On-line sentence reading in people with aphasia: Evidence from eye tracking

People with aphasia (PWA) often exhibit impaired sentence comprehension. According to the Lexical Bias Hypothesis (e.g., Gahl, 2002), these comprehension impairments may emerge due to conflicts between sentence structure and the biases of the words in the sentence. It is unclear whether this hypothesis can be extended to include biases – or expectations – based on the relative frequency of different syntactic structures. For example, there is a lot of evidence that PWA have more difficulty understanding structurally complex sentences (e.g., object clefts - example 2) compared to simpler sentences (e.g., subject clefts - example 1). In this case, structural complexity reflects a variety of features, including deviation from the typical subject-verb-object word order of English. However, subject clefts also occur more frequently than object clefts. Thus, it is possible that both structural complexity and frequency affect how PWA process these sentences types.

1. Subject Cleft: It was the father that entertained **the baby** during the party last week.
2. Object Cleft: It was the baby that **the father** entertained during the party last week.

Recent work identified patterns of reading times associated with both building a complex structure and violations of syntactic expectations (Staub, 2010). Staub reported slower reading times for college-age adults for both the embedded verb and the second noun phrase in sentences with object versus subject relative clauses. Longer reading times for the verb in object relatives are typically interpreted as evidence of operations associated with building a more complex syntactic structure. However, the second noun phrase is the first point in the sentence at which the object relative structure can be detected. On this basis, Staub claimed that processing disruptions at the second noun phrase occurred because the participants' expectation for the more common structure (i.e., the subject relative) was violated. The present study asked whether PWA would show effects of complexity and frequency when reading object and subject cleft sentences, as would be expected if the Lexical Bias Hypothesis can be extended to syntactic biases.

Methods

Participants

The participants were nine PWA (4 Anomic, 4 Broca, 1 Conduction) and eight age-matched controls. PWA completed a battery of language assessments to characterize their aphasia and ensure adequate word comprehension for the task.

Stimuli

The stimuli consisted of 24 object cleft and 24 subject cleft sentences (examples 1 & 2). Sentences were constructed in pairs and varied only with respect to word order. Nouns were matched for frequency and length across sentence pairs. Each sentence was followed by a comprehension question (e.g., *Did the baby entertain the father?*).

Task

The task was eye tracking during reading, which permits a more fine-grained and ecologically valid analysis of reading performance than measures such as self-paced reading. In this task, participants read sentences on a computer screen while a camera records their eye

movements. The sentence remains on the screen during the entire trial, allowing participants to re-read portions of the sentence as needed.

Results

Reading times were analyzed in 2 (sentence type) by 2 (group) ANOVAs. Significant interactions were explored using Tukey post-hoc tests with a criterion of $p<.05$. Following Staub (2010), we analyzed reading times for the verb and the second noun phrase (underlined in examples 1 & 2). Here, we report two reading measures: go-past time and rereading time. Go-past time is the time spent reading a critical region, including fixations following regressive (leftward) eye movements. Rereading time is the time spent rereading a critical region after a progressive (rightward) eye movement out of the region. Go-past time is sometimes referred to as an "early measure," which may reflect processes associated with building an initial interpretation of the sentence. In contrast, rereading time is a "late" measure, which may reflect processes involved in reanalysis or text integration. Data are presented in Table 1.

Second Noun Phrase

Go-past time: PWA read more slowly than controls, $F(1,15)=17.3$, $p<.001$. The main effect of sentence type was significant, $F(1,15)=13.0$, $p=.003$. Similar to Staub (2010), both groups showed longer go-past times for object compared to subject clefts. This finding suggests that both groups were sensitive to the violation of the expectation for the simpler structure.

Rereading time: PWA had slower rereading times than controls, $F(1,15)=70.0$, $p<.001$. There was also a significant interaction between group and sentence type, $F(1,15)=16.0$, $p=.001$. Tukey tests showed that PWA had longer rereading times for subject clefts than object clefts. In contrast, controls had numerically longer rereading times for object clefts than subject clefts, though the difference was not significant.

Verb

Go-past time: PWA read more slowly than controls, $F(1,15)=23.65$, $p<.001$. The interaction between group and sentence was significant, $F(1,15)=10.1$, $p=.006$. As predicted, controls had numerically longer reading times for object than subject clefts, though the Tukey test was not significant. In contrast, PWA had significantly longer reading times for subject versus object clefts.

Rereading time: PWA had longer rereading times than controls, $F(1,15)=176.33$, $p<.0001$. Both groups had longer rereading times for object than subject clefts, $F(1,15)=30.6$, $p<.001$. However, the effect of sentence type was greater in PWA than controls, as shown by a significant interaction between group and sentence type, $F(1,15)=13.0$, $p=.003$.

Analysis of Broca's aphasia

Some authors have argued that people with Broca's aphasia show different patterns of comprehension than other aphasia types. Specifically, they may have more difficulty with object clefts than subject clefts (e.g., Thompson & Choy, 2009). Post hoc analysis of the present data suggested that for both critical segments, participants with Broca's aphasia showed similar patterns of reading times as the full group of PWA.

Discussion

Using eye tracking, the present study revealed subtle differences in how PWA and controls read and reread object and subject cleft sentences. The go-past reading times for the second noun phrase suggest that PWA are sensitive to disconfirmed syntactic expectations. On this basis, the Lexical Bias Hypothesis can be extended to include at least some structural frequency biases. However, the eye-tracking data also revealed differences between how PWA and controls process subject and object clefts. Surprisingly, PWA read the verb in object cleft sentences relatively quickly on the first pass through the sentence. On subsequent passes, PWA spent more time rereading the last word of the clause: the verb in object clefts and the second noun phrase in subject clefts. These rereading times may reflect more time spent in clausal wrap-up processes, which would be consistent with the idea that lexical integration is impaired in PWA (cf. Thompson & Choy, 2009).

Table 1: Reading Time Data

	People with Aphasia		Controls	
	Subject Cleft	Object Cleft	Subject Cleft	Object Cleft
Reading times for the Second Noun Phrase				
Go-past Time	640.21	813.24*	345.60	446.12*
Rereading Time	2325.45*	1841.67	309.93	426.69
Reading times for the Verb				
Go-past Time	819.86*	588.42	238.59	340.95*
Rereading Time	1473.94	2044.26*	134.52	253.93*

* Denotes a significant ($p<.05$) difference between object and subject clefts.

References

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