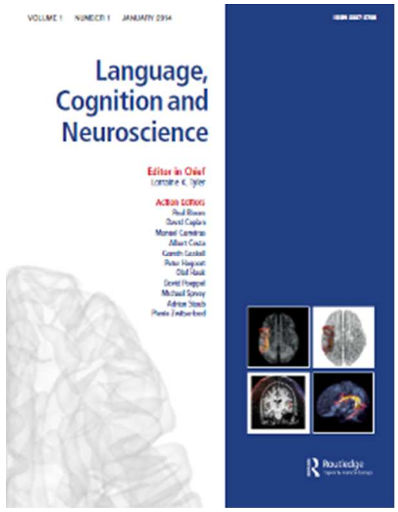

Eye-tracking the effect of word order in sentence comprehension in aphasia: Evidence from Basque, a free word order ergative language.

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Complete List of Authors:	Arantzeta, Miren; University of Groningen, International Doctorate for Experimental Approaches to Brain and Language (IDEALAB), Universities of Groningen (NL), Newcastle (UK), Potsdam (DE), Trento (IT) & Macquarie University Sydney (AU). Bastiaanse, Roelien; University of Groningen, Center for Language and Cognition Groningen (CLCG) ; International Doctorate for Experimental Approaches to Brain and Language (IDEALAB), Universities of Groningen (NL), Newcastle (UK), Potsdam (DE), Trento (IT) & Macquarie University Sydney (AU) Burchert, Frank; University of Potsdam, Department for Linguistics Wieling, Martijn; University of Groningen, Center for Language and Cognition Groningen (CLCG) Martínez-Zabaleta, Maite; Biodonostia Health Research Institute, San Sebastian University Hospital Laka, Itziar; University of the Basque Country, Linguistics and Basque Studies
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Eye-tracking the effect of word order in sentence comprehension in aphasia: Evidence from Basque, a free word order ergative language.

Miren Arantzeta[a]*, Roelien Bastiaanse[a,b], Frank Burchert[c], Martijn Wieling[b], Maite Martinez-Zabaleta[d] & Itziar Laka[e]

[a] International Doctorate for Experimental Approaches to Brain and Language (IDEALAB), Universities of Groningen (NL), Newcastle (UK), Potsdam (DE), Trento (IT) & Macquarie University Sydney (AU), PO Box 716, 9700 AS Groningen, The Netherlands

[b] Center for Language and Cognition Groningen (CLCG) University of Groningen, The Netherlands

[c] Department of Linguistics, University of Potsdam, Potsdam, Germany.

[d] Biodonostia Health Research Institute, San Sebastian University Hospital, Donostia-San Sebastian, Spain.

[e] Department of Linguistics and Basque Studies, University of the Basque Country (UPV/EHU), Vitoria-Gasteiz, Spain.

Abstract:

Some studies have shown that agrammatic speakers of languages with overt grammatical case show impaired use of the morphological cues to establish theta-role relations in sentences presented in non-canonical word orders. To gain insight into the underlying nature of this impairment, we analysed the effect of word order on the sentence comprehension of aphasic speakers of Basque, an ergative, free word-order and head-final (SOV) language.

Ergative languages like Basque establish a one-to-one mapping of the thematic role and the case marker. We collected behavioural (i.e. accuracy and reaction time) and gaze-fixation data while agrammatic speakers performed a picture-matching task with auditory presented sentences with different word orders. We found that PWA had difficulties in assigning theta-roles in non-canonical Theme-Agent order. The gaze data indicated that in verb final and verb initial sentences, correct and incorrect answers in the PWA group showed distinctive fixation patterns at the second and first arguments. This result is in line with processing accounts. In the correctly answered stimuli, PWA processed case-morphology cues as rapidly as the Non-Brain-Damaged group. Contrary to previous findings, our data do not suggest a systematic delay in the integration of morphological information in the PWA group, but limitations in predictive processes.

Keywords: aphasia; comprehension; Basque; thematic roles; sentence processing; eye-tracking

*Corresponding author. Email: m.arantzeta.perez@rug.nl

1. Introduction

Aphasia is a condition present in 21-38% of acute stroke patients, and it frequently persists in chronic stages (Pedersen, Jørgensen, Nakayama, Raaschou, & Olsen, 1995; Pedersen, Vinter, & Olsen, 2004). Although language production impairment is the most noticeable symptom, people with aphasia (PWA) with a variety of different syndromes present persistent sentence comprehension deficits (Caramazza, Basili, Koller, & Berndt, 1981; Vallar, Basso, & Bottini, 1990), independently of production abilities (see Caplan & Waters, 1990; Grodzinsky, 2000 for a review). The deficits that underlie sentence comprehension impairment are still unclear, and the heterogeneity of the clinical profiles increases the research challenges in this area.

In one of the earliest publications on agrammatic sentence comprehension, Caramazza and Zurif (1976) pointed out that PWA make systematic use of heuristic rather than algorithmic strategies to comprehend sentences (e.g. Bayesian computations). That is, PWA infer thematic roles of arguments from semantic and word order information, among other cues. This strategy may be illustrated with reference to the examples (1-2) below:

(1) The boy washes the dish.

(2) The nurse calls the doctor.

For correct interpretation of the sentence in (1) the listener may rely solely on lexical comprehension, rather than on syntactic relations. This is because a semantic restriction of 'to wash' only allows the animate 'boy' to be the agent of the action and not the inanimate 'dish'. Therefore, it is expected that PWA with spared lexical comprehension will not have problems understanding such a sentence.

However, a sentence like (2) shows that lexico-semantic information is not always sufficient to identify who performs the action, since both 'nurse' and 'doctor' are plausible agents of the action (i.e., 'to call'). Sentences like (2) are hence known as 'semantically reversible constructions'. In such structures in English, word order information plays an important role. It is widely accepted in linguistics that languages have a base word order, which is, generally, the order of declarative active sentences where all information is new (Comrie, 1981; e.g., Subject-Verb-Object in English, and Subject-Object-Verb in Japanese). Sentences with other word orders are assumed to be derived from the base word order. Previous research has shown that PWA retain sensitivity towards the base word order of their language, and that they use this knowledge to infer the thematic roles of sentence constituents (i.e., Agent-

Theme; Bates, Friederici, & Wulfeck, 1987), as healthy speakers do (Ferreira, 2003). Conversely, the comprehension of sentences with derived word order involves higher cognitive demands as suggested by greater error rates and longer reaction times in both PWA and healthy speakers, respectively (Bastiaanse & Van Zonneveld, 2006; Bornkessel, Schlesewsky, & Friederici, 2002; Caplan & Waters, 2003; Erdocia, Laka, Mestres-Missé, & Rodriguez-Fornells, 2009; Hanne, Sekerina, Vasishth, Burchert, & De Bleser, 2011).

When correct comprehension of sentences cannot be achieved by means of lexical guesswork, the hierarchical relations between constituents have to be considered. This is the reason why PWA are prone to misinterpreting reversible sentences with non-base word order (Berndt, Mitchum, & Haendiges, 1996; Caramazza & Zurif, 1976; Caplan & Futter, 1986; Saffran, Schwartz, & Marin, 1980). In sentences like (3-5), where both animate Determiner Phrases (DPs) are plausible Agent/Theme of the verb and the thematic roles display a non-canonical order (i.e. Theme-Agent), neither of the heuristic strategies mentioned above leads to the correct interpretation of the sentence. Thus, the listener must necessarily process syntactic structure to infer Agent-Theme roles. In fact, it is precisely disentangling the Agent-Theme roles in these types of structures what is at the core of the impairment in PWA with agrammatic comprehension.

(3) The nurse is called by the doctor.

(4) It is the nurse whom the doctor called.

(5) The nurse who the doctor called is tall.

However, it is not only the position of the arguments which affects sentence comprehension deficits, but also the position of the verb. It is still unclear how PWA process the information contained in the verb, but some studies have pointed out that lexical access to the verb and its argument structure in agrammatic aphasia is unimpaired. Using cross-modal lexical decision tasks, Shapiro and Levine (1990) showed that lexical decision times to visually presented stimuli were higher in the vicinity of the verbs with more argument structure options, in both healthy individuals and individuals with agrammatic aphasia. This indicates that the core impairment of people with agrammatic aphasia (PWA) eradicates on the post-activation process required for the assignment of thematic roles to the phrasal arguments (Grodzinsky, 1986), as suggested by preserved abilities in grammaticality judgement tasks involving argument structure violations (Kim & Thompson, 2004). However, ERP studies have suggested that receptive processing of argument structure is incomplete and temporally delayed in PWA (Kielar, Meltzer-Asscher, & Thompson, 2012).

Although the underlying cause of the inability to correctly interpret semantically reversible sentences is far from understood, several hypotheses have been proposed. Two sets of theories can be identified from representational and processing related accounts; the Trace Deletion Hypothesis (TDH; Grodzinsky, 1986; 1995, 2000; Drai & Grodzinsky, 2006ab) and the Derived Order Problem Hypothesis (DOP-H; Bastiaanse & Van Zonneveld, 2006), respectively. The main difference between the two theories is that the TDH, heavily relying on the Government and Binding model of grammar (Chomsky, 1981), claims that aphasic individuals suffer from a representational deficit, whereas the DOP-H is a processing based account, largely neutral as to a specific model of grammar. We discuss the particulars of each proposal in the next section.

Based on the tenants of the Government and Binding (GB; Chomsky, 1981), Grodzinsky proposed the Trace Deletion Hypothesis (TDH; 1986; 1995, 2000; see Drai & Grodzinsky, 2006ab for a later revision). In the Government and Binding model of generative grammar (Chomsky, 1981), upon which Grodzinsky's hypothesis is based, syntactically displaced constituents are assumed to have moved from their based generated position where they leave a trace. Thus, sentence comprehension requires keeping track of both the element in the derived position and the trace left in the base-generated position. The TDH postulates that inability to represent the trace is the underlying cause of the comprehension deficits in PWA when confronted with sentences such as (4-5). According to this hypothesis, since the trace is missing from syntactic representation, individuals with Broca´s aphasia cannot assign a thematic role to the moved argument and can only resort to heuristics. They apply a linear-order based assignment of the thematic roles along the sentence and assign the thematic role of Agent to the first DP encountered in the sentence. The thematic role to the non-moved DP (i.e. 'the doctor' in 4-5) is correctly assigned, leaving the aphasic individual with a structure with two Agents. When the individuals with Broca's aphasia are forced to select one out of two pictures that only differ in the thematic roles of the persons depicted (e.g., a doctor calling to a nurse and a nurse calling to a doctor), they have to guess (see 4-5). Thus, the TDH predicts that PWAs will perform at ceiling level in comprehension of semantically reversible sentences with base word order, and at chance-level (between 33.3 and 67.7 % correct) in those with derived word orders.

