Title

Preservation of passive constructions in a patient with primary progressive aphasia

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Abstract

Research into agrammatic comprehension in English has described a pattern of impaired understanding of passives and retained ability on active constructions. Some accounts of this dissociation predict that patients who are unable to comprehend actives will also be impaired in the comprehension of passives. We report the case of a man with primary progressive aphasia (WR), whose comprehension was at chance on active sentences, but at ceiling on passives. In a series of reversible sentence comprehension tests WR displayed difficulties with active transitives and truncated actives with an auxilliary. In passive sentences, he displayed sensitivity to the agent marker *by*, as well as the passive morphology of the verb. This pattern of dissociation challenges current theories of agrammatic comprehension. We explore explanations based on the distinction between morphological and configurational cues, as well as on the semantic and discourse related differences between active and passive constructions.

Keywords

syntax; agrammatic comprehension; primary progressive aphasia; reversible sentences

1. Introduction

One of the signs of aphasic impairment can be agrammatic comprehension, i.e., a difficulty in deriving information from sentence structures as opposed to single words in both spoken and written language. Agrammatic comprehension manifests most clearly in the interpretation of semantically reversible sentences such as *The man pushes the elephant* or *The elephant pushes the man* where both *man* and *elephant* are possible agents on the basis of lexical-semantic information. Successful interpretation rests on sensitivity to syntactic structures in order to identify thematic relations and determine "who did what to whom". Agrammatic performance on sentence-picture matching tasks can be at or below chance when sentences are semantically reversible (Ansell & Flowers, 1982; Berndt, Mitchum, & Haendiges, 1996; Caramazza & Zurif, 1976; Schwartz, Saffran, & Marin, 1980). Syntactic comprehension impairment can be present in people with different neurological profiles, including patients with vascular aphasia and those with primary progressive aphasia (PPA) due to frontotemporal degeneration (Gorno-Tempini, Hillis, Weintraub, Kertesz, Mendez, Cappa, ... Grossman, 2011; Hanne, Sekerina, Vasishth, Burchert, & De Bleser, 2011; Martin, 2006; Thompson, Meltzer-Asscher, Cho, Lee, Wieneke, Weintraub, & Mesulam, 2013; Wilson, Galantucci, Tartaglia, & Gorno-Tempini, 2012).

Investigations of syntactically impaired comprehension explore processing of different sentence types. The dominant profile that is reported is of less difficulty with transitive active constructions (*The man pushes the elephant*) than with passive constructions (*The elephant is pushed by the man*). This profile is strongly associated with cases of "agrammatism", characterized by non-fluent, agrammatic production and comprehension resulting from damage to the left inferior frontal gyrus, and Broca's area in particular. It has been proposed that processing of passives (and other non-canonical sentences) demands additional cognitive resources, and that people with agrammatic comprehension either lack these resources or have difficulties using them (e.g., Menn, 2000). A range of models has been proposed to describe the cognitive underpinnings of agrammatic comprehension, and to account for this "typical profile".

First accounts suggested a loss of sensitivity to syntactic information and subsequent dependence on lexical and heuristic strategies in guiding interpretation (Caramazza & Zurif, 1976). The first psycholinguistic investigations of agrammatism were published at a time when generativist theories were becoming the dominant conceptualization of syntactic processing, and generativist models of agrammatism quickly emerged. The Trace-Deletion-

Hypothesis (*TDH*) in particular has been prominent (Grodzinsky, 1984, 1995, 2000) and is based on the hypothesis that passives result from a transformational movement rule which changes the canonical constituent order. In English, where the canonical word order is agent-verb-patient, the patient NP moves from its canonical postverbal position at the level of "deep" or underlying structure to the preverbal position in surface structure. It leaves behind a trace which is needed for interpretation (*The elephant*$_i$ *was pushed t*$_i$ *by the man*). According to the TDH, the agrammatic comprehension observed in typical Broca's aphasia can be the result of the trace being deleted, making the interpretation of English passives (and also object relatives and object clefts) difficult. The Double-Dependency Hypothesis (Mauner, Fromkin, & Cornell, 1993; Beretta & Campbell, 2001) similarly relies on the processing of traces. In more recent generativist theories traces appear in active constructions as well, which makes it harder for solely trace-based approaches to explain the dissociation in the typical profile (Grodzinsky, 2000). More recent accounts of agrammatic comprehension focus on deviation from canonical order and put less emphasis on traces (Bastiaanse & Edwards, 2004; Bastiaanse & van Zonneveld, 2006; Drai & Grodzinsky, 2006).

Other explanations for syntactic comprehension impairments concern working memory capacity (Just & Carpenter, 1992). Compared to actives, passive constructions require the additional morphology of the passive auxiliary, the past participle inflection on the verb (*-ed*/*-en*), and, in the full passive, the agentive marker *by*. One proposal is that impairment in verbal or syntactic memory systems, resulting slowed activation, manipulation or retention of information (Caplan & Waters, 1999; Haarmann, Just, & Carpenter, 1997; Haarmann & Kolk, 1991; Swinney & Zurif, 1995), might affect the processing of passives more than actives. There are other reasons why passives may pose higher cognitive demands than actives and even healthy adults process them more slowly and less accurately (Baddeley, 1968; Ferreira, 2003; Street & Dąbrowska, 2010, in press). Actives are acquired earlier by children (Baldie, 1976; Brooks & Tomasello, 1999; de Villiers & de Villiers, 1985; Horgan, 1978; Maratsos, Fox, Becker, & Chalkley, 1985; Maratsos, Kuczaj, Fox, & Chalkley, 1979). They are also considerably more frequent in language use: only 3% of all spoken and 9.23% of all written verb phrases in the British National Corpus (BNC) are in the passive voice (Roland, Dick, & Elman, 2007). This may result in actives being more 'entrenched'. Lexical integration and bias has also been suggested to be a factor in the processing of passives (Menn, 2000; Street & Dąbrowska, in press). Passives may be harder because most verbs appear more frequently in active constructions. Gahl et al. (2003) reported that aphasic participants generally found passives harder to comprehend than actives. However, passives were less difficult when the main verb was more likely to appear in passive structures (e.g., *injure*) than when the verb had an active bias.

