Online Comprehension of Verbal Time Reference in Primary Progressive Aphasia: Evidence from Eyetracking

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Introduction

Primary progressive aphasia (PPA) is a degenerative disease affecting language while leaving other cognitive facilities relatively unscathed (Mesulam, Wieneke et al., 2012). The three major variants of the disease affect language in different ways. The agrammatic variant is associated with grammatical impairments; the logopenic variant with deficient word retrieval; and the semantic variant with impaired lexical-semantic representations. Here we investigate verbal time reference in PPA. Verbal time reference specifies the information about when an event happens/happened. For example, *drinks* and *is drinking* indicate events in the present, but *drank* and *has drunk* indicate events that happened in the past. Prior evidence from many languages suggest that reference to past events is more tightly linked to complex grammar than reference to present events, hence past reference is more difficult to comprehend and more vulnerable to impairment in people with agrammatic aphasia resulting from stroke (Bastiaanse et al., 2011). The present study examined verbal time reference in patients with PPA, with the expectation that those with the agrammatic variant would evince greater difficulty with past than present time reference, but that logopenic or semantic variants would not show this pattern due to the relative sparing of complex syntax in these PPA variants.

Methods

Participants completed a visual world eye-tracking task of sentence comprehension, which was analyzed for accuracy and eye movement patterns. The task comprised 20 action photos (e.g., *drink*), each in a past reference form ("drank" or "has drunk") or a present reference form ("drinks" or "is drinking"). Participants listened to a sentence as they viewed an array of two action photos – one with the action ongoing (present) and one with the action completed (past) and pointed to the matching picture.

Results

Results from the eye-tracking data indicate that all PPA groups fixated on the correct picture less than the healthy controls for past time reference. This pattern also was found for present time reference in the logopenic and semantic, but not the agrammatic, groups. The agrammatic group also showed delayed looks to the correct picture relative to healthy controls, but only for past time reference. These results are consistent with prior findings for agrammatic participants, and consistent with a grammatical deficit that impacts comprehension of past time reference. The results from the logopenic and semantic subgroups suggest a lexical deficit that affects verb comprehension, but not specifically comprehension of past time reference.

Conclusions

These data add to the growing body of knowledge concerning the nature of the language deficits across the three variants of PPA. Our study implicates that grammatical impairment in past time reference is an important feature for language assessment of PPA.

References
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Mesulam, M., Wieneke, C., Thompson, C., Rogalski, E., & Weintraub, S. (2012). Quantitative classification of primary progressive aphasia at early and mild impairment stages. Brain, 135(Pt 5), 1537-1553.
Thompson, C., Cho, S., Hsu, C., Wieneke, C., Rademaker, A., Weitner, B., & Weintraub S. (2012). Dissociations between fluency and agrammatism in primary progressive aphasia. Aphasiology, 26(1), 20–43.

Eye Data Analysis on Time Reference
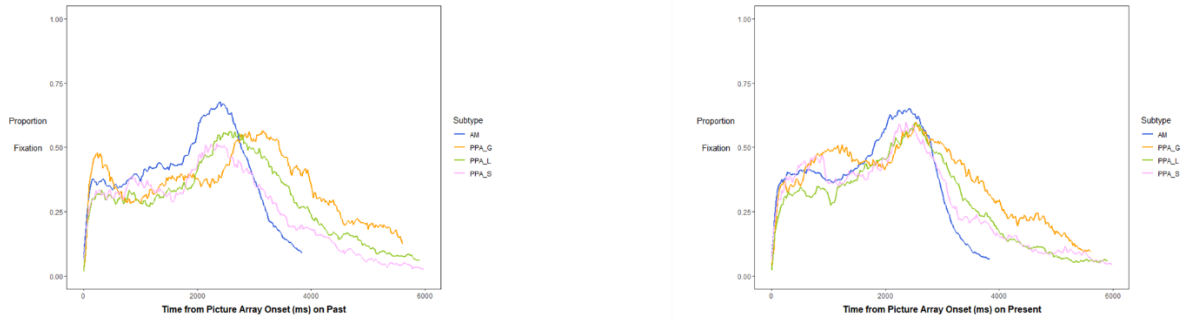
past	AM (n=19)	G (n=5)	L (n=10)	S (n=6)	AM-G: p	AM-L: p	AM-S: p
time to peak	2428 (317)	3071 (674)	2765 (531)	2284 (1170)	0.009	ns	ns
peak height	0.70 (0.11)	0.60 (0.14)	0.58 (0.10)	0.58 (0.18)	0.054	0.008	0.014
onset slope	734 (617)	1030 (952)	924 (790)	403 (353)	ns	ns	ns
offset slope	535 (216)	1001 (734)	804 (590)	799 (653)	0.019	ns	ns

present	AM (n=19)	G (n=5)	L (n=10)	S (n=6)	AM-G: p	AM-L: p	AM-S: p
time to peak	2388 (312)	2408 (760)	2665 (628)	2011 (730)	ns	ns	ns
peak height	0.70 (0.11)	0.63 (0.15)	0.61 (0.10)	0.58 (0.15)	ns	0.015	0.014
onset slope	711 (660)	1032 (1207)	1132 (927)	908 (1137)	ns	ns	ns
offset slope	510 (270)	1235 (846)	689 (284)	1033 (700)	<0.001	ns	0.006

Figure 1. Proportion of gazes over time to the target (correct picture) for past (left) and present (right) tense verbs for the age-matched control group (AM) and the three PPA groups (PPA-G, PPA-L, PPA-S). The array of pictures appeared on the screen at time 0. Mean parameter values (with standard deviation) for each group are given for past (left) and present (right) tense verbs as well. M = time to peak (ms); H = peak height (target gaze proportion); S1 = onset slope; S2 = offset slope. Note that larger values for the slope parameters correspond to shallower slopes. Parameter values that were significantly different to the AM group (*p<.05) are shaded in gray.