unlikely that the across-group results for this test can be considered reliable.

More interesting is the difference in English monolingual performance across the two vowel duration tests, namely the language-ambiguous condition in the /m_t/ environment and the German-language condition in the /ʃ t_ t/ environment. The significant difference between the two groups of monolinguals in this test suggests that changing the phonetic environment to one which was not assimilable to real words in the English subjects' native language impaired their ability to classify the German vowel contrast on the basis of duration alone, although they had
been able to match German performance in an environment which allowed such assimilation. This cross-language difference also contrasts with the findings of Barry (1974) that there was no systematic duration difference between the vowels in English hut and German hat.

The fact that the bilinguals were able to match the monolingual German subjects' performance for categorisation of the vowel duration continuum in the /ʃtʃ t/ context shows that, as a group, they were able to use the duration cue alone to categories the stimuli which were, for them, assimilable to real words in the test language. However, these results do not give any information about code-switching behaviour, since this test was taken by bilingual subjects in the German condition alone.

**IV.2 Production of vowel duration contrasts**

**IV.2.0 Introduction**

Before subjects' production of vowel duration contrasts could be analysed, it was necessary to normalise the measurements for the effects of speech rate. This was done by using the differential between the long and short vowels produced by each subject as a basis for analysis, rather than the absolute values for short and long vowels. The differential for each subject was calculated by dividing the mean duration for long vowels by the mean duration for short vowels, and multiplying by 100 to get a percentage. For the English condition the differentials between long and short vowels in the two different environments (before fortis and lenis final consonants) were calculated separately, and both sets of figures (which contained equal numbers) were included in the calculation of the mean differential. The resulting value expressed the mean duration of long vowels as a percentage of the mean duration of short vowels, and this figure was used for all subsequent calculations. The values of the mean differentials and the standard deviation for each group of subjects are given in Table IV.1 below.
Table IV.1
Mean differentials (percentages) for vowel duration production

<table>
<thead>
<tr>
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<th>Mean</th>
<th>SD</th>
</tr>
</thead>
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<tr>
<td>Monolinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>223.77</td>
<td>42.50</td>
</tr>
<tr>
<td>Monolinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>216.53</td>
<td>33.04</td>
</tr>
<tr>
<td>Bilinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English condition</td>
<td>250.0</td>
<td>49.56</td>
</tr>
<tr>
<td>Bilinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>German condition</td>
<td>247.0</td>
<td>43.53</td>
</tr>
</tbody>
</table>

IV.2.1 Statistical analysis

The smaller standard deviation for the German monolinguals shown in the tabled results above suggests that the differentials for these subjects might be more tightly clustered than those for the bilinguals and the monolinguals in the English condition. These values were analysed using a t-test, which showed no statistically significant differences between the two subject groups or the two language conditions. The two groups of monolinguals were not significantly different from one another (t=0.31, df=10, p>0.1), and the same was true of the bilinguals in each of the languages (t=0.18, df=22, p>0.5). In both languages the performance of the bilinguals matched that of the monolinguals (t=1.10, df=16, p>0.1; t=1.58, df=16, p>0.1 for English and German conditions respectively).

The analysis of individual results showed that only a few subjects were more than one standard deviation from the monolingual mean: bg106, bg110, bg113 (English condition); bg106, bg110, bel02 (German condition). All these subjects showed a substantially greater differential between the long and short vowels than the monolingual norms; none showed a smaller differential.

IV.2.2 Discussion

The lack of statistically significant effects for language or subject groups suggests that inter-subject differences are not mediated by language condition. This is confirmed by the fact that some of the same subjects performed outside the monolingual norm in each language, while the remainder performed within the norm in both conditions; a subsequent correlation analysis (see section V.3 below) showed that, for all bilingual
subjects, mean duration differentials were positively correlated across the two language conditions.

Two interpretations of this finding are possible. It may be that a large differential between long and short vowels is simply an individual characteristic. However, it is also possible that some bilinguals are employing a strategy which maximises differences between phonological categories in production, and that this strategy applies in both languages.

IV.3 Perception of vowel quality

IV.3.0 Introduction
The most significant feature of this data is the clear split between the responses in the English condition, in which all subjects divided the continuum into three categories, corresponding to the English words bet, bat and but, and the responses in the German condition in which all subjects divided the same continuum into two categories, corresponding to the German word fest and fast. All subjects were able to categorise the continuum into the number of categories that was appropriate to the language condition, showing that all the bilinguals had established a category of some kind corresponding to the English front open vowel /æ/. This is particularly remarkable in view of the nature of the open-labelling task, which did not predispose subjects to choose a particular number of categories.

The tables and graphical displays in Section III.4.3 (Tables III.4-6 and Figures III.10-15) above show clearly the different categories operated in each of the language conditions. The boundaries between the three categories for the English monolinguals are marked by steep curves and low inter-subject variability (as measured by the one standard deviation error bars). This suggests that for the English subjects the three categories spanned by the continuum were stable and clearly defined, with sharp boundaries.

For German monolinguals the boundary between the two possible categories in the German condition is marked by a much shallower curve, with a high degree of inter-subject variability. This suggests that part
of the continuum corresponding to English /æ/ was not consistently identified by German subjects with one of the adjacent vowels, but was simply divided between them. The location of the phoneme boundary in German confirms this impression, since it occurred between steps 6 and 7, which corresponds exactly to the mid-point of the continuum, the default location for a boundary which is not mediated by phonetic considerations (Rosen, 1979).

The labelling behaviour of the bilinguals is more complex. Although all bilinguals had established a category corresponding to English /æ/, the boundary curves are shallower than those of the English monolinguals, and characterised by a higher degree of variability, particularly for the /e-æ/ boundary. This suggests that the categories which the bilinguals were operating in the English condition were less stable than those of the monolinguals, and also that there was a higher degree of inter-subject variation in the way the continuum was perceived.

A further interesting finding is the labelling behaviour of the bilinguals in the German condition. Unlike the German monolinguals, for whom the /æ/ category was simply divided at the mid-point of the continuum, the boundary curve for bilinguals in the German condition shows a clear skew to the left, and is steeper than that of the monolinguals. This suggests that the bilinguals' categorisation of the front open vowel in the German condition was not random as for the monolinguals, but was mediated by their linguistic experience in English, although this would not have been relevant to the German task.

IV.3.1 Statistical analysis
A t-test was performed on the values for phoneme boundary and gradient extracted from the MLE procedure for the two groups of monolinguals. The statistical results show firstly that the category boundary for the German monolinguals was significantly different from either of the category boundaries operated by English monolinguals. The effect of phoneme boundary between the English /e-æ/ boundary and the German boundary was significant at the level t=-5.63, df=10, p<0.0005; the shift between German boundary and the English /æ-a/ boundary was also significant (t=4.17, df=10, p<0.005). The gradients of the two English
functions were also significantly steeper from the gradient of the German function among the monolingual subjects (t=-2.53, df=10, p<0.05 and t=4.19, df=10, p<0.005 for the /e-æ/ and /æ-a/ boundaries respectively), confirming that the German monolinguals differed from English monolinguals both in the placement of the boundaries and the degree of categorical labelling.

The same tests were performed on the data from the bilingual subjects in each of the two language conditions, to see whether the switch in their labelling behaviour as a function of their language mode was as great as that of the monolingual subjects. For the bilingual subjects, the difference between the first phoneme boundary in the English condition (/e-æ/) and the /e-a/ phoneme boundary in the German condition was highly significant (t=-5.49, df=22, p<0.0001), while the function gradient did not differ significantly between these two conditions (t=1.72, df=22, p>0.05). When the German /e-a/ boundary was compared with the second English boundary (/æ-a/), the difference in phoneme boundary was again highly significant (t=9.50, df=22, p<0.0001), while the difference in gradient was not significant (t=-1.24, df=22, p>0.1).

Statistical comparison of the bilinguals' results in each language condition with that of the monolinguals confirms that they were able to match the performance of the English monolinguals in labelling English categories. There was no significant difference between monolinguals and bilinguals in the English condition either with regard to the location of PB for the /e-æ/ boundary (t=0.50, df=16, p>0.5) nor the /æ-a/ boundary (t=0.48, df=16, p>0.5). The gradient of the two functions for the bilinguals also did not differ significantly from that of the monolinguals (t=1.22, df=16, p>0.1 and t=-0.96, df=16, p>0.1 respectively).

However, in the German condition, the performance of the bilinguals did differ significantly from that of the monolinguals. The phoneme boundary was shifted significantly leftwards (t=2.67, df=16, p<0.05) and the function gradient was significantly steeper (t=-2.42, df=16, p<0.05).

Again, analysis of individual identification functions was undertaken to analyse the individual variability concealed within the group results and to identify those bilinguals whose performance was outside the
monolingual range, defined as greater than one standard deviation from the monolingual mean.

In the English condition, the /e-æ/ boundary seemed to cause particular problems among the bilingual subjects, with six subjects performing outside the monolingual range on both PB and slope (bgl03, bgl04, bgl05, bgl06, bgl08, bgl13), and one each on PB alone (bgl10) and slope alone (bgl09). For the /æ-a/ boundary three subjects were outside the range on PB and slope (bgl05, bgl06, bgl13); three more on PB alone (bgl03, 08, 09) and two on slope alone (bgl04, bgl10).

As expected from the group results, almost all bilingual subjects were outside the monolingual range for perception in the German condition. Two were out of range on both PB and slope (bgl08, bgl11), three on PB alone (bgl03, bgl04, bes03) and five on slope alone (bgl06, bgl09, bgl10, bel02, bel03).

IV.3.2 Discussion
The fact that all bilinguals perceived the appropriate number of categories in each language condition shows that they were able to switch perceptual modes according to the language-set they were in. This clear between-language difference is all the more striking in view of the fact that the task was an open labelling one, which did not predispose subjects to choose a particular number of categories for their responses.

Moreover, the finding that the group results for bilinguals in the English condition matched the performance of English monolinguals shows that the categories they had developed were sufficiently accurate and stable to enable them reliably to label vowels corresponding to the English sequence /e-æ-a/.

However, the individual results show a considerable degree of variation in the extent to which these categories resembled those of monolinguals. Graphical display of individual identification curves provides a striking illustration of these discrepancies. Figures IV.1-3 below show the identification curves for three bilingual subjects who seem to have established stable categories for English /æ/. These three curves resemble
one another closely in the location of the phoneme boundaries and the shape of the curve, and also correspond closely to the mean curve for English monolingual subjects (Figure III.14 above), suggesting that these three subjects have perceptual categories that are close to the monolingual norm.

![Graph](image1)

**Figure IV.1**
% /æ/ responses for subject bg109 in English condition

![Graph](image2)

**Figure IV.2**
% /æ/ responses for subject bg11 in English condition
Figures IV. 4-6 below show identification curves for bilingual subjects that clearly deviate from the monolingual norm. For these three subjects there appears to be no stable category for English /æ/; figure IV.4 shows an example of a subject who never reaches 100% /æ/ responses for any of the stimuli; the other two subjects do reach this level, but differ from each other in which stimuli are identified as /æ/. The overall shapes of the identification function are also clearly different from one another, as well as from the monolingual English mean.
The final figure below shows an intermediate labelling strategy: this subject does not quite match the identification curves of English monolinguals, but the category is considerably more stable and native-like than those shown in figures IV.4-6 above.
The graphs of individual labelling functions shown above give some idea of the extent and the nature of individual variability present in this task, despite the fact that, as a group, the bilinguals were able to match monolingual performance in the perception of English categories. It is clear that subjects vary widely in their perception of the English front open vowel and that, while some subjects' perceptual categories match those of native speakers quite closely, others clearly do not. Moreover, those who deviate from the monolingual categories do so in different ways. Some common features do emerge, however. The boundary between /e/ and /æ/ shows a much greater degree of variability than the /æ/-/a/ boundary, suggesting that for these subjects it is the distinction between /e/ and /æ/ which is problematic. Indeed the curves shown in Figures IV.5-7 never reach 100% identification of /e/. There is also a tendency for that part of the continuum identified as /æ/ to be shorter than for the monolinguals or the more native-like bilinguals.

These results are in accordance with the findings of other studies that the English front open vowel /æ/ presents a perceptual problem to German listeners (Barry, 1989; Bohn & Flege, 1990); specifically, inexperienced German listeners tend to confuse /e/ with /æ/. However, the degree of inter-subject variability found in the present results suggests that some although not all subjects may be able to overcome this perceptual difficulty and acquire stable and native-like categories for the English vowel. Bohn &
Flege (1990) found comparable variability among their German subjects, and suggest that one of the sources of this variability may be that increasing experience in English enabled the German listeners to make use of the same spectral cues which mediate the vowel contrast for English listeners, while less experienced listeners relied on the German strategy of vowel duration to distinguish the two English phonemes, resulting in a less native-like performance (see also Barry, 1974).

The present results give information about spectral cue processing only, since duration was held constant for all stimuli, but it does appear that subjects with greater experience in English were more likely to process the spectral information in a native-like manner.

In contrast, in the German condition the findings show that bilinguals as a group do differ from monolinguals in their categorisation of stimuli corresponding to English /æ/. The leftward shift in the bilingual labelling function as compared to the German monolingual labelling function suggests that the bilinguals are using phonemic criteria in their labelling behaviour, although there are no German phonetic criteria which are relevant to this category. It also suggests that in the German condition bilingual subjects are inclined to class English /æ/ with German /a/, contrasting with the finding in the English condition that weaker bilinguals confuse it with /e/.

The graphs of some individual identification functions illustrate the nature of the variation in responses.

The three monolingual curves shown in Figure IV.8 below illustrate the type of response obtained from individuals without extensive exposure to English /æ/ category, showing a categorisation towards the middle of the stimulus range.
Figure IV.8
% /e/ responses for three German monolingual subjects

In contrast, the three bilingual curves shown in Figures IV.9-11 below show that for these individuals the phoneme boundary between German /e/ and /a/ is shifted leftwards.

Figure IV.9
% /e/ responses for subject bes03 in German condition
Overall these three graphs show very similar identification functions for these individuals, and they are representative of the functions of most of the bilingual subjects. There was far less inter-subject variability in this condition than in the English condition; it appears that an effect of exposure to English is apparent even in those subjects who did not appear to have established stable categories for English /æ/.

Subject bgll3 (Figure IV.12 below) was the only bilingual subject to display a labelling function in the German condition which resembled more
closely that of the German monolinguals; she was also one of the subjects with the least exposure to English.

All other bilinguals deviated to some extent from the labelling curves of the German monolinguals, indicating that their exposure to English had affected their categorisation in German, even though there was no advantage for applying English strategies in the German condition.

The finding that subjects with significant exposure to English appeared to be using English-mediated categories to label the continuum in the German condition suggests that both languages remained active even during an apparently monolingual processing task, and is in keeping with the findings of this study and of other authors of processing at the lexical level (Section IV.5 below). More specifically, other studies (Cutler et. al., 1992; Hazan & Boulakia, 1993) have shown that listeners who have been sensitised to a particular feature tend to apply it in both languages, even when it would not normally form part of a monolingual speaker's processing strategy. The present results suggest that such cross-influence may apply even where the individual has not reached monolingual-like norms for that feature, and that it may be triggered by relatively short periods of exposure to the other language.
IV.4 PRODUCTION OF VOWEL QUALITY CONTRASTS

IV.4.0 Introduction
The tables of raw data (Tables III.7-8) suggest that /e/ and /a/ may not in fact be phonetically identical in German and English, since there are noticeable differences in the mean formant frequencies values for these two vowels produced by monolingual speakers of each language. For both vowels the mean F1 and F2 values are lower for the German speakers than for the English speakers. The between-speaker variation is relatively low, as shown by the close clustering in the graphical displays of formant values for each vowel (Figs. III.16-19). However, it must be pointed out that formant frequencies are subject to a considerable degree of inter-speaker variation, and that the number of subjects tested was relatively small; hence these values are not necessarily representative of a wider population.

These displays suggest that, in the English condition, the bilinguals match monolingual performance for /a/, although there appears to be greater variability. For /e/ and /æ/ the productions of the bilinguals are much less closely clustered than those of the monolinguals, and there is some overlap in the vowel space of the two phonemes, suggesting that some bilingual subjects did not reach monolingual formant frequency targets for the production of these vowels. It is also clear that, in the production modality, it is the distinction between /e/ and /æ/ which is blurred for the bilinguals. This contradicts the suggestion that bilinguals tend to maximise acoustic differences in production.

In the German condition the bilingual clusters appear to correspond more closely to those of the monolinguals, although for some bilingual subjects /a/ was closer in phonetic space to /e/ than was the case for monolinguals.

