Neuropsychologia 65 (2014) 180–190

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Research Report

Losing track of time? Processing of time reference inflection in agrammatic and healthy speakers of German

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ARTICLE INFO

Article history:
Received 19 June 2014
Received in revised form
3 October 2014
Accepted 7 October 2014
Available online 28 October 2014

Keywords:
Visual-world paradigm
Spoken language comprehension
Time reference
Morphology
Agrammatism
Eye-tracking
Aphasia
Discourse linking

ABSTRACT

Background: Individuals with agrammatic aphasia (IWAs) have problems with grammatical decoding of tense inflection. However, these difficulties depend on the time frame that the tense refers to. Verb morphology with reference to the past is more difficult than with reference to the non-past, because a link needs to be made to the past event in discourse, as captured in the PAst DIscourse LInking Hypothesis (PADILIH; Bastiaanse, R., Bamyaci, E., Hsu, C., Lee, J., Yarbay Duman, T., Thompson, C. K., 2011. Time reference in agrammatic aphasia: A cross-linguistic study. J. Neurolinguist. 24, 652–673). With respect to reference to the (non-discourse-linked) future, data so far indicate that IWAs experience less difficulties as compared to past time reference (Bastiaanse, R., Bamyaci, E., Hsu, C., Lee, J., Yarbay Duman, T., Thompson, C. K., 2011. Time reference in agrammatic aphasia: A cross-linguistic study. J. Neurolinguist. 24, 652–673), supporting the assumptions of the PADILIH. Previous online studies of time reference in aphasia used methods such as reaction times analysis (e.g., Faroqi-Shah, Y., Dickey, M. W., 2009. On-line processing of tense and temporality in agrammatic aphasia. Brain Lang. 108, 97–111). So far, no such study used eye-tracking, even though this technique can bring additional insights (Burchert, F., Hanne, S., Vasishth, S., 2013. Sentence comprehension disorders in aphasia: the concept of chance performance revisited. Aphasiology 27, 112–125, doi:10.1080/02687038.2012.730603).
Aims: This study investigated (1) whether processing of future and past time reference inflection differs between non-brain-damaged individuals (NBDs) and IWAs, and (2) underlying mechanisms of time reference comprehension failure by IWAs.
Methods and procedures: A visual-world experiment combining sentence–picture matching and eye-tracking was administered to 12 NBDs and 6 IWAs, all native speakers of German. Participants heard German sentences with periphrastic future ('will+V') or periphrastic past ('has+V-d') verb forms while they were presented with corresponding pictures on a computer screen.
Results and discussion: NBDs scored at ceiling and significantly higher than the IWAs. IWAs had below-ceiling performance on the future condition, and both participant groups were faster to respond to the past than to the future condition. These differences are attributed to a pre-existing preference to look at a past picture, which has to be overcome. Eye movement patterns suggest that both groups interpret future time reference similarly, while IWAs show a delay relative to NBDs in interpreting past time reference inflection. The eye tracking results support the PADILIH, because processing reference to the past in discourse syntax requires additional resources and thus, is problematic and delayed for people with aphasia.

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1. Introduction

Individuals with agrammatic aphasia (IWAs) typically show tense processing difficulties (Burchert et al., 2005; Friedmann and Grodzinsky, 1997; Wenzlaff and Clahsen, 2004, interalia). Several accounts for the problems with tense inflections exist, but recently, the role of the time frame to which is referred – with

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http://dx.doi.org/10.1016/j.neuropsychologia.2014.10.026
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either tense inflection or other verb forms – has been highlighted. More specifically, verb forms that refer to the past are impaired in agrammatic aphasia, both in production and comprehension (Abuom and Bastiaanse, 2013; Bastiaanse et al., 2011). Based on an extensive data set of aphasiological production and comprehension, the PAst DIscourse LInking Hypothesis (PADILIH; Bastiaanse et al., 2011; Bastiaanse, 2013) was formulated to describe the pattern of selective impairment of past time reference. The PADILIH claims that reference to the past is discourse linked,[1] regardless of the anaphoric means[2] employed (i.e., not only through tense as suggested by Zagona (2003)). In order to refer to an event in the past, a link has to be made in discourse. The event is then processed by discourse syntax,[3] which requires more resources and is, therefore, affected in IWAs (Avrutin, 2000, 2006). Events in here-and-now do not require this link and hence, reference to this time frame is relatively spared. For future time reference, no discourse linking is needed either, because the event is not in current discourse. Instead, future time reference is derived from present time reference by modal and aspectual morphemes, as suggested by Aronson (1977), Partee (1973), and Zagona (2013).

