Comprehension of the Matrix Clause in Embedded Sentences in Agrammatic Aphasia: A Test of the Trace-Deletion Hypothesis

Despite the early belief that persons with agrammatic aphasia have intact language comprehension, research in the fields of both linguistics and speech-language pathology has documented that these individuals often have difficultly comprehending certain sentence structures in English. Such core structures include those in which the standard subject-verb-object (SVO) English word order is violated. These deficits have been specifically noted in passive sentences (e.g., The tiger (O) was chased (V) by the lion (S).), object-relative clause constructions (e.g. It was the tiger (O) that the lion (S) chased (V)), and object-cleft constructions (e.g., The tiger (O) that the lion (S) chased (V) is big.).

During the past thirty years, researchers have tried to find a theory to most parsimoniously describe these selective impairments in comprehension and their patterns in persons with agramatism. Attempts explain these comprehension deficits have mostly been within the realm of linguistic theory. To date, some of the most influential work has come from Grodzinsky (1986, 1990, 1995a) who first accounted for the above findings by presenting a theory to explain the sentence comprehension difficulties, called the Trace-Deletion Hypothesis (TDH). The TDH assumes that, in agrammatism, all traces of noun phrase (NP) movement are deleted from the surface structure representation of a sentence and, therefore, the moved NP lacks a theta role. As a result, a cognitive default strategy then assigns any NP lacking a theta role a default role according to its linear position in the sentence based on a "standard" canonical order (Grodzinsky, 1995a). This theory has faced multiple revisions (e.g., Hickok, Zurif, & Cansecogonzalez, 1993) and continues to confront challenges posed by recent published findings (Caplan, Waters, DeDe, Michaud, & Reddy, 2007; Caramazza, Capasso, Capitani, & Miceli, 2005; Caramazza, Capitani, Rey, & Berndt, 2001).

The purpose of the present study was to replicate and extend the experiment reported by Hickok and colleagues (1993) in an effort to retest their methods of evaluation of the TDH with persons diagnosed with agrammatic aphasia. Hickok and colleagues argued for a revised version of the TDH (RTDH), to explain findings based on data gathered from a single participant (Hickok, Zurif, & Cansecogonzalez, 1993).

The present study used a within-subjects design to investigate the comprehension abilities of individuals with agrammatic aphasia, using sentence types known to be problematic in this population. Prior to enrollment in the study, the participants completed formal language testing using the Boston Diagnostic Aphasia Exam (Goodglass, Kaplan, & Barresi, 2001) to confirm a profile of Broca's aphasia. Data to test comprehension was gathered over the course of three separate sessions. Two paradigms, a sentence-to-picture matching task and a truth-value judgment paradigm, were used to examine the comprehension of the matrix clause in center-embedded relatives such as; *The tiger that chased the lion is big*. These sentence structures provide a crucial test of the TDH because comprehension of the matrix clause (i.e., knowing the tiger is big and not the lion) is predicted to be unimpaired.

During the first session, participants were required to listen to a sentence read out loud and then chose the picture that best depicted the stimulus sentence (sentence-to-picture). This session contained a total of 30 items and included subject cleft, object cleft, and predicate adjective constructions. The second and third sessions required the participants to view pre-videotaped situations that were wordlessly acted out with animal figurines. Then participants listened to a sentence read aloud about the situation, and responded 'yes' or 'no' regarding

whether or not the sentence correctly described the situation seen in the preceding video (truth-value judgment). These sessions contained 52 items total and included subject cleft, object cleft, predicate adjective, control, and passive sentence types. The study recruited two individuals with agrammatic aphasia and one age and gender matched adult control participant.

The data was analyzed using one-tailed t-tests comparing participant performance to (1) control (typical) performance and (2) chance (50%) performance. An examination of hit-rate (correct acceptances of true sentences) and false-alarm (incorrect acceptances of false sentences) rate was performed to assess any differences in the pattern of responses for different sentence types during the truth-value judgment paradigm.