IV.4.1 Statistical analysis
A two-way General Linear Models procedure, which is more suitable than ANOVA for unbalanced groups, was performed on the F1 and F2 frequency values for the vowels produced by the female speakers across all groups of subjects in order to compare performances in the two language conditions, and the behaviour of the monolinguals and bilinguals.
For the production of /e/, there were no significant effects, indicating that the vowels produced in the English condition did not differ significantly from those of the German condition (F(1,50)=1.57, p>0.1), and that vowels produced by the monolinguals in each language did not differ from those of the bilinguals (F(1,50)=2.10, p>0.1).

For the production of /a/ the main effect of language was significant (F(1,50)=7.95, p<0.01), indicating that the spectral characteristics of the English vowel differed from those of the German vowel. The interaction of subgroup with language was also significant (F(1,50)=4.39, p<0.05), showing that, on a group level, the productions of the monolinguals differed from those of the bilinguals.

For the production of /æ/ the main effect of subject group was not significant (F(1,24)=1.00, p>0.05); there was no effect of language since this vowel did not form part of the German condition for either group.

The analysis of individual results to identify those subjects performing outside the monolingual range confirms the impression gained from the graphical displays of raw data that the bilinguals matched the German monolinguals more closely than they matched the performance of English monolinguals.

In the English condition six subjects produced utterances of /e/ with a mean F1 and F2 frequency more than one standard deviation from the monolingual mean (bgl05, bgl08, bgl09, bgl11, bgl13, bel02), with an additional two subjects outside the monolingual range on F1 only (bgl03, bgl06), and one on F2 only (bgl10). For /æ/ three subjects were more than one SD from the monolingual mean for both F1 and F2 (bgl03, bgl09, bgl10), two for F1 only (bgl05, bgl11) and three for F2 only (bgl06, bgl08, bel02). For /a/ three subjects were outside the monolingual range for both F1 and F2 (bgl05, bgl09, bgl10), three for F1 only (bgl03, bgl11, bel02) and two for F2 only (bgl08, bgl13).

The individual subjects who were more than one standard deviation from the monolingual mean for some aspect of all three vowels in the English condition were as follows: bgl03, bgl05, bgl08, bgl09, bgl10, bgl11, bel02.
In the German condition, one subject (bgl03) was outside the monolingual range for production of /e/ on both F1 and F2; the following subjects were outside on F2 alone: bgl08, bgl13, bel02. For production of /a/ two subjects (bgl03, bgl13) performed outside monolingual norms for both F1 and F2; subjects outside monolingual range for F2 alone were bgl06, bgl08, bgl11, bel02 and bes03.

IV.4.2 Discussion
The finding that there was no significant effect of language for the production of /e/ confirms the widespread assumption that English and German /e/ are phonetically very similar or identical (Barry, 1977; 1989; Bohn & Flege, 1990; 1992), and since there was no overall language effect, it is unsurprising that the monolinguals did not differ from the bilinguals.

The implications of the between-language and between group differences in the production of /a/ are less clear. Barry (1977; 1989) found no systematic difference between English and German speakers in the production of this vowel, and the values found by monolingual studies of formant frequencies in each language also do not suggest systematic spectral differences (Fry, 1979; Kohler, 1977; Ladefoged, 1993).

It appears from the graphical displays in Section III.4.4 above that the distinction between the English and German vowels made by the monolingual subjects is not matched by the bilinguals, who show a much wider scatter of F1 and F2 frequencies. Again, this would seem to contradict the suggestion that bilinguals tend to maximise acoustic differences between their two languages on production tasks; however, it must be emphasised again that the number of subjects involved was relatively small, and that formant frequency values are subject to a high level of individual variability; these results may not, therefore, be representative of a wider population.

Another important result is the finding that, as a group, bilinguals matched monolingual performance on the production of /æ/. Since the subjects tested were mostly experienced in English, this corresponds to the findings of Bohn & Flege (1992) that experienced L2 speakers approached or reached native-like targets on the production of this vowel. However,
the graphical displays and the analysis of individual performances suggest that a great deal of inter-subject variability was present and that, as for perception, the group results conceal different individual speaker strategies. It is, however, clear that perception and production of all the vowels are not directly linked, since subsequent analysis found no statistically significant correlation between perception and production performance in either language condition (Section IV.9 below).

IV.5 ON-LINE PHONOTACTIC PROCESSING

IV.5.0 Introduction
Several important findings emerge from the table of raw data (Table III.9 above). The first four columns of the table, which contain nonword data only, can be divided into two classes according to the phonotactic status of the stimulus items in the test language. The first two columns, LL and LI, both contain items which are legal in the test language; the second two columns, IL and II, both contain items which are illegal in the test language. For monolingual subjects the expected findings would be that reaction times were significantly longer for items in the first two columns, since they are phonotactically legal and would trigger a search of the lexicon; reaction times for items in the second two columns are likely to be shorter, since the illegal initial cluster should ensure that items are rejected immediately, without a search of the lexicon. Within each of these two classes, no differentiation would be expected, since the phonotactic status is the same; ie. there should, for monolingual subjects, be no substantial difference between the categories LL and LI, or between the categories IL and II. The phonotactic status of items in the other language should be irrelevant to the monolingual's task. A similar finding would be expected for those items which are real words in the other language; they should be judged on their phonotactic status in the test language alone, with legal items (category LO) classes with the other legal nonwords, and illegal items (category IO) classed with the other illegal nonwords.

English monolinguals seem to conform to the pattern described above: items in categories LL and LI had mean response times of 0.77 and 0.78 secs respectively, while both the illegal categories IL and II had mean response
times of 0.62 secs. In other words, the criterion governing the English monolinguals' response times appears to be solely the phonotactic legality of the item in English, with illegal items being rejected faster than legal ones. The other-language real words, in columns 5 and 6, were treated exactly like nonwords; those which were legal (LO) show a reaction time similar to that for the other legal items (0.76 secs), while the illegal ones had a mean response time of 0.62 secs, exactly like the other illegal stimuli.

The picture is similar for German monolinguals; although the overall reaction times were faster, the two-way differential between the legal and illegal items remains. The legal nonword categories LL and LI had mean response times of 0.69 and 0.67 secs respectively, while the two illegal nonword categories had response times of 0.55 and 0.56 secs respectively. Again real words in the other language were judged by the German monolinguals solely on their phonotactic status in the test language: those which were legal (LO) had a longer reaction time (0.69 secs), grouping them with the legal nonword categories, while the illegal items were rejected faster (0.59 secs), grouping them with the illegal nonwords.

An examination of the table of raw data (Table III.9) suggests that bilingual behaviour did differ from that of monolinguals. In both conditions bilinguals showed longer overall response times, although this was particularly pronounced in the English condition.

The data also suggests that bilinguals' knowledge of the phonotactic constraints of both languages will interfere with their processing of the test language. Rather than falling into two categories of legal and illegal, as the monolingual responses did, the bilinguals' reaction times show a more complicated pattern. As for the monolinguals, the two legal categories LL and LI showed the longest reaction time, but for both sets of bilinguals reactions to the LI category were substantially slower than to LL. Furthermore, the two illegal nonword categories IL and II were not treated equally as was the case for the monolinguals; rather, stimuli in the II category were rejected the fastest, with the IL category forming an intermediate stage. The other language real word categories again seemed to show intermediate results rather than being clearly grouped with the relevant set of nonwords as was the case for the bilinguals.
IV.5.1 Statistical analysis

A two-way General Linear Models procedure, which is more suitable than ANOVA for unbalanced groups, with one between factor (language) and one within factor (the stimulus category) was performed on the data for the monolingual subjects.

The main effect of stimulus category was highly significant ($F(5,25)=7.47$, $p<0.001$), confirming the finding described above that monolinguals reacted differently to stimulus items according to their phonotactic legality in the test language. Comparisons of means for different stimulus categories were made using the post-hoc Duncan-Waller range test. The resultant groupings are shown below: underlined categories are not significantly different from each other.

<table>
<thead>
<tr>
<th>English monolinguals</th>
<th>German monolinguals</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI 0.78 LI 0.77 LI 0.76</td>
<td>LO 0.69 LO 0.67 LO 0.66</td>
</tr>
<tr>
<td>LL</td>
<td>LI 0.62 LI 0.62 LI 0.62</td>
</tr>
<tr>
<td>LO 0.59</td>
<td>LI 0.56 LI 0.55</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

The clear two-way grouping confirms the validity of the prediction that items which are phonotactically legal in the test language (regardless of their status in the other language) are rejected more slowly than illegal items; this longer reaction time is assumed to be a correlate of the extra time taken to search the lexicon.

A GLM procedure was computed with two between factors (subject group (monolingual vs bilingual) and language (English vs German) and one within factor (stimulus category) to compare the reaction times of monolingual and bilingual subject groups to the different stimulus categories for each language condition.
The first finding was that the main effect of subject group was significant (F(1,80)=38.55, p<0.001), indicating that the performance of the bilinguals differed significantly from that of the monolinguals.

The interaction of subject group with stimulus category was also significant (F(5,105)=2.85, p<0.05), confirming that the monolinguals and the bilinguals showed different patterns of reaction time according to the phonotactic status of the test item. Duncan-Waller groupings for bilingual subjects in each of the two language conditions confirmed that the bilinguals' reactions to the various categories of stimulus was more complex than was the case for the monolinguals. The bilingual groupings are given below.

Table IV.3
Reaction times for stimulus categories: bilingual subjects

<table>
<thead>
<tr>
<th>English condition</th>
<th>LI</th>
<th>LL</th>
<th>LO</th>
<th>IL</th>
<th>IO</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.23</td>
<td>1.14</td>
<td>0.94</td>
<td>0.85</td>
<td>0.77</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>German condition</th>
<th>LI</th>
<th>LO</th>
<th>LL</th>
<th>IO</th>
<th>IL</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.96</td>
<td>0.81</td>
<td>0.78</td>
<td>0.74</td>
<td>0.72</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IV.5.2 Discussion
The statistical analyses confirm that bilinguals differed from monolinguals in their processing of the phonotactic information, showing that information from the latent language affected processing of the test language. This cross-influence is shown firstly in the longer overall reaction times for bilingual subjects, which is assumed to be a correlate of a search of two lexica, or of an extended lexicon before an item can be rejected, a finding which corresponds to that of Soares & Grosjean (1984). It also suggests that the difference between the monolinguals and the bilinguals in the present study was more robust than that found by Altenberg & Cairns (1983), who found no overall difference in reaction
time between their English-dominant bilingual subjects and the English monolingual controls. However, as discussed above, results from subjects with different dominance patterns as well as a comparison with monolinguals of the other language (as undertaken in the present study) are not available, an omission which is likely to have affected the results.

Cross-language influence is also shown in the breakdown of the clear two-way groupings of different stimulus categories found with both groups of monolinguals. As for the monolinguals the three legal categories (LL, LI and LO) prompted the longest reaction times but, unlike the monolinguals, there was no clear division between legal and illegal categories. This corresponds to Altenberg & Cairns' findings that the bilinguals showed different patterns of responses to the monolinguals despite the lack of difference in overall RT.

Reactions to the LO category are particularly interesting. This category consisted of items which were real words in the latent language but not in the test language. Despite the longer overall reaction times, items in this category were rejected relatively more quickly by the bilinguals than by the monolinguals, suggesting that the bilinguals' knowledge of the status of the item in the latent language was cutting short the search of the lexicon in the test language. In the English condition, this knowledge was sufficient for the LO category to be grouped statistically with the illegal rather than the legal categories; in the German condition the groupings shown by the Duncan-Waller range test are rather more complicated, but LO is part of a grouping which includes illegal as well as legal categories, a pattern which can be explained only by cross-influence from the bilinguals' latent language.

These findings are in accordance with the findings of other studies that bilinguals are unable completely to exclude information from the latent language, even when it is clearly irrelevant to the task (Hamers, 1973; Altenberg & Cairns, 1983; Soares & Grosjean, 1984). These studies also show that different levels of activation of the latent language are possible, and that factors such as language-set, frequency of occurrence of lexical items and use of linguistic precursors might affect the readiness with which information from the latent language was activated.
The present findings show that, for bilinguals as a group, phonotactic information from both languages is accessed when monitoring for items in one language only. They further show that, although the effect of this latent language information seems to be an increase in overall reaction times, bilinguals were also able to use this information to their advantage, as when LO items were rejected relatively more quickly than was the case for monolinguals. However, the group results do not show us to what extent these behaviours were true of all bilinguals, or whether individual subjects differed in the strategies they employed for processing test-language and other-language information.

IV.5.3 Analysis of individual results
The principal problem with group analyses of the type described above for the results of the bilingual subjects is that they fail to reflect in a useful way the amount and the nature of the within-group variability. Table III.8 indicates that the results for the bilinguals in most of the categories were subject to a substantially greater degree of variation than was the case for the monolingual subjects. It seems likely that for such interactions as subject group x stimulus category, the rather complex and opaque groupings produced by the Duncan-Waller procedure are concealing a variety of important and interesting sources of variance. Possible sources of such variance include the language-dominance and, if applicable, the degree of such dominance, of the bilingual subjects, as well as various factors relating to language-acquisition and patterns of language-use such as age of acquisition and length of residence (cf. Chapter 1).

In order to investigate these factors further, a GLM analysis was performed on all subjects, monolingual and bilingual, with one between factor (language) and one within factor (subject), and a Duncan-Waller grouping for individual performances in each language condition was obtained. The intention was to provide a better insight into the natural groupings into which the subjects fell: by analysing individual bilinguals together with individual monolinguals it would be possible to see whether some bilinguals performed like monolinguals, or whether all bilinguals formed a separate group together. In the light of the significant effect of overall RT between bilinguals and monolinguals it was hoped that comparing RTs
across different stimulus categories would make it possible to pinpoint individual differences among the subjects.

For both language conditions the main effect of individual subject was highly significant, at the level F(17,85)=10.95, p<0.0001 in the English condition, F(17,85)=15.83, p<0.0001 in the German condition, indicating that individual subjects differed significantly from one another in their overall response times to the nonword stimuli. The Duncan-Waller groupings for each subject condition are given below. The figure given for each subject represents the mean reaction time across all stimulus categories.

Table IV.4
Cross-category RTs for individual subjects

<table>
<thead>
<tr>
<th>English condition</th>
<th>German condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>bgl04 1.5067 A</td>
<td>bgl04 1.1666</td>
</tr>
<tr>
<td>bgl06 1.4650</td>
<td>bgl06 0.9050</td>
</tr>
<tr>
<td>bgl09 1.2633</td>
<td>bgl08 0.8783</td>
</tr>
<tr>
<td>bgl13 1.0200</td>
<td>bgl10 0.8066</td>
</tr>
<tr>
<td>bgl05 0.9550</td>
<td>bgl09 0.8066</td>
</tr>
<tr>
<td>bgl08 0.8850</td>
<td>bel02 0.7733</td>
</tr>
<tr>
<td>mel17 0.8217</td>
<td>bgl05 0.7333</td>
</tr>
<tr>
<td>bgl10 0.8100</td>
<td>bel03 0.7266</td>
</tr>
<tr>
<td>bel02 0.7800</td>
<td>mgs06 0.6816</td>
</tr>
<tr>
<td>mel18 0.7583</td>
<td>mgs02 0.6750</td>
</tr>
<tr>
<td>bgl03 0.7517</td>
<td>bgl03 0.6733</td>
</tr>
<tr>
<td>bgl11 0.7417</td>
<td>bgl13 0.6633</td>
</tr>
<tr>
<td>mel20 0.7383</td>
<td>bgl11 0.6400</td>
</tr>
<tr>
<td>bel03 0.7300</td>
<td>mgs04 0.6316</td>
</tr>
<tr>
<td>mel22 0.7233</td>
<td>bes03 0.5866</td>
</tr>
<tr>
<td>mel21 0.5800</td>
<td>mgs03 0.5800</td>
</tr>
<tr>
<td>bes03 0.5633</td>
<td>mgs05 0.5766</td>
</tr>
<tr>
<td>mel19 0.5633</td>
<td>mgs01 0.5333</td>
</tr>
</tbody>
</table>

These results show a complex set of groupings, but some features stand out quite clearly.
There appears to be a considerable amount of individual variability in the reaction time across all categories of stimulus. Some subjects (bgl04, bgl06) showed overall far longer response times than other bilingual subjects, and maintained this pattern across both language conditions. Other bilingual subjects maintained consistently faster response times across both language conditions (bes03, bgl11). If a faster overall response time is taken as a correlate of the efficiency with which negative influence from the latent language is kept to a minimum, then these results suggest that some subjects are able to effect a more complete separation between the two language systems than others, and that this ability has a positive effect on processing efficiency in both languages. Subsequent correlation analysis (see section V.3 below) showed that overall reaction times for individual subjects were positively correlated across language conditions, suggesting that the degree of cross-language influence manifested by individual subjects on this task was not a language-specific phenomenon, but possibly a higher-level strategy for keeping the two languages separate during processing. Unfortunately, comparisons with the findings of other studies are not possible here, since other authors have not undertaken analysis of the individual variability within their group results.