Importantly, there is a distinction between tense and time reference. In languages such as German and English, an auxiliary in present tense in combination with a participle can be used for past time reference, the present perfect, such as *hat rasiert*: 'has shaved'. For reference to the future, an auxiliary in present tense combined with an infinitive can be used, such as *wird rasieren*: 'will shave'. The problems of IWAs with reference to the past do not only affect past tense, but all verb forms that refer to the past. Dutch IWAs, for example, made more errors in completing sentences with both types of past time reference, present perfect and simple past, than with simple present verb forms (Bos and Bastiaanse, 2014). In non-brain-damaged speakers (NBDs), electrophysiological and behavioral responses to time reference violations demonstrate differences between present and past tense processing (Dragoy et al., 2012). In a follow-up study, Bos et al. (2013) showed that these differences are, in line with the PADILIH, not related to tense, but to the time reference of the entire verb form.

Recently it has been shown that eye-tracking studies applying the visual-world paradigm (Allopenna et al., 1998; Cooper, 1974; for a review of visual world studies see Huettig et al. (2011)) can provide insights into language processing in non-brain-damaged speakers, as well as in the online and behavioral performance of aphasic individuals (Dickey et al., 2007; Dickey and Thompson, 2009; Hanne et al., 2014, 2011; Meyer et al., 2012; Mack et al., 2013; Thompson and Choy, 2009; for a review on aphasiological visual-world studies see Burchert et al. (2013)). This technique can clarify what occurs when time reference is interpreted incorrectly in agrammatic aphasia, and whether processing mechanisms differ per time frame.

The following paragraphs review the additional relevant literature on agrammatic aphasic comprehension of time reference, and describe previous eye-tracking studies on processing of time reference in NBDs. Furthermore, some of the insights into IWAs' sentence comprehension provided by eye-tracking studies will be discussed.

1.1. Aphasiological time reference comprehension studies

Several studies investigated time reference in aphasia, but only a few of them included comprehension tasks. Nanousi et al. (2006) reported results from grammaticality judgment tasks in Greek including a range of different verb forms: periphrastic future,[4] simple present, past continuous, simple past, and past perfect. IWAs made errors on all tenses. Faroqi-Shah and Dickey (2009) studied online grammaticality judgment of time reference (measuring reaction times) in agrammatic and healthy speakers of English. They did not distinguish between tense and time reference. To test future time reference, their materials included an auxiliary plus infinitive, e.g., *Next year*/*Last year*, *my sister will live in Boston*. For present time reference, they included a present tense auxiliary with an infinitive, for example, *These days*/*last month*, *my younger sister does not live in Boston*, and a lexical verb in simple present, e.g., […] *lives* […]). For past time reference they used a past tense auxiliary with an infinitive, e.g., […] *did not live* […], or a lexical verb in simple past, e.g., […] *lived* […]. Response latencies for detecting violations by verbs with future time reference and past time reference were similar and both longer than for those by verbs with present time reference. Accuracy of IWAs did not differ between time frames and was lower than accuracy of NBDs.

Grammaticality judgment data are, however, not informative with respect to the point at which processing breaks down: errors can be due to incorrect processing of the temporal adjunct, the verb, or both, since a verb–adverb *combination* is manipulated. Sentence–picture matching tasks are more revealing in that respect, because errors can be related to the time reference of the verb form alone. Furthermore, a yes-bias, often exhibited by people with aphasia, poses a problem for interpreting the data of a grammaticality judgment task but is not an issue in sentence–picture matching tasks. Jonkers and de Bruin (2009) showed that Dutch-speaking IWAs were more impaired in interpreting past tense inflection than present tense inflection. Bastiaanse et al. (2011) studied agrammatic comprehension of time reference using the sentence–picture matching task of the Test for Assessing Reference of Time (TART; Bastiaanse et al., 2008). This test includes the most frequently used verb forms for reference to the future, present, and past in three languages: English, Turkish and Chinese. The comprehension scores on future time reference were in between those on past and present; past was most difficult for agrammatic IWAs. Similar results were obtained for aphasic speakers of Catalan and Spanish (Martínez-Ferreiro and Bastiaanse, 2013). In a study involving Swahili–English agrammatic aphasic bilinguals, however, participants were selectively impaired in the past condition of the TART only (Abuom and Bastiaanse, 2013). These results suggest that for IWAs, the complexity of discourse linking leads to errors in past time reference comprehension, whereas accuracy is higher for present. However, performance on future is prone to errors, too. In conclusion, past-time reference is impaired in agrammatic production and comprehension.

1.2. Previous eye-tracking studies manipulating time reference

Several studies demonstrated that eye movements are rapidly influenced by the interpretation of visual events, in particular the time reference deducted from them. In Altmann and Kamide (2007), participants heard sentences with past or future time reference such as *the man will drink…* or *the man has drunk…*

[1] For a discourse-linked element, the syntactic representation needs to be connected to a referent (set) in discourse, beyond sentence boundaries.

[2] Anaphoric means are linguistic features used for referring to a particular referent (set). Time reference can for example be conveyed through a combination of tense, aspect and contextual information.

[3] Discourse syntax is the level of syntactic processing where discourse representations are identified.

[4] Nanousi et al. (2006) refer to the periphrastic future with the term 'simple future'.

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