However, it has been argued that the "typical" profile of superior performance on actives over passives may misrepresent the population of people suffering from sentence comprehension impairments. Systematic investigation of individual patients reveals a wider range of comprehension profiles (Berndt & Caramazza, 1999; Berndt, Mitchum, & Haendiges, 1996; Burchert, De Bleser, & Sonntag, 2003; Caramazza, Capasso, Capitani, & Miceli, 2005; Caramazza, Capitani, Rey, & Berndt, 2001; Kolk & van Grunsven, 1985; Luzzatti et al., 2001). For example, Caramazza et al. (2005) tested the comprehension of reversible sentences by 38 aphasic speakers of Italian with non-fluent agrammatic speech and lesions to Broca's area. Only 15% of the participants performed at chance on passives and above chance on actives. The majority showed equal performance on both sentence types. The dominance of a typical profile in the literature may be the result of overreliance on group averages, or even a selection bias favoring publication of cases that fit common models of agrammatism (Druks & Marshall, 1996).

We explore a particular profile of syntactic comprehension impairment: people with aphasia who perform well on comprehension of passives, but display chance performance on actives. Druks and Marshall (1995) describe the case of BM, a 68-year-old man with a left fronto-temporal lesion due to stroke. According to the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1972), his clinical profile was best described as that of Broca's aphasia, although his phrase length was better than the upper limit for Broca's aphasia. BM was tested on comprehension of spoken reversible sentences with different syntactic structures. He performed at chance on reversible active sentences (including declaratives, questions and existentials), but above chance on the corresponding passives. These observations present a challenge to theories which focus on the passive as transformed from canonical word order. It is difficult to explain how transformational movement could take place when the canonical order representation is not available. Furthermore, explanations based on working memory are also problematic as actives are considered to place less demand on memory systems. Druks and Marshall (1995, 1996) criticize the association of the term "agrammatism" with a single 'typical' profile and argue that, even if profiles such as BM's are rare, a theory of agrammatism needs to be able to account for them. They develop a generative account of BM's pattern of impairment based on the distinction between structural and inherent case (Chomsky, 1981, 1986, 1988). According to this version of generative grammar, inherent case is a lexical feature and assigned by specific prepositions or verbs. In passive sentences, inherent case is assigned by the passive morpheme as well as the preposition *by*. Structural case is a configurational feature. In English actives, it is the result of constituent movement to inflection nodes (*AGR* and *TNS*). Druks and Marshall suggest that inherent and structural case are dissociable, and damage to the structural case sub-module would result in impaired performance on actives but normal, or at least above chance, performance on passives. In patients with impaired performance on passives but not actives, it is assumed that both case modules have been damaged and interpretation is based on a linear "agent first" decoding to identify agent and patient.

In this report, we describe WR, a man with PPA and an unusual pattern of sentence comprehension impairment. He displayed no difficulty in processing passives but performed at chance level on actives. WR had severe problems with comprehension and production of spoken language while processing of written information was more intact. Although theories of agrammatic comprehension have largely been built upon evidence from vascular patients with focal damage and non-fluent speech, robust neurocognitive theories should be able to account for syntactic impairments that occur in other neuropathologies, such as focal degeneration of left perisylvian cortex. We offer independent, but not mutually exclusive, explanations for how WR's selective deficit might come about, and examine their implications for theories of agrammatic comprehension. One account is related to Druks and Marshall's distinction between configurational and lexical language features and concerns the surface structure of active and passive constructions. English actives are to a high degree configurational, i.e., they require interpretation of word order to determine thematic relations. English passives, on the other hand, contain morphological as well as configurational cues. Disruption in the processing of configurational information may explain BM's and WR's behavioral profile. A second explanation looks at the semantic and discourse related differences between the constructions which may determine how the syntactic network is structured. Because active constructions are used in a wider range of contexts than passives, it may take a higher degree of semantic control to accurately interpret active structures. Syntactic performance of BM, WR and similar cases may be caused by disruption of these control processes. Finally, we suggest that generativism does not provide the most parsimonious account for the investigation of agrammatism and explore a usage-based connectionist framework.

1.1 Case description

WR was a 62-year-old, right-handed man. He was educated to post-graduate level and is a retired medical librarian. Five years prior to the investigations reported here, he began to notice difficulties in speech production, making phonetic/phonological errors on multisyllabic words. Problems in understanding speech emerged soon after and his difficulties gradually increased over the course of a year. He sought medical advice and was referred to a neurology clinic for assessment. MRI scan revealed subtle atrophy of the left superior temporal gyrus. Neuropsychological evaluation indicated intact cognition in non-language domains, with above average scores in short-term and long-term visual memory as well as executive and attentional functioning. At 18-months after symptom onset, he was diagnosed with primary progressive aphasia due to fronto-temporal lobar degeneration. Consistent with the diagnosis of PPA, WR continued to display specific impairment of language for a period of five years, with no deterioration in non-language cognition (Mesulam, 2001).

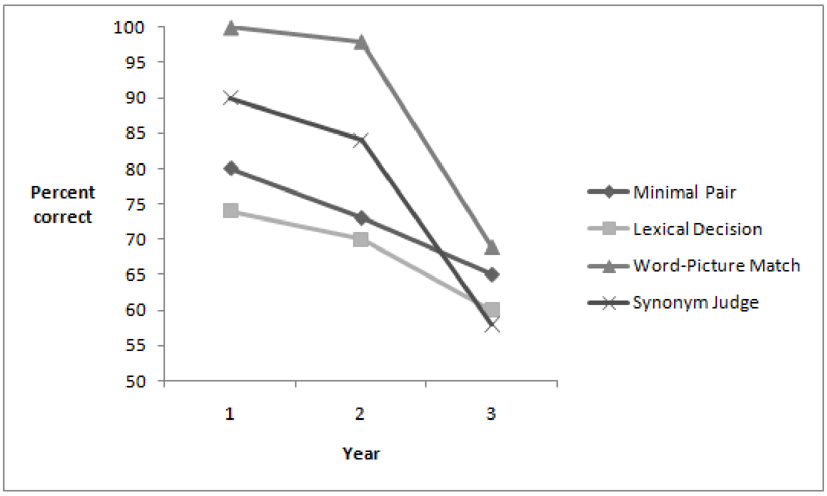
At diagnosis, WR's speech output was without grammatical or apraxic errors but contained phonemic paraphasias. The nature of WR's language impairment was categorized as that of logopenic PPA (Gorno-Tempini et al., 2011; Wilson et al., 2010). In logopenic PPA cell loss is initially apparent in posterior-superior temporal lobe structures (Wilson et al., 2010). The behavioral profile is considered similar to that of vascular conduction aphasia (Gorno-Tempini, Dronkers, Rankin, Ogar, La Phengrasamy, Rosen, … Miller, 2004), although Rohrer, Rossor and Warren (2010) suggest that in some cases there is overlap between features of logopenic PPA and the non-fluent variant of PPA, characterized by agrammatism. Impaired sentence comprehension has been reported in groups of people with logopenic PPA (Gorno-Tempini et al., 2004; Thompson et al., 2013). Rogalski, Cobia, Harrison, Wieneke, Weintraub & Mesulam (2011) report that with disease progression, atrophy extends anteriorally to the inferior frontal gyrus. With regard to comprehension performance, single word comprehension is relatively preserved in the early phase of the non-fluent and logopenic variants.