This analysis is confirmed by the Duncan-Waller groupings shown above. If the longest response time for any monolingual subject is taken as a cut-off point between bilingual and monolingual performance, it is clear that some bilinguals have scores that group them with monolingual subjects (grouping D for the English condition; grouping G in German condition), while those whose mean response times were longer than those of the slowest monolingual form a separate group. These individual groupings are striking evidence of the variability concealed within the group results given earlier; although as a group the bilinguals showed longer response times, these individual statistics show that some bilinguals were functioning within monolingual norms while others were clearly outside the monolingual range. As indicated above, some individuals were unable to match monolingual performance in either language, while others were within the monolingual range in both conditions, suggesting that cross-influence from the latent language, at least on this type of task, is not a language-specific phenomenon, but rather the correlate of some higher-level processing strategy.
Some language-effects were apparent, however, since some subjects (bel02, bel03, bg113, bg110) showed a native-like performance in one language but not in the other.

IV.6 METALINGUISTIC JUDGMENTS

IV.6.0 Introduction
For monolingual subjects the pattern of acceptability judgments on the four categories of nonword used in the lexical decision task mirrors the two-way split between the phonotactically legal and illegal items found in the response times to the on-line processing task (Table III.10).

For English monolinguals the legal categories LL and LI received the same rating of 1.88, while German monolinguals rated items in the category LI even more highly than LL items (1.58 and 1.85 respectively). The two illegal categories received low acceptability ratings, with IL being rated lower than LI. IL was rated 4.76 by English monolinguals and 4.91 by Germans, while IL received ratings of 4.4 and 4.5 from English and German monolinguals respectively.

The bilinguals' judgment of the illegal categories mirrors that of the monolinguals: LI was rated 4.82 and 4.85 in the English and German conditions respectively; IL was rated 4.70 and 4.31 respectively. It is noticeable that IL did not form an intermediate stimulus category for bilingual subjects as it appeared to in the on-line lexical decision task.

The bilinguals' ratings of the phonotactically legal items in categories LL and LI showed a higher level of acceptability than the illegal items. However, the bilinguals' ratings in these two categories were substantially lower than the monolinguals'. LL items were rated 2.49 and 2.76 in English and German conditions respectively, while LI items received ratings of 2.41 and 2.35.

IV.6.1 Statistical analysis
A three-way GLM (analysis of variance for unbalanced groups) with two between factors (language: English and German; subject group:
monolingual and bilingual) and one within factor (stimulus category) was computed for the data.

The main effect of stimulus category was significant ($F(3,128)=285.58, p<0.0001$), as was the main effect of subject group (monolinguals vs bilinguals) ($F(1,128)=11.22, p<0.005$); the main effect of language was not significant ($F(1,128)=0.03, p>0.5$). The interaction of subject group with stimulus category was also significant ($F(3,128)=3.52, p<0.05$), confirming that the bilinguals differed from the monolinguals in their assessment of the acceptability of the different categories of stimulus.

Post-hoc comparisons of each subject group's mean ratings for the different stimulus categories were made using the Duncan-Waller range test. The resultant groupings are shown below: underlined categories are not significantly different from one another.

Table IV.5
**Metalinguistic judgments for monolingual subjects**

<table>
<thead>
<tr>
<th></th>
<th>English monolinguals</th>
<th>German monolinguals</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>IL</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>4.76 4.40</td>
<td>4.91 4.50</td>
</tr>
<tr>
<td></td>
<td>LL</td>
<td>LL</td>
</tr>
<tr>
<td></td>
<td>1.88 1.88</td>
<td>1.85 1.58</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

Table IV.6
**Metalinguistic judgments for bilingual subjects**

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals English condition</th>
<th>Bilinguals German condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>IL</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>4.82 4.70</td>
<td>4.85 4.31</td>
</tr>
<tr>
<td></td>
<td>LL</td>
<td>LL</td>
</tr>
<tr>
<td></td>
<td>2.39 2.20</td>
<td>2.76 2.15</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

169
IV.6.2 Discussion

On this task the responses for the two groups of monolinguals are similar both in overall rating and in the pattern of rating for each of the stimulus categories; the non-significant language-effect confirms the suggestion that both these groups agreed in their judgments of the potential acceptability of the nonword items in their respective languages; the responses of the bilinguals in the two language conditions were also not significantly different from one another. The latter finding contrasts with the results of Altenberg & Cairns, who found a significant difference between language conditions for their bilingual subjects; however, as mentioned previously, the subject population contained individuals with different dominance patterns rather than all English-dominant; moreover, subjects’ performances were compared against monolinguals in both languages rather than just one.

The second important finding in the present experiment is that the ratings given to the nonword items by the bilinguals differed significantly from those of the monolinguals. Again, this contrasts with the findings of Altenberg & Cairns (1983), who found that their bilingual subjects matched monolingual behaviour in their dominant language (the caveats mentioned above apply). In the present data the hierarchy of acceptability among the four categories is the same for each subject group in each language condition; however, the two legal nonword categories (LL and LI) are rated substantially lower by the bilinguals in both language conditions than by the monolinguals. It seems likely that this difference can only be accounted for by the presence of cross-language influence, with information from the latent language affecting the judgments made in the test language.

As the box plots of acceptability ratings clearly show (Figures III.24-27 above) this difference is greatest in the responses to those categories of stimulus that were phonotactically legal in the test language, which were rated as significantly less acceptable by the bilinguals than by the monolinguals in both language conditions. This finding also suggests that the metalinguistic judgment of the stimulus items is not directly linked to RT during the on-line task, since one might reasonably expect an item rated as less acceptable to be rejected more quickly as a potential real word;
in fact, as we have seen, legal nonwords were rejected more slowly than illegal items, despite the fact that they were rated as less acceptable in the present task.

The metalinguistic judgment of the illegal items matched the ratings of the monolinguals more closely, and showed far less overall variability than the legal categories. It seems that, while the bilinguals were able reliably to judge items that were unacceptable in each language, it was much more difficult for them to separate phonotactic information from their two languages in order to make metalinguistic judgments about potentially acceptable items. However, the results of the lexical decision task shows that they had integrated knowledge about phonotactic legality from both their languages, and that this information was accessed in an on-line processing task. Their inability to apply the same information in a metalinguistic task, in particular the fact that there was less, rather than more variation in the LI category than in the LL category, suggests that these results point to an overall lower ability to use phonotactic information in a metalinguistic context, rather than specific cross-language influence.

IV.7 GLOBAL ACCENT JUDGMENTS

IV.7.0 Introduction
In order to analyse the pattern of results from the judgments of accentedness, the mean scores received by all subjects, both monolingual and bilingual, in each language condition were placed in descending order according to their score. Bilingual subjects were then given a ranking of 1-12 for each language, as shown in the table below. Figures in brackets for the bilingual subjects indicate the ranking received in the other language condition.
### Table IV.7

Rank ordering of accent judgments:

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Subject</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
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<td>9.22</td>
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<td>9 (11)</td>
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<td>10 (2)</td>
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</tbody>
</table>

The absolute score cannot be compared across language condition, since the judgments were made by different listeners, and different ranges of accentedness among the speakers may have mediated different use by the listeners of the 1-10 judgment scale. However, absolute scores can be compared within each language condition, and the rankings of the bilingual subjects can be compared across languages.

The judgments of the listeners appear to be highly reliable, since the monolingual subjects in each language consistently received scores at the top end of the scale. The ratings received by the monolingual speakers across the different speech samples were also fairly consistent: the largest and smallest differentials for monolingual speakers were 1.5 and 0.5 respectively in the English condition, and 1.1 and 0.6 respectively in the
German condition (a breakdown of the scores given to each speech sample for each speaker is given in Tables III.13-14 above).

The range of scores obtained by the bilingual speakers was much greater than that for the monolinguals, with a range of 1.32-8.90 in the English condition, and 5.07-9.22 in the German condition. There was also greater variation in judgments across the four speech samples for the bilingual speakers: the largest and smallest differentials were 3.1 and 0.4 respectively in the English condition, and 2.1 and 0.5 respectively in the German condition, indicating that accentedness was perceived more strongly in some speech samples than in others. However, as shown in Tables III.13-14, the distribution of higher and lower scores for individual subjects varied across the different speech samples; hence these differentials can be attributed to individual characteristics of the speaker rather than to item effects in the material.

The most striking finding to emerge from the rank-ordering of the accent scores is the division between the ratings of the bilingual and monolingual speakers. In English the lowest mean score for a monolingual was 9.05, and the highest for a bilingual was 8.90: in other words, all the bilinguals scored lower than any of the monolinguals. In the German condition the results are similar: the lowest monolingual score was 9.02, and one bilingual (bgl05) scored 9.22, i.e. within the monolingual range; all other bilinguals scored below the monolingual range. Analysis by the ± 1 Standard Deviation method showed the same result: the only bilingual who performed within monolingual norms on either language was subject bgl05 in the German condition.

IV.7.1 Discussion
The finding that (with one exception) no bilinguals matched monolingual performance in either language condition in producing accent-free utterances is an extremely interesting one. Similar studies of L2 acquisition have shown that L2 learners consistently perform outside monolingual norms in their second language (Oyama, 1976; Major, 1987), and the findings have been interpreted as evidence of the existence of a critical or sensitive period for the acquisition of L2 phonology (Larsen-Freeman & Long, 1991).
However, the results of the present study, in testing subjects in both their language conditions suggests the limitations on native-like production may be more complex. It seems from the present results that cross-language effects or interference at the phonetic level is a bi-directional phenomenon. In other words, rather than producing native-like output in their dominant language, and L1-accented output in their non-dominant language, all except one bilingual subject showed effects of some kind that made their speech less than entirely native-like in both languages. It must be pointed out that the sentences were especially constructed to induce accent in native speakers of the opposite language; however, this does not in itself account for the findings, since most bilingual subjects performed outside the monolingual range in both language conditions; moreover, the judgments of accent on the relatively free speech produced in the map description task were not consistently higher. The results also confirm the findings of Flege (1984) that listeners are highly sensitive to the phonetic details of categories occurring in their native language, and are able reliably to detect very slight deviations from these categories even in small samples of speech.

However, the ranking of individual scores shows that there is a tendency for rankings in the two languages to be inversely proportional to one another, a tendency which reached statistical significance in a subsequent correlation analysis (Section IV.10 below): in other words, a higher ranking in one language tends to be associated with a lower ranking in the other, and subsequent correlation analysis showed that this inverse relationship was statistically significant (see section V.3 below). This is a general tendency rather than a rule; for example one subject (bgl08) scored low in both conditions, coming 9th in English and 11th in German. No subject was ranked highly in both languages.

These findings suggest that there may be a limit on the degree of nativeness that can be attained in the production of two languages, and that an improved level of performance in one language may be achieved at the expense of a deterioration in the other language. This possibility is not allowed for within the maturational state hypothesis, but is present within the framework Flege's interference hypothesis, which states that it is insufficient separation between the two systems which is the source of
phonological interference (Flege, 1995). By providing a framework which allows for the possibility of the relative strength of the two systems changing over time in an individual, such a model permits a much more complex view of the ultimate attainment achieved by the individual, one in which experience and individual circumstances can play as significant a part as the single criterion of age of learning.

IV.8 SYNTACTIC-SEMANTIC JUDGMENTS

IV.8.0 Introduction

As for the accent judgments, these results were analysed by placing the scores obtained by the individual speakers in order, and giving a ranking to the bilingual subjects in each language condition. These rankings are shown in the table below.

Table IV.8
Rank ordering of syntax-semantic judgments:

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<th>Score</th>
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<td>mel22</td>
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</table>

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<td>4 (8)</td>
<td>bgl04</td>
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<tr>
<td>5 (3)</td>
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<td>7.09</td>
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<tr>
<td>6 (5)</td>
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<tr>
<td>7 (4)</td>
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<tr>
<td>8 (7)</td>
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<tr>
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<tr>
<td>10 (6)</td>
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<tr>
<td>11 (10)</td>
<td>bgl03</td>
<td>5.72</td>
</tr>
<tr>
<td>12 (1)</td>
<td>bel03</td>
<td>3.79</td>
</tr>
</tbody>
</table>
As with the accent judgments, there is a tendency for monolingual speakers to receive the higher scores: the lowest monolinguals score was 7.54 in the English condition, 8.03 in the German condition. However, in contrast to the findings for accent judgments, several bilingual speakers in each condition performed within the monolingual range. Despite the greater overlap of scores for monolingual and bilingual speakers, a comparison of the ratings received by the bilingual speakers in each language condition reveals that there is a similar tendency for a high ranking in one language to be correlated with a low ranking in the other, although some subjects rank low in both conditions (e.g. bgl03); again, none rank very highly in both languages.

A syntactic/semantic analysis of the passages produced by the speakers may give some insight into the features to which the readers were responding (Black, 1995, personal communication and Selinker (1995) "Interlanguage/Interdialect/Interculture? Trying to sort it", Inaugural Lecture, Birkbeck College, 17th March 1995). Full transcriptions of all the passages are given in Appendix VI.

In the English condition, noticeable deviations from native-like performance fell into four main categories.

(i) **Perspective**

Subjects were free to decide how they wished to approach the description task: the most popular approach among monolinguals was to describe the journey as if giving directions to another person. This generally involved the use of the second person singular and simple present tense verbs ("you go left..."; "you turn right..."). However, a significant number of bilingual subjects (bg103, bg105, bg108, bg109, bg113, bes03) chose to describe their own journey using an I-perspective. This is in itself an unnatural perspective in English, and tended to lead to unusual tense constructions, particularly inappropriate use of the present continuous. Examples of such utterances include: "then I'm going under a bridge..." (bg109); "there's a sign saying town centre..." (bg108); "the road is slightly bending to the left..." (bg109). The reason for this use of I-perspective is not immediately clear, since the same subjects did not use it in the German condition; however, it may have
been linked to the subjects' reluctance to use the second person singular in the absence of a specific impersonal pronoun corresponding to the German 'man'.

(ii) Static NP with verb of motion
Inappropriate noun-verb combinations were widespread. Errors of this type include: "I see a golf course, and it's going there to the town centre..." (bgl09); "I noticed a sign which directed the traffic to the town centre..." (bgl03). These types of errors are directly attributable to cross-language influence from German in which these structures are legal.

(iii) Lexical choices
The picture map contained some items which required a high degree of verbal precision in their description, and some of these cases caused problems with lexical choice for several speakers. In some cases the word chosen was simply inappropriate in English: "the little place with the fountain..." (bgl13); "I come to another section..." (bgl05); "a little area with a fountain..." (bgl06); "a lake with some plantation at the side..." (bgl09). In other cases the speaker's difficulty in retrieving the appropriate lexical item led to complicated and unnatural periphrastic constructions: "you don't follow the town centre direction..." (bgl10); "it's going there towards the town centre..." (bgl09); "a kind of little roundabout for pedestrians, if you want..." (bgl04); "with a fountain in the centre and some seats on the edge..." (bgl09); "you can pass either the right way round it or the left way round it..." (bgl10).

(iv) Over-lexicalisation
Consistently replacing English verb phrases with single lexical items also contributed to the perceived unnaturalness of some of the passages. Commonly-used phrases such as "carry on up the road...", "head up...", "keep on going..." tended to be replaced in the speech of the bilinguals by single items such as "continue" and "proceed". This tendency among the bilinguals is likely to be attributable to the difficulty of verb phrases for learners, which leads some speakers to avoid them where a lexical alternative exists; however, persistent avoidance of such verbal structures is likely to be perceived as unnatural in informal speech. The passages also contained occasional
examples of inaccurately-used VPs, for example "I come up to a fountain..." (bgl05).

The German passages also showed some characteristic features of cross-language interference which are likely to have influenced the judgments of their nativeness.

(i) Prepositional errors
Several subjects produced incorrect prepositional constructions. In some cases these were self-corrected: "dann bieg't man bisschen zu... nach links..." (bel03); "wo so 'ne Straße von links... nach links abgeht..." (bel02). Another example of prepositional error is the attempt to mimic the English usage of 'left' and 'right' as prepositions in their own right: however, utterances like "die Straße biegt ein wenig links und dann rechts" (bgl03) are not legal in German, where a prepositional phrase would be required. Similarly, the English use of 'left' and 'right' as nouns is not permissible in German: hence an utterance like "da mach' ich erst 'ne links" (bgl03) is illegal in German.

(ii) Verbs of motion and position
German requires a greater degree of precision in the description of movement or position than English does, and the failure to use the appropriate verb is perceived as an error. Unusual utterances of this type produced by bilingual speakers include the following: "dann geht es links um die Kurve..." (bel02); "davor sitzt der Bahnhof..." (bel03); "dann steht links zur Stadtmitte..." (bgl03); "unter der Brücke geht es hindurch..." (bg10).