Bastiaanse & Van Zonneveld (2006) proposed the Derived Order Problem Hypothesis (DOP-H) as a processing account. The DOP-H (Bastiaanse & Van Zonneveld, 2006) states that the production and comprehension of sentences with a derived word order are harder for individuals with agrammatic aphasia than sentences with base word order. For production, the effect is that PWA tend to produce sentences in base word order (Bastiaanse & Edwards, 2004). For comprehension, the disorder is mainly visible in semantically reversible sentences, when the arguments are in derived position (e.g. passives and object relatives in English). These sentences with derived word order are more complex and, therefore, harder to process for PWA. Notice that Bastiaanse and Van Zonneveld (2005; 2006) do not assume that the syntactic representations are affected; rather, they propose a disorder that makes it hard (but not always impossible) to process derived word order structures. Some studies attribute such processing deficits to an overall cognitive slow-down across executive functions, memory, and attention (e.g. Burkhardt, Avrutin, Piñango, & Ruigendijk, 2008; Burkhardt, Piñango, & Wong, 2003; Caplan & Waters, 1999; Caplan, 2006; Caplan, Waters, DeDe, Michaud, Reddy, 2007; Dickey, Choy, & Thompson, 2007; Haarmann & Kolk, 1991). For the sentences under study, the DOP-H claims that sentences are harder to process when there is no linear Agent-Theme order, regardless of the position of the verb in the sentence. The DOP-H can fully account for comprehension data from agrammatic speakers of languages with rather rigid word order (e.g. English and Dutch; Bastiaanse & Edwards, 2004; English and Swahili; Abuom, Shah, & Bastiaanse, 2013), and flexible word order (e.g. Spanish and Galician; Juncos-Rabadán, Pereiro, & Souto, 2009). Nevertheless, the characterization of aphasic speakers of languages with case morphology seems to be slightly different.

Languages with overt case morphology mark the arguments of the verb depending on their grammatical function or thematic role. Correlated with this, sentences in these languages display a greater variety of word orders and, therefore, the word order cue is not as strong as in more rigid word order languages, like English. Several studies have shown that processing of case morphology is impaired in PWA (German; Burchert, De Bleser, & Sonntag, 2003; Russian; Friedmann, Reznick, Dolinski-Nuger, & Soboleva, 2010; Hebrew; Friedmann & Shapiro, 2003; Serbo-Croatian; Smith & Mimica, 1984; Turkish: Duman, Altınok, Özgirgin, & Bastiaanse, 2011). However, some cross-linguistic comparisons suggest that aphasic speakers of languages with case marking have certain advantages when it comes to processing derived order sentences. For example, aphasic speakers of German perform better on comprehension of passive sentences than Dutch speakers do (Bastiaanse & Edwards, 2004; Burchert, De Bleser, & Sonntag, 2003; see also Bates, Friederici, & Wulfeck, 1987).

In conclusion, individuals with agrammatic aphasia have problems comprehending semantically reversible sentences when the order of the arguments is derived. Nevertheless, one could wonder whether this deficit is language dependent or not. To gain insight into this topic, more studies of PWA speaking free word order languages with rich case morphology are necessary.

One of the differences between the TDH (Grodzinsky, 1986, 1995, 2000; Drai & Grodzinsky, 2006ab) and the DOP-H (Bastiaanse & Van Zonneveld, 2006) is the predictions they make regarding the performance of PWA in comprehension tasks. As a representational account, the TDH states that PWA miss the traces of the arguments and, hence, have to guess when they have to choose a picture corresponding to a semantically reversible sentence with non-base order of thematic roles, resulting in chance level performance. The DOP-H (Bastiaanse & Van Zonneveld, 2006) does not make predictions in terms of chance, but suggests that the processing deficits will result in lower performance on semantically reversible sentences in which the arguments are not in base order (i.e. Theme-Agent order). A growing body of on-line processing data support this latter prediction (Dickey, Choy, & Thompson, 2007; Hanne et al., 2011).

The introduction of on-line techniques in psycholinguistic and neurolinguistic studies has led to significant advancement in research. Studies with neuroimaging and eye-tracking (ET) techniques offer insight in real-time language processing to complement the behavioural off-line data. This introduces two main advantages: First, on-line data permit disambiguation of different processes involved in the same final result, and, therefore, it offers the possibility of reviewing linguistic symptomatology. Second, it offers the possibility to distinguish brain reactions accompanying correct answers from those accompanying incorrect choices, by comparing real-time language processing of PWAs with healthy non-brain-damages (NBD). This is relevant, because chance-level performance has been interpreted as expression of guessing (e.g. Grodzinsky, 1986, 2000; see Burchert, Hanne, & Vasishth, 2013, for a review). Dickey, et al. (2007), followed by Hanne et al., (2011), report evidence indicating that PWA do not guess. Dickey et al. (2007) studied on-line comprehension of PWA with ET while comprehending sentences with wh-movement. They analysed the gaze-fixation patterns by convergence analysis and found that PWA showed a similar eye-movement pattern to that of

NBD participants in the correct answers, but not so in the incorrect answers. Hanne et al. (2011), using the same technology, tested comprehension in PWA speakers of German by comparing reversible sentences with SVO and OVS word orders. In line with Dickey, et al. (2007), results revealed that the fixation patterns of PWA for correct and incorrect answers were qualitatively different. Thus, real-time language processing suggests that chance-level performance of PWA is partly guided by normal patterns of language processing (see also Meyer, Mack, & Thompson, 2012).

The Visual World Paradigm (VWP) is based on the idea that language processing results in attention shifts across the visual display. Hence, cognitive processes involved in language comprehension are analyzed by aligning the timing and pattern of eye-gaze fixations to potential referents displayed on the visual workspace (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). This is feasible because eye fixations are time-locked with the continuous auditory stimuli within a margin of 200 ms (Matin, Shao, & Boff, 1993) and this tight link allows insight into real-time sentence processing by inferring from the gaze fixations on the visual stimuli. Healthy listeners fixate to the target referent after the auditory stimulus provides sufficient selectional restrictions to discard competitors. Interestingly, several studies have pointed out that they display an anticipatory behaviour in thematic role assignment while doing a sentence resolution task (Kamide, Scheepers, & Altmann, 2003; Kamide, Altmann, & Haywood, 2003; Knoeferle, Crocker, Scheepers, & Pickering, 2005). That is, they assign thematic roles to critical objects in the scene before the names of the objects have been mentioned in the auditory input. The building up of expectations about elements that have not yet been presented auditorily is due to the influence of the visual context information on incremental thematic role assignment, as has been shown for two case marking languages, German (Kamide, Scheepers & Altmann, 2003; Knoeferle et al., 2005) and Japanese (Kamide, Altmann & Haywood, 2003), although under different selective constraints. Altogether, this suggests that VWP is a useful framework to monitor language comprehension deficits of PWA and, more specifically, their sensitivity towards word order and case morphology information when it comes to comprehend semantically reversible sentences. The use of the VWP thus seems to be a promising way to study how PWAs parse grammatical functions in real-time.

To sum up, sentence comprehension deficits in PWA are most noticeable in semantically reversible sentences with derived word order, but TDH (Grodzinsky, 1986; 1995, 2000; Drai & Grodzinsky, 2006ab) and DOP-H (Bastiaanse & Van Zonneveld, 2006) provide different explanations for the underlying causes of such impairments in PWA. The current study aims to further our insight into sentence processing in aphasia by analysing the effect of word order on sentence comprehension by PWA speakers of Basque, a free word order and head-final (SOV) ergative language with rich case morphology.

Linguistic background: Basque

Basque is a free word-order language, with SOV as base order (De Rijk, 1969, Erdocia et al. 2009). The frequency of usage of each word order varies as quantified by means of written corpora analyses: SOV (56.8%); SVO (14.8%); OVS (13.8%); OSV (9.9%); VOS (3.3%); VSO (1.1%) (Aldezabal, et al. 2003). Basque is a richly inflected language in which the inflected verb agrees with the subject, the direct object and the indirect object, which are all case marked. That is, the auxiliary verb presents polypersonal agreement with all the arguments of the sentence. This combination of agreement and morphological case is an infrequent typological pattern. Basque is an ergative language (Levin, 1983; Ortiz de Urbina, 1989; Laka, 2006). Hence, subjects of unaccusative verbs and objects of transitive verbs are morphologically identical (6-7), marked by zero case and called 'absolutive', while the agentive subject of transitive clauses carries ergative case (-*k*) (1).

(6)	Txakurr-a-k	katu-a- Ø	harrapatu	du.
	Dog-det-erg	cat-det-abs	caught	aux.has
	The dog has caught the cat.			
(7)	Txakurr-a- Ø	etorri	da.	
	Dog-det-abs	arrived	aux.is	
	The dog has arrived.			

If a DP marked with absolutive case (Ø) appears at the beginning of a sentence, it can be initially interpreted as the subject of an intransitive/unacussative verb (7), as a sentence-initial object with a null-subject subject (8), or as a topicalized object in a sentence with OSV word order (9) (see also Laka, 2012).

(8)	(katu-a-k)	txakurr-a- Ø	harrapa-tu	du.
	(cat-det-erg)	dog-det-abs	catch-perf.	aux.has

(the cat) has caught the dog

(9)	txakurr-a-Ø	katu-a-k	harrapa-tu	du.
	dog-det-abs	cat-det-erg	catch-perf.	aux.has

The cat has caught the dog.

Note that the combination of the singular determiner (-*a*) and the ergative case marker (-*k*) yields a sequence that is homophonous with the plural absolutive marker (-*ak*) in Basque. Consequently, the first DP marked with –*ak* is temporary ambiguous to the listener, since it may correspond either with a singular agent (6) or with a plural object (10).

(10)	Katu-ak-Ø	txakurr-a-k	harrapa-tu	ditu.
	cat-det.pl-abs	dog-det.sg-erg	catch-perf.	aux.has

The dog has caught the cats.

Inspired by this free word order property of Basque, Erdocia et al. (2009) compared online processing of SOV-OSV sentences using self-paced reading and ERP techniques in healthy participants. Both sentence types were either morphologically unambiguous or ambiguous ergative DPs or plural absolutive DPs, as illustrated above in (10). The authors found that Basque speakers employed a 'subject-first' processing strategy and systematically reanalysed OSV sentences at the second DP position. In addition, SOV word order imposed the lowest cognitive demands, as revealed by shorter reading times and a modulation of anterior negativities and P600 components. In another study Carreiras, Duñabeitia, Vergara, de la Cruz-Pavía, & Laka (2010) used the same ambiguous Agent/Theme morphological marking as Erdocia et al. (2009), but in Subject/Object relative clauses (henceforth SRC and ORC respectively) involving a temporal ambiguity between subject/object-gap that was resolved at the auxiliary verb of the main sentence. Longer reading times and larger amplitudes in the P600 were interpreted by the authors as evidence that ORC are easier to process than SRC in Basque. In agreement with the results of previous studies, speakers deployed an agent first strategy for the ambiguous sentence-initial DP, yielding lower processing demands for ORC. To sum up, converging evidence shows that healthy speakers of Basque use word-order information to disentangle morphological ambiguities affecting the interpretation of thematic roles (for an overview, see: Laka & Erdocia, 2012).

Hypothesis and expectations:

In the current study, the predictions of the TDH and the DOP-H on sentence comprehension processing in PWAs will be tested with behavioural data (i.e. accuracy and reaction time) and using eye fixations as an on-line measure of language processing.

The original version of the TDH (Grodzinsky, 1986, 1995, 2000) predicts that behaviourally the PWA group will perform above chance in comprehension of sentences when the moved argument does not cross the verb in a hierarchical manner (11).

(11) $[_S\ NP_S\ [_{VP}\ NP_O\ V]]$

(12) $[_{S'}\ V_i\ [_S\ NP_S\ [_{VP}\ NP_O\ t_i]]]$

(13) $[_{S'}\ NP_{Oi}\ [_S\ NP_S\ [_{VP}\ t_i\ V]$

(14) $[_{S'}\ V_j\ [_{S'}\ NP_{Oi}\ [_S\ NP_S\ [_{VP}\ t_i\ \ t_j]$

(See [†] for further clarifications.)

