What Explains Metacomprehension Accuracy in Adults with Aphasia?

Adults with aphasia have difficulty comprehending narratives. Main ideas are easier to comprehend than details, though implied information poses challenges as well (e.g., Nicholas & Brookshire, 1995). Knowing if something is understood or misunderstood helps guide self-control decisions, such as requesting a repetition when communication breaks down. Studies of typical and brain injured adults have established that "meta" processes, or *judging* comprehension or memory are separate from the process itself (Dunlosky, Hertzog, Kennedy, & Thiede, 2005). However, this might not be the case for adults with aphasia.

Aphasia has been characterized as both a linguistic and cognitive impairment (Chapey, 1994; Helm-Estabrooks, 2002). Impaired self-monitoring and repair production errors are well documented after aphasia (Oomen, Postma, & Kolk, 2001; Whitney & Goldstein, 1989). It has been assumed that auditory comprehension and monitoring ones comprehension reflect an internal feedback loop. However, models of self-monitoring include executive functions and may also be involved in monitoring comprehension (Stuss, 1991). Very few investigations exist of the executive functions of adults with aphasia however, because of the language load in many cognitive tasks (Purdy, Duffy & Coelho, 2002).

In smaller study, adults with aphasia were highly variable in their metacomprehension accuracy (MetaC) when listening to short narratives (Brookshire & Nicholas, 1993) and making judgments about how confident they were in their answers to questions (Kennedy & Chiou, 2005). A significant association was found between the aphasia quotient (AQ) (Western Aphasia Battery, Kertesz, 1982) and MetaC, although other associations were significant as well, such as narrative comprehension, Design fluency - switching, and Wisconsin Card Sorting Test – perseveration (WCST, Heaton, Thompson, & Gomez, 1999). This study was limited by a small number of participants, whereas the current study has sufficient numbers of participants and thus, sufficient power to thoroughly investigate the following questions: **Do both linguistic and non-linguistic factors contribute to the accuracy of metacomprehension for narratives in adults with aphasia, and if so, to what extent?** We expected linguistic and non-linguistic factors to contribute to MetaC, though the extent of each contribution was uncertain.

METHODS

Participants

Twenty adults with aphasia and four matched, healthy controls participated in this study (Table 1)[1]. Adults with aphasia had left-hemisphere strokes, were right handed, and had chronic aphasia (Table 2). All were native speakers of English and had adequate hearing and vision to participate confirmed by screenings. None had prior neurological

[1] This small sample of controls was included to show that they have ceiling (or near ceiling) and compression effects in comprehension and metacomprehension accuracy, making this kind of analysis unreliable for controls (see Table 3 for control data).

disease. Three types of aphasia were represented: Anomic, Broca's and Global. Eleven had mild, seven had moderate and two had severe aphasia.

Procedures

Eight narratives with corresponding yes/no questions from the *Discourse Comprehension Test* (DCT, Brookshire & Nicholas, 1993) served as stimuli. Questions captured salient (main idea-MI, detail-DT) and explicit (stated-S, implied-I) information from each narrative such that 2 questions captured MI-S, MI-I, DT-S, and DT-I information (8 questions per narrative). Narratives and questions were digitally pre-recorded and presented auditorially using E-prime computer software. Four randomly arranged narrative sequences were generated and presentation was balanced across participants.

Yes/no questions were asked immediately following each narrative. After the participant answered, they were instructed to provide a confidence rating about their answer by pointing along a Likert rating scale. This was elicited as follows:

How confident are you that your answer is correct?

0%	25%	50%	75%	100%

Thus, every question/answer had a corresponding confidence rating. Participants could point to the rating or state it aloud.

A battery of linguistic and non-linguistic tests was administered (see Tables 2 and 4): the WAB, WCST, and selected subtests from the *Delis-Kaplan Executive Function System* (D-KEFS, Delis, Kaplan & Kramer, 2001).

RESULTS

Comprehension and Metacomprehension

The proportion of correctly answered yes/no questions (Table 3) served as the dependent variable in a repeated measures explicitness x salience ANOVA. As expected, adults with aphasia comprehended main ideas better than details [$F(1,19)=16.89$, $p=.0006$], though comprehension of stated and implied information did not differ [$F(1,19)=1.48$, $p=.24$]. The interaction was ns. Collapsed across all kinds of information, adults with aphasia comprehended less than controls [$F(1,22)=9.01$, $p=.007$].

Goodman-Kruskal gamma (G) correlations are relative measures of MetaC, the most appropriate measure when combining Likert ratings and binary data. Gamma correlations were created for each participant by type of information (Table 3). In a repeated measures of explicitness x salience ANOVA, neither main or interaction effects approached significance for adults with aphasia. Collapsed across types of information, metacomprehension of adults with aphasia was less accurate than controls [$F(1,22)=15.19$, $p=.0008$].

Relationships between Linguistic and Non-linguistic Measures and Metacomprehension

Table 4 lists non-linguistic measures of executive function. These along with the AQ, overall DCT comprehension, and overall MetaC (G) were combined to create a correlation matrix. Pairwise correlation probabilities revealed 13 significant correlations ($p \leq .05$) (Table 5). Therefore, the data had to be reduced.