(iii) Perspective
As with the English passages, the choice of perspective affected the perceived naturalness of the utterances. As in English, it was mainly, though not exclusively, those subjects whose utterances received a lower rating who made use of the I-perspective. Of these subjects, several used a fluctuating perspective, alternating between the first person singular and the impersonal 'man' (bel03, bes03).
IV.8.1 Discussion

The ranking of bilingual subjects in each language tended to be inversely proportional, suggesting that high performance in one language tends to be correlated with lower performance in the other. This is similar to the findings of the cross-language comparison for the accent judgments, and confirms the suggestion that there may be a tendency for both languages to influence one another at this level. However, this tendency was less pronounced than for the accent judgments, and subsequent correlation analysis (Section IV.10 below) showed that it did not reach statistical significance.

However, in contrast with the accent scores, several bilingual subjects in each language condition performed within the monolingual range. This suggests either that grammatical and semantic aspects of native-like production are easier to attain or maintain than the phonetic and phonological aspects, perhaps since they are more open to introspection and more amenable to correction. However, no subject performed within the monolingual range in both languages. This is in contrast to the findings of Patowski (1980), whose results showed that childhood learners (pre-puberty) were able to reach monolingual standards in their L2. However, this study used only two native listeners to rate the transcripts which may have been too few to establish representative judgments. An additional factor which might contribute to an explanation of these results is that native listeners may be less efficient at detecting discrepancies at the grammatical than at the phonetic level.

There was a considerable degree of variability in the extent to which subjects' performance on accent was correlated with their grammatical-semantic performance. Some subjects had similar rankings for accent and for grammatical-semantic features (bel03, bel09); other subjects ranked relatively highly on accent but scored low on grammatical features (bg103), and for others the relationship was reversed, with a low ranking on accent and a higher ranking on non-phonetic aspects of their speech (bes03).

Clearly the relationship between these levels is far from straightforward. The findings emphasise that the perceived 'foreignness' of speech output is carried not just at the phonetic-phonological level, but may be marked at the grammatical and lexico-semantic levels as well. Furthermore, the
relationship between the relative performance of subjects at each of these levels is not necessarily symmetrical, but individually determined, and unpredictable.

IV.9 CROSS-TEST PATTERNS

IV.9.0 Introduction
In order to compare subjects' performances across different levels of testing and across languages, tables were drawn up for both languages which ranked each bilingual subject's results in each of the test modalities.

These analyses were carried out by calculating a single value per test for each bilingual subject. In the cases of the speech processing tests (vowel duration perception and production; vowel quality perception and production) this figure represented the distance of each subject's score from the monolingual mean; for the lexical decision test the absolute reaction time figure across all stimulus categories was used (Table III.9); for the accent and syntactic-semantic judgments each subject's score was used. The resulting table of absolute values is given in Appendix VIII; tables of each subject's ranking in each component of the test battery are given in Tables IV.9-10 below.

These rankings were then compared in two different ways: firstly by analysing cross-level variation within each language condition, to see whether subjects' performance in each language was consistent across different levels of encoding and different task types; and secondly by analysing cross-language performance for each test type, in order to investigate the relationship between the two languages across the different levels and tests.

IV.9.1 Statistical analysis
A Spearman rank-order correlation coefficient was calculated on subjects' performances in each test in each language condition; the rankings achieved by each subject are shown in the tables below. The results ranked in each column are as follows:
English condition
1. Accent judgment
2. Syntactic-semantic judgment
3. Lexical decision task
4. Perception of vowel duration (/m_t / environment): PB
5. Vowel duration production
6. Perception of vowel quality (/e_æ / boundary): PB
7. Perception of vowel quality (/æ - a / boundary): PB
8. Production of /e/: mean of F1 and F2 ranking
9. Production of /æ/: as above
10. Production of /a/: as above

German condition
1. Accent judgment
2. Syntactic-semantic judgment
3. Lexical decision task
4. Perception of vowel duration: mean of /m_t / and /ʃt_t / ranking
5. Production of vowel duration
6. Perception of vowel quality: PB
7. Production of /e/: mean of F1 and F2 ranking
8. Production of /a/: as above

Table IV.9
Cross-test rankings for bilinguals: English condition

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<td>4=</td>
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<td>3=</td>
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Table IV.10
Cross-test rankings for bilinguals: German condition

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The raw figures were used as input to calculate a Spearman rank-order correlation coefficient for non-parametric data for each pair of test results within each language condition, to investigate the extent to which the subjects' performance on the individual components of the test battery were independent of each other (the full values used for the correlation analysis are given in Appendix VIII).

For the English condition the correlations indicated that performance on several of the conditions were related to one another. Firstly, accent scores were positively correlated with syntactic-semantic scores (r=0.68, n=12, p<0.05), showing that a high score on accent was related to a high score on syntactic-semantic performance; however, the level of significance was not particularly high, suggesting that performance on the two modalities admitted a considerable degree of variability.

The dimension of accent was also correlated with the nativeness of the production of /æ/ (r=-0.74, n=12, p<0.01), suggesting that the ability to produce a front open vowel with native-like spectral structure is an important element in the perceived nativeness of phonological output, and that subjects who cannot produce a native-like /æ/ are more likely to
be judged as having a significant degree of foreign accent. Those features which were not correlated at a statistically significant level are also worthy of comment; in particular, given the correlation between accent and production of /æ/, it is interesting that there was no correlation between accent and perception of vowel quality phoneme boundaries, nor between perception and production of these boundaries. This suggests that performance on the perceptual dimensions may well vary independently of production of the same contrasts.

A few other correlations were found, which are rather more difficult to interpret. Firstly, accent was negatively correlated with reaction time for the lexical decision task (r=-0.78, n=12, p<0.005), indicating that a more native-like accent was related to a better performance (ie. faster reaction time) on the lexical decision task. It is not immediately clear why this should be the case, except for the general observation that good performance on the lexical decision task indicated a good level of fluency and facility in that language, which would tend to be linked with a more native-like accent. Similarly, there was a correlation between syntactic-semantic scores and performance on lexical decision (r=-0.58, n=12, p<0.05). Other correlations which are difficult to interpret is that between syntactic-semantic scores and native-like perception of the phoneme boundary /e-æ/ (r=-0.63, n=12, p<0.05), and between syntactic scores and native-like production of /æ/ (r=-0.73, n=12, p<0.01).

In the German condition the only significant result was a positive correlation between accent scores and syntactic-semantic scores (r=0.72, n=12, p<0.01), suggesting that, as for the English condition, subjects whose accent was perceived as more native-like also tended to show a more native-like performance on grammatical and semantic measures.

IV.9.2 Discussion
The most interesting overall observation on the cross-test correlation analyses is that, apart from the specific cases mentioned above, performances on so many of the modalities were not linked, but varied independently of each other. This is significant particularly for the speech processing tests which had a perceptual and a productive dimension, since these results indicate that, in both languages, native-like perception of a
contrast is not necessarily directly linked with native-like production, a finding which is in keeping with many other investigations into the relationship between speech perception and speech production (Bohn & Flege, 1990; Llisterrri, in press; Mack, 1989).

The present findings suggest that these observations on the complexity of the relationship between phonological perception and production are applicable on a wider scale to different aspects of linguistic performance. Certainly the relative independence of the various linguistic modalities tested show that a subject's facility at one level of language encoding cannot be taken as predictive of ability at other levels. It is necessary to keep in mind the possibility that individuals may employ different strategies across linguistic levels, and that these strategies can interact in complex and varied ways with the individual, linguistic and task-based variables discussed in Chapter I (see Llisterrri, in press, for review of relevant findings at the phonological level).

IV.10 CROSS-LANGUAGE PATTERNS

IV.10.0 Introduction
All data was included in a single Spearman rank-order correlation test, to investigate the cross-language performance of bilingual subjects at each level of encoding and each task type. Again, three patterns of association are possible: a positive correlation, indicating that good performance on a particular test in one language is associated with good performance in the other language; a negative correlation, showing that higher performance in one language is associated with lower performance in the other; or no correlation, indicating that performances in each language condition vary independently of one another.

IV.10.1 Statistical analysis
The results of the correlation analyses suggest that, across all the test types included in the test battery, all three patterns of association are found.

A negative cross-language correlation was found for accent scores in each of the two languages ($r=-0.69$, $n=12$, $p<0.05$), confirming the suggestion
made in Section IV.7.1 above, that subjects whose accents were rated highly in one language tended to have a lower performance in the other language. However, the level of significance is not particularly high, suggesting again that there was a certain amount of variability among individual subjects. No significant cross-language correlation was found for syntactic-semantic scores, although they were positively correlated with accent scores within each language condition.

Negative cross-language correlations were also found for the formant structure of certain vowels produced in the English and German conditions indicating that, as for accent scores, better performance in one language was associated with a less native-like performance in the other. This pattern was found for the production of English /æ/ and German /a/ (r=-0.58, n=12, p<0.05), and for the production of English /a/ and German /a/ (r=0.80, n=12, p<0.005).

A positive cross-language correlation was found for the reaction times in the lexical decision task (r=0.75, n=12, p<0.005), suggesting that subjects who performed well in one language were likely to perform well in the other.

The differentials between long and short vowels spoken by subjects were also positively correlated across language condition (r=0.58, n=12, p<0.05).

**IV.10.2 Discussion**

The results of the correlations lend weight to the hypothesis that different levels of language and different types of task may be subject to different patterns of cross-language influence.

The negative correlation of the accent scores for subjects' speech confirms the suggestion made earlier that there may be a ceiling on the phonological nativeness that can be achieved in two languages simultaneously, and that an improved performance in one language tends to be offset by a deterioration in the other. This is confirmed by the analyses of formant frequencies in subjects' production of English and German vowels, where a similar negative correlation was found between English /æ/ and German /a/, and between English /a/ and German /a/.
This suggests that, at least for those sounds where categories are not fully congruent across languages, the categories of each language represent competing standards for the bilingual or the language learner, and that the conflict is likely to be resolved in favour of one or the other. This interpretation is in accordance with Flege's model of cross-language interference, which hypothesises that, as mastery of the second language improves, the second language begins in turn to influence the pronunciation of the first language, so that complete separation between the two phonological systems cannot be achieved (Flege, 1995). It also supports his view that where L1 and L2 have categories which are similar but not identical, such as English and German /a/, it is more difficult for the learner to acquire a new L2 category than it is for instances where clear distinctions exist between sounds in the two languages.

The absence of a correlation between perceptual categories in English and German confirms the suggestion made in the previous section that perceptual strategies do not necessarily mirror production. One possible explanation that has been suggested for this phenomenon is that while bilinguals try to assimilate the perceptual categories of their two languages into one system, in production they try to maximise the phonetic difference between the two. Several studies which investigated both perception and production have found that bilinguals showed evidence of cross-language switching behaviour in production, but seemed to use the same perceptual categories in both language conditions (Flege & Eefting, 1987; Hazan & Boulakia, 1993).

The lack of cross-language correlation for the syntactic-semantic aspects of subjects' speech suggests that, although mastery of the phonological and syntactic aspects of a language are linked (as shown by the positive correlations described in the previous section), the syntactic and semantic level may not be as susceptible to cross-language influence as the accent level (or, alternatively, native listeners are more sensitive to accent-level effects than to syntactic effects). In the context of real language-use, the two levels are of course intimately linked, so that non-nativeness exists in both accentual and grammatical features simultaneously, and it may not be apparent on which aspects the listener is focussing. However, in the context of the present test series, the accent judgments were made on the basis of sentences that were read aloud, and on a very short extract of
relatively free speech from the map description, and it seems likely that the listeners' judgments were based on phonological features; for the grammatical judgments, all accent information was of course removed, since the judgments were made on orthographic transcriptions of the passages.

A different pattern of cross-language results was found for the lexical decision task. Here reaction times to the stimuli were positively correlated across language conditions, so that a higher performance in one language was associated with a higher performance in the other and, conversely, lower scores were also related. This might suggest that performance on the lexical decision task was determined by individual aptitude alone, and that the test does not provide any useful information about cross-influence between the two languages. However, as previous analyses have shown, the bilingual subjects as a groups differed significantly from the monolingual subjects in each language condition, suggesting that other-language influence was a factor in determining performance.

It seems more likely that the correlation is due to differences in subjects' facility with the processing strategies needed for this test. The nature of the task required that subjects be able to make a clear separation between lexical material and phonotactic information belonging to each of their two languages in a context which required them to focus exclusively on data from one language while screening out non-relevant information from the other. Previous studies have shown that other-language information is always decoded to some extent, but that the extent to which such non-relevant information from the 'latent' language intrudes as interference on the 'active' language is variable and depends, among other factors, on the relative levels of activation of the two languages (Hamers, 1973; Soares & Grosjean, 1984). In the context of the present results, it seems likely that those subjects who showed short reaction times in both language conditions had developed more efficient language-separation mechanisms for this task, and that the processing benefits of such a successful strategy were felt in both languages; on the other hand, those subjects who showed longer reaction times in both languages had failed to develop efficient mechanisms for separating the two systems, and their processing was thus hampered in both conditions by competing information from the latent language.
A similar pattern of positive correlation across language condition was found for the duration differential between short and long vowels spoken by subjects, indicating that those subjects who made the greatest duration distinctions between long and short vowels were likely to do so in both languages, rather than changing strategies according to language. As suggested for the analysis of the lexical decision task above, it is possible that this was an individual idiosyncracy of particular speakers; alternatively, it is possible that those speakers making a greater distinction between the two categories of vowel than others constituted a particular subgroup of bilinguals who had adopted a different strategy for distinguishing long and short vowels at the production level to the rest of the subjects.

**IV.11 GENERAL COMMENTS**

The analysis and discussion of the wide range of data produced by the test battery has shown the complexity of the task of modelling bilingual performance. Several points, however, emerge with particular clarity. Firstly, the data has shown the extent of the individual variability which may be present within the larger group results. In the light of the number of variables affecting the ways in which individuals become and remain bilingual, this appears to be a particularly significant dimension in analysing data from bilingual and L2 learner studies.

The second important observation is the asymmetrical nature of bilingual performance, both with regard to the different levels of processing within a particular language, and with regard to the processing of a particular level in each of the bilingual's languages. Moreover it seems likely that the remarkable degree of independence shown across the different levels and test types might interact with individual variables or the variables of particular subgroups within a bilingual population.

The next chapter attempts to integrate the performance data presented in this chapter with the background information on individual subjects obtained from the questionnaire, and considers how these two aspects might be related.
CHAPTER V
GENERAL DISCUSSION AND CONCLUSIONS

V.0 INTRODUCTION
This chapter undertakes a review of the results from individual subjects and groups of subjects across the different levels and modalities of testing in an attempt to identify particular patterns of behaviour, relate these to subgroups within the subject population and establish likely biographical correlates for different types of bilingual behaviour.

In particular the analysis attempts to characterise the concept of dominance by examining the nature of cross-language influence in individual bilinguals, and to see how such a concept might relate to current theoretical models in explaining and predicting bilingual performance. The following key questions relating to the concept of dominance underlie this review.

(i) Is some degree of cross-language influence inevitable for bilinguals?
Both the maturational state and the interference hypotheses propose a limit on the degree of performance that can be attained in two languages simultaneously. For models based on a critical period, this limitation is directly linked to age of acquisition; for interference-based models, it is linked to the relative strength of the two languages at any given time, a feature which is, however, in turn often linked to age of acquisition, but which allows for the influence of other dimensions as well. By examining patterns of language cross-influence for subgroups and individuals within the subject population the data from the test battery can shed some light on the nature and extent of cross-language effects and on possible biographical correlates in the individual.

(ii) Is cross-influence a uni- or bidirectional process?
Models based on a maturational state hypothesis propose a unidirectional concept of cross-language influence, proceeding from the primary early language to the second or subsequent language(s), while co-existence models, such as Selinker's interlanguage (Selinker, 1972; 1992), or Flege's interference model (Flege, 1995) allow, if not always explicitly, for the bidirectional influence of two languages on each other. The present study is unusual in providing data on subjects' performance in both their
language conditions, as well as on monolingual controls; this material makes possible an analysis which examines cross-language effects in both a bilingual's languages and can illuminate this under-researched question with its important theoretical implications.

(iii) Are some linguistic levels and processes more subject to cross-language influence than others?
Again, models of bilingualism such as those of Flege and Selinker, which use the characteristics of particular pairs of languages to make predictions for their co-existence, are sufficiently flexible to allow for asymmetrical patterns of behaviour across linguistic levels. However, it is possible that not all linguistic levels may be equally explicable by one particular model of performance. Again, the present data is unusual in providing information about the performance of the same subject group across a range of linguistic levels and tasks; a comparison of performances across these levels can shed light on the ways in which particular behaviour patterns might be linked to different types of linguistic task.