In sentences with VSO word order (12), no argument has moved from its base position and therefore, PWA are expected to present above-chance accuracy. Conversely, in the OSV (13) and VOS (14) there is an additional crossing of the subject by the object and the use of agent-first strategy will not result in the correct interpretation of the sentence. Therefore, chance level accuracy is expected. Drai & Grodzinsky (2006 a, b) laid out some explicit predictions of the TDH for Germanic languages, also with SOV base word order, where they slightly modified the original TDH. According to the authors, comprehension of passive sentences in Dutch is not impaired in PWA because in this construction the internal argument that becomes the subject of the sentence does not cross the lexical Verb (see Bastiaanse & Van Zonneveld, 2006, for a reply). If we assume that this restriction needs to be fulfilled to consider comprehension deficits, neither the OSV nor VOS word order should be impaired according to the TDH, since the Object does not cross the Verb in any of these two constructions. Therefore, PWA speakers of Basque should correctly understand sentences presented in these conditions. Contrary to this, the DOP-H predicts that PWA will score higher in sentences with Agent/Theme linear order (i.e. SOV, VSO) than in sentences with Theme/Agent order (i.e. OSV, VOS). Therefore, these hypotheses on the underlying disorders make different predictions regarding the sentence processing patterns in PWA.

[†] Following Kayne (1994) and Fukui and Takano (1998), we assume that there is no rightward movement of the arguments within the sentence. Thus, the only possible derivations for (12-14) are the ones shown in this section.

In addition, it should be noted that due to the pluripersonal character of verb agreement in Basque, and regardless of the sensitivity that PWA may have to the argument structure of the lexical verb, the auxiliary will also support thematic-role information by means of agreement with the Agent and Theme of the sentence. That is, the argument structure of the verb will be over-specified at the auxiliary verb in both VSO and VOS conditions. A performance pattern of preserved comprehension in the VSO condition and impaired abilities in the comprehension of VOS supports that even when thematic role assignment does not require full access to argument structure information because thematic roles are unambiguously marked by case morphology, there is an impaired assignment of thematic roles onto the DPs. Contrary to this, preserved comprehension of VOS sentences and impaired comprehension in the OSV condition would indicate that PWA assign thematic roles correctly to the DPs when those are offered beforehand by means of agreement morphology on the verb, but they do present impairment in reanalysis processes in verb final constructions.

TDH does not make explicit predictions about reaction times (RTs). The DOP-H predicts that for PWA sentence with derived word order (i.e. OSV, VSO, VOS) will take longer to process due to the increased processing load.

Regarding gaze data, distinct patterns are predicted by TDH and DOP-H. The former predicts that gaze-fixation patterns of the sentences for which the PWA have to guess (i.e. OSV and VOS) will be qualitatively different from those of healthy participants, whereas the fixation pattern and timing-window is expected to be similar to control participants in conditions with above-chance accuracy (i.e. SOV and VSO). The DOP-H predicts that trials eliciting correct and incorrect answers in PWA should correspond to qualitatively different fixations patterns. Moreover, it is expected that the slow-down of linguistic processing in PWA will cause a temporal delay from the auditory presentation of the stimuli until the fixation to the visual target, as compared to NBD participants.

2. Methods

The study obtained the approval of the Basque Clinical Research Ethics Committee (CEIC-E). All participants received written and oral information about the study, rights and implications of their participation, and signed an informed consent form.

Participants

Eight individuals with aphasia (mean age 66.37 years; SD= 14.37; range= 43-83; male/female= 6:2) met the inclusion criteria to take part in this study. They were all L1Basque-L2Spanish bilingual speakers[‡] and had experienced a left hemisphere stroke between 3-24 months prior to the study. They were right handed pre-morbidly, as assessed by the Edinburgh Handedness Inventory (Oldfield, 1971). The NBD group was composed of eight L1Basque-L2Spanish bilingual speakers without any history of neurological or sensory impairments. They were matched on age range, education level and literacy language with the clinical group (mean age 62.25 years; SD= 13.31; range= 38-80; male/female= 5:3). They all demonstrated normal or corrected-to-normal vision and hearing.

The PWA were Basque-Spanish bilingual speakers whose native language was Basque. They had acquired Spanish at an early age (2-5 years). They were all literate only in Spanish, their language of instruction at school, with the exception A4 who was literate in Basque as well, having used both Spanish and Basque as languages of instruction at school. See **Appendix 1** for detailed individual data.

Prior to their participation in this study, the PWA had been assessed with the Cognitive Neuroscience Laboratory language screening battery (CNL; Chialant, 2000; adapted to Basque by Erdocia, Santesteban & Laka, 2003) for working memory using the Digit-span task (WAIS-III; Wechsler, 1997), auditory discrimination and comprehension abilities. In the latter test, both word (i.e. nouns and verbs) and sentence comprehension were assessed using picture-matching tasks. Lexical materials were controlled for imageability, animacy as well as frequency; sentences included simple and embedded declaratives presented in both base word order (SOV) and a non-base order (OSV). The sentences were counterbalanced for semantic reversibility, number/person agreement and number of arguments required by the verb, and were marked with ergative, absolutive and dative case morphology, when necessary.

As shown in **Appendix 2**, all eight PWAs had preserved word comprehension abilities for both verbs and nouns, and impaired sentence comprehension abilities. The latter was characterized as chance or below chance performance on comprehension of semantically reversible sentences in at least one condition (i.e., base SOV versus derived OSV word order).

[‡] Currently Basque speaking monolinguals are rare, since both Spanish and French are required by law, depending on geopolitical territories.

Visual neglect was excluded as a cause of poor performance among all participants using the Behavioural Inattention Test (BIT; Wilson, Cockburn, & Halligan, 1987).

Since no normalized assessment tools are available for PWA speakers of Basque, we analysed samples of spontaneous speech to characterize the clinical participants as non-fluent based on the criteria described below. The samples were taken through spontaneous conversation and elicited language while participants were describing pictures as the *Cookie Theft* (BDAE; Goodglass, Kaplan & Barresi, 2000) or *Flood Rescue* (Olness, 2006). The analysis was focused on the Mean Length Utterance (MLU), finiteness, grammaticality and speed (i.e. number of words per utterance) in samples of 200 words, unless otherwise indicated. Detailed results are available in **Appendix 3**. Subsequently these samples were compared with the spontaneous language of 10 native Basque speakers matched by age range, dialect and gender using *Ahotsak Ahozko Tradiziozko Korpusa* (*Traditional Oral Language Corpus Ahotsak;* Badihardugu Euskara Elkartea, 2008; see **Appendix 4**). Although the sample materials have not being recorded under similar circumstances, we believe that it offers a rather good picture of language production handicaps shown by the PWA included in the current study.

Design and Materials:

Materials for the eye tracking study consisted of single sentences presented auditorily, simultaneously with the presentation of pairs of pictures. One of the pictures depicted the action described by the spoken sentence, while the other showed the same action with an Agent-Theme reversal (see **Figure 1**). There were 176 trials consisting of 80 experimental items, 80 fillers, and 16 practice items.

[Figure 1 near here]

Linguistic stimuli:

Twenty-two transitive verbs were selected to create the items. Each verb was complemented with two animate, singular DPs to create declarative sentences in the following word orders (a) SOV; (b) OSV; (c) VSO; and (d) VOS. The assignment of the Agent-Theme roles to the DPs in each pair of DPs was randomized and balanced within the four conditions. Hence, each DP was the Agent of the sentence in two out of four conditions. The filler stimuli were created using 22 unaccusative verbs in combination with a single animate DP. In addition, a temporal adverb functioning as an adjunct was added to keep sentence length between target and filler stimuli constant. Filler stimuli were also presented in the four word orders described above, although in this case the adjunct (i.e., temporal adverb) replaced the position of the grammatical object in the sequence. All arguments of both target and filler sentences were highly imageable, had four syllables and comparable lemma frequency (<1000 words/million) as extracted from the *Euskal Hiztegiaren Maiztasun Egitura* ('The Frequency Structure of the Basque Dictionary'; Acha, Laka, Landa & Salaburu, 2013).

In the semantically reversible target sentences, the Agent was overtly marked with the ergative case marker attached to the DP (*-k*), while the Theme was zero-marked for absolutive case, as illustrated in (15-18) below; all sentences mean 'the lady has combed the girl ('s hair).

(15) Subject – object – verb (– aux)

Andere-a-k	neskato-a-Ø	orraz-tu	du
lady-det-erg	girl-det-(abs)	comb-perf.	aux.has

(16) Object – subject – verb (– aux)

Neskato-a-Ø	andere-a-k	orraz-tu	du
girl-det-abs	lady-det-erg	comb-perf.	aux.has

(17) Verb (– aux) – subject – object

Orraz-tu	du	andere-a-k	neskato-a-Ø
comb-perf.	aux.has	lady-det-erg	girl-det-abs

(18) Verb (– aux) – object – subject

Orraz-tu	du	neskato-a-Ø	andere-a-k
comb-perf.	aux.has	girl-det-abs	lady-det-erg

As is the case in ergative languages, the object of the transitive verb carries the same morphological marker (Ø) as the subject of unaccusative verbs. As shown by Erdocia et al. (2009), Basque listeners use a subject-first strategy to resolve this syntactic ambiguity, thus, they assume that the first DP is the subject of an intransitive verb. The processer detects that parsing is incorrect when it reaches the subject marked with the ergative -k as the second DP, and it is forced to reanalyse the sentence. One of the points of interest in the present study was to investigate whether Basque speaking PWA are able to revise their initial grammatical parsing, and hence, reanalyse the sentences (i.e. OSV). To maintain the syntactic ambiguity filler items with unacussative verbs were combined with the target stimuli.

Additionally, two of the experimental conditions, VSO and VOS, were selected to test the sensitivity to verb morphology in PWA. We wanted to see whether PWA process verb agreement morphology, and if so, if this overwrites the impact of word order in the comprehension deficits. Recall that in Basque the inflected verb agrees in case, number and person with all arguments of the sentence, and therefore, the listener may disentangle thematic roles resorting to agreement morphology, with the support of the visual stimuli, as soon as the verb and the first DP are presented (see Ros, Santesteban, Fukumura & Laka, 2015). In such a case, incremental thematic role assignment is expected from the off-set of the first DP, without the need to process the subsequent case markers affixed to the second argument (as shown in Kamide, Scheepers & Altmann, 2003; Knoeferle et al., 2005; Kamide, Altmann & Haywood, 2003 with NBD participants).

In the filler sentences, the subjects were not Agents but Themes, zero-marked for absolutive case, with unnacusative verbs (see 19-22). Hence,

Filler sentences:

(19)	Dantzari-a- Ø	bapatean	argaldu	da
	dancer-det-abs	suddenly	become.thin	aux.has
(20)	Bapatean	dantzari-a-Ø	argaldu	da
	suddenly	dancer-det-abs	become.thin	aux.has
(21)	Argaldu	da	dantzari-a- Ø	bapatean
	become thin	aux.has	dancer-det-abs	suddenly
(22)	Argaldu	da	bapatean	dantzari-a- Ø
	become thin	aux.has	suddenly	dancer-det-abs

The dancer has suddenly become thin

Sentences were recorded by a female native speaker of Basque in a soundproof booth (IAC) using a digital microphone (audio-technica AT4022a). Recordings were normalized using Audacity (v.2.0.3), a cross-platform sound editor. A similar constant prosodic contour was used across all sentence conditions to avoid giving cues biasing one or another interpretation (Weber, Grice, & Crocker, 2006). A rather slow speech rate of 3.57 syllables per second was used, which is still within the parameters for normal speech (3-6 syllables/sec; Levelt, 2001). Since the constituents of the sentences were matched on length (i.e. four syllables/constituent) and speech rate, all constituents and sentences had a duration of 1.12 seconds and 3.36

seconds respectively across all conditions. This fact allowed the subsequent analysis of the longitudinal data (i.e., gaze-data) in time windows match by length across constituents and stimuli.