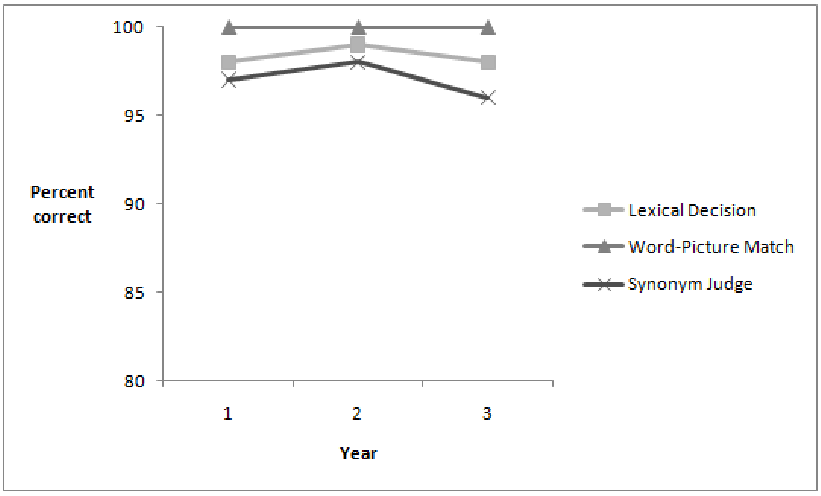
Speech and language assessment at diagnosis indicated retained comprehension of high imageability spoken and written words in word-picture matching tasks (Comprehensive Aphasia Test (CAT) Comprehension of spoken words 30/30; Comprehension of written words 30/30 (Howard, Swinburn, & Porter, 2004)). With regard to sentence comprehension tested by sentence-picture matching tasks, understanding of written sentences was minimally impaired, but there was a marked impairment of spoken sentence comprehension (CAT Comprehension of spoken sentences 22/32; Comprehension of written sentences 30/32). Speech output was syntactically well-formed, and produced with no evidence of dysarthria or apraxia. Word retrieval was intact in picture naming, CAT Naming Objects 48/48; Graded Naming Test 21/30 'bright normal range' (McKenna & Warrington, 1983). Surface forms contained phonemic paraphasias. WR was able to write in grammatically well-formed sentences. Word and nonword repetition was impaired (42/80, Action for Dysphasic Adults (ADA) Comprehension Battery (Franklin, Turner, & Ellis, 1992)), with greater errors elicited on repetition of nonwords (13/40) than words (29/40).

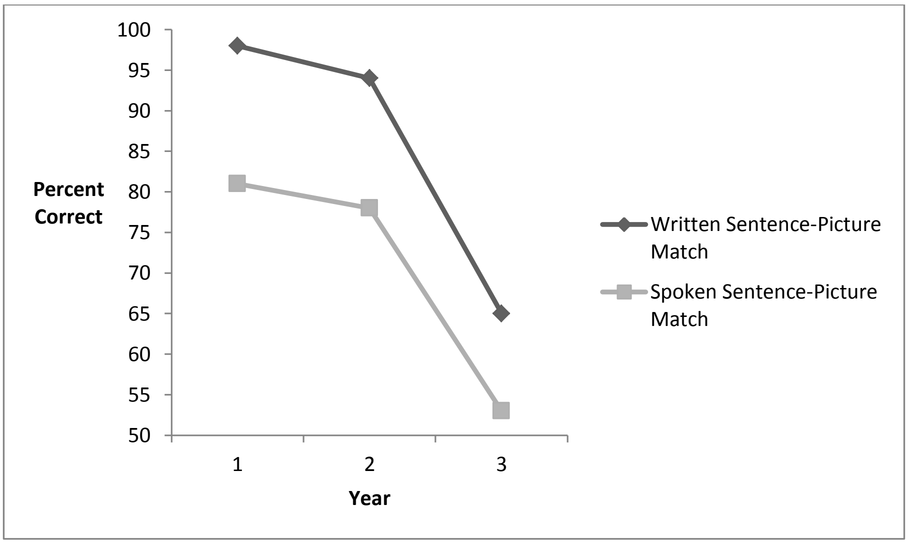
After diagnosis, and in the three years prior to this study, WR's performance was tracked on a battery of auditory processing, written lexical processing, and spoken and written sentence comprehension tests. Auditory and lexical processing tests were taken from the ADA Battery (Franklin et al., 1992), and sentence comprehension tests from Psycholinguistic Assessments of Language Processing in Aphasia (PALPA; Kay, Lesser, & Coltheart, 1992). The capacity to process words and sentences in the auditory domain showed insidious decline over this period, consistent with continuing atrophy.

There was a marked diminution of auditory processing capacity between years 2 and 3 in the tracking evaluations (Figure 1a & c). By the third year, scores on a range of auditory tasks including spoken minimal pair judgment (deciding if two forms were the same or different), auditory lexical decision (categorizing forms as words or non-words), and auditory synonym matching (judging if two words had similar meanings) were at or near to chance level. Spoken word-picture matching scores showed more resilience, but were still subject to decline between years 2 and 3. Audiological assessment was undertaken to determine the source of the auditory processing difficulties. Pure tone audiometry indicated no significant peripheral hearing loss and auditory brain stem responses were within normal limits bilaterally. However cortical evoked responses revealed bilateral abnormality, and difficulties were consistent with cortical deafness. By contrast to the vulnerability of auditory processing, written lexical processing was more resilient, and scores on written lexical decision, written word-picture matching, and written synonym matching showed little change over time (Figure 1b). As a result of these auditory perceptual difficulties, the subsequent experimental evaluations of sentence comprehension were undertaken using written stimuli.