(iv) How do patterns of performance relate to individual language background variables?
Many studies within the framework of these models have shown the importance of dimensions such as age of learning and L2 experience or training in determining bilingual performance. The present study provides very detailed data on performance variation at the individual level, and could give information on the extent to which individuals might be grouped on the basis of patterns of language cross-influence, and how these groupings could be related to the language history and patterns of language-use of these individuals.

V.1 LANGUAGE CROSS-INFLUENCE AND DOMINANCE
This section provides an overview of the results of the test battery and the questionnaire data, which form a basis for analysing the relationship between language cross-influence and dominance, and between language dominance and language background.

Tables V.1 and V.2 below summarise the information on bilingual performance and on the language-acquisition and language-use patterns of
bilinguals. Table V.1 draws on the ±1 Standard Deviation measure of bilingual performance to identify bilingual subjects who were performing within the monolingual range. Those subjects who did perform within this range in either language condition were assumed to match monolingual norms, and this is denoted by an E or a G for the English and German conditions respectively in the appropriate column. Where subjects performed outside the range of ±1 SD from the monolingual mean they were assumed not to have reached monolingual norms for performance on that test, and this is denoted by a dash (--) in the appropriate column.

Where a particular level or test type was represented by several results, for example the parameter of vowel quality production, where formant measurements were made for three vowels in the English condition and for two vowels in the German condition, a subject was deemed to be within the monolingual range if more than half of the results were within that range, or outside it if the greater part of the results were outside. The tests of vowel duration processing were not included in this summary of results: since the performance of the two groups of monolinguals did not differ from each other, these tests were not considered as providing reliable information about language-specific processing in the bilingual subjects, and hence were omitted.

Table V.2 displays the principal features of the biographical information extracted from the questionnaire. The language given in response to each of the areas of acquisition or usage is represented by an E or a G as appropriate; where both languages were given, EG was entered in the relevant cell. The feature 'language of education' represents language-use at school and at university where applicable. The feature 'Main residence' represents the country in which most of the subject's life had been spent in total (not necessarily consecutive years of residence). Where approximately equal periods had been spent in both countries (a difference of less than 5 years), both languages are marked. The column 'self-assessment' represents the subject's own assessment as to which of his or her languages was the stronger. Individuals who were childhood bilinguals (AOL<5 years) are indicated by an asterisk.
**Table V.1**
Patterns of dominance in test results

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**Table V.2**
Patterns of language-acquisition and language-use

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<td>bes03</td>
<td>E</td>
<td>E</td>
<td>G</td>
<td>E</td>
<td>G</td>
<td>--</td>
<td>E</td>
</tr>
</tbody>
</table>

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Perhaps the most striking feature of the results displayed in these two tables is the contrast between the patterning of languages in the performance data and in the biographical information. The table of performance results (Table V.1) shows that there are very few cases in which individuals perform within the monolingual norm in both languages (the pattern one would expect from a 'balanced' or interference-free bilingual). Moreover, those individuals who do meet this standard do so only at particular levels of processing: no subject produced what could be described as a consistently native-like performance in both languages across all or even most levels of processing.

This lack of balance is in clear contrast to the results of the language-background questionnaire (LBQ) displayed in Table V.2, where both languages featured in response to many of the questions. With the obvious exceptions of country of birth and country of current residence, where only one response was possible, each condition featured some subjects whose language-usage patterns were balanced for that criterion. Across columns, a predominance of one language on a particular feature was often balanced by a predominance of the other language for another feature; for example, although many subjects spoke German with their parents, most of these subjects gave English as their current language of principal usage.

It would appear from this data that the concept of the balanced bilingual, meaning one whose performance is free from interference in either language, is a myth, at least at the level of performance, and that language cross-influence is highly pervasive, as well as asymmetrical across different levels of processing. The data also supports the view of the interference model that the bilingual's two languages can be regarded as competing; here a balanced distribution of E and G scores in the table of background information (ie. extensive exposure to and use of both languages in a variety of situations) is associated with low scores for native-like performance in either language.

Such an association follows logically from the premise of inter-linguistic competition put forward by interference models, since widespread use of both languages across several situations implies that the two languages will be competing to a greater extent than if one language predominates. A
further implication, based on the present data, is that childhood bilinguals are not necessarily advantaged in terms of the nativeness of their performance in both language conditions since, depending on individual circumstances, a greater potential for language conflict exists if both languages have been extensively used since early childhood.

Indeed, a significant feature of the performance data in Table V.1 is the number of cases where individuals fail to reach monolingual norms in either language. This data suggests that models which are based on unidirectional language influence may be failing to account fully for the complex patterns of cross-influence exhibited by the subjects in the present study, since they do not explain how so many subjects could fail to reach monolingual norms in either language. This performance pattern is clearly of considerable significance, since it is not just restricted to particular individuals; every subject showed evidence of bidirectional influence significant enough to result in performance outside monolingual norms in both languages at at least one level of processing, and one subject (bgl08, a childhood bilingual) performed outside monolingual standards for both languages at every level tested.

It appears from this data that modelling cross-language influence in bilinguals and learners is not simply a question of accounting for the limitations in ultimate attainment in L2, since such limitations are apparent in both languages; moreover, acquiring both languages in early childhood does not enable an individual to bypass such limitations, since some evidence of cross-language effects were found in all subjects, regardless of AOL. It is clear that this pattern of findings can be adequately explained only by a model which allows for a high level of bidirectional cross-influence, in which the first language is affected by the acquisition of a second, even when the second language is acquired relatively late in life, and when mastery of the L2 is not at a native-like level.

Another finding is that, where cross-influence is unidirectional, ie. the subject performs within monolingual norms in one language but not in the other, this pattern is not consistent across different levels of testing. A variety of patterns can be seen: some subjects show unidirectional cross-influence at some levels, and bidirectional at other levels; some subjects show a bias towards one language at some levels and appear to reach a
balanced performance at other levels. However in general, where there is a bias, as shown by a predominance of one language over the other, an overall tendency is identifiable for many subjects, even if it is not completely consistent over all levels.

This bias represents a predominance of the standards of one language over those of the other; in other words, a dominance pattern. Different types of dominance were apparent from the data, and may be subdivided as follows:

Strong dominance: unidirectional language cross-influence in three or more of the five levels tested.

- English dominant: bel02, bel03, bes03
- German dominant: bgl05, bgl13

Weak dominance: unidirectional cross-influence in one or two of the five levels.

- English dominant: bgl06, bgl11
- German dominant: bgl04, bgl09, bgl10

No dominance: performance balanced (either within or outside monolingual norms) for all levels in both languages.

- bgl03, bgl08

It is interesting to compare these results with the subjects' self-assessment of their stronger language.

Three subjects (bgl03, bgl06, bgl08) identified themselves as balanced in both languages, and for two of these (bgl03 and bgl08) their judgment seems to have been correct in that no particular pattern of dominance was detectable. However, their balance was achieved at a level outside the monolingual norm in both languages, and so they can be regarded as balanced bilinguals only in the sense that their pattern of cross-language influence was bidirectional, and not in the sense that they were free from interference.
The three subjects who showed strong English dominance (bel02, bel03, bes03) had assessed themselves as stronger in English; the two subjects who showed strong dominance in German (bgl05, bg113) were also accurate in their self-assessment.

Those subjects who manifested weaker dominance tended to be less accurate in their self-assessment. Subject bgl06, who assessed herself as balanced was in fact dominant in English, while subject bg110, who felt that English was her stronger language was dominant in German. Other assessments were accurate.

V.2 LEVELS OF LINGUISTIC ENCODING
Before making detailed analyses of individual behaviour patterns, it is necessary to analyse patterns of performance across levels of language, since it is possible that some levels or test types may be more prone to language cross-influence than others.

It is clear from the table, as well as from the analysis of individual test results in Chapter IV above, that subjects show different patterns of results across levels of processing and test types. Such non-linearity is well-attested for perception and production at the phonological level (Llisterrri, in press); it is also in accordance with results from different studies across linguistic levels (reviewed in, for example, Larsen-Freeman & Long, 1991); however, the present data is particularly interesting since the results for all the linguistic levels tested were obtained from the same subjects.

Asymmetry in the degree of cross-language effects is particularly noticeable for the detection of accent, where only one subject (bgl05) performed within the monolingual norm in either language; all other subjects were outside monolingual norms in both languages. There are two possible explanations for this finding: the phonetic/phonological level may be more sensitive to cross-language influence than other levels, and hence it is more difficult for subjects to approximate to native-like performance on the accent dimension than at other levels of testing. Alternatively, it is possible that native listeners are so sensitive to deviations from monolingual norms that it may be almost impossible for learners to
acquire perfect mastery at this level. Both explanations find support in the literature (Flege, 1984; 1988; Major, 1987; Oyama, 1976).

The correlation analyses (Section IV.9 above) showed that performance on the accent dimension was linked with the ability to match native-like spectral structure in the production of English /æ/. Table V.1 shows that several subjects were able to reach monolingual norms in at least one language for the dimension of vowel quality production, while only one did so for accent; it seems likely that, while the ability to produce the front open vowel accurately is clearly an important factor in the perceived nativeness of accent, it is the multidimensionality of overall accent which makes it such a challenge for bilinguals. It also seems that accent is extremely sensitive to bidirectional influence, and that effects of L2 on L1 may take place at a fairly early stage in the mastery of L2 phonology (Flege, 1995; Flege, Munro & MacKay, 1995b).

Nonetheless, the extent of the susceptibility to cross-influence of the accent level is remarkable, particularly since the majority of the subjects tested could pass, on a purely observational level, as native speakers of at least one of their languages, and some (bgl03, bgl11, bel02) reported passing as native speakers in both languages. Moreover, many of these subjects were first massively exposed to the L2 relatively late (well past puberty); the apparent effect of L2 on their primary early language is therefore particularly interesting.

Given the problems posed by wider-level phonological mastery, as shown by performance on the accent dimension, it is not surprising that the two other phonological-level tests, vowel quality perception and vowel quality production, also showed evidence of widespread cross-language influence. Bidirectional interference was not as apparent here as in the accent dimension, but a significant number of subjects were outside the monolingual range in both languages on both of these dimensions, while most others were outside in one language. It seems that the narrower focus of these tests meant that subjects were more likely to attain monolingual standards in one language, the language in which they were overall dominant.
Similar patterns were found in the test of syntactic-semantic production: again, more subjects reached monolingual standards on this dimension than the accent judgments, but no subject was within monolingual norms for both languages, again suggesting that unidirectional cross-influence or dominance was governing performances.

The on-line processing of phonotactic information in the lexical decision task seemed to be the level that was most robust in the face of cross-language influence. Three subjects achieved balanced performances within monolingual standards on this test, with six others were outside monolingual standards in both languages; only three subjects showed evidence of dominance.

Given the results of the cross-language correlation analysis (Section IV.10 above), which showed that performances in this test were positively correlated across languages, with higher performance in one language associated with a higher performance in the other, this pattern of results is not particularly surprising. It was hypothesised earlier that this test might have been measuring some supralinguistic facility for separating the two languages, of which the performance correlate was a faster reaction time, and that this facility might be more developed in some subjects than in others. Certainly, for the purposes of the present analysis, it seems that the lexical level, at least as measured by a lexical decision task of this type, may be relatively resistant to cross-language influence, so that subjects who otherwise have pronounced dominance patterns here seem relatively balanced across their languages, regardless of whether this balance was within or outside monolingual norms.

This independence of linguistic levels has several implications for studies of bilingual processing. Firstly, the above review shows that any discussion of dominance in individual bilinguals must be accompanied by an awareness that dominance patterns in performance are related to the level tested and the type of test used for the investigation.

Secondly, and more interestingly, it means that a subject’s performance at a particular level cannot be interpreted as representative of their overall competence. If, as the data suggests, native-like competence in an L2 is particularly difficult to attain at the level of accent, a pronounced foreign
accent cannot be taken as evidence of that individual's overall language dominance (see, for example, the results of subject bg11 and bg106, who both scored relatively low on the accent parameter for English, but manifested overall dominance in their English L2).

A further implication relates to the models of bilingualism which the data can support. The finding that, for some linguistic tasks, performance may be positively correlated across languages in adult as well as childhood learners is incompatible with the concept of a maturational state limitation on ultimate attainment in L2. It also suggests that there may be constraints on the ability of interference-based models to account for all types of linguistic performance. As discussed earlier, it is possible that separation between the two languages in tasks such as lexical decision might take a different, language-independent, form, which an interference model, based on an inverse relationship between the bilingual's two languages, cannot account for.

V.3 DOMINANCE AND INDIVIDUAL VARIABILITY
The following dimensions of individual variability seem to be particularly important in contributing to an explanation of the different dominance patterns shown by subjects.

(i) **Age of acquisition**
Despite evidence that language-specific speech perception may begin in infancy (see Section 1.3.1 above), it is still often assumed, explicitly or implicitly, that individuals who become bilingual in childhood are somehow qualitatively different from those who acquire an L2 in adulthood, and that if both languages are acquired early enough, interference-free mastery will be attained. This attitude is explicit in much of the work on second language acquisition, exemplified by the following extract from Selinker: '...at least two distinct types of individuals are being studied in the bilingual literature: established bilinguals, with two or more languages from birth or early childhood, and second language learners who become IL [=interlanguage] speakers.' (Selinker, 1992). However, as discussed above, this distinction does not necessarily follow from a model based on interference between two competing linguistic systems, since one might hypothesise that childhood bilingualism, and consistent use of both
languages in many areas of daily life, might maximise the conflict between the two languages, and hence the extent of the compromise undergone by both languages in order to maintain this co-existence.

Certainly the results of the present study indicate that the association of childhood bilingualism with later interference-free mastery does not correspond to the facts. The three subjects who were childhood bilinguals (bg08, b02, bel03), far from showing balanced performance across different levels of testing, either show clear evidence of dominance (bel02 and bel03) or appear to deviate from monolingual performance in both conditions (bg08).

Closer examination of the LBQ material helps explain why this might be so. Subjects bg08 and bel03 spoke both languages at home as children, but in neither case was the one parent-one language principle (see Section 1.3.2 above for a discussion of the parameters of childhood acquisition) rigidly adhered to: in the first instance, both parents spoke both languages, and also communicated between themselves in both; in the second, the subject spoke English with her father, and both German and English with her mother. Both these patterns of communication represent a breakdown of the strict separation of the two spheres of language use which form the optimal basis for interference-free acquisition.

Subject bel02, the other childhood bilingual, grew up in Germany, but spoke only English at home, the language in which her parents communicated (although her father was a native speaker of German). This pattern of language behaviour is also associated with a greater degree of cross-language interference.

It appears that the mere fact of learning two languages in childhood is no guarantee of subsequent native-like performance in those two languages and that, in extreme cases such as that of subject bg08, may mean that an individual does not approach native-like performance in either language. This possibility is rarely explored in the literature, although it is in principle congruent with the premises of interference-based models; for example, Selinker's response to the question of when bilingualism begins is that 'in the IL framework we avoid that question since... interlanguage begins at the beginning whenever one attempts to express meaning in the
target language.' (Selinker, 1992). Clearly this analysis assumes that the target language is acquired on the basis of a pre-existing native language, a situation which is not applicable to those who acquire two languages more or less simultaneously in early childhood. However, Selinker's analysis can also be deliberately misread to account for subjects like bg108, whose performance did not match native speakers on any parameter in either language, by admitting that interlanguage may indeed be present 'at the beginning', and that it may be possible for an individual to speak interlanguage or in this case interlanguages as his or her first language, if those languages are acquired in an environment which inhibits the maximisation of separation between the two systems.

However, it seems from the data that later L2 acquisition is not necessarily a guarantee that a subject will not end up with two interlanguages rather than one. Subject bg106, for example, who became fluent in her L2 (English) in adulthood, showed native-like performance on only one parameter, and that in her L2 rather than her L1. Similarly, subject bg110, with a comparable language background, reached native-speaker standards, this time in her L1 (German) on only one test.

Several other late learners showed extensive bidirectional interference patterns by reaching native-like standards in one language on fewer than three modalities (defined as weak dominance), while subject bg103 showed native-standard performance in both languages on the lexical decision task only (the test most likely to elicit such a pattern), without meeting monolingual levels on any other task.