These analyses revealed that, contrary to the TDH, the comprehension of the matrix clause by one of the participants with Broca's aphasia was impaired, reflecting chance performance (i.e., guessing) that was significantly different from typical (control) levels of comprehension. However, the dichotomy found by Hickok and colleagues (1993) on the basis of an analysis of hit-rate versus false alarm rate was not substantiated by the results of this study. These findings call into question the validity of the reformulation of the TDH proposed by Hickok and colleagues (1993, 1995).

The second participant with aphasia did not demonstrate comprehension deficits for any of the sentence constructions tested. His performance was found to be significantly better than chance, mirroring the comprehension patterns of the control participant. These results call into question the very population on which the TDH is based. However, there are uncertainties as to whether or not these results are secondary to confounding factors related to his the second participants diagnostic profile (e.g., co-occuring apraxia, time post onset, variability in aphasia presentation) that is clinically relevant for decision making with this population. Moreover, neither participant displayed any deficit in their comprehension of passive sentence constructions, calling into question whether or not this sentence type is truly a core feature of this type of aphasia. Not only does this finding contest the findings of Hickok and colleagues and their proposed RTDH, it also provides additional evidence against the core data on which the TDH is based.

More importantly, these results add to the ever growing body of literature detailing performance patterns for individuals with aphasia, well documented in agramatic aphasia, that points to a pattern of inconsistency and variability (Kolk, 2007). This includes within individual, moment to moment variability in processing capability, between individual patterns of deficits, and the reluctance of persons with aphasia to fit neatly into categories based on diagnostic label or type and location of brain damage (Caplan, Waters, DeDe et al., 2007; Caplan, Waters, Kennedy et al., 2007; Kolk, 2007).

The results of this study have implications for the assessment and differential diagnosis of persons with Broca's aphasia, as well as family and communication partner training, and the level of complexity of syntactic stimuli and probes for treatment. These findings also add to the body of knowledge pertaining to language representation in the brain and syntactic theory within the discipline of linguistics.

Tables and Figures

Table 1: *A dichotomy in sentence level comprehension performance of persons with agramatic aphasia*

Thematic grid for "chase" = <Agent, Patient/Theme>

Sentence Type	***Examples***	***Performance***
Active	*The tiger chased the lion.*	Above chance
Subject-relative	*It was the tiger that chased the lion.*	Above chance
Subject cleft	*The tiger that chased the lion is big.*	Above chance
Passive	*The tiger was chased by the lion.*	Chance
Object-relative	*It was the tiger that the lion chased.*	Chance
Object cleft	*The tiger that the lion chased is big.*	Chance

(adapted from Hickok et al., 1993)

Table 2: *Deep structure versus surface structure*

	Deep Structure (d-structure)	*Surface Structure (s-structure)*
Active	The tiger chased the lion. [Agent] [Patient]	The tiger chased the lion. [Agent] [Patient]
Passive	The lion chased the tiger. [Agent] [Patient]	***The tiger*** was chased [***t***] by the lion. [Patient] [Agent]

Table 3: *Resulting agrammatic representation following trace deletion and default assignment*

Agrammatic Representation	*Normal Theta Representation*	*Performance*
(a) ***The man*** is [***t***] pushing the woman. [Agent] [Patient]	<Agent, Patient>	Above chance
(b) ***The woman*** is [***t***] pushed [***t***] by the man. [Agent] [Agent]	<Patient, Agent>	Chance
(c) ***The man*** is [***t***] interested in the woman. [Agent] [Patient]	<Experiencer, Patient>	Above chance
(d) ***The man*** is [***t***] hated [***t***] by the woman. [Agent] [Experiencer]	<Patient, Experiencer>	Below chance

(Grodzinsky, 1995b)

Table 4: *Structural similarities between matrix clause and simple active sentence*

Sentence Type	Syntactic structure
a. Embedded Sentence	The tiger [that chased the lion] is big.
b. Simple Active	The tiger is big.