Visual stimuli:

Visual stimuli consisted of 88 black-and-white line drawings divided into 44 pairs separated by a black vertical line in the middle of the screen. Each pair of pictures depicted the same reversible action differing in the role of Agent/Theme. A sample of the visual display is presented in **Figure 1** (see above). The pictures were approximately 15x15 cm. and the elements on them were presented at a similar size, while keeping the proportional differences between different elements in the real world (e.g., a child is smaller than an adult). The pictures were controlled for name and comprehension agreement in a norming study with 20 healthy participants. This group was comprised of twenty L1Basque-L2Spanish bilingual speakers (mean age 31.7 years; SD= 2.55; range= 27-38; male-female= 10:10). In the normalization process, the visual stimuli were presented on a 14.1” screen, with a resolution of 1280x800. To test name agreement, the picture was shown and the verb was given to the participants in order to elicit a sentence describing the picture. Attention was focused on the use of nouns and assignment of the Agent-Theme roles in the answer provided by the participants. The use of synonyms or substitution of the nouns was counted as correct as long as they represented the same referent (e.g., the nouns *ama* ‘mother’ and *anderea* ‘lady’) and showed unambiguous recognition of the depicted elements. For comprehension agreement, each pair of pictures was shown to the participants simultaneously with an auditory presentation of a sentence. The latter always corresponded to the canonical sentence word order (SOV) and referred to one of the two pictures randomly. Participants were instructed to point to the picture that best depicted the auditory stimuli. After implementing the necessary changes, an agreement of 90.90% and 96.13% was reached in naming and comprehension normalization, respectively.

After normalization, the order of the visual stimuli was pseudo-randomized for the experimental stage based on two criteria. First, the position of the target item on the screen was pseudo-randomized in order to avoid a preference in selecting the drawing depending on its location (i.e., left/right) on the visual display. No more than two target stimuli were displayed in a row on the same side of the screen. Secondly, the direction in which the action was performed in the picture was randomized in order to avoid preferences in left-to-right scanning strategy (Scheepers & Crocker, 2004).

Procedure:

The order of both target and filler stimuli was randomized and divided into four blocks of 40 items for presentation. In each experimental session, two blocks of items were administered, preceded by the presentation of eight trial items. No more than two experimental items from the same condition were presented in a row. The experiment was conducted using E-prime 2.0 software with extensions for Tobii 2.1. (Psychology Software Tools, Pittsburgh, PA).

The visual stimuli were presented on a screen of 23 inches with a resolution of 1280x720, and the auditory stimuli were played through stereo headphones (Sony, MDR-XD100). Gaze movements were monitored using a Tobii T120 remote portable eye-tracker (sampling rate: 120 Hz) located below the screen. Participants were placed at 60 to 70 cm distance from the screen, with a visual angle under 15º (max. Allow 35º).

Each of the four blocks of stimuli was preceded by a short calibration of the eye-tracker. Such calibration was performed to re-assess the eye position and to ensure that the device correctly detected the eye-gaze of the participants. The participants were required to fixate into five calibration points that appeared in sequence along the screen. Once the initial calibration was performed successfully, each experimental session started by providing written instructions on the laptop screen to describe the experimental task. The same instructions were verbally explained to all participants before running the experiment.

The participants performed a picture-matching task. Each trial started with the presentation of a fixation smiley face in the centre of the screen. They needed to fixate on the image for 250 ms to before the presentation of the stimuli was executed. This measure was taken to ensure that the participants did not have a fixation bias at the onset of the stimuli. Subsequently, the visual stimulus was presented on the screen. After 1000 ms of previsualization, the auditory stimulus was presented. The participants' task was to select the picture that best corresponded to the meaning of the presented sentence by pressing specific buttons on the keyboard using the left hand. Trials without answer within a 8000 ms time window from the off-set of the sentence were registered as 'no answer' and the next stimulus was presented automatically.

Non-answered trials were excluded from the data analysis, corresponding to the 2.07% of the total target data. Only fixations lasting more than 90ms (11 data points) were included in the data analysis to avoid blinks and saccades to interfere in the results. In addition, it was checked that there was no trial answered before 500ms from the onset of the auditory presentation since such answers may be due to accidental button press rather than to a conscious answer. Gaze fixation data was switched 200 ms to correct the delay of the gaze fixation in relation to the auditory stimuli (Matin, Shao, & Boff, 1993).

3. Data analysis

In addition to standard descriptive statistics, Generalized Linear Mixed-effects Models (GLMM) and Linear Mixed-effects Models (LMM) were used to identify determinants of sentence comprehension across behavioral and gaze data (i.e. GLMMs for the accuracy data, LMMs for the reaction time and gaze data). (G)LMM is a statistical technique assessing the linear effect of both fixed-effects terms (i.e. regression coefficients) and random-effects terms in a single model (see Bates, 2005). Thus, it simultaneously considers repeatable covariates and the unexplained variation introduced by a specific selection of subject and linguistic stimuli, which are treated as samples from the population of interest. (G)LMMs are suitable to analyze longitudinal and repeated measures studies for a number of reasons. It has been shown to accommodate missing data satisfactorily and to be robust towards outliers (Verbeke & Molenberghs, 2000), which are crucial properties to take into account in the analysis of reduced sample sizes. The difference between a GLMM and LMM is that in the former case, the dependent variable is binary (with 1 indicating a correct answer, and 0 indicating an incorrect answer) and the estimates have to be interpreted with respect to the logit scale (i.e. the log of the odds of observing a correct answer). A positive estimate on this scale indicates that (an increasing value of) the predictor has a positive effect on the probability of observing a correct answer. Similarly, a negative estimate indicates a negative effect on the probability of observing a correct answer. In the latter case (i.e. LMM), the dependent variable is numerical.

Empirical model building was conducted with the off-line (i.e. accuracy and RT) and on-line (i.e. gaze-fixation) data. For that, separate (G)LMMs were fitted by progressively introducing random effects, fixed effects and correspondent interactions. Random slopes were not included in the models due to convergence problems, likely due to the limited sample size. Instead, nested random intercepts were used to account for the variability of the subjects and stimuli in relation to some explanatory factorial predictors (e.g., a random intercept for the combination of subject and condition). Model comparison was conducted based on the Akaike's Information Criterion (AIC; Akaike, 1974), with a reduction in AIC of 2 indicating a better fitting model (taking into account the complexity of the models). Models with the lowest AIC were kept. When comparing models with a different fixed-effects structure, these were fitted using maximum likelihood estimation (ML). Restricted maximum likehood estimation (REML; Patterson & Thompson, 1971**;** Harville, 1974) was used when comparing random effects and for our final model (for a detailed review see, McCulloch & Searle, 2000; Verbeke & Molenberghs, 2000). Subsequently, least square means (LSMeans) and 95% confidence intervals (95% CI) were calculated and *pairwise* comparisons were carried out with a Tukey correction. Effects are considered significant at the p < .05 level, unless otherwise indicated. The RT data were log transformed and the numerical predictors Age and Trial number were centered.

In the case of the RT data, the empirical (i.e. best) model did not fully cover the research questions of the study. Therefore, a second model was fitted specified according to our hypothesis, where the inclusion of fixed-effect predictors was predetermined, and the best random-effects structure was assessed via AIC comparison. The analysis was conducted using R Statistic software (R Core Team, v.3.1.2.) using the *lme4* package (Bates et al., 2015).

4. Results

Comprehension accuracy:

General descriptives of accuracy scores at group level are provided in **Table 1**. The NBD group did not perform at ceiling level in either of the sentence types, offering a fully sensitive measure to differentiate among the conditions and between groups. See **Appendix 5** for individual participant scores.

[Table 1 near here]

A logit link function was used for the GLMM, as indicated before. The final model obtained for the accuracy data contained two-way interactions for group and condition as fixed effects, and stimuli and subject variables as random effects. In addition, the analysis highlighted that the strength of the condition was different between subjects, thus a nested random-effect (i.e. for each combination of subject and condition) was added to enable a more precise estimation of the effect of sentence condition in each subject.

Overall, the PWA group performed significantly less accurately than NBDs across all sentence conditions. Thus, they presented difficulties comprehending sentences in both canonical word order (i.e. SOV) and non-canonical word order (i.e. OSV, VSO and VOS), although under different significance levels as presented in **Table 2**.

[Table 2 near here]

Within-group-comparisons in the PWA group uncovered significant differences in the comprehension abilities across sentence conditions. In this group, stimuli were significantly better comprehended when presented in conditions SOV and VSO than in OSV and VOS. See **Table 3.** The NBD group did not present accuracy differences across sentence conditions.

[Table 3 near here]

Response reaction time:

Two separate LMMs were fitted for the RT data. The first one was built following the empirical procedure described previously, where variables that better explained the observed data were included in the model. The second one was a hypothesis-driven model that included the variables required to answer the research question of the current study, also including predictors which were excluded (due to lack of explanatory power) from the other model.

[Table 4 near here]

[Figure 2 near here]

The empirical model consisted of two-way interactions between the group, sentence condition and trial number, in addition to random intercepts for subject and stimulus and the nested random intercepts of subject with condition and stimulus with condition (i.e. specified in *lmer* as "(1|Subject/Condition) + (1|Stimulus/Condition)"). As presented in **Table 5**, this model showed no significant RT differences between groups across any of the conditions. *Pairwise* comparisons were conducted by condition within each group and the results are presented in **Table 6**. The aphasic group did not show differences in RTs in the different conditions, but NBDs showed significantly longer RTs in OSV and VOS conditions when compared to SOV (base order of the arguments), but not when compared to VSO condition (base order of the arguments).

[Table 5 near here]

[Table 6 near here]

Moreover, there was a significant interaction between group, condition and trial number. That is, NBD participants became faster along the experiment, but this was not the case for the PWA group. Detailed information is provided in **Table 7**. The PWA group did not show an effect of Trial number across any of the sentence conditions, while in the NBD group Trial number significantly influenced both SOV and OSV conditions, but not VSO and VOS conditions.

[Table 7 near here]

The hypothesis-driven-model consisted of a three-way interaction between group, sentence condition and accuracy of the response as fixed effects, in addition to the same random effects structure as for the exploratory model. The results of the comparisons between the groups and sentence conditions were close to the previous model and results are reported in **Tables 8-10** (see additional material). The main interest of developing this new model was to test if the accuracy of the answers had an effect on the RT of the participants. We compared correct and incorrect answers solely for the PWA group, since the number of incorrect answers within the NBD group was too small. As presented in **Table 11**, the results showed that the accuracy of the answer (i.e. correct, incorrect) did not have any effect on the RT.

[Table 11 near here]

Gaze-data analysis:

To conduct the gaze-data analysis, the difference in the proportion of fixations between the correct and incorrect visual stimuli was computed from the onset of the first argument (ROI1) to 1120ms after the offset of the third argument (ROI4). Therefore, a temporal frame of 4480 ms was analysed divided in four windows (i.e., ROIs). As described in the method section, each of the four ROIs had the same length across all stimuli and conditions (i.e., 1120 ms). ROI 1, 2 and 3 corresponded to the first, second and third constituent of the sentence, while ROI 4 corresponded to the post-offset silence. Missing gaze data motivated by answers provided before the offset of ROI4 (i.e. RT<4480ms) were treated by logical imputation based on the accuracy of the response. Positive values indicated a margin of difference of fixations towards the correct picture: negative values indicated the inverse pattern. For hypothesis testing, an LMM was fitted with a four-way interaction between the group, sentence condition, ROI and accuracy of the response as fixed effects. In addition, random intercepts for subject and stimuli were included, as well as nested random intercepts for subject together with condition and accuracy, and nested random intercepts for stimulus with condition.