Seven measures that were significantly correlated with AQ, MetaC, or DCT comprehension were reduced using principle component analysis (PCA) with varimax rotation to three factors:

- WCST perseveration responses (-.95) and perseveration errors (-.96) loaded negatively onto factor 1 (Eigenvalue 2.13) (31% of the variance);

- Design fluency switching (.82) and set loss (.88) loaded positively onto factor 2 (Eigenvalue 1.60) (23% of the variance);

- AQ (.84), DCT comprehension (.81) and Design fluency repetition score (.70) loaded positively onto factor 3 (Eigenvalue 2.10) (30% of the variance).

Factor scores for each measure and participant were entered into a regression analysis, to identify their contribution to MetaC, i.e., the ability to judge the accuracy of yes/no questions. Entered together, the three factors (factor 1=perseveration, factor 2=switching, factor 3=aphasia/comprehension) accounted for 57% (R^2=.57) of MetaC variance and was statistically significant [$F(3,15)=6.71$, $p=.004$). The aphasia/comprehension factor accounted for 36% of the variance, whereas the non-linguistic factors of perseveration and switching together, accounted for 21% of the variance.

DISCUSSION

The primary purpose of this study was to investigate the metacomprehension of adults with aphasia by identifying the linguistic and non-linguistic components that contribute to it. Although not the primary intent of the study, it was important to establish that adults with aphasia performed differently from healthy controls; adults with aphasia comprehended less and were less accurate in judging the accuracy of their answers than controls, although the control sample was small.

Adults with aphasia are a heterogeneous group; indeed, there was a broad range of performance across linguistic and non-linguistic measures, including metacomprehension. Multiple correlations led to a reduction of the data into factors.

- Three factors emerged: perseveration (non-linguistic); switching (non-linguistic) and aphasia/comprehension (linguistic).

- As a model, these factors accounted for a significant amount of the variance of metacomprehension; the linguistic factor accounted for most of the variance, whereas the two non-linguistic factors contributed to lesser extents. Thus, metacomprehension accuracy is attributed to more than just comprehension or linguistic factors. The cognitive flexibility of switching, in the absence of perseverating, two non-linguistic factors appear to contribute as well. Seen as executive functions by many, switching and perseveration play a role in metacomprehension.

The limitations of this study include the absence of adults with Wernicke's aphasia, and the difficulty finding tasks that challenge controls in the same way that simpler tasks challenge adults with aphasia. Until then, we cannot compare these two groups or identify the processes that contribute to complex thought processes in healthy adults in the same way.

REFERENCES

Brookshire, R.H., & Nicholas, L.E. (1993). *The Discourse Comprehension Test*. Minneapolis, MN: BRK Publishers.

Chapey, R. (1994). Cognitive intervention: Stimulation of cognition, memory, convergent thinking, divergent thinking, and evaluative thinking. In R. Chapey (Ed.), *Language Intervention Strategies in Adult Aphasia, 3rd Edition,* Philadelphia: Wiliams & Wilkins.

Delis, D.C., Kaplan, E., & Kramer, J.H. (2001). *Delis-Kaplan Executive Function System.* San Antonio, Texas: The Psychological Corporation.

Dunlosky, J., Hertzog, C., Kennedy, M., & Thiede, K. (2005). The self-monitoring approach for effective learning. *Cognitive Technology, 10,* 4-11.

Heaton, R.K., Thompson, J.A., & Gomez, E. (1999). *Wisconsin Card Sorting Test: Computer version 3 for windows research edition*. Odessa, Florida: Par Psychological Assessment Resources, Inc.

Helm-Estabrooks, N. (2002). Cognition and aphasia: a discussion and a study. *Journal of Communication Disorders, 35*, 171-186.

Keil, K. & Kaszniak, A.W. (2002). Examining executive function in individuals with brain injury: A review. *Aphasiology, 16*, 305-335.

Kennedy, M. R. T. & Chiou, H.H. (2005, November). *Relationships between comprehension, self-monitoring and executive functions in aphasia adults.* ASHA Convention, San Deigo, CA. Kertesz, A. (1982). Western Aphasia Battery. New York: The Psychological Corporation.

Kertesz, A. (1982). *Western Aphasia Battery*. New York: The Psychological Corporation.

Nicholas L.E., & & Brookshire, R.H. (1995). Comprehension of spoken narrative discourse by adults with aphasia, right-hemisphere brain damage, or traumatic brain injury. *American Journal of Speech-Language Pathology, 4*, 69-81.

Oomen, C.C.E., Postma, A., & Kolk, H.H.J. (2001). Prearticulatory and postarticulatory self-monitoring in Broca's aphasia. *Cortex, 37,* 627-641.

Purdy, M. H., Duffy, R. J., & Coelho, C. A. (1994). An Investigation of the communicative use of trained symbols following multimodality training. In P. Lemme (Ed.), *Clinical Aphasiology*: *Vol.22* (pp.345-356). Austin, TX: ProEd.