Figure 1. WR's performance on language assessments post-diagnosis (year 1 = one year post-diagnosis = two-and-a-half years post-symptom onset). a) Percent correct on the auditory processing battery (chance level on minimal pair, lexical decision and synonym judgment tests is 50%, and 25% on word-picture matching). b) Percent correct on the written word processing battery. c) Percent correct on PALPA Auditory and Written Sentence Comprehension tests (chance performance is 33%).





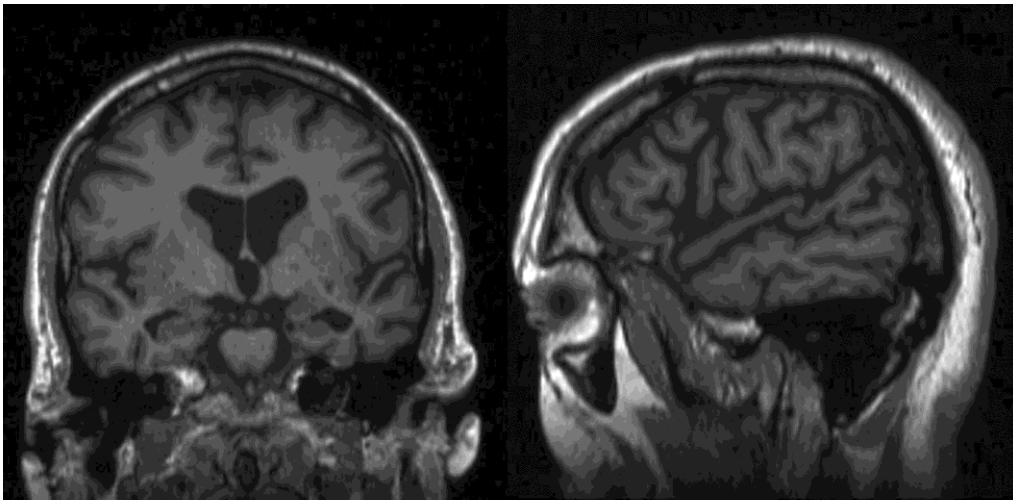


With regard to sentence comprehension measured by PALPA spoken and written sentence-picture matching tests (Kay et al., 1992), consistent with WR's difficulties in processing information in the auditory domain, spoken sentence comprehension was impaired across time periods. Written sentence comprehension was relatively intact for the first two years of tracking but a marked decline was evident between years 2 and 3 (Figure 1c). Thompson et al. (2013) also report syntactic comprehension difficulties in groups of logopenic PPA patients between 2.8 and 3.9 years after symptom onset. In this group report, participants with logopenic-variant PPA typically displayed greater impairment of processing sentences with canonical word order (e.g., actives and subject relatives) than non-canonical structures such as passives. In the written domain, WR's sentence comprehension difficulties were relatively mild at 3.5 years post-symptom onset (tracking year 2). However, at the point of the experiments reported here (4.5 years post-symptom onset) an unusual pattern of sentence comprehension difficulty emerged, with greater preservation of non-canonical structures. In parallel with increasing difficulties in sentence understanding, WR's output developed signs of agrammatism, with more marked impairment in spoken than written language. In speech, WR used the words *is a* as a filler, often repeating them several times in succession until a content word was retrieved. He also used *is a* to link together nouns and create sentence-like outputs (e.g., *Mary is a holiday is a Turkey*). At the time of these experiments, WR communicated by writing. During visits to the clinic, the only sentences he produced were in the passive voice (*Can it be used in treatment?*; *As research was Vitor created*). However, WR also wrote a diary at home using Microsoft Word. In his diary, he also produced a few transitive actives (*I enjoy the garden work*). Sentences displayed omission of finite verbs and some function words, and contained non-canonical word order (*I also the difficult to write. Trouble the right words and the language small*; *I am angry with public*). We do not know the degree in which the diary texts were edited with the help of software auto-correction features or WR's wife.

Comment [V1]: There was a mistake in the sentence structure.

At the time at which the investigations were conducted, WR experienced no difficulties in activities of daily living and there was no evidence of extension of impairment to non-language cognition. The Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) revealed a Performance IQ of 119, and the Pyramids and Palm Trees test (3-picture version, Howard & Patterson, 1992) produced a score of 52/52, indicating no impairment in visually-based semantic knowledge. A repeat MRI scan was performed at the same time (Figure 2). This showed focal atrophy of the fronto-temporal perisylvian region which was more marked on the left than the right. The left superior temporal gyrus showed the greatest atrophy, although there was subtle evidence of change in the homologous right hemisphere zone. There was also subtle bilateral atrophy of part of Broca's area (Pars Opercularis, BA44), again with greater change within the left hemisphere than the right. There was no evidence of generalized cortical atrophy.

Figure 2. Structural MR images of WR's brain in coronal and sagittal (left) views, indicating atrophy of fronto-temporal perisylvian regions.



Given the emerging pattern of agrammatic impairment, WR's capacity to understand written sentences was explored in more detail. Investigations were restricted to the written modality due to WR's severe auditory processing deficit that impaired performance at pre-lexical and lexical levels of processing. His processing of active and passive constructions was examined in three tests of reversible sentence comprehension. Experiment 1 tested comprehension of active transitives and full passives. Experiment 2 tested interpretation of the by-phrase as an agent marker. Experiment 3 tested interpretation of truncated actives and passives. Materials were tested on a group of ten male participants without neurological damage (Mean age 67, range 62-72). Controls were native English speakers and had at least 14 years full-time education. We compare WR's performance with controls using the "Quand"-programme presented by Crawford and Garthwaite (2008) and provide z-scores in relation to the control distribution. We also look for lexical bias by analyzing whether WR consistently interpreted the subject of specific verbs as either agent or patient.

WR gave informed consent to participation in the research and ethical approval for the program of research was granted by the local NHS Research Ethics Committee (08/H1308/32). Testing of healthy controls was approved by the University of Reading's School of Psychology and Clinical Language Sciences Research Ethics Committee.

2. Reversible sentence comprehension tests

2.1 General methods

All experiments employed sentence-picture matching tests. In each trial, two pictures and one written sentence were presented. Participants were required to match each sentence to a corresponding picture by pointing at the picture. The written sentence remained visible until a response was made. Picture material consisted of figures drawn in black on a white background. Pictures were printed on A4-sized paper, with two in vertical array on each sheet. One depicted an actor performing a transitive action on another. The other showed the same action, but with reversed roles. Correct pictures were counterbalanced for position. Sentences were presented in a randomized order.

WR was tested on all sentences. Each of the three experiments was conducted in one session. For the ten controls all sentences were split into two lists A (148 sentences) and B (144 sentences). Five participants were tested on each list. Controls were tested in a single session.