Particularly remarkable are the two subjects whose dominance patterns appeared to have shifted in the course of L2 acquisition (bg106 and bg111), since they performed within monolingual norms in some aspects of their L2, while failing to meet these norms in their L1. Again this possibility is not allowed for within the maturational state hypothesis, with its unidirectional and monolithic concept of dominance. Interference-based models, however, can in principle be interpreted to allow for a change in overall dominance, provided that dominance is defined in the spirit of the present framework, as not necessarily implying monolingual-like behaviour in all modalities of a particular language, but rather the overall balance of a subject's patterns of cross-influence.
These findings show how widespread and pronounced the effect of L2 can be on L1, and that it is not necessary to be an early childhood bilingual growing up in a linguistically chaotic environment in order to reach a state where performance is outside monolingual norms in both languages -- in other words, to be a speaker of two interlanguages. They also highlight the importance of integrating the often only tangentially acknowledged possibility of L2-L1 transfer into the design of research studies, since this appears to be an important and relatively unexplored area of bilingualism and second language acquisition.

(ii) Experience
In contrast to those speakers whose competence seems to consist of two interlanguages are those who, more in keeping with traditional models of cross-language interference, show evidence of relatively consistent patterns of dominance. Less expected, perhaps, is the heterogeneity of this group, comprising as it does childhood bilinguals such as bel02 and bel03, late learners with relatively little L2 experience such as bgl05 and bgl13, and late learners with considerable experience in L2, such as bes03. Clearly, performance alone is inadequate in explaining the discrepancies between these individuals, identified above as strongly dominant in one of their languages.

A model borrowed from second language acquisition may help to clarify this impasse by enabling us to distinguish between Type 1 individuals, whose IL is characterised by stability, and Type 2 individuals, who continue to 'learn' in the sense that their IL is changing over time" (Tarone et. al., 1976). Without wishing to push this analysis too far, and acknowledging that such change may affect both languages rather than one, we can hypothesise that the childhood bilinguals in this group and late learners with long experience in L2 might currently be stable in their dominance, while those learners with relatively short exposure to English-speaking environments might be in a period of instability, in which the effects of increasing L2 mastery had not yet manifested extensively in the L1. In other words, very different predictions for future behaviour or ultimate achievement would be made for individuals whose dominance patterns at a given time were apparently similar, but who differed substantially with regard to their language experience.
It is important that stability should not be equated, as it often is, with fossilisation, a state in which the ceiling on L2 acquisition is reached, and the individual's language systems do not change further (e.g. Flege & Hillenbrand, 1984; Selinker, 1992). Indeed, the present data has shown that an overall change in patterns of dominance is possible in the course of an individual's lifetime; it might well be that the dominance patterns of those individuals identified as currently stable might be equally susceptible to change if the individual's linguistic circumstances changed.

The most obvious measure of a subject's experience in each language is the length of time spent living in each language environment. However, the data shows that this is not necessarily straightforwardly linked to current dominance patterns. For example subjects bgl06, bgl11 and bel02, who were dominant in English, had lived in German-speaking environments for at least five years longer than English-speaking ones; for other subjects there was a clear link between language experience and dominance (e.g. bgl04, bgl05 and bgl13, who had lived most of their lives in Germany and were German dominant, and bel03 and bes03, who had lived longer in England and were English dominant). Nor is a balance of immersion between two language environments necessarily associated with balanced performance.

It seems likely that length of exposure to a language interacts with other aspects of individual variability in influencing a subject's dominance. So, for example, those subjects who showed evidence of a change of dominance over the course of their lifetime (bgl06 and bgl11) did so despite having spent relatively less time in L2 environments as compared with L1 environments, while other subjects who had spent more time in L2 environments were still dominant in their primary early language (e.g. bgl09 and bgl10).

(iii) Language of current principal usage
Another variable which seems to play a significant role in influencing the dominance patterns of individual subjects is the language of current principal usage. Clearly it cannot be the sole determinant of an individual's current dominance, since no subject gave German as their language of main use, although several were in fact dominant in German.
However, its relationship with other aspects of a subject’s language background are interesting.

Current language-use interacts, as suggested above, with language experience; subjects who have only recently been massively exposed to L2 are unlikely to show a shift in dominance patterns until a certain critical degree of experience has been reached. Again the concept of stability can be invoked to differentiate between the three subjects who gave both languages in response to this dimension: subjects bgI05 and bgI13 had relatively short exposure to English, their L2, and were strongly dominant in German; one might hypothesise that their current mixed language usage (both worked in English-speaking environments, but used German at home) was hampering the development of new L2 categories, leading to a strong predominance of the L1 categories on the processing of L2. Subject bes03, on the other hand, who also reported currently using both languages extensively (he commuted regularly between home in England and his workplace in Germany) had extensive experience in both languages, and could be assumed to have reached a state of relative stability, with English as his dominant language. This distinction is likely to be of particular significance for predicting the future language-development of these individuals, even where no clear differences appear in their current performance.

Language of principal usage is clearly also of crucial significance in explaining the lifetime change in dominance patterns shown by subjects bgI06 and bgI11 whose primary early language was German, but who were currently dominant in English; however, as discussed above, neither current language usage nor language experience are sufficient to explain the different outcomes in terms of dominance patterns displayed by individual subjects. The discussion above also shows that the feature of principal usage conceals a considerable degree of potential variability in patterns of language use, each of which may affect output performance.

(iv) Language of education
One such variable which is relatively easy to quantify is the language of education. Language of education was here taken to mean formal educational experience at either school or university, and it is noticeable from the data how many of the subjects did have educational experience
in both languages. Again, the patterns of such experience are subject to variability: subjects bel02 and bg108 had school experience in both languages, while the pattern for the other subjects who were educated in both languages was that primary and secondary education took place in the primary early language, with a change of language environment at further education level.

Despite these differences, the characteristics of formal education might be assumed to constitute a particular subgroup of linguistic experience, which might affect performance in specific ways. Firstly, formal education requires the accessing of a more abstract level of experience through the medium of the language in which it is taught, which in itself constitutes a type of language use identifiably distinct from that of daily conversation, whether at home or at work. Furthermore, academic work requires and fosters a facility in modalities of language use (such as reading, writing and formal speaking) which would not be employed in such a structured manner in other circumstances, while the register and conventions of educational communication might also be assumed to affect an individual's overall competence in other spheres of language use.

However, as with the other dimensions, language of education is not a straightforward predictor of dominance or performance patterns, since the subgroup of those with educational experience in two languages includes some with clear dominance in their primary early language, both stable and unstable, (eg. bg113, bes03), those with no clear dominance pattern, such as bg108, and those whose dominance pattern had changed over time (bg106, bg111). One can hypothesise that the experience of formal education in L2 was of significance particularly for this latter category; however, it is difficult to explain why not all subjects with educational experience in L2 were affected in the same way.

(v) Individual aptitude
Clearly none of the language-background variables acts alone in influencing bilingual acquisition and competence; rather, they interact with each other and with the dimensions of individual aptitude. This latter feature is notoriously difficult to characterise and quantify, yet it is an obvious explanation for the different outcomes attained by subjects whose language experiences were apparently similar. So, for example,
subjects bgl03, bgl10 and bgl11 all had German as their primary early language; all learnt English at school and were first massively exposed to English when they moved to an English-speaking environment in early adulthood; all were currently living in England with English-speaking partners, and had English as their language of current principal usage. However, of these three superficially similar subjects, one (bgl10) was found to be dominant in German, one (bgl11) had shown an apparent dominance shift to English, and the other (bgl03) appeared to have lost her early German dominance without acquiring monolingual standards in English, thus showing no overall dominance of either language.

Clearly individual abilities and aptitude must play a significant role in explaining such different outcomes in the light of similarities in circumstances, but it is difficult to see how these factors could be analysed. However, the detailed characterisation of language-background features makes it possible at least to narrow down the amount of variability which is due to opaque individual differences such as aptitude, and to establish some features of language background which do appear to relate to performance patterns, albeit not in a straightforward and predictive manner.

V.4 CONCLUDING REMARKS

The research for the present study produced a large quantity of data and a range of interesting findings, some of which support the results of other studies, and some of which suggest ways in which research into and models of bilingualism and second language acquisition could be modified and developed.

The most significant of these findings, and the most wide-reaching in its implications, is the degree and extent of the cross-language effects present in all subjects and at all levels of linguistic processing. The existence of such interference is not in itself new; the contribution of the present investigation lies firstly in showing the importance of bidirectional language cross-influence, and secondly in demonstrating its pervasiveness in all subjects, whether childhood bilinguals or later learners.
Bidirectional interference has not been shown by most studies simply because researchers have failed to look for it, either because subjects were tested in their second language only, or because monolingual controls were not provided for both language conditions. The present study suggests that this omission is a significant one, and one which, if remedied, could contribute to a more balanced understanding of the processes involved in acquiring and using more than one language.

The extent of bidirectional interference is also important in showing that the absolute distinction between childhood bilinguals and later learners need not be a valid one, and that many of the same processes can be seen to operate in both groups. The ultimate performance of both childhood and adult bilinguals may display one of several different dominance patterns. It may show a dominance in the primary early language, which is the pattern assumed by most studies; however, a lifetime shift in dominance also appears to be possible, so that an individual may display an overall dominance in a language learnt later in life. It is also possible for no overall pattern of dominance to be present, either because bidirectional cross-language interference has been present from the earliest stages of language learning, or because the original dominance of a primary early language has been lost without being replaced by a corresponding level of performance in a subsequent language.

These findings provide clear counter-evidence to the maturational state hypothesis, since the concept of an age-related limitation on language learning does not allow for changes in dominance patterns, and predicts clear differences in performance between early and late learners. The findings are, on the other hand, at least potentially congruent with models of bilingualism such as the interference hypothesis, in which performance is determined by the competition in the individual between two co-existing language systems. However, in most discussions based on the latter model, both the notion of bidirectional interference and potential similarities between early and late learners are implicit rather than explicit, and are not incorporated into the design of most research studies based on these models. The present study suggests that an expansion of the model to take into account these possibilities would widen and enrich the research basis of bilingual studies and enhance our understanding of this important area of linguistic knowledge.
REFERENCES


**ADDENDA**


"An Autumn Effect"
(from Essays of Travel)

Bidding good morning to my fellow-traveller, I left the road and struck across country. It was rather a revelation to pass from between the hedgerows and find quite a bustle on the other side, a great coming and going of schoolchildren on by-paths, and, in every second field, little houses and farmers ploughing. The way I followed took me through many fields thus occupied, and through many strips of plantation, and then over a little space of smooth turf, very pleasant to the feet, set with tall fir-trees and clamorous with rooks making ready for winter; and so back again into the quiet road. I was now not far from the end of my day's journey. A few hundred yards further, and passing through a gap in the hedge, I began to go down hill through a pretty extensive tract of young beeches. I was soon in shadow myself, but the afternoon sun still coloured the utmost boughs of the wood, and made a fire over my head in the autumnal foliage.

Robert Louis Stevenson

"Aus dem Leben eines Taugenichts"


Sonst war die Lebensart gar nicht so übel. Ich legte mich, wie auf einem Kanapee, bald in die eine, bald in die andere Ecke des Wagens und lernte
Menschen und Länder kennen, und wenn wir durch Städte fuhren, lehnte ich mich auf beide Arme zum Wagenfenster heraus und dankte den Leuten, die höflich vor mir den Hut abnahmen, oder ich grüßte die Mädchen an den Fenstern wie ein alter Bekannter, die sich dann immer sehr verwunderten und mir noch lange neugierig nachguckten.

*Josef von Eichendorff*
APPENDIX II
DETAILS OF VOWEL DURATION PERCEPTION TESTS

Synthesis details for /ɾtʰaːt/ syllables

#include "kspan.h"
#include <math.h>

#define NUM_STIM 12

SYNTH() {  
  int i, delay;
  for (i=0; i<NUM_STIM; i++) {
    DEFAULT_PARAMETERS;
    /* prolong duration in slices of 10 msecs */
    delay = (20+i*10);
    at(0);
    SILENCE;
  wait(10);
  SILENCE;
  fx(0); f1(100); f2(1800); f3(2560); f4(3200); f5(5000);
  ah(0); af(0); av(0);
    /* /-onset */
  wait(10);
  ah(5); af(5); av(0);
  wait(50);
    fx(100); ah(40); af(40); av(0);
    f2(1800); f3(2560); f4(3200); f5(5000);
    a2f(20); a3f(30); a4f(30); a5f(35);
  wait(130);
    fx(100); ah(50); af(50); av(0);
    a2f(20); a3f(30); a4f(30); a5f(35);
  wait(10);
    ah(30); af(30); av(0);
    /* t-closure */
  wait(10);
    fx(100); f1(100); f2(1800); f3(2560); f4(3200); f5(5000);
    ah(0); af(0); av(0);
  wait(10);
    SILENCE;
    /* t-burst */
  wait(10);
    ah(50); af(50); av(0);
    a2f(30); a3f(30); a4f(10); a5f(10);
  wait(20);
    ah(30); af(30); av(0);
    fx(100);
    /* vowel onset */
}
wait(10);
    fx(100); av(10);
    f1(680); f2(1100); f3(2500); f4(4000);
/* beginning of initial transition */
wait(10);
    av(40);
wait(10);
    f1(720); f2(1200); f3(2500); f4(4000);
/* steady state */
wait(10);
    fx(100); av(40);
wait(delay);
    f1(680); f2(1250); f3(2500); f4(4000);
/* final transition */
wait(10);
    fx(80); av(20);
wait(10);
    fx(70);
    f1(720); f2(1200); f3(2100); f4(4000);
    av(0); af(0); ah(0);
wait(5);
    SILENCE;
    fx(0);
/* t-start */
wait(40);
    av(0); af(0); ah(0);
wait(5);
    f1(841); f2(1600); f3(2360); f4(4000); f5(5000);
    b1(200); b4(300); b5(5000);
    ah(30); af(30); a2f(22); a3f(22); a4f(55); a5f(40);
wait(10);
    af(28); a2f(22); a3f(18); a4f(55); a5f(40);
/* t-steady state */
wait(10);
    a2f(18); a3f(18); a4f(55); a5f(60);
wait(50);
    ah(10); af(15); a4f(50); a5f(40);
wait(20);
    ah(10); af(10); a2f(6); a3f(7); a4f(8); a5f(7);
wait(20);
    SILENCE;
wait(150);
    SILENCE;
FLUSH;
CLEAR; } }
APPENDIX III
DETAILS OF VOWEL DURATION PRODUCTION TESTS

Randomised stimulus lists

<table>
<thead>
<tr>
<th>English condition</th>
<th>German condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. heart</td>
<td>1. Naht</td>
</tr>
<tr>
<td>2. cart</td>
<td>2. Stadt</td>
</tr>
<tr>
<td>3. cud</td>
<td>3. satt</td>
</tr>
<tr>
<td>4. bard</td>
<td>4. satt</td>
</tr>
<tr>
<td>5. cart</td>
<td>5. Saat</td>
</tr>
<tr>
<td>6. card</td>
<td>6. Staat</td>
</tr>
<tr>
<td>7. hut</td>
<td>7. matt</td>
</tr>
<tr>
<td>8. cut</td>
<td>8. Saat</td>
</tr>
<tr>
<td>9. heart</td>
<td>9. Staat</td>
</tr>
<tr>
<td>10. bud</td>
<td>10. Staat</td>
</tr>
<tr>
<td>11. cut</td>
<td>11. Saat</td>
</tr>
<tr>
<td>12. card</td>
<td>12. Stadt</td>
</tr>
<tr>
<td>13. bard</td>
<td>13. Naht</td>
</tr>
<tr>
<td>14. hut</td>
<td>14. matt</td>
</tr>
<tr>
<td>15. cart</td>
<td>15. Naht</td>
</tr>
<tr>
<td>16. hut</td>
<td>16. satt</td>
</tr>
<tr>
<td>17. bud</td>
<td>17. Stadt</td>
</tr>
<tr>
<td>18. card</td>
<td>18. matt</td>
</tr>
<tr>
<td>19. cud</td>
<td></td>
</tr>
<tr>
<td>20. bud</td>
<td></td>
</tr>
<tr>
<td>21. heart</td>
<td></td>
</tr>
<tr>
<td>22. cut</td>
<td></td>
</tr>
<tr>
<td>23. bard</td>
<td></td>
</tr>
<tr>
<td>24. cud</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX IV
DETAILS OF VOWEL QUALITY PERCEPTION TESTS

Synthesis details for /bet-bæt/ continuum

```c
#include "kspan.h"
#include <math.h>

#define NUM_STIM 7

SYNTH() {
    int i;
    int f1_value, f2_value, f3_value; /* vowel formants */

    for (i=0; i<NUM_STIM; i++) {
        f1_value = interpolate (650,800,i);
        f2_value = interpolate (1900,1550,i);
        f3_value = interpolate (2640,2460,i);
        dostimuli (f1_value, f2_value, f3_value);
        FLUSH;
    } /* end I loop */
} /* end main */

/* logarithmic interpolation function */
int interpolate (vl, v2, stim)
int vl, v2, stim;
{
    float slope;
    float lv1, lv2; /* log values */
    lv1 = log((double)vl);
    lv2 = log((double)v2);
    slope = (lv2-lv1)/(NUM_STIM -1);
    return((int) (0.5+exp(lv1+stim*slope)));
}

dostimuli(f1_value,f2_value,f3_value)
int f1_value, f2_value, f3_value;
{
    DEFAULT_PARAMETERS;
    at(0);
    SILENCE;
    wait(50);
    SILENCE;
    fx(100); f2(1000); f3(1800); f4(3100); /*b-burst */
    wait(5);
    fx(100);
    ah(30); af(30); av(0);
}
```