The analysis focused on two distinct aspects. First, we compared the fixation pattern of the NBD and PWA groups in the correctly responded stimuli. Pairwise comparisons of each ROI across the sentence conditions were conducted between groups (see **Table 12)**. The results revealed that there were no differences between the groups for the fixation pattern for the visual stimuli in each ROI across the different sentence conditions, with the exception of the post-offset region in the VOS condition (See **Figure 3**). In this case, there were significantly fewer fixations to the correct picture for the PWA group than for the NBD group. Apart from that, in the correctly answered trials, gaze data of NBD and PWA groups were indistinguishable based on the progressive increase in fixations towards the correct stimulus over time.

[Figure 3 near here]

[Table 12 near here]

Second, we compared the fixation pattern of the PWA group between correctly and incorrectly answered stimuli. This yielded significant differences, as illustrated in **Figure 4**. Correct and incorrect answers were statistically distinguishable from the ROI 2 onward in the SOV (i.e. Object position), OSV (i.e. Subject position), VSO (i.e. Subject position) and VOS (i.e. Object position) sentence conditions, as detailed in **Table 13**.

[Figure 4 near here]

[Table 13 near here]

In this section we have analysed behavioural and gaze data from PWA and NBD groups while performing a picture-matching task. Accuracy data have pointed out that the order of the arguments within a sentence has a significant effect on the comprehension deficits of the PWA group. Sentences containing linear Agent-Theme order of arguments were understood significantly better than sentences with the inversed order of constituents. The reaction time data have shown no significant differences between groups, presumably due to high variability in the PWA group. In line with this, within group comparison has uncovered no differences across sentence conditions in the PWA group. Conversely, the NBD group has shorter RTs in base word order (i.e. SOV) in relation to OSV and VOS, contrary to VSO word order. These data converge with the fixation pattern analysed. Comparison of correctly and incorrectly answered trials in the PWA group show that fixation patterns diverge from the second and first argument in verb final and verb initial sentences, respectively. Fixation patterns shown in correctly answered trials are indistinguishable, in both timing and proportion, between the PWA and NBD group, except in the post-offset region of the VOS condition.

5. Discussion

In the current study we aimed to provide further insight into: a) the effect of the order of the arguments on sentence comprehension deficits of PWA in a free-word order language; b) the validity of the Trace Deletion Hypothesis (TDH, Grodzinsky, 1986, 1995, 2000; Drai & Grodzinky, 2006ab) and Derived Order Problem-Hypothesis (DOP-H, Bastiaanse & Van Zonneveld, 2006) to explain online and offline sentence comprehension in aphasia. Based on representational and processing perspectives, the TDH and DOP-H have proposed diverging explanations about the underlying deficits that PWA face in sentence processing. This study confronts these hypotheses with results from processing a free word order and morphologically rich language and draws attention to certain cross-linguistic universals in sentence comprehension deficits in PWA.

Sentence comprehension accuracy and reaction times:

The findings of this study reveal that the PWA group had a poorer sentence comprehension than the control group regardless of the word order in which the sentence was presented. Since we demonstrated that the PWA in this study had preserved lexical comprehension, difficulties in the comprehension of sentences presented with base word order (i.e., SOV) indicate difficulties in syntactic processing. The comprehension of sentences presented in SOV and VSO order was not intact, but still above chance. Thus, these results converge with the two hypotheses tested in this paper.

Within group comparison confirmed differences between conditions. When we compared the results of PWA across conditions, there was no difference between the SOV and VSO order. They turned out to perform worse on OSV and VOS than on SOV and VSO conditions, although OSV and VOS sentences are more frequent than VSO in Basque (Aldezabal, et al. 2003). Hence, the error pattern found cannot be explained as a function of frequency of use of the structure in Basque. This finding converges with Bornkessel, Schlesewsky, & Friederici

(2002), who observed that neurophysiologically distinct responses were observed on the basis of the linguistic properties of the stimuli, but not as a function of the frequency of these structures in a given language. In addition, the NBD group performed equally well on all structures. Thus, differences across conditions support the predictions of the DOP-H and do not support the predictions of the TDH (see Drai & Grodzinsky, 2006ab).

In contrasts to previous studies reporting longer RTs for PWA than for healthy listeners (Caplan & Waters, 2003; Hanne et al., 2011), PWA participating in the current study did not show significantly longer latencies to provide an answer than the NBDs. This result does not seem to support the cognitive slow-down as the deficit source of comprehension impairment in PWA. However, exploratory analysis of the data suggests a trend for longer RTs in the PWA group across all sentence types. It is possible that the rather small sample size and large variability in the PWA group may prevent reaching statistical significance. PWA presented a trend for larger RTs than NBD independently of base or derived order of the sentence, a trend that is compatible with the processing account rational (Burkhardt et al., 2008; Burkhardt, Piñango, & Wong, 2003; Caplan, 2006; Caplan, et al., 2007; Dickey, et al., 2007; Haarmann & Kolk, 1991).

Contrary to what the DOP-H suggests, PWA group did not respond quicker sentences presented in base word order (i.e. SOV) than to the ones with derived order. Meanwhile, the NBD group answered faster to SOV word order sentences than to those in OSV and VOS order. These results converge with previous studies demonstrating that healthy speakers benefit from sentences with canonical argument order since they use an agent-first strategy to process them (Erdocia et al., 2009). Notice that the requirement for reanalysis in OSV sentences does not imply longer RTs than for VOS sentences, where listeners may assign the thematic roles unambiguously already to the first DP, thanks to the information about grammatical functions on the verb.

Altogether, the behavioural data suggest that PWA have difficulties assigning thematic roles to DPs in OSV word order sentences, which requires syntactic reanalysis. In addition, they present deficits making use of the information provided by verbal morphology and case marking to disentangle the thematic role assignment in the case of VOS word order sentences. This may be either because PWA do not fully access the argument structure of the lexical verb and/or inflection information of the verb. An alternative interpretation could be that the application of a linear Agent-Theme strategy overrides the information provided by case and agreement morphology. The trend in RT measurements converge with previous studies suggesting that PWA do access the argument structure information at the verb position to some extent, but have difficulty processing the case morphology that guides the assignment of the thematic roles to specific DPs (Grodzinsky, 1986; Shapiro & Levine, 1990). Severe impairment in processing of case morphology was also reported by Burchert, De Bleser, and Sonntag (2003) in a group of German agrammatic speakers. Still, in line with that study, individual analyses of PWA participants in the current study suggest that not all PWA with comprehension impairments have these deficits to the same degree.

In the current experiment, two out of eight participants (A3-A8) performed above chance level on the experimental task, although they had shown chance-level scores in pre-test. Working memory limitations may explain these discrepancies depending on the length of the linguistic stimuli, as suggested by Caplan and Waters (1999). These two participants scored in a rather low percentile of the digit-span task for their age, suggesting poor working memory functioning. This may prevent them from fully comprehending longer sentences as the ones presented in the Cognitive Neuroscience Laboratory language screening battery (CNL; Chialant, 2000; adapted to Basque by Erdocia, Santesteban & Laka, 2003) while comprehension of the shorter sentences on the experimental task was relatively well-preserved. The other PWA showed variable performance across conditions, but in each case sentences with derived order of the arguments were understood significantly worse than sentences where the arguments were in base order.

Gaze fixation data:

On-line language processing data are informative to check the validity of the different theoretical approaches. Using this methodology, we can identify a guessing pattern and diminished grammatical parsing routines that were proposed as potential causes of these deficits by the TDH and DOP-H, respectively. The analysis of the fixation pattern of PWA and NBD across the different sentence types reveals two things: First, there were no different gaze patterns for the correct trials for the two groups. Second, gaze-fixation patterns of PWA in the correct and incorrect answers were different from those as for the correct trials for all word orders.

Both NBD and PWA showed incremental thematic role assignment, as described in other languages with case morphology (Kamide, Sheepers & Altmann, 2003; Kamide, Altmann & Haywood, 2003; Knoeferle et al. 2005). In the correctly answered trials, all participants presented a progressive increase of fixations to the target picture even before all the arguments of the sentences were heard. The fixation pattern along the presentation of each argument of the sentence was indistinguishable between the groups. There was one exception, which corresponds to the post-offset region in the VOS sentence type, where participants from the PWA group fixated less often to the correct picture, although they answered correctly. This may be related to the longer RTs of the PWA to comprehend this word order, suggesting that they wait for the presentation of the ergative case marker of the subject to confirm their choice. This is in line with the ERP-findings of Kielar, Meltzer-Asscher, and Thompson (2012) who showed that processing verb arguments in PWA is not always complete.

These results show not only that PWA and NBD participants process sentences similarly when they point to the correct picture, but also that they do so time aligned for each argument of the sentence, contrary to what was found by Hanne et al. 2011. Our findings also contradict the slowdown framework within the processing account. If we assume that slowing down of basic cognitive functions is the cause of language processing deficits in PWA, a delayed application of the same routines of the NBD group is expected. However, PWA in the current study showed the same rapid, automatic processing of sentences as the NBDs. Interestingly, these results converge with another eye-tracking study on comprehension of *wh*-questions conducted by Dickey et al., (2007). They concluded that contrary to what representational and processing accounts suggest PWA processed the *wh*-questions like healthy listeners in the correct answers. In line with their claim, we think that it is possible that previous studies implying consciously controlled responses may have slightly biased on-line measures because of the involvement of a secondary cognitive task, as button press. Still, Hanne et al. (2011), using eye-tracking have shown real-time processing delays as measured by gaze-fixation patterns. We believe that the procedures used in the current study and in the study of Dickey et al. (2007) may not detect subtle processing delays, because the temporal windows in which the data are analysed are too wide for this purpose. Therefore, we can only conclude that PWA do not present an aberrant processing delay compared to the NBD group.

So far we have shown that correctly interpreted sentences were processed similarly by both PWA and NBD groups. In addition to this, a comparison of fixation patterns of PWA across correct and incorrect trials supported a non-guessing pattern in PWA (see Burchert et al., 2013 for a review). In line with previous literature (Dickey et al., 2007; Hanne et al., 2011), the fixation advantage towards the target picture was different for the correctly and incorrectly answered trials. For the correctly answered trials, the advantage of fixations on the correct pictures showed a progressive increase, while for incorrectly answered trials the same pattern of looks towards the picture with the reverse interpretations was observed. The time resolution of these divergences was the same across sentence types (i.e., second ROI). In the SOV condition, the morphological cue is unambiguously provided on the first argument, but correctly and incorrectly answered trials diverge from the second argument onward. This can be explained by the fact that case morphology is presented at the end of each argument DP and the temporal window (i.e., ROI) ends as soon as this information cue is presented. Therefore, it shows that participants need more than 200 ms (i.e., temporal swift applied to gaze data to be align with the auditory presented stimuli) to process this information and subsequently fixate on the correct picture. In the OSV condition, the resolution point is again at the subject position, but PWA show an anticipatory effect by fixating on the correct picture already while the second argument is being presented. This suggests that PWA are not sensitive to the temporal ambiguity of OSV constructions, probably because the visual material provides enough information about the transitivity of the verb as consolidated by learning effect along the experiment. That is, listeners may develop an inference rational to know the transitivity of the verb as soon as the image is presented which overrides the garden path effect. Interestingly, in the VSO and VOS word order, gaze data also diverge from the second ROI onward, which corresponds to the first argument of the sentence. When we analyse VSO and VOS together, data indicate that PWA tend to use an “Agent-first” strategy that lends to the correct interpretation in VSO condition and incorrect interpretation in VOS condition. Note that in the latter the difference of fixations between the correctly and incorrectly answered trials is basically due the increase of fixations on the incorrect picture in the incorrect answers. The data suggest that PWA rely more strongly in the ergative (i.e., agent) than in the absolutive case markers to disentangle thematic-role assignment, as shown by the slow progression of fixations into the correct picture in VOS. This indicates limited resources to build up anticipatory behaviour in thematic role assignment in Agent-second sentences. These results reinforce the trend set by the RT data, that is, they suggest that incorrect answers in the PWA group are motivated by deficits in the thematic role assignment to specific arguments in the sentence, and not by a complete failure to access argument structure information.