2.2 Experiment 1

2.2.1 Material

A set of 100 sentences was created, 50 of which were active transitives (e.g., *The man kills the lion*) and 50 were full passives (e.g., *The lion is killed by the man*). The set contained 25 different verbs. Each verb was used four times, twice in active and twice in passive sentences. Each sentence had a matching sentence with reversed roles (e.g., *The man kills the lion; The lion kills the man*). For a verb list see Appendix A.

2.2.2 Results

Controls correctly matched 98.8% (SD=1.9) of the transitive actives and 96.8% (SD=4.5) of the full passives with their pictures, with no significant difference in accuracy between sentence types. WR correctly matched transitive actives with their pictures 18/50 times (36%; z=-33.1, 95% CI [-48.1, -18.1]). He correctly matched full passives with their pictures 47/50 times (94%; z=-0.6, 95% CI [-1.3, 0.1]). WR's performance on active transitives did not differ significantly from chance, although there was a trend toward below chance performance (p=.065) and a tendency to interpret the first NP as patient. Performance on full passives was significantly above chance, p<.001 (two-tailed binomial test).

Given that WR's performance on actives show a trend towards a simple 'patient-first' linear strategy, we used chi-square statistics to further explore performance. There was a highly significant association between sentence type and whether WR interpreted the first NP as patient, $\chi^2(1) = 13.56$, $p<.001$. Based on the odds ratio, WR was 8.8 times more likely to interpret the first NP as the patient if the sentence was in the passive voice than if the sentence was in the active voice.

2.2.3 Discussion

WR displayed a pattern of performance that is rarely reported in the literature. Similar to the case presented by Druks and Marshall (1995), WR was not able to determine agent or patient in transitive active structures. However, he appeared to display comprehension of full passives. Predominant theories of agrammatic comprehension such as the TDH or working memory accounts are unable to account for WR's performance as they would predict that a person who comprehends passive constructions would also comprehend actives. Furthermore, WR's performance is unlikely to be due to a linear interpretation in sentence decoding ("patient appears first"): while his performance on active sentences displayed a trend towards a "patient first" interpretation, he was much more likely to interpret the first NP as patient if the sentence was in the passive voice, suggesting that he was sensitive to differences between sentence types.

Given the rarity of WR's sentence comprehension profile in the literature, his capacity to process sentences was explored further. One possibility is that WR's performance can be explained by difficulties using word order to identify thematic relations, as interpretation of word order is essential for understanding the transitive actives tested in the experiment. Full passives however have a rich morphology which serves as a cue to identify the agent and patient.

The data do not demonstrate that WR was able to interpret the entire morphology of the full passive structure. To achieve above chance performance in Experiment 1, it is sufficient to identify either the agent or the patient. After one is identified, the other can be determined by exclusion. In passive constructions the agent NP is marked by the preposition *by*. The semantic role of the patient NP is signaled by the passive morphology of the verb (*be* and the past participle). One possible explanation of WR's performance is that he was not able to fully process the passive sentences, but used one of these morphological cues to identify agent or patient. WR's performance could be due to interpretation of only the by-phrase, only the morphology of the verb, or of both elements.

2.3 Experiment 2

Experiment 2 was designed to explore whether WR interpreted the by-phrase as an agent marker, and specifically, whether he made decisions solely based on this interpretation. This was done by testing comprehension of transitive active sentences with *by* as a spatial preposition (e.g., *The man shoots the rabbit by the woman*; *The man by the woman shoots the rabbit*). Pictures showed the agent, patient, and a "bystander" (Fig. 5). The sentences were semantically reversible in the sense that both the subject and the NP in the by-phrase were plausible agents on the basis of their lexical-semantic specification. If further syntactic context is unavailable, the preposition *by* is likely to be interpreted as a marker for agency: While it has several other functions, including marking the means (*you can find out by comparing both entries*), time (*by the end of March*), and various idiomatic uses (e.g., *by nature, by heart, by the sound of it*), the use as a cue for agency is by far the most common and hence the most entrenched. In a random sample of 256 uses of *by* extracted from the British National Corpus the preposition occurred 144 times in its passive use and 36 times in agentive nominalizations (e.g., *a strike by lorry drivers, a book by Fred Hoyle*). The difference between the number of instances of *by* in passives or agentive nominalizations (180 instances) and the number of instances in various other functions (71 instances) was highly significant, $\chi(1)=47.33$, $p<.001$.

Since WR previously performed at chance on active transitives, indicating that he could not interpret active constructions, it was predicted that he would assign agent role to the NP in the by-phrase (*The man shoots the rabbit <u>by the woman</u>*). In a sentence-picture matching task, he would therefore select the picture in which the bystander performed the action.

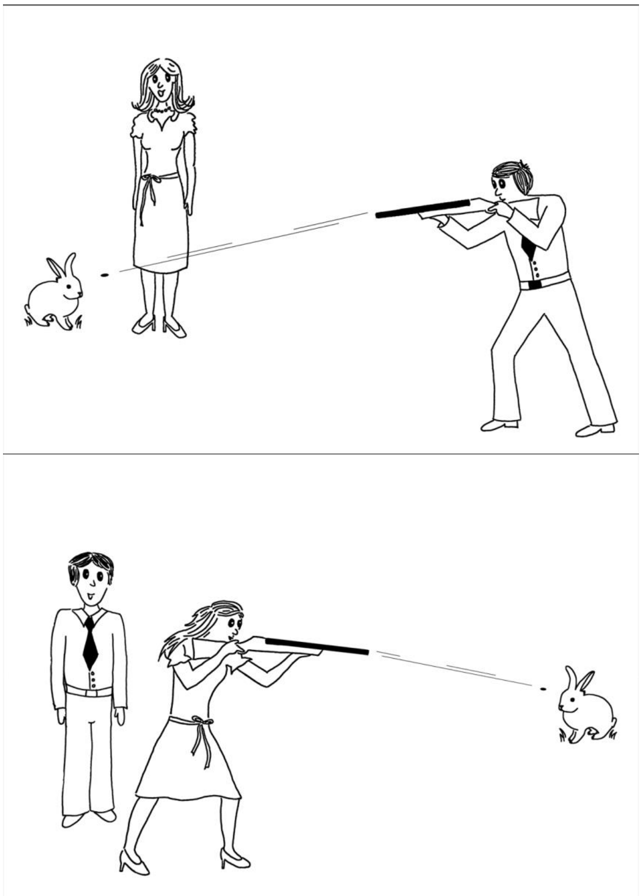
In addition to active transitives with a spatial by-phrase, Experiment 2 contained irreversible active transitives without the by-phrase (*The man shoots the rabbit*) as well as irreversible passives (*The rabbit is shot by the man*). Response pictures again showed agent, patient and a bystander. Performance on irreversible actives was expected to be above chance since WR needed to assign the agent role to the only plausible agent in the sentence. For irreversible passives, WR's performance was expected to be above chance since he was able to interpret the reversible passives of Experiment 1. WR was tested seven months after Experiment 1.