229
To create the /bæt - bæt/ continuum, the same synthesis was used, but
the interpolation endpoints for the vowel formants were:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>800 - 700</td>
</tr>
<tr>
<td>F2</td>
<td>1550 - 1250</td>
</tr>
</tbody>
</table>
Synthesis details for /fest-fast/ continuum

```
#include "kspan.h"
#include <math.h>

#define NUM_STIM 7

SYNTH0 {  
  int i;
  int fl_value, f2_value, f3_value; /* vowel formants */

  for (i=0; i<NUM_STIM; i++) {
    fl_value = interpolate (650,800,i);
    f2_value = interpolate (1900,1550,i);
    f3_value = interpolate (2640,2460,i);
    dostimuli (fl_value, f2_value, f3_value);
    FLUSH;
  } /* end I loop */
} /* end main */

/* logarithmic interpolation function */
int interpolate (vl, v2, stim)
int vl, v2, stim;
{
  float slope;
  float lv1, lv2; /* log values */
  lv1 = log((double)vl);
  lv2 = log((double)v2);
  slope = (lv2-lv1)/(NUM_STIM-1);
  return((int) (0.5+exp(lv1+stim*slope)));
}

dostimuli(f1_value,f2_value,f3_value)
int f1_value,f2_value,f3_value;
{
  DEFAULT_PARAMETERS;
  at(0);
  SILENCE;
  wait(50);
  SILENCE;
  /* f-onset */
  wait(10);
  SILENCE;
  f1(100); f2(1800); f3(2500); f4(3200); f5(5000);
  af(0); av(0);
  wait(20);
```

231
af(15);
wait(30);
    fx(100); af(40);
f2(1800); f3(2500); f4(3200); f5(5000);
a2f(35); a3f(35); a4f(35); a5f(35);
wait(30);
    fx(100); af(45);
a2f(35); a3f(35); a4f(35); a5f(35);
wait(20);
    af(40); av(0);
f2(1800); f3(2500); f4(3200); f5(5000);
    /* vowel onset */
wait(5);
    af(0); av(45);
wait(5);
    fx(100); av(45);
    f1(f1_value); f2(f2_value); f3(f3_value); f4(4000); f5(4500);
    /* steady state */
wait(80);
    fx(90); av(25);
    /* final transition */
wait(10);
    fx(75);
    fx(60); f1(f1_value); f2(f2_value); f3(f3_value); f4(4000); f5(4500);
    av(0); af(0); ah(0);
wait(5);
    SILENCE;
    /* s-start */
wait(5);
    af(30); av(0);
    f2(2000); f3(4500); f4(4800); f5(5500);
    a2f(0); a3f(35); a4f(35); a5f(35);
wait(50);
    af(50);
    f2(2000); f3(4500); f4(4800); f5(5500);
    a2f(0); a3f(45); a4f(45); a5f(45);
wait(20);
    af(20); av(0);
    a2f(0); a3f(20); a4f(20); a5f(15);
    /* t-start */
wait(20);
    fx(0); av(0); af(0); ah(0);
wait(5);
    f1(841); f2(1600); f3(2360); f4(4000); f5(4500);
    b1(200); b4(300); b5(500);
    ah(30); af(40); a2f(22); a3f(22); a4f(55); a5f(40);
    /* t-steady state */
wait(10);
As described above, the second set of formant frequency values was used to create the second half of the continuum.
Individual labelling functions for vowel quality perception:

% perception of /æ/: English condition

Figure A.IV.1
Subject mel17: English condition

Figure A.IV.2
Subject mel18: English condition
Figure A.IV.3
Subject mel19: English condition

Figure A.IV.4
Subject mel20: English condition
Figure A.IV.5
Subject mel21: English condition

Figure A.IV.6
Subject mel22: English condition
Figure A.IV.7
Subject bgl03: English condition

Figure A.IV.8
Subject bgl04: English condition
Figure A.IV.9
Subject bgI05: English condition

Figure A.IV.10
Subject bgI06: English condition
Figure A.IV.11
Subject bgl08: English condition

Figure A.IV.12
Subject bgl09: English condition
Figure A.IV.13
Subject bg110: English condition

Figure A.IV.14
Subject bg111: English condition
Figure A.IV.15
Subject bgI13: English condition

Figure A.IV.16
Subject bel02: English condition
Figure A.IV.17
Subject bel03: English condition

Figure A.IV.18
Subject bes03: English condition
Figure A.IV.19
Subject mgs01: German condition

Figure A.IV.20
Subject mgs02: German condition
Figure A.IV.21
Subject mgs03: German condition

Figure A.IV.22
Subject mgs04: German condition
Figure A.IV.23
Subject mgs05: German condition

Figure A.IV.24
Subject mgs06: German condition
Figure A.IV.25
Subject bgl03: German condition

Figure A.IV.26
Subject bgl04: German condition
Figure A.IV.27
Subject bg105: German condition

Figure A.IV.28
Subject bg106: German condition
Figure A.IV.29
Subject bg108: German condition

Figure A.IV.30
Subject bg109: German condition
Figure A.IV.31
Subject bg110: German condition

Figure A.IV.32
Subject bg111: German condition
Figure A.IV.33
Subject bgl13: German condition

Figure A.IV.34
Subject bel02: German condition
Figure A.IV.35
Subject bel03: German condition

Figure A.IV.36
Subject bes03: German condition
## APPENDIX V

### DETAILS VOWEL QUALITY PRODUCTION TESTS

**Randomised stimulus lists**

<table>
<thead>
<tr>
<th>English condition</th>
<th>German condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. must</td>
<td>1. lecker</td>
</tr>
<tr>
<td>2. bet</td>
<td>2. Ratte</td>
</tr>
<tr>
<td>3. sat</td>
<td>3. Alter</td>
</tr>
<tr>
<td>4. gut</td>
<td>4. lecker</td>
</tr>
<tr>
<td>5. get</td>
<td>5. Wette</td>
</tr>
<tr>
<td>6. mess</td>
<td>6. älter</td>
</tr>
<tr>
<td>7. gut</td>
<td>7. Alter</td>
</tr>
<tr>
<td>8. bat</td>
<td>8. Wette</td>
</tr>
<tr>
<td>9. guest</td>
<td>9. Säcke</td>
</tr>
<tr>
<td>10. but</td>
<td>10. retten</td>
</tr>
<tr>
<td>11. bag</td>
<td>11. Watte</td>
</tr>
<tr>
<td>12. gas</td>
<td>12. älter</td>
</tr>
<tr>
<td>13. gas</td>
<td>13. Ratte</td>
</tr>
<tr>
<td>14. mass</td>
<td>14. Sack</td>
</tr>
<tr>
<td>15. bet</td>
<td>15. Lack</td>
</tr>
<tr>
<td>16. mess</td>
<td>16. Lack</td>
</tr>
<tr>
<td>17. guest</td>
<td>17. Watte</td>
</tr>
<tr>
<td>18. but</td>
<td>18. Sack</td>
</tr>
<tr>
<td>19. bat</td>
<td>19. retten</td>
</tr>
<tr>
<td>20. bug</td>
<td>20. Säcke</td>
</tr>
<tr>
<td>21. get</td>
<td></td>
</tr>
<tr>
<td>22. gust</td>
<td></td>
</tr>
<tr>
<td>23. beg</td>
<td></td>
</tr>
<tr>
<td>24. bug</td>
<td></td>
</tr>
<tr>
<td>25. gust</td>
<td></td>
</tr>
<tr>
<td>26. bag</td>
<td></td>
</tr>
<tr>
<td>27. beg</td>
<td></td>
</tr>
<tr>
<td>28. mass</td>
<td></td>
</tr>
<tr>
<td>29. must</td>
<td></td>
</tr>
<tr>
<td>30. sat</td>
<td></td>
</tr>
</tbody>
</table>

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APPENDIX VI
DETAILS OF MAP DESCRIPTION TASK

Picture map: English condition
Picture map: German condition
Map description passages
English monolingual subjects

mel17
If you take a left out of your house, go down the road, past the tennis courts on your left, go past the park, and then take a left, underneath the bridge. Carry straight along, and you'll see the greenhouses on your right, if you carry straight along and take a right at the golf course, not towards the town centre which is to the left. If you follow the road round, you'll notice the lake on the right and the golf course on the left, and further down the road you'll see a beech wood on your left. If you go straight across the fountain and then head straight up, and you'll see the station on the left.

mel18
Leave the house and go towards the tennis courts. Walk along the road with the park on your left. Then go under the bridge and keep going round, and you'll find the greenhouses on your right. Just keep going and you'll come to a fork in the road. Don't go towards the town centre, keep on going, take the left-hand fork, sorry, the right-hand fork past the lake. And then keep on going, past the beech wood, and then you'll come to a little ring road with a fountain. Go straight across, and then you'll see the station on your left.

mel19
Okay, well starting from home, um, you proceed along the main road, with the tennis court to your left, um, and if you keep going you'll, you'll see the park, and the swings in the park on the left-hand side. You should come to, er, the point where the road, there's a left turning, and, er, the road curves round underneath a bridge. Carry on up the road, with the greenhouses to your right, you should come after a short distance to the, er, the golf course, which is on the left-hand side, and the lake, which is on the right-hand side. You just, um, carry on, erm, up, keeping those, the golf course to your left and the lake on the right. Carry on up, and you should find that there's a beech wood on the left-hand side, um, and you keep going until you, er, see a fountain, and you carry straight on over the road there, it's a roundabout that runs round the fountain, you just go, obviously, um, you know, round the road, um, but carrying straight on,
there aren't any turnings, and you should see, once you come off that road, the station in front of you.

**mel20**
Okay, turn left out of here, into the main road, and carry on past the tennis court and park, till you come to a left-hand bend and a bridge. Go under the bridge, and after a little way you'll see greenhouses on the opposite side of the road. Go past that, and carry on up, until you get to a fork in the road, where there's a golf course and a sign saying to the town centre on the left, and a lake on the right. You take the right-hand fork, and walk on up, past, er, the golf course and the beech wood, and you'll come to a fountain, in the middle of a roundabout. You go past the fountain, and continue on up to the station, which is on your left.

**mel21**
Okay, well, you go out of the house and turn left, you follow the main road along, there's a tennis court on the left, and you go past a park on the left as well, the road curves round to the left, and you'll go underneath a bridge. Erm, keep walking following the main road round, you'll see some greenhouses on the right, erm you've got the park on your left-hand side... Keep going, then you'll come to a turning off to the left, which is signposted to the town centre, but you keep going straight on there, erm, there's a golf course on your left, and a lake on the right, so keep walking following the road, it goes round a bend to the right, and then there's a beech wood on the left-hand side, um, you come to a roundabout with a fountain in the middle and benches round the outside, go straight across past the fountain, and the station's right in front of you.

**mel22**
Right, well, the way from home to the station is quite easy to find. From the house you turn left, out of the house, along the main road, and as you walk along you'll see the tennis court and the park on your left. Um, you take the first road left, and it goes under a bridge, and you carry straight along, past the greenhouses on your right, and straight along. There's a turning on the left, which is signposted to the town centre, but you don't take that, you just keep going on the same road, and it goes round a bend to the left and then to the right, and there's a golf course on your right, I mean your left, on the right is the lake... The road curves
round the lake, on the opposite side is a beech wood, and just past the lake and the wood the road comes into a roundabout, with a fountain in the middle, and just beyond that is the station.

**German monolingual subjects**

**mgs01**
Du gehst also am Haus los, die Hauptstraße entlang, und kommst dann an... an 'nem Tennisplatz vorbei, der ist links, und direkt danach kommt auch links ein Park, gehst unter so 'ner kleinen Brücke durch, dann geht rechts so ein kleiner Weg rein zu Gewächshäusern, den gehst du nicht, gehst geradeaus weiter, dann nach einiger Zeit geht's links zur Stadtmitte, da gehst du auch nicht lang, sondern wieder geradeaus, dann kommst du an 'nem Teich vorbei, der ist rechts, und links ein Wald, und dann kommst du zu so 'ner Art Kreisel, wo in der Mitte ein Springbrunnen ist, und, ja, dahinter is dann gleich links der Bahnhof.

**mgs02**
Du gehst also immer die Hauptstraße entlang, dann siehst du vielleicht nach einem halben Kilometer auf der linken Seite ein altes Bauernhaus, ein Stück weiter kommst du an den Tennisplätzen vorbei, die ein bisschen zurückliegen, von der Straße ab, entlang am Park, an den Schaukeln, immer geradeaus, dann kommst du über eine Brücke, gehst weiter, auf der rechten Hand liegen Gewächshäuser, immer auf der selben Straße, auch dort wo's dann links wieder in die Stadtmitte abgehen würde, da liegen auch die Golfplätze, also immer auf der selben Straße bleiben, das heißt also bisschen rechts abbiegen, am Teich entlang, auf der andern Seite siehst du ein kleines Stückchen Wald, dann weiter geradeaus, bis zu einem großen Platz, in der Mitte ist ein Springbrunnen, gerade über den Platz rüber, und dann kannst du eigentlich schon den Bahnhof sehen.

**mgs03**
Also, um vom Haus zum Bahnhof zu gelangen, äh, geht man zunächst, wenn man vor dem Haus steht, nach links, und dann kommt man an einen Tennisplatz, den man auf der linken Seite sieht, vorbei, danach sieht man so zwei Bäume, ähm, zwei Schaukeln dahinter, dann geht es weiter, die Straße macht so 'ne Biegung nach links, unter so 'ner kleinen
Brücke durch, dann weiter geradeaus, man kommt an... auf der rechten Seite, an Gewächshäusern vorbei, geht weiter nach vorne, äh, da, dort ist 'ne Abbiegung nach links, man geht aber weiter geradeaus, beziehungsweise rechts, ähm, mann sieht dann auf der linken Seite einen Golfplatz, und auf der rechten Seite ist so ein größerer Teich, man geht dann weiter auf der Straße, man sieht links den Wald, äh, kommt dann an so ein ähm, so eine Art Rondell, so eine runde Stelle auf der Straße, wo ein Springbrunnen in der Mitte ist, und äh, links und rechts stehen Bänke, geht dann weiter, also genauso weiter, geradeaus, sieht dann rechts noch so einen vereinzelten Baum, und kommt dann schon direkt an den Bahnhof.

mgs04

mgs05
Also, zuerst gehen Sie mal die Hauptstraße entlang, da sehen Sie dann links einen Tennisplatz, und einen Park mit zwei Schaukeln, dann biegt die Straße links ab, und führt über einen Fluß oder sowas, und dann, nee, nicht, unter einer Brücke, dann ist, sind rechts so Gewächshäuser, dann gehen Sie dann weiter, und kommen an 'ne Kreuzung, wo's links zur Stadtmitte geht, aber da gehen sie nicht hin, sondern weiter geradeaus und so, rechts an 'nem Teich vorbei, und links an 'nem Golfplatz, und Sie
kommen dann an einen Platz, mit einem Springbrunnen in der Mitte, und da gehen Sie dann weiter, und wenn Sie dann direkt danach links gehen, kommen Sie an den Bahnhof.

mgs06
Also, du gehst die Hauptstraße entlang, am Tennisplatz vorbei, dann re... links ist's am Park vorbei, immer geradeaus auf der Hauptstraße, dann kommt links eine Brücke, da mußt du drunter durch, immer auf der Straße bleiben dann, rechts sind dann so Gewächshäuser, an denen vorbei, wenn sich die Straße dann gabelt geht's links zur Stadtmitte, du gehst aber rechts weiter, am Teich vorbei, dann liegt links der Golfplatz, immer auf der Straße bleiben, links der Wald, dann kommst du zu einem Springbrunnen, zu einem Platz mit einem Str... Springbrunnen, um dem Springbrunnen rum, hinten geht die Straße weiter zum Bahnhof.