6. Conclusions

The effect of word order on sentence comprehension in PWA has been a focus of research for decades. This study contributes to the debate by introducing data from a richly inflected ergative language with free word order, and helps to disentangle the relation between language properties and the cognitive demand that distinct word orders may impose to PWA.

The current study aimed to investigate the effect of word order on sentence comprehension deficits in PWA speakers of Basque. The results suggest that although PWA demonstrated preserved lexical comprehension, at group level sentence comprehension is poorer than that of NBDs, both for sentences with base word order and for sentences with derived word orders. This contradicts the predictions made by the TDH (as formulated in Drai & Grodzinsky, 2006ab), but not the original version of this hypothesis (Grodzinsky, 1986, 1995, 2000). That is, PWA were more impaired in comprehension of sentences in which there was no linear Agent-Theme argument order, regardless of the position of the verb.

For the correct answers, real-time fixation patterns during the presentation of the auditory stimuli were indistinguishable from the control group, with a single exception (i.e. post-offset of VOS). However, the pattern diverged for the incorrectly answered trials. This suggests that correct answers of PWA are due to control-wise language processing and not caused by guessing as suggested by the TDH. No general delay in sentence processing was found in the PWA group, suggesting that PWA taking part in this study present a control-wise rapid and automatic processing of linguistic stimuli for sentences they answered correctly. This converges with the findings of Dickey et al. (2007) and suggests that there is inconsistent grammatical parsing, compatible with the DOP-H and other processing accounts. Still, the results need to be interpreted with caution, since they do not necessarily imply that both groups process the stimuli with the same speed: the delay may not have been large enough to be detected with the current methodology and data analysis used in this study.

Altogether, the study suggests that word order has a significant effect on sentence comprehension abilities on PWA speakers of free word order languages. Thus, the order in which arguments are perceived influences sentence processing, regardless of the morphological information carried by the verb and the DPs. Hence, sentences where the Theme precedes the Agent are harder to process and comprehend than Agent-Theme sentences, independently of the corpus frequency of the sentences at stake. PWA present with serious problems in processing case morphology, even when they are sensitive to the argument structure of the verb: their comprehension performance decreases depending on the demand imposed by the word order, as suggested by the DOP-H.

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Appendices:

Appendix 1:

Detailed information about PWA (A) and *NBD* (C) participants.

Participant	Age	Gender	Education level	Literacy language	Months post-onset	Location
A1	80	M	1	Spanish	18	Ischaemic, LMCA
A2	70	M	2	Spanish	9	Ischaemic, LMCA
A3	53	M	2	Spanish	12	Ischaemic, LMCA
A4	43	F	3	Basque	23	Ischaemic, LMCA
A5	80	M	1	Spanish	10	Ischaemic, LMCA
A6	62	M	1	Spanish	13	Ischaemic, LMCA
A7	83	F	1	Spanish	20	Ischaemic, LMCA
A8	60	M	2	Spanish	3	Ischaemic, LMCA
C1	80	M	1	Spanish	n/a	n/a
C2	62	M	2	Spanish	n/a	n/a
C3	54	M	3	Spanish	n/a	n/a
C4	38	F	3	Basque	n/a	n/a
C5	74	F	1	Spanish	n/a	n/a
C6	60	F	1	Spanish	n/a	n/a
C7	77	M	1	Spanish	n/a	n/a
C8	53	M	2	Spanish	n/a	n/a

F= Female; M= Male; 1= Elementary; 2= Technical; 3=University; LMCA= Left Middle Cerebral Artery; n/a= not applicable

Appendix 2:

Summary of the individual scores obtained in the Cognitive Neuroscience Laboratory language screening battery (CNL; Chialant, 2000; adapted to Basque by Erdocia, Santesteban & Laka, 2003).

Partici-pant	Digit-span (pCTL)	Auditory discr. [0-1]	Lexical compr. [0-1]	Sentence comprehension [0-1]			
				SOV	(R-)SOV	OSV	(R-)OSV
A1	70	.97	.71	.55	.53	.50	.40
A2	14	1.00	.93	.70	.53	.68	.60
A3	14.7	1.00	.97	1.00	1.00	.75	.60
A4	14.7	1.00	1.00	1.00	1.00	.68	.50
A5	14	1.00	.89	.75	.69	.68	.60
A6	-	.70	.71	.55	.47	.56	.60
A7	52	.85	.91	.40	.30	.50	.50
A8	6.8	1.00	1.00	.90	.92	.75	.60

pCTL = percentile by age range; Auditory discr.= auditory discrimination; Lexical compr.= lexical comprehension; (R-)= Semantically reversible

Appendix 3:

Analysis of spontaneous speech samples of PWA.

Subject	MLU	Finiteness (%)	Grammaticality (%)	Num.words/min.
A1	5.05	69.44	64	25
A2	5.16	62.16	56.52	39
A3*	4.68	86.36	57.89	28
A4**	6.39	69.56	68.75	63
A5	3.52	65.45	77.77	52
A6***	-	-	-	-
A7	4.22	71.11	43.75	27
A8	5.90	74.19	60.86	39

MLU= Mean Length of Utterance; *120words; **160 words; ***spontaneous language sample collection was not possible due to Global aphasia.

Appendix 4:

Analysis of spontaneous speech samples of NBD speakers from *Ahotsak Ahozko Tradiziozko Korpusa* (*Traditional Oral Language Corpus Ahotsak;* Badihardugu Euskara Elkartea, 2008).

Subject	**Gender**	**Age**	**MLU**	**Finiteness (%)**	**Grammaticality (%)**	**Num.words/ min.**
C1	male	79	6.67	85.71	95.83	102
C2	female	81	8.5	95.45	95.43	84
C3	male	74	7.33	88	100	92
C4	male	66	8.8	95.23	95	105
C5	male	77	7.91	91.66	95.45	117
C6	female	82	8.52	91.30	100	95
C7	male	70	11.8	93.33	100	120
C8	male	65	9.73	100	94.73	116
C9	male	65	8.22	90.47	100	122
C10	female	66	10.79	94.11	100	94
x̄		72.5	8.83	92.53	97.64	104.70
se		(sd 6.91)	0.49	1.28	0.79	4.24

MLU= Mean Length of Utterance

Appendix 5:

Sentence comprehension accuracy (%) in the experimental task.

	PWA				NBD				
Group	**Sentence condition**					**Sentence condition**			
PWA	**SOV**	**OSV**	**VSO**	**VOS**	**NBD**	**SOV**	**OSV**	**VSO**	**VOS**
A1	75	27	61	72	C1	90	75	100	84
A2	60	20	70	35	C2	100	95	90	90
A3	95	95	95	85	C3	95	100	94	90
A4	95	15	95	10	C4	95	95	100	89
A5	75	57	82	63	C5	75	90	90	85
A6	57	36	35	38	C6	94	100	100	95
A7	63	45	50	42	C7	100	95	90	95
A8	84	68	73	73	C8	80	73	85	75
x̄	75.81	45.80	71.14	52.28	**x̄**	91.19	90.56	93.71	87.97
se	3.47	4.01	3.72	4.05	**se**	2.25	2.32	1.93	2.59

PWA= People With Aphasia; NBD= Non Brain Damaged

Tables:

Table 1. Comprehension accuracy and standard error (SE) as a function of group and sentence condition.

Condition	Accuracy % (SE)	
	PWA	**NBD**
SOV	75.81 (3.47)	91.19 (2.25)
OSV	45.80 (4.01)	90.56 (2.32)
VSO	71.14 (3.72)	93.71 (1.93)
VOS	52.28 (4.05)	87.97 (2.59)

NBD= Non Brain Damaged; PWA= People with Aphasia

Table 2. Comparison of response accuracy between groups across sentence conditions.

	Group	LSMeans (95% CI)	β	SE	z-ratio	p
SOV	**NBD**	2.65(1.80–3.51)	1.315	0.564	2.328	0.0199
	PWA	1.34(0.60–2.08)				
OSV	**NBD**	2.57(1.73–3.42)	2.736	0.553	4.944	<.0001
	PWA	-0.15(-0.87–0.55)				
VSO	**NBD**	3.00(2.09–3.91)	1.946	0.583	3.334	0.0009
	PWA	1.05(0.32–1.79)				
VOS	**NBD**	2.23(1.42–3.03)	2.102	0.534	3.932	0.0001
	PWA	0.12(-0.58–0.84)				

NBD= Non Brain Damaged; PWA= People with Aphasia; Significance level p<.05

Table 3. Comprehension accuracy differences between sentence conditions in PWA and NBD groups.

	LSMeans (95% CI)	OSV				VSO				VOS			
		β	**SE**	**z-ratio**	**p**	**β**	**SE**	**z-ratio**	**p**	**β**	**SE**	**z-ratio**	**p**
PWA group													
SOV	-0.15(-0.87–0.55)	-1.502	0.360	-4.170	**0.0002**	-0.286	0.344	-0.829	0.8403	-1.217	0.356	-3.419	**0.0035**
OSV	1.34(0.60–2.08)	-	-	-	-	1.216	0.359	3.384	**0.0040**	0.285	0.368	0.774	0.8658
VSO	0.12(-0.58–0.84)	-	-	-	-	-	-	-	-	-0.931	0.355	-2.621	**0.0435**
VOS	1.05(0.32–1.79)	-	-	-	-	-	-	-	-	-	-	-	-
NBD group													
SOV	2.57(1.73–3.42)	-0.081	0.468	-0.174	0.9981	0.347	0.447	0.777	0.8649	-0.428	0.495	-0.864	0.8233
OSV	2.65(1.80–3.51)	-	-	-	-	0.429	0.451	0.949	0.7781	-0.346	0.499	-0.693	0.8998
VSO	2.23(1.42–3.03)	-	-	-	-	-	-	-	-	-0.775	0.478	-1.620	0.3671
VOS	3.00(2.09–3.91)	-	-	-	-	-	-	-	-	-	-	-	-

PWA= People with Aphasia; NBD= Non Brain Damaged; Significance level p<.05

Table 4. Mean Reaction Time (RT) and Standard Error (SE) as function of group and sentence condition.

Condition	**Mean RT (SE) in ms.**	
	PWA	**NBD**
SOV	4635.64 (161.96)	3619.69 (102.58)
OSV	4898.85 (174.77)	3953.67 (100.91)
VSO	4921.31 (168.28)	3891.77 (107.44)
VOS	5022.03(173.55)	4125.95 (90.58)

PWA= People With Aphasia; NBD= Non Brain Damaged.

Table 5. Reaction time differences between groups across sentence condition.

		LSMeans (95% CI)	**β**	**SE**	**z-ratio**	**p**
SOV	**NBD**	8.11(7.86–8.36)	-0.233	0.163	-1.433	0.1719
	PWA	8.35(8.10–8.59)				
OSV	**NBD**	8.23(7.98–8.48)	-0.168	0.163	-1.031	0.3184
	PWA	8.40(8.15–8.65)				
VSO	**NBD**	8.22(7.97–8.47)	-0.216	0.163	-1.326	0.2042
	PWA	8.43(8.19–8.68)				
VOS	**NBD**	8.29(8.04–8.54)	-0.145	0.163	-0.893	0.3857
	PWA	8.43(8.18–8.68)				

NBD= Non Brain Damaged; PWA= People with Aphasia; Significance level $p<.05$

Table 6. Reaction time differences between sentence conditions in PWA and NBD groups.