2.3.1 Materials

Experiment 2 contained 120 sentences. 60 sentences were active transitives with a spatial by-phrase. In half of these sentences, the by-phrase modified the agent (e.g., *The man by the woman shoots the rabbit*). In the other half, the by-phrase modified the patient (e.g., *The man shot the rabbit by the woman*). Thirty sentences were irreversible active transitives without the by-phrase (e.g., *The man shoots the rabbit*), 30 were irreversible full passives (e.g., *The rabbit is shot by the woman*). The sentences contained 15 different verbs, each used twice in a given sentence type. Because of the positional requirements of agent, patient and bystander, verbs either described actions that can be performed from a distance (such as *shoot* or *photograph*) or in which the patient is propelled (such as *kick* or *throw*). For a verb list see Appendix A.

Picture material showed the agent, patient and bystander (Fig. 3). Target pictures with a spatial by-phrase were always contrasted with pictures which supported interpretation of the by-phrase as an agent marker, and vice versa.

Figure 3. Sample of stimulus pictures for Experiment 2. The sample pictures were used for the sentences *The man shoots the rabbit by the woman*, *The woman by the man shoots the rabbit*, *The man shoots the rabbit* and *The rabbit is shot by the woman*.



2.3.2 Results

Controls correctly matched 100% (SD=0) of the sentences with their pictures. WR's performance on active transitives with a spatial by-phrase was at floor: 0/30 for sentences with the by-phrase modifying the agent (0%), and 1/30 for sentences with the by-phrase modifying the patient (3%). His performance on irreversible active transitives and full passives was at ceiling (100% on both). Z-scores cannot be provided due to the SD of the control group being zero. All results represent significant deviations from chance, $p<.001$ (two-tailed binomial tests).

2.3.3 Discussion

The experiment yielded ceiling-level-performances on irreversible transitive actives and full passives. The performance on irreversible passives was expected given WR's comprehension of reversible passives in Experiment 1. The performance on irreversible transitive actives cannot be seen as evidence for retained active processing. When presented with one likely agent in a target sentence, and two possible agents in the pictures, he assigned the agent role to the entity mentioned in the sentence.

On active transitives with a spatial by-phrase, WR performed at floor. When a by-phrase was added to an irreversible active transitive sentence, WR interpreted the NP in the phrase as the agent. This happened regardless of the preposition being spatial, and regardless of its position in the sentence. The performance leads to two conclusions: First, it demonstrates that WR was able to interpret the by-phrase as an agent marker. Second, it shows that WR could make consistent judgments based on a single cue instead of interpreting the entire syntactic structure. Third, the data further reduce the plausibility of WR using a linear "patient first" strategy as in cases where the by-phrase modifies either the agent or the patient, agency is not assigned to the first-mentioned NP.

Based on Experiments 1 and 2 it is not clear whether WR's above chance performance on full passives was based on the interpretation of the by-phrase alone, or whether he could also interpret the verb morphology. To address this question in Experiment 3 we tested his comprehension of truncated passives (which lack the by-phrase).

2.4 Experiment 3

Experiment 3 investigated comprehension of the verb morphology (the auxilliary *be* and the past participle inflection) in passive sentences. The experiment used truncated passives (*The elephant is pushed*) as well as truncated actives (*The elephant is pushing*) as constructions with minimal contrast. Morphologically, both sentence types differ only in their inflection of the verb (past participle -*ed/-en* vs. present participle -*ing*). Since Experiment 2 showed that WR could interpret the preposition *by* as an agent marker, above chance performance on truncated passives would indicate his ability to comprehend the entire full passive construction presented in Experiment 1 rather than isolated morphological markers.

The role of morphology differs between the truncated passives and actives used in this experiment. While the auxiliary in combination with the past participle *-ed/-en* marks the passive construction, and therefore indicates that the subject is the patient rather than the agent of the action, the auxiliary in combination with the present participle conveys no information about semantic roles (i.e., the preceding NP could be an agent, as in *She is selling the dress*, a patient, as in *This dress is selling very well*, an experiencer, as in *She is feeling well*, etc.). Chance performance on truncated actives therefore does not necessarily suggest difficulties with interpreting morphology. Experiment 3 was conducted four months after Experiment 2.

2.4.1 Materials

The experiment contained 72 sentences. 36 sentences were truncated passives and 36 were truncated actives. 18 verbs were used, each appearing twice in each sentence type. Each sentence had a counterpart with reversed roles. For a verb list and the order of presentation see Appendix A. Picture material was similar to that of Experiment 1.

2.4.2 Results

Controls correctly matched 99.4% (SD=2) of truncated actives and 99.4% (SD=2) of truncated passives with their pictures. Accuracy did not significantly differ between sentence types. WR correctly matched truncated actives and pictures in 17/36 trials (47%; z=-26.2, 95% CI [-38.1, -14.3]), which did not differ from chance according to a two-tailed binomial test, p=.868. He correctly matched 31/36 truncated passives to their pictures (86%; z=-6.7, 95% CI [-9.8, -3.6]). This performance was above chance, p<.001.

2.4.3 Discussion

The results indicated comprehension of truncated passives. Taken together with the results of Experiment 2, WR appeared able to use grammatical cues to identify both the agent and patient in passive sentences, rather than simply identifying the agent on the basis of identification of the *by*-phrase and assigning the patient role to the other participant mentioned in the sentence. His chance-level-performance on truncated actives is further evidence for a more general inability to interpret active constructions. Again, the data cannot be explained by WR using a “patient first” strategy.

2.5 Analysis of lexical bias

The experiments were not specifically designed to investigate lexical bias (Gahl et al., 2003). However, we analyzed WR's data with regard to consistent responses to specific verbs which would suggest such bias. Given his ceiling performance on passives and floor performance on actives with the preposition *by* (Experiment 2), it was assumed that WR's sensitivity to passives and passive related cues would override any potential lexical bias. Lexical bias is therefore likely to be a subsidiary factor to sensitivity to syntactic cues.