Bilingual subjects: English condition

bgl03
Okay, I left home, and went out of the gate, and walked along the main road. On the left-hand side I saw a tennis court, and there were some people playing tennis. I continued, and I went past a, a park, with some swings. I continued underneath the bridge, and on the right-hand side I saw some greenhouses. I continued along the main road, and on the left-hand side I watched a, I saw a golf course, and also I noticed a, a sign which, um, directed, er, the traffic to the town centre. I continued, and on the right-hand side there was a big lake. I continued along the main road, and I we... I passed a beech wood. Erm, I then came to a roundabout, and in the middle of that roundabout was a large fountain. And, um, I crossed the road to the other side of the road, because I wanted to go to the right-hand side, erm, to the station.

bgl04
Well I'll I'll just explain how to, how you get from my home to the station. Um st... get out... come out of the house and um turn right into the main road. Just follow the road past the tennis court and the park. Um, after the first bend you'll pass under a little footbridge. Continue, and you'll see on the right some greenhouses which you'll pass as well. Um,
don't take the next left, um, which would go to the town centre, but you're not going to the town centre, you pass the golf course on the left, and continue through, um, past the lake on the right, and, um, there's a kind of little roundabout for, um, for um, pedestrians, if you want, and you pass a fountain, and you see the station on your left.

bgl05
I leave home and go down to the main road, past the tennis court and the park on the left-hand side. Then I come to a crossroad where I turn to the left, I pass under a bridge, and I pass a greenhouse on my right-hand side. Then I work, walk further down the road, come to another section and go to the, turn to the right, where I see a golf course on the left-hand side, and a lake on the right-hand side. Then I come up to a fountain, and I come to the station.

bgl06
Right, as you come out of the house, turn left, walk along the road, you'll come past tennis courts, and some children's swings, er, then the road turns left again, under a bridge, just continue up the road past the greenhouses, until you come to a fork in the street, and you take the right-hand fork, er, and you go up in between the lake and a sort of golf putting green or whatever, and on your right-hand side there are then some trees, and you'll come to a little area with a fountain in the centre, and some seats, er um, on the edge. You pass this little area, and the station is right in front of you.

bgl08
Er, when I leave my home, and go down the main road towards the station, I first of all go past a tennis court on my left-hand side, and a little park. Then I go under a bridge, and past the greenhouses which are on my right-hand side, and the road is a bit wiggly there, and I keep on going, and on my left-hand side there is a sign saying town centre, and there is also a golf course, and opposite is a little lake. I keep going, and the road is still slightly wiggly, and I come to a sort of roundabout with a fountain in the middle, and I go past the fountain, and walk straight on, and I can already see the station, which is sort of straight ahead on the left.
I'm leaving home now, walking along the main road. On my left is the tennis court, and I, er, I walk past the park, where I can see some swings, and then I'm going under a bridge. I walk along, seeing on the right-hand side some greenhouses, and I follow the road, which is slightly bending to the left and to the right. On my left I see a golf course, and it's going there towards the town centre, on my right as I proceed on the same road I see a beautiful lake, with some plantation at the side, um, on my left-hand side again I see more of the golf course, and also a beautiful beech wood, um, then I come to a kind of a roundabout, where the fountain is splashing rather high, and there are some benches where you can sit watching the fountain, and I go straight on towards the station.

Right, when you turn out of the house, you turn left, turn left out of the house, and then you walk along the road, pass by the tennis courts in the distance, and then you pass by two fir trees, and then there is, er, on the left-hand side still, um, it looks like, what does it look like, er, a children's playground with swings. Now after a while the road turns to the left, and when you've done, when you, you turn with it, you turn to the left, and there's a bridge, and once you have passed under the bridge, you walk along, on the right-hand side you see some greenhouses, you just walk along, keep walking along, the road then forks after a while, er, it says, um, town centre on a sign there, but you don't follow the town centre direction, you go straight on, er, until you come to er, a golf course, um, well, it's a bunker with a flag in it, and er, you see that after that there is a bit of a wooded area, just follow the road, it bends to the right, and after a while you come to um, er, a type of square, in the middle of it there's a fountain, you can pass either the right way round it or the left way round it, it doesn't matter, as long as you just go ahead, and er, then there is a kind of crossroads, you can see that towards the left-hand side there is the station.

Okay, you leave the house, and, um, you walk along the main road, and there's a tennis court on the left, and you walk along, and there's a park with swings, and you follow the road round, and go underneath the bridge, and then there's a, there are greenhouses on the right-hand side,
and you walk along till you come to a crossing, and there’s a golf course on
the left, and er, a fairly big lake on the right, and you walk past the beech
wood, and round the fountain, there’re benches on either side, and you
just follow the road, and the station is on the left-hand side.

bgl13
When I walk from home to the station I usually go past the tennis court,
which is on my left side, and which is very near the park. I follow the road
until I get to the bridge, and I walk underneath the bridge, until I see the
greenhouses on my right side, I sometimes stop and have a look at the
plants. Then I walk on towards the golf course, there is a little road which
goes off to the south... town centre on the left, but I don’t take that road, I go
straight on past the lake and the beech wood. The lake is on my right side,
and it’s a very big lake and a very nice lake, and I sometimes go there
swimming, um, the beech wood is on my left side, and it’s just before I
come to the little square, or it’s not really a square, it’s a round place with a
fountain in the in the centre, um, and shortly after the little place with the
fountain, there’ll be the station.

bel02
Right, this is the way from home to the station. Um, you set off and turn
left when you go out of the house, along the main road, and immediately
um, as you set off, you pass the tennis court on your left, and um, there’s a
park area with two fir trees and then some swings, this is all on the left,
and um, you go along, and the road turns to the left, and you follow the
road along, under the bridge, and you walk along, and then you pass some
greenhouses on your right. Um, carry on for a bit, you’ll pass a sign that
says town centre to the left, you don’t go to the left, you just go straight on,
past the golf course to your left, and there’s a lake on your right. So you
walk along, and when you’ve passed the golf course there’ll be a wood, a
beech wood, and then you come to a fountain, with a roundabout and
some benches, on the outside of the roundabout, so you just go straight on
and come to the station.

bel03
To go from here to the station you go straight along the main road, past
the park, which has a tennis court and some swings, like, a a children’s
playground, and the road goes round to the left, under a footbridge. You go
under the footbridge and straight ahead, past the greenhouses, and then there's a sort of a crossroads, a turning to the town centre on the left, and a path to the lake on the right, but you go straight over, you don't turn off, and the road goes between a golf course on the left-hand side and a lake, a pond really, on the right-hand side, and and as you go along, the road broadens out, like a roundabout going round the fountain on either side, and there's there's like benches round the outside you can sit on, but you go straight past that, past the fountain, and the station's right in front.

bes03
Okay, well, when I leave home in the morning, I turn left as I come out, walk along the main road, past the tennis court on the left, in the park, past the children's playground, and then left into the park, under the footbridge. To the right of the path there's the greenhouses, and when you come to the fork, where the left-hand fork goes down to the town centre, you take the right-hand fork, which takes you along the side of the golf course, and on the right you've got a lovely lake. Beyond the golf course on the left there's the beech wood. You then come to a sort of roundabout, with a nice open area with benches to sit, and a nice fountain in the middle, and walk past the fountain. A few yards beyond there the path broadens out, and you're already at the station.

Bilingual subjects: German condition

bgl03
Also, wenn Sie aus Ihrem Haus, äh, rausgehen, biegen Sie links in die Hauptstraße ein, ähm, am Tennisplatz vorbei, und an 'nem Park vorbei, über 'ne Brücke, auf der rechten Seite sind dann Gewächshäuser, ähm, Stückchen weiter die Straße entlang, ähm, nicht links Richtung Stadtmitte abbiegen, sondern mehr oder weniger geradeaus, leicht rechts halten, ähm, an 'nem Teich vorbei, auf der linken Seite ist 'ne, is'n Wald, nur als Anhaltspunkt, äh, dann kommt ein Springbrunnen, äh, an dem Sie vorbeigehen, und dann sehen Sie auf der linken Seite schon den Bahnhof.


Also, wenn Sie aus dem Haus herauskommen, gehen Sie nach links, die Hauptstraße entlang, am Tennisplatz vorbei, und da ist auch noch ein kleiner Park mit Schaukeln, dann unter der Brücke durch, die Straße geht dann nach links wieder, äh, auf der rechten Seite sind Gewächshäuser, dann kommen Sie zu einer Gabelung. Da nehmen Sie die rechte Gabel, äh, der Weg führt zwischen einem Teich und einem Golfplatz durch, Sie kommen dann an einen Springbrunnen, aber da immer geradeaus, und der Bahnhof liegt dann auf der linken Seite.

Ah, wenn ich aus dem Haus zum Bahnhof geh', geh' ich aus dem Haus links, erst am Tennisplatz vorbei, dann am Park vorbei, und unter einer Brücke durch, und dann ist rechts, rechts sind Gewächshäuser, und dann immer die Straße entlang, an einem Teich vorbei auf der rechten Seite, und 'nem Golfplatz auf der linken Seite, und dann komme ich zu einem kleinen Platz mit einem Springbrunnen, und an 'nem, an dem Springbrunnen geh' ich rechts oder links vorbei, und dann zum Bahnhof.
Ja, also wenn Du zum Bahnhof willst, dann mußt Du jetzt aus dem Haus gehen, und aus dem Haus, wenn Du aus der Haustür trittst, dann geht's nach links, am Tennisplatz vorbei, dann kommt ein kleiner Park, und ähm, äh, eine Art Kinderspielplatz, äh, mit äh, ja. Dann den Weg geradeaus, bis man links zu einer Abzweigung kommt, und dann nach links reingehen, unter der Brücke geht es hindurch, an einem äh Gewächshaus, oder Gewächshäusern vorbei, zur rechten Seite, immer geradeaus weiter, dann gabelt sich die Straße, und äh, man geht nicht zur Stadtmitte hin, sondern quasi so mehr nach rechts, ja? Und, äh, am Golfplatz vorbei, dann äh, am am kleinen Gehölz vorbei, an einer, äh, bis man zu einem, äh, kleinen Rondell kommt, in der Mitte ist dann ein Springbrunnen, an beiden Seiten eine Bank, äh entweder rechts oder links dran vorbeigehen am Springbrunnen, dann wieder gerade aus, und wenn man dann wieder zur linken Seite hinsieht, sieht man den Bahnhof.

Also, du... von unserem Haus aus gehst du die Hauptstraße entlang, und dann ist auf der linken Seite ein Tennisplatz und ein Park, dann gehst du um die Ecke und unter der Brücke hindurch, und dann siehst du auf der rechten Seite Gewächshäuser, wenn du weitergehst kommst du an eine, äh, Gabelung, wo's zur Stadtmitte geht, und dort ist ein Golfplatz auf der linken Seite, du gehst geradeaus, und auf der rechten Seite ist ein Teich, du folgst dann dem Weg, du folgst der Straße, ähm, auf der linken Seite liegt auch ein Wald, und gehst am Springbrunnen vorbei, und wenn du dann geradeaus gehst, ist auf der linken Seite der Bahnhof.

Wenn ich zum Bahnhof gehen will, verlasse ich mein Haus an der Hauptstraße, und laufe am Tennisplatz und am Park vorbei. Nach einigen... einiger Zeit muß ich unter einer Brücke hindurchgehen, auf der rechten Seite sehe ich dann ein paar Gewächshäuser. Ich komme zu einer Kreuzung wo's links zur Stadtmitte geht, und wo links der Golfplatz liegt, ich geh' aber geradeaus, rechts am Teich vorbei, oder vielmehr geh' ich links am Teich vorbei, der rechts liegt, und dann am Wald vorbei, der auf der linken Seite ist. Ich komm' an einem Springbrunnen vorbei, und
danach muß ich eigentlich immer nur geradeaus, bis ich zum Bahnhof komme.

bel02
Ich erkläre jetzt den Weg vom Haus bis zum Bahnhof. Also, du gehst aus dem Haus raus, gehst dann erst mal nach links, auf die Hauptstraße. Und dann gehst du erst mal ein Stück geradeaus, links kommst du dann an einem Tennisplatz vorbei, und an 'nem Park, mit, mit Bäumen und, nun, dann gehst du weiter, dann geht es links um die Kurve, und du gehst dann unter 'ner Brücke durch, das ist so 'ne Fußgängerbrücke. Dann gehst du weiter, rechts siehst du Gewächshäuser, gehst immer weiter geradeaus, und, äh, dann kommst du an so 'ne kleine Kreuzung, wo so 'ne Straße von links, ähm, nach links abgeht, aber du gehst dann geradeaus weiter, ähm, rechts gehst du an so 'nem großen Teich vorbei, und ähm, links kommt dann so 'nem ziemlich großer Wald, ähm, dann kommst du an einen Springbrunnen, und mehrere Bänke die um den Springbrunnen 'rumstehen, ähm, da gehst du geradeaus 'über weg, und dann siehst du auf der linken Seite schon den Bahnhof.

bel03
Also, von dem Haus, komm' ich raus, da mach' ich erst 'ne links, und dann sieht man auf der linken Seite einen Tennisplatz und auch einen Park. Also da geht man geradeaus, und dann biegt man bisschen zu... nach links, über eine Brücke, ähm, auf der rechten Seite sieht man dann die Gewächshäuser, also das ist ein ziemlich, ein ziemlich großes Gebäude, man geht die Straße entlang, ähm, und dann kommt man an einem Teich vorbei, und auch an einem Golfplatz, das ist also der Teich liegt auf der rechten Seite, und der Golfplatz auf der linken Seite. Die Straße biegt ein wenig links, und dann rechts, und dann geht man an einem großen Springbrunnen vorbei, und geradeaus davor sitzt der Bahnhof.

bes03
Mein Haus liegt an der Hauptstraße, und wenn ich rauskomme bieg' ich links ab, geh' auf der linken Seite die Straße entlang, links liegt der Tennisplatz, hinter einer Hecke, im Park. Dann komm' ich an Schaukeln vorbei, und biege links rein in den Park, unter einer Fußgängerbrücke. Der Weg durch den Park führt zunächst an Gewächshäusern auf der linken Seite vorbei, und man kommt dann zu eine... äh, zu einer Gabelung, wo's
links zur Stadtmitte geht, geradeaus sieht man, äh, dann den großen Golfplatz, man nimmt dann, äh, den rechten Zweig, die, die rechte Gabel, und, äh, und läuft dann weiter durch den Park, an einem Teich vorbei, links is'n kleiner Wald, und dann kommt man zu einem Rondell, in diesem Rondell ist ein Springbrunnen, in der Mitte, rundherum stehen Bänke. An diesem Rondell vorbei, geradeaus, dann kommt man gleich zum Bahnhof.
APPENDIX VII

QUESTIONNAIRE

The questionnaire was conducted orally in the first session using the test language. Questions were asked on the following topics:

I Background
1. Date of birth
2. Place of birth
3. Places lived in for more than one year
4. Regular visits abroad in childhood
5. Father's country and region of origin
6. Mother's country and region of origin
7. Father's occupation
8. Mother's occupation

II. Health
1. Hearing problems
2. Respiratory disease
3. Speech therapy or voice training
4. Left- or right-handed
5. Dyslexia

III. Language history
1. Language(s) used at home in childhood
2. Father's native language
3. Mother's native language
4. Other languages spoken by parents
5. Languages used with other caretakers
6. Languages used with siblings
7. Languages used with friends
8. Language of learning to read
9. Other languages used for reading
10. Language exposure via other media

IV. Education
1. Highest educational qualification
2. Foreign languages learnt at school
3. Degree subject (if applicable)
4. Language of instruction at school/university
5. Other language(s) used at school/university
6. Native language of other pupils
7. Educational experience in other languages

V. Employment
1. Present and previous occupations
2. Languages used most at work
3. Other languages used at work
4. Translation work

VI. Language use at home
1. Language of principal use at home
2. Other languages used at home
3. Languages used for
   - counting
   - mental arithmetic
   - reading newspapers
   - reading fiction
   - keeping private diary
   - shopping lists
   - swearing
   - dreaming
4. Which language is the stronger?
5. Has this language always been the stronger?
6. If you had to lose one of your languages, which one would you keep?
7. Any other information
APPENDIX VIII
DETAILS OF CORRELATION ANALYSES

The results ranked in each column are as follows:

**English condition**
1. Accent judgment
2. Syntactic-semantic judgment
3. Lexical decision task
4. Perception of vowel duration (/m_t/ environment): PB
5. Vowel duration production
6. Perception of vowel quality (/e_æ/ boundary): PB
7. Perception of vowel quality (/æ_a/ boundary): PB
8. Production of /e/: mean of F1 and F2 ranking
9. Production of /æ/: as above
10. Production of /a/: as above

*Table A.VIII.1*
Cross-test scores for bilinguals: English condition

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270
German condition
1. Accent judgment
2. Syntactic-semantic judgment
3. Lexical decision task
4. Perception of vowel duration: mean of /m_t/ and /ʃt_t/ ranking
5. Production of vowel duration
6. Perception of vowel quality: PB
7. Production of /e/: mean of F1 and F2 ranking
8. Production of /a/: as above

Table A.VIII.2
Cross-test scores for bilinguals: German condition

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