LSMeans (95% CI)		OSV				VSO				VOS			
		β	**SE**	**z-ratio**	**p**	**β**	**SE**	**z-ratio**	**p**	**β**	**SE**	**z-ratio**	**p**
PWA group													
SOV	8.35(8.10–8.59)	-0.050	0.042	-1.207	0.6252	-0.089	0.042	-2.101	0.1652	-0.087	0.042	-2.076	0.1738
OSV	8.40(8.15–8.64)	-	-	-	-	-0.038	0.042	-0.914	0.7975	-0.036	0.041	-0.876	0.8171
VSO	8.43(8.19–8.68)	-	-	-	-	-	-	-	-	0.002	0.042	0.048	1.0000
VOS	8.43(8.19–8.68)	-	-	-	-	-	-	-	-	-	-	-	-
NBD group													
SOV	8.11(7.86–8.36)	-0.116	0.041	-2.786	**0.0360**	-0.106	0.042	-2.547	0.0640	-0.175	0.041	-4.203	**0.0006**
OSV	8.23(7.98–8.48)	-	-	-	-	0.009	0.041	0.228	0.9958	-0.059	0.041	-1.421	0.4919
VSO	8.22(7.97–8.47)	-	-	-	-	-	-	-	-	-0.068	0.041	-1.642	0.3641
VOS	8.29(8.04–8.54)	-	-	-	-	-	-	-	-	-	-	-	-

PWA= People with Aphasia; NBD= Non Brain Damaged; Significance level p<.05

Table 7: Trial number effect on the reaction time across sentence conditions in PWA and NBD groups.

		LSMeans (95% CI)	β	SE	z-ratio	p
PWA group						
SOV	**≈1**	8.37(8.12–8.63)	0.053	0.074	0.716	0.4751
	≈80	8.32(8.06–8.58)				
OSV	**≈1**	8.42(8.16–8.67)	0.038	0.073	0.524	0.6009
	≈80	8.38(8.12–8.63)				
VSO	**≈1**	8.45(8.19–8.72)	0.038	0.074	0.522	0.6022
	≈80	8.42(8.16–8.67)				
VOS	**≈1**	8.44(8.19–8.70)	0.022	0.077	0.297	0.7671
	≈80	8.42(8.16–8.68)				
NBD group						
SOV	**≈1**	8.30(8.04–8.56)	0.373	0.072	5.143	<.0001
	≈80	7.93(7.67–8.19)				
OSV	**≈1**	8.33(8.07–8.58)	0.198	0.068	2.888	0.0043
	≈80	8.13(7.87–8.39)				
VSO	**≈1**	8.25(8.00–8.51)	0.072	0.069	1.045	0.2975
	≈80	8.18(7.93–8.44)				
VOS	**≈1**	8.33(8.07–8.58)	0.078	0.073	1.059	0.2905
	≈80	8.25(7.99–8.51)				

≈1= initial Trials; ≈80= final Trials; NBD= Non Brain Damaged; PWA= People with Aphasia; Significance level $p<.05$

Table 8: Hypothesis driven model. Reaction time differences between groups across sentence conditions.

		LSMeans (95% CI)	β	SE	z-ratio	p
SOV	**NBD**	8.10(7.85–8.35)	-0.269	0.163	-1.641	0.1201
	PWA	8.37(8.12–8.62)				
OSV	**NBD**	8.29(8.04–8.54)	-0.105	0.163	-0.645	0.5282
	PWA	8.40(8.15–8.64)				
VSO	**NBD**	8.26(8.00–8.51)	-0.184	0.165	-1.117	0.2800
	PWA	8.44(8.19–8.69)				
VOS	**NBD**	8.27(8.02–8.52)	-0.162	0.162	-1.000	0.3325
	PWA	8.43(8.18–8.68)				

NBD= Non Brain Damaged; PWA= People with Aphasia; Significance level p<.05

Table 9: Hypothesis driven model. PWA group: reaction time differences between sentence conditions.

LSMeans (95% CI)		OSV				VSO				VOS			
		β	SE	z-ratio	p	β	SE	z-ratio	p	β	SE	z-ratio	p
SOV	8.37(8.14–8.60)	-0.027	0.043	-0.636	0.9200	-0.071	0.044	-1.610	0.3792	-0.063	0.043	-1.446	0.4756
OSV	8.40(8.17–8.63)	-	-	-	-	-0.044	0.043	-1.022	0.7375	-0.035	0.042	-0.839	0.8355
VSO	8.44(8.21–8.67)	-	-	-	-	-	-	-	-	0.008	0.043	0.202	0.9970
VOS	8.43(8.20–8.66)	-	-	-	-	-	-	-	-	-	-	-	-

PWA= People with Aphasia; Significance level p<.05

Table 10: Hypothesis driven model. NBD group: reaction time differences between sentence conditions.

LSMeans (95% CI)		OSV				VSO				VOS			
		β	**SE**	**z-ratio**	**p**	**β**	**SE**	**z-ratio**	**p**	**β**	**SE**	**z-ratio**	**p**
SOV	8.10(7.86–8.33)	-0.191	0.055	-3.435	**0.0042**	-0.156	0.059	-2.628	**0.0453**	-0.169	0.053	-3.139	**0.0109**
OSV	8.29(8.06–8.53)	-	-	-	-	0.034	0.059	0.589	0.9353	0.022	0.053	0.413	0.9762
VSO	8.26(8.02–8.49)	-	-	-	-	-	-	-	-	-0.012	0.057	-0.223	0.9961
VOS	8.27(8.04–8.50)	-	-	-	-	-	-	-	-	-	-	-	-

NBD= Non Brain Damaged; Significance level p<.05

Table 11. Hypothesis driven model. PWA group: reaction time differences between correct and incorrect responses.

		LSMeans (95% CI)	**β**	**SE**	**z-ratio**	**p**
SOV	**I**	8.41(8.15–8.66)	0.078	0.043	1.782	0.0751
	C	8.33(8.08–8.58)				
OSV	**I**	8.40(8.15–8.65)	0.000	0.039	0.024	0.9813
	C	8.40(8.15–8.65)				
VSO	**I**	8.46(8.21–8.71)	0.041	0.043	0.957	0.3386
	C	8.42(8.17–8.67)				
VOS	**I**	8.40(8.15–8.65)	-0.060	0.039	-1.518	0.1292
	C	8.46(8.21–8.71)				

PWA= People with Aphasia; C=correct answers; I=incorrect answers; Significance level p<.05

Table 12. Between group comparison of the gaze fixations patterns in the correct answers as a function of ROI and sentence conditions.

		SOV						OSV				
		LSMeans (95% CI)	**β**	**SE**	**z-ratio**	**p**		**LSMeans (95% CI)**	**β**	**SE**	**z-ratio**	**p**
ROI1	**NBD**	0.04(-0.10–0.18)	-0.022	0.107	-0.210	0.8335	**NBD**	-0.09(-0.24–0.05)	-0.117	0.117	-1.00	0.3166
	PWA	0.06(-0.09–0.22)					**PWA**	0.02(-0.16–0.20)				
ROI2	**NBD**	0.23(0.08–0.38)	-0.110	0.107	-1.027	0.3040	**NBD**	0.14(-0.00–0.28)	-0.048	0.117	-0.412	0.6799
	PWA	0.34(0.18–0.50)					**PWA**	0.18(0.00–0.37)				
ROI3	**NBD**	0.51(0.36–0.66)	0.034	0.107	0.324	0.7456	**NBD**	0.52(0.37–0.67)	0.094	0.118	0.800	0.4233
	PWA	0.47(0.32–0.63)					**PWA**	0.43(0.24–0.61)				
ROI4	**NBD**	0.67(0.52–0.82)	0.160	0.108	1.482	0.1382	**NBD**	0.611(0.46–0.75)	0.094	0.117	0.802	0.4225
	PWA	0.51(0.35–0.67)					**PWA**	0.51(0.33–0.69)				
		VSO						**VOS**				
		LSMeans (95% CI)	**β**	**SE**	**z-ratio**			**LSMeans (95% CI)**	**β**	**SE**	**z-ratio**	**p**
ROI1	**NBD**	-0.01(-0.16–0.12)	0.068	0.109	0.624	0.5324	**NBD**	-0.08(-0.23–0.06)	-0.136	0.115	-1.177	0.2388
	PWA	-0.08(-0.24–0.07)					**PWA**	0.05(-0.12–0.22)				
ROI2	**NBD**	0.236(0.09–0.38)	0.065	0.109	0.601	0.5478	**NBD**	-0.02(-0.17–0.12)	-0.061	0.116	-0.523	0.6009
	PWA	0.17(0.00–0.33)					**PWA**	0.03(-0.14–0.21)				
ROI3	**NBD**	0.45(0.30–0.59)	0.019	0.109	0.175	0.8609	**NBD**	0.22(0.07–0.37)	0.008	0.116	0.075	0.9401
	PWA	0.43(0.26–0.59)					**PWA**	0.21(0.04–0.39)				
ROI4	**NBD**	0.68(0.54–0.83)	0.189	0.110	1.71	0.0860	**NBD**	0.67(0.52–0.82)	0.321	0.116	2.755	**0.0059**
	PWA	0.49(0.33–0.66)					**PWA**	0.35(0.18–0.53)				

ROI= Region Of Interest; ROI 1= first constituent of the sentence; ROI 2= second constituent of the sentence; ROI 3= Third constituent of the sentence; ROI 4= Post-offset region; NBD= Non Brain Damaged; PWA= People with Aphasia; Significance level p<.05

Table 13. Comparison of gaze fixation patterns as a function of ROI and response accuracy in PWA group.

		SOV						OSV				
		LSMeans (95% CI)	**β**	**SE**	**z-ratio**	**p**		**LSMeans (95% CI)**	**β**	**SE**	**z-ratio**	**p**
ROI1	**I**	-0.12(-0.35–0.11)	-0.185	0.131	-1.410	0.1585	**I**	-0.03(-0.21–0.14)	-0.053	0.114	-0.463	0.6432
	C	0.06(-0.09–0.22)					**C**	0.02(-0.16–0.20)				
ROI2	**I**	-0.14(-0.37–0.09)	-0.485	0.131	-3.686	**0.0002**	**I**	-0.15(-0.33–0.02)	-0.344	0.114	-3.005	**0.0026**
	C	0.34(0.18–0.50)					**C**	0.18(0.00–0.37)				
ROI3	**I**	-0.06(-0.29–0.16)	-0.548	0.128	-4.195	**<.0001**	**I**	-0.19(-0.36–-0.01)	-0.622	0.115	-5.39	**<.0001**
	C	0.47(0.32–0.63)					**C**	0.43(0.24–0.61)				
ROI4	**I**	-0.22(-0.45–-0.00)	-0.741	0.130	-5.672	**<.0001**	**I**	-0.06(-0.24–0.11)	-0.584	0.115	-5.047	**<.0001**
	C	0.51(0.35–0.67)					**C**	0.51(0.33–0.69)				
		VSO						**VOS**				
		LSMeans (95% CI)	**β**	**SE**	**z-ratio**			**LSMeans (95% CI)**	**β**	**SE**	**z-ratio**	**p**
ROI1	**I**	0.00(-0.21–0.22)	0.089	0.126	0.710	0.4771	**I**	-0.03(-0.21–0.15)	-0.085	0.115	-0.738	0.4604
	C	-0.08(-0.24–0.07)					**C**	0.05(-0.12–0.22)				
ROI2	**I**	-0.09(-0.31–0.12)	-0.26	0.125	-2.099	**0.0358**	**I**	-0.21(-0.39–-0.02)	-0.244	0.115	-2.118	**0.0341**
	C	0.17(0.00–0.33)					**C**	0.03(-0.14–0.21)				
ROI3	**I**	-0.07(-0.30–0.14)	-0.510	0.126	-4.020	**<.0001**	**I**	-0.30(-0.48–-0.11)	-0.518	0.114	-4.515	**<.0001**