Our analysis included only conditions in which WR performed at chance, i.e., reversible transitive actives and truncated actives (Experiments 1 and 3). Responses were categorized as "consistent" if WR interpreted the subject of a given verb in all four conditions (2 x reversible transitive actives, 2 x truncated actives) as either the agent or the patient. Eleven verbs appeared in both reversible transitive actives and truncated actives: *attack, chase, entertain, help*, *kick*, *kill*, *photograph*, *scold*, *splash*, *wash* and *weigh* (see Appendix A). WR's responses were consistent for only one verb, *wash*, where he interpreted the subject as patient in all four conditions. This may be an effect of the verb's argument structure. *Wash*, but not the other verbs, allows an intransitive reflexive reading in which the subject on an active sentence is also the patient (e.g., *The boy washed [himself] after lunch*). However, given the number of verbs that were tested in both Experiments, this result may also be due to chance (1/11). We conclude that WR's data do not provide sufficient evidence for lexical bias.

2.6 Possible cognitive decline

Given that seven months passed between Experiments 1 and 2, and four months between Experiments 2 and 3, we explored the extent of further linguistic decline between experiments. Semantic memory and written lexical processing tests conducted before Experiment 1 were repeated after Experiment 3. They show no changes in performance across the period of the experiments (Appendix B). Performance across the three sentence comprehension experiments also suggests a coherent pattern of interpretation, with ceiling performances on all passive types.

3. General discussion

Influential theories of agrammatic comprehension have been built upon the profile of patients displaying greater impairment in understanding passive sentences than active ones. In three experiments testing the interpretation of semantically reversible sentences, we investigated syntactic comprehension in a man with primary progressive aphasia. His profile was unusual: WR was able to correctly interpret full and truncated passives, but was not able to interpret the structure of transitive and truncated actives. The experiments showed that he was able to use the *by* phrase as well as the passive marking on the verb to assign the agent and patient roles. Interestingly, WR also interpreted *by* as an agent marker even in active sentences where it served as a spatial preposition. This result further underlines his very severe difficulties with actives. Table 1 provides an overview of the results.

Table 1. Summary of WR's responses in sentence-picture matching tasks (* denotes significant deviations from chance) sorted by performance. The '<' symbol indicates linear precedence in the sentence structure.

Sentence type	**Sentence structure and example**	**No. of correct responses (percentage)**
Good performance		
Reversible full passive (Experiment 1)	PATIENT < *BE* < TRANSVERB-PastP, *by* < AGENT (e.g., *The man is pushed by the elephant*)	47/50* (94%)
Irreversible active transitive (Experiment 2)	AGENT NP < TRANSVERB < PATIENT NP (e.g., *The man shoots the rabbit*)	30/30* (100%)
Irreversible full passive (Experiment 2)	PATIENT < *BE* < TRANSVERB-PastP, *by* < AGENT (e.g., *The rabbit is shot by the man*)	30/30* (100%)
Truncated passive (Experiment 3)	PATIENT < *BE* < TRANSVERB-PastP (e.g., *The man is pushed*)	31/36* (86%)
Chance performance		
Reversible active transitive (Experiment 1)	AGENT NP < TRANSVERB < PATIENT NP (e.g., *The man pushes the elephant*)	18/50 (36%)
Truncated active (Experiment 3)	AGENT NP < *BE* < TRANSVERB-PresP (e.g., *The man is pushing*)	17/36 (47%)
Floor performance		
Irreversible full active (agent *by* BYSTANDER) (Experiment 2)	AGENT NP < by < NP < TRANSVERB < PATIENT NP (e.g., *The man by the woman shoots the rabbit*)	0/30* (0%)
Irreversible active transitive (patient *by* BYSTANDER) (Experiment 2)	AGENT NP < TRANSVERB < PATIENT NP < by NP (e.g., *The man shoots the rabbit by the woman*)	1/30* (3%)

WR's profile of syntactic comprehension is similar to the case reported by Druks and Marshall (1995). Both WR and BM pose a challenge to some theories of agrammatic comprehension. Druks and Marshall note that explanations of agrammatic comprehension such as the TDH, which describe passives as derived from the canonical word order through transformational movement, cannot explain this performance. Someone who has severe difficulties comprehending canonical actives would be expected to also fail on passives. Similarly, impaired working memory is assumed to disrupt interpretation of passives more than of actives. Theories of impaired working memory are also challenged by BM and WR's behavior since passives are assumed to pose greater working memory demands than actives. Furthermore, there was no evidence of lexical bias underlying grammatical performance.

One important question is whether this profile is more likely to occur when written sentences are presented, such as in our experiments, Reversible sentence tasks often contain only spoken material, and passives occur more often (but still rarely, see Introduction) in written language. It is possible that WR's education and his former occupation as a medical librarian contributed to this performance. Given that BM (whose educational status was not reported) was tested using spoken sentences, we can at least assume that our results cannot be attributed exclusively to the written modality. Similarly one might ask whether such particular dissociation is more likely to occur in people with PPA. The dissociation observed in WR has not been reported in the PPA literature, although we note that to date there have been few detailed psycholinguistic reports of individual language decline in PPA. However, as BM suffered from a focal vascular lesion to left inferior frontal cortex, it is not exclusive to PPA.

Given the spectrum of agrammatic comprehension, no single theory will be able to account for all cases. However, we argue that a comprehensive model of syntactic cognition and agrammatism needs to accommodate, or at least allow for, the pattern of behavior reported here, even if it is rare. We consider possible explanations which account for data from both WR and BM. They are independent from one another, but not mutually exclusive.

One explanation draws parallels to the "reverse frequency effect" observed in aphasic lexical impairment. Marshall, Pring, Chiat and Robson (2001) report a patient with jargon aphasia who produced lower frequency nouns in the face of retrieval failure on higher frequency forms. Hoffman, Jefferies and Lambon Ralph (2011) describe two aphasic individuals who in a delayed repetition task performed worse on high frequency than low frequency words. Their explanation for this finding was that higher frequency words appear in a wider range of linguistic contexts and therefore have a wider semantic diversity. Aphasia may result in reduced semantic control which makes it more difficult to access relevant information (or inhibit irrelevant information) in use of semantically diverse forms. It is possible that individuals who have difficulties with actives, but not with passives, have similar difficulties, as actives are more diversely used than passives (Rice, 1987). For instance, in passive constructions the interacting entities must be distinct (*e.g., Steve shaved himself* vs. **Steve was shaved by himself*; Rice, 1987). These differences in semantic and discourse contexts contribute to passives being encountered less frequently than actives. If reduced control disrupts access to more diverse syntactic forms, WR's performance could be explained by this account.