TABLE 5: Participant comprehension performance by sentence type in sentence-to-picture matching condition

	Subject clefts (10 trials)	Object clefts (10 trials)	Predicate adjectives (10 trials)	Total (30 trials)
JO	100%	50%	60%	70%
DS	100%	100%	100%	100%
PJ (control)	100%	100%	100%	100%

TABLE 6: Participant comprehension performance by sentence type in truth-value judgement condition

	Subject clefts (10 trials)	Object clefts (10 trials)	Predicate adjectives (10 trials)	Passives (20 trials)	Total (50 trials)
JO	100%	80%	70%	100%	90%
DS	100%	90%	100%	100%	98%
PJ (control)	100%	100%	100%	100%	100%

FIGURE 1: *Examination of the hit rate versus the false alarm (adapted from Hickok et. al, 1993)*

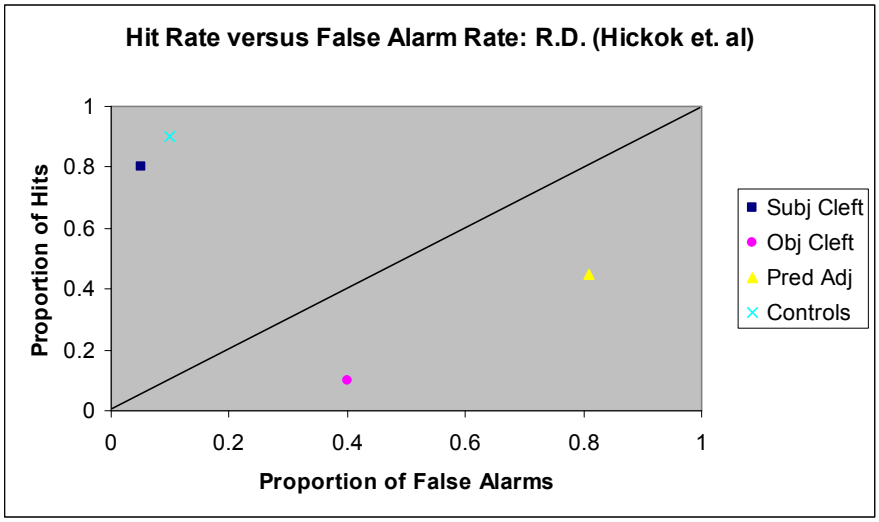

FIGURE 2: *Examination of hit rate versus the false alarm rate* for participant J.O.

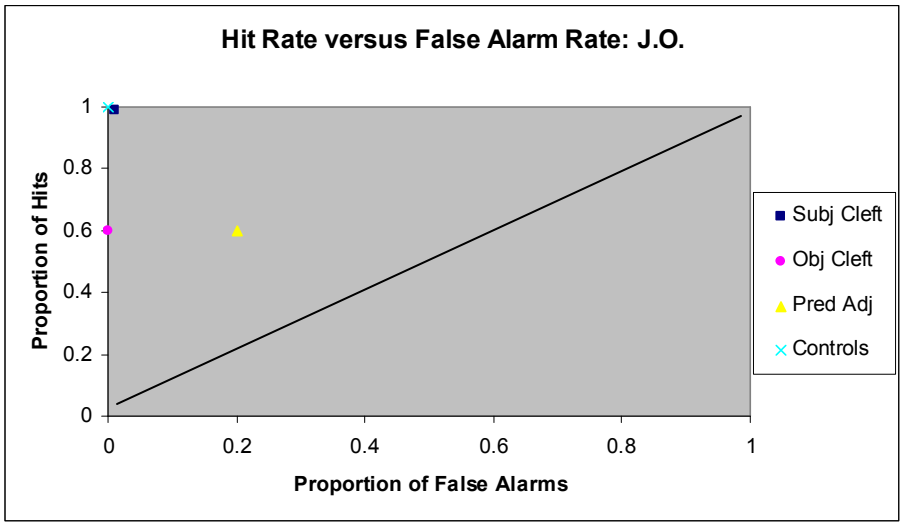

FIGURE 3: *Percentage (%) of hits versus false alarms per condition for participant J.O.*

Sentence Type	**Hits**	**False Alarms**
Object Clefts	60%	0%
Predicate Adjectives	60%	20%

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