	C	0.43(0.26–0.59)					**C**	0.21(0.04–0.39)				
ROI4	**I**	-0.22(-0.44–0.00)	-0.722	0.129	-5.597	**<.0001**	**I**	-0.17(-0.36–0.00)	-0.534	0.115	-4.61	**<.0001**
	C	0.49(0.33-0.66)					**C**	0.35(0.18–0.53)				

ROI= Region Of Interest; ROI 1= first constituent of the sentence; ROI 2= second constituent of the sentence; ROI 3= third constituent of the sentence; ROI 4= Post-offset region; I= incorrect answer; C= correct answer; Significance level p<.05

Figures:

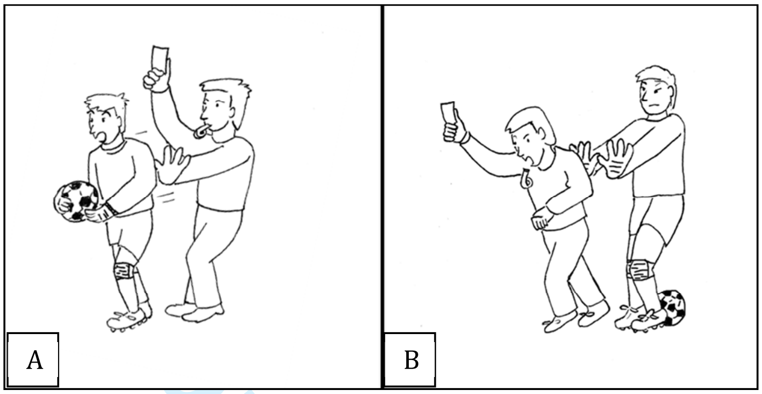

Figure 1. Sample visual display. Target stimulus (SOV): "Atezainak arbitroa bultzatu du" (The goalkeeper has pushed the referee). A) Target picture; B) Foil.

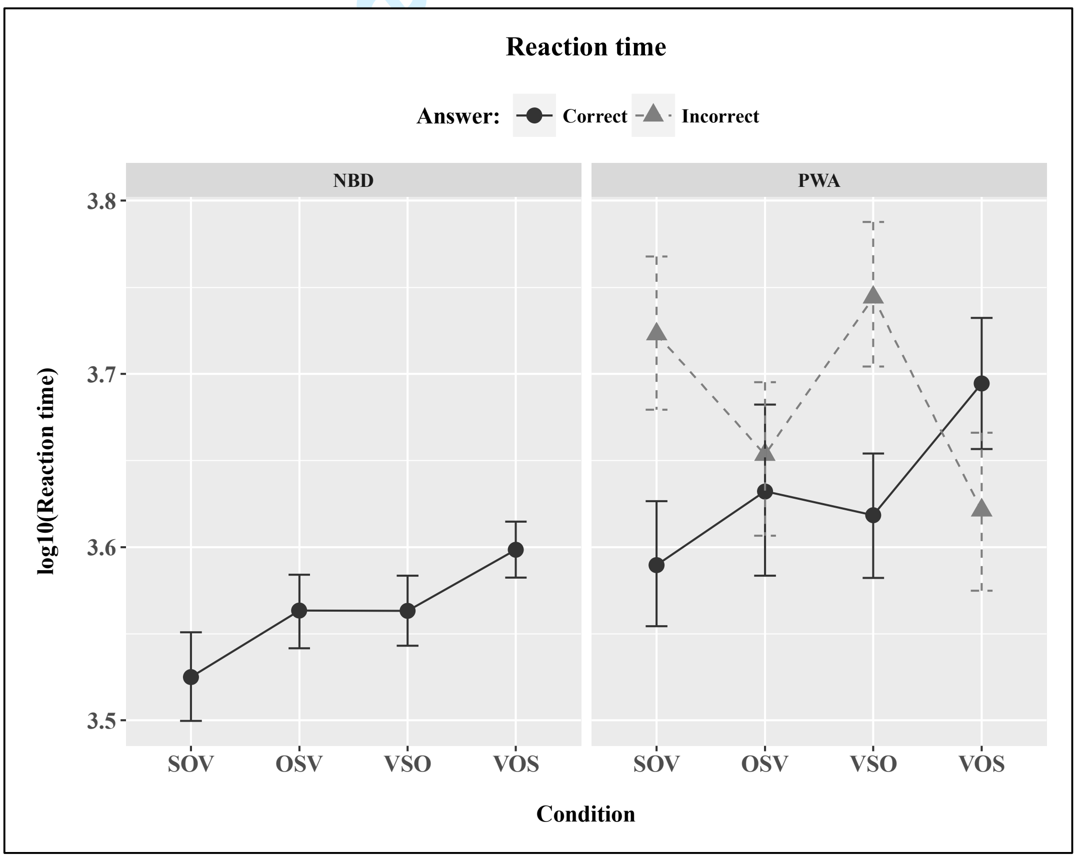

Figure 2. Log transformed reaction times as a function of group, sentence condition and correctness of the response. PWA= People With Aphasia; NBD= Non Brain Damaged.

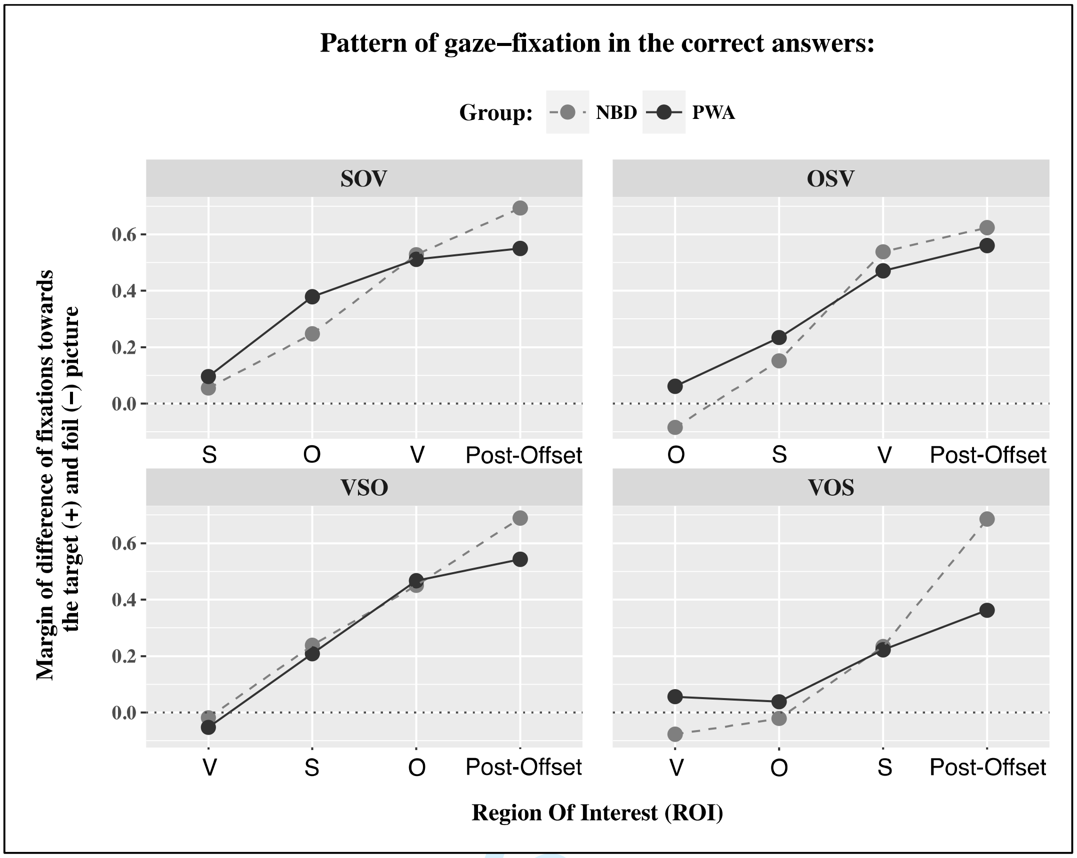

Figure 3. Gaze-fixation pattern across the visual stimuli during the auditory presentation of the sentence. Between group comparison in the correct answers. PWA= People With Aphasia; NBD= Non Brain Damaged

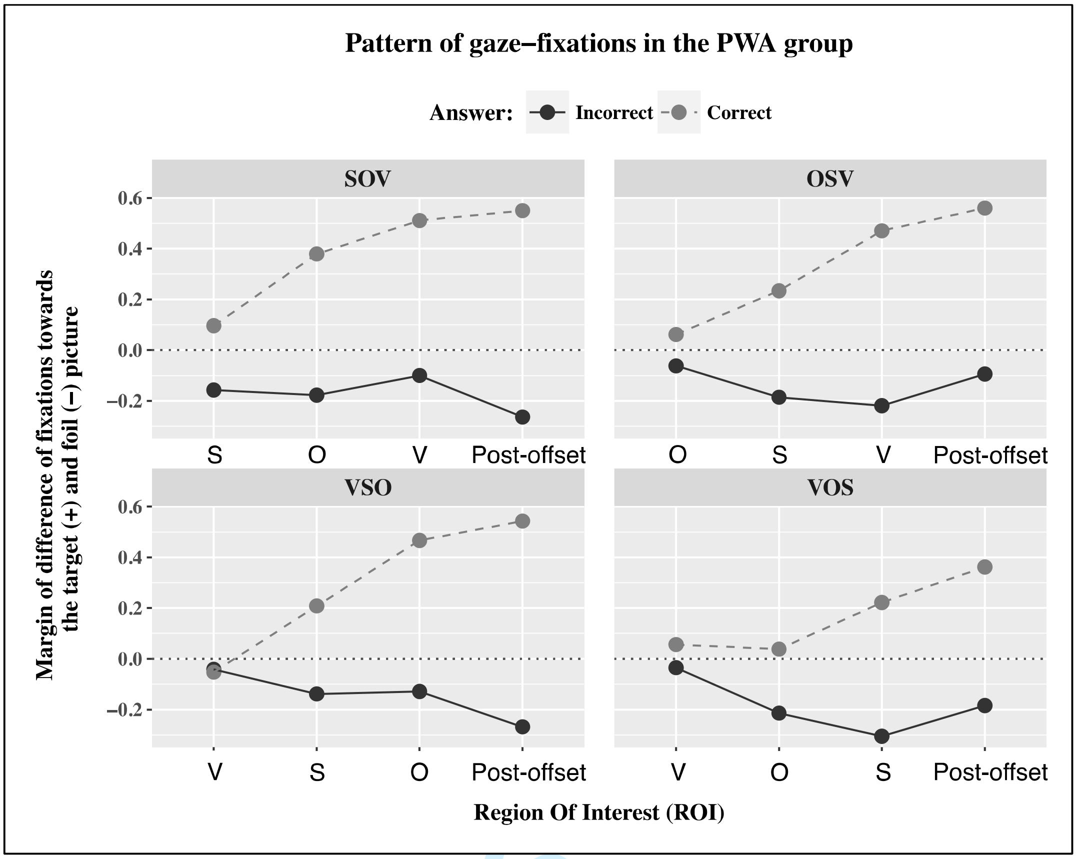

Figure 4. Gaze-fixation pattern across the visual stimuli during the auditory presentation of the sentence. Comparison between the correct and incorrect answers in the PWA group. PWA= People With Aphasia.