Our second explanation agrees with Druks and Marshall's distinction between two types of cues that can be used to determine agent and patient. In passive sentences, thematic relations are cued morphologically. The passive auxiliary and the past participle inflection signal that the noun phrase immediately before the verb refers to the patient. The *by*-phrase reliably cues agency (see Experiment 2). A capacity to correctly interpret morphological cues would thus result in ceiling performance. Active constructions require interpretation of configurational (word-order) cues, with the agent appearing first. While the truncated actives of Experiment 3 as well as the sentences used in Druks & Marshall (1995) contain morphological marking, it is not a strong cue for agency. If an individual is unable to correctly process configurational cues, he or she would have to guess the agent of the active sentence, resulting in chance performance. The configurational impairment account is supported by data from artificial grammar learning experiments which suggest that some people with syntactic disorder find it difficult to process sequential regularities in stimulus order (Christiansen, Louise Kelly, Shillcock, & Greenfield, 2010; Hoen et al., 2003; Zimmerer, Cowell, & Varley, under review; Zimmerer & Varley, 2010). While the relationship between impairment of artificial grammar processing and syntactic disorder requires further exploration, the data show that if BM and WR suffer from such impairment their morphological processing remains unaffected.

However, the morphological and configurational processing we describe here is different from the notions of "structural case marking" and "inherent case marking" explored by Druks and Marshall, which are very specific to the generativist framework. In particular, structural case marking is the result of several movements from deep-structure to surface-structure: the subject NP moves to the Spec(ifier) position of the AGR(reement)-S(ubject) node, the object NP moves to the Spec position of the AGR-O(bject) node, and the verb moves to the TNS (tense) node (Druks and Marshall, 1995). It is assumed that a patient with damage to the structural case "module" can use a "non-linguistic linear strategy" (such as an "agent first" interpretation; see also Grodzinsky, 2000, and Ferreira, 2003) to correctly interpret actives. We make no claims about movement and instead propose that processing of word order may be disrupted due to impairment of linear order processing. If linear order processing is automatic, it may be an important property of language networks and essential for interpretation of constructions with little morphology, such as English active sentences. Explaining aphasic profiles does therefore not require assuming “strategies”.

WR’s diary contained some active constructions in writing (*I enjoy the garden work*). If they are not the result of editing (see Case Description), they seem at odds with the conclusion that he suffers from a general disruption of cognitive processes underlying interpretation of actives. However, depending on usage-related factors such as frequency, people with aphasia may find some forms easier to process than others (Gahl et al., 2003). This can be due to partial or complete lexicalization of constructions. Zimmerer & Varley (2010) report the case of a severely aphasic patient PR who correctly produced the sentence *I don’t know*, but never a related form (i.e., with a different verb or subject). It is possible that the active forms that WR used were idiomaticised formulas such as “*I enjoy X*” which have a very narrow semantic diversity and a very simple configurational structure. Such lexically specific structures (“verb islands”) are assumed to play a role in language development (Tomasello, 2003) and to remain relevant in adult language processing (Goldberg, 2006).

On closer examination, generative grammar theories with their specific claims about surface- and deep-structure, movement, traces or case modules, do not appear to be the most parsimonious framework for investigations of syntax in aphasia. All considerations we offer in this article (cue strength, lexical bias, morphological processing, configurational processing) take place only at the periphery of the generative framework. They are however at the centre of more recent theoretical frameworks such as construction grammar (Croft, 2001, 2007; Goldberg, 2006). Construction grammar frameworks do not assume covert elements such as traces or transformations of basic underlying structures; instead, all linguistic generalizations are expressed in statements about surface form and meaning. Importantly, passives are not viewed as derived from underlying structures with active word order: they are independent constructions in their own right. The transitive active (AGENT NP < TRANSVERB < PATIENT NP; the ‘<’ symbol indicates linear precedence) poses higher configurational processing demands. The full passive (PATIENT < *BE* < TRANSVERB-PP, *by* < AGENT) contains strong morphological cues (see also Table 1). The construction grammar framework can therefore more easily accommodate patterns of impairment in which a particular construction, or set of constructions, is selectively affected or spared. Because of the lack of transformation rules, the framework can offer more parsimonious explanations for cases like BM and WR. However, construction grammar has not yet been applied to aphasic language impairment, although it has been used to provide powerful accounts of language acquisition and developmental language impairments (Tomasello, 2003). Based on data from children with SLI, Riches (2013) suggests that acquisition and comprehension of the full passive is built upon a range of simpler but related constructions such as the agentive by-phrase and adjectival passives (e.g. *it's broken*). Constructionist approaches appear a fruitful direction for future investigations of agrammatism.

Finally, the question remains of how frequent WR and BM's profile is in the aphasic population. We agree with Caramazza et al.'s (2005) statement that selection and publication bias may distort the representation of agrammatic population in the literature. Researchers may be more likely to ignore, and less likely to publish results which do not fit dominant theories. Research into individual variation can be a challenge to these theories, but also a contribution towards understanding aphasia and agrammatism. For this reason it is important to avoid associating agrammatism with a single profile of syntactic performance.

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Appendix A. Test verbs used in all experiments

Experiment 1: reversible active transitives, reversible full passives	admire, astonish, attack, chase, delight, entertain, find, follow, frighten, grab, greet, hear, help, kick, kill, notice, photograph, protect, scold, see, shock, splash, surprise, wash, weigh
Experiment 2: irreversible active transitives, irreversible full passives, actives with by-phrase	control, chase, feed, fix, hit, kick, kill, photograph, pull, shoot, sweep, throw, wash, watch, water
Experiment 3: truncated actives, truncated passives	attack, carry, chase, entertain, follow, help, hit, hug, kick, kill, kiss, photograph, pull, push, scold, splash, wash, weigh

Appendix B. WR's scores on lexical and semantic assessments before and after the three experiments.

Assessment	Before Experiment 1	After Experiment 3
Pyramids & Palm Trees	52/52	52/52
ADA Written lexical decision	157/160	155/160
ADA Written word-picture match	66/66	66/66
PALPA spoken name	60/60 (output distorted by paraphasic errors)	59/60 (output distorted by paraphasic errors)
PALPA written name	57/60	59/60