Stuss, D.T. (1991). Disturbance of self-awareness after frontal system damage. In G.P.Prigatono & D.L. Schacter (Eds.), *Awareness of deficit after brain injury* (pp. 64-83). New York: Oxford University Press.

Whitney, J. L., & Goldstein, H. (1989). Using self-monitoring to reduce disfluencies in speakers with mild aphasia. *Journal of Speech & Hearing Disorders, 54,* 576-586.

Table 1. Demographics of Subjects

	Age	Gender	Years of Education
Aphasia (20)			
M	68.00	14M;6F	15.30
SD	14.82		3.16
Control (4)			
M	66.75	2M;2F	15.50
SD	8.06		1.91

Table 2. Aphasia Characteristics of Participants with Stroke.

Participant	Months post onset	Aphasia quotient	Severity of Aphasia	Type of Aphasia
1	26.00	86.50	mild	Anomic
2	289.00	61.00	mild	Broca's
3	30.00	90.80	mild	Anomic
4	141.00	58.40	mild	Broca's
5	41.00	82.70	mild	Anomic
6	67.00	91.90	mild	Anomic
7	141.00	59.80	mild	Broca's
8	12.00	16.80	severe	Global
9	40.00	19.20	severe	Global
10	102.00	77.82	moderate	Anomic
11	54.00	46.20	moderate	Broca's
12	6.00	82.80	mild	Anomic
13	8.00	34.40	moderate	Broca's
14	59.00	41.70	moderate	Broca's
15	20.00	78.60	moderate	Anomic
16	14.00	74.40	moderate	Anomic
17	51.00	67.70	mild	Broca's
18	8.00	61.00	mild	Broca's
19	61.00	74.40	moderate	Anomic
20	32.00	69.10	mild	Broca's
M	60.00	63.76		
SD	67.06	22.19		
Range	6.00 to 289.00	16.80 to 91.90		

Table 3. Comprehension (proportion correct) and metacomprehension accuracy (gamma correlations) from the Discourse Comprehension Test by group

Comprehension		Aphasia (20)	Controls (4)
MI-S			
	M	0.83	1.00
	SD	0.15	0.00
MI-I			
	M	0.76	0.95
	SD	0.14	0.05
DT-S			
	M	0.68	0.89
	SD	0.20	0.06
DT-I			
	M	0.69	0.81
	SD	0.12	0.05
Overall comprehension collapsed across types			
	M	0.74	0.91
	SD	0.11	0.02
	Range	.53 - .88	.89 - .93
Metacomprehension			
MI-S			
	N	12	0
	M	0.21	na
	SD	0.81	na
MI-I			
	N	16	3
	M	0.24	0.92
	SD	0.69	0.14
DT-S			
	N	18	2
	M	0.19	1.00
	SD	0.73	0.00
DT-I			
	N	18	3
	M	0.28	0.33
	SD	0.77	1.33
Overall metacomprehension collapsed across types			
	N	20	4
	M	0.45	0.92
	SD	0.24	0.08
	Range	-0.13 to 0.82	0.83 to 1.00

Table 4. Performance on linguistic and non-linguistic tests by adults with aphasia

Test and Measure	Aphasia performance
WCST - Errors	
N	20
M	36.65
SD	7.08
Range	20 to 53
WCST - Perseveration Reponse	
N	20
M	45.9
SD	14.82
Range	20 to 80
WCST - Perseveration Errors	
N	20
M	45.75
SD	15.32
Range	20 to 80
WCST - Nonperseveration Errors	
N	20
M	35.95
SD	11.54
Range	20 to 55
WCST - Conceptual Level Reponses	
N	20
M	38.70
SD	10.61
Range	22 to 73
Trail Making - Number/letter Switching Errors (rank)	
N	14
M	35.64
SD	30.47
Range	5 to 100
Design Fluency - Switching	
N	19
M	8.21
SD	2.53
Range	3 to 12
Design Fluency - Total correct composite	
N	19
M	7.47
SD	2.41
Range	3 to 12
Design Fluency - Total Set Loss	
N	19

M	10.84
SD	2.79
Range	1 to 13
Design Fluency - Total Repeated Responses (errors)	
N	19
M	8.47
SD	3.22
Range	3 to 18
Design Fluency - Total Attempted	
N	19
M	8.47
SD	3.22
Range	3 to 18
Design Fluency - Total Percent Accurate	
N	19
M	5.95
SD	4.48
Range	1 to 13

WCST=Wisconsin Card Sorting Test; Trail Making and Design Fluency=Delis-Kaplan Executive Function Systems (D-KEFS)

Table 5. Correlation Matrix

	Aphasia Quotient	MetaC	DCT Comprehension
Aphasia Quotient	1		
MetaC	**0.632**	1	
DCT Comprehension	**0.829**	**0.694**	1
WCST - errors	0.119	-0.185	-0.085
WCST - perseveration response	-0.336	**-0.568**	**-0.564**
WCST - perseveration errors	-0.325	**-0.550**	**-0.566**
WCST - nonperseveration errors	0.229	0.173	0.202
WCST - conceptual level responses	-0.139	-0.410	-0.307
Trail-Making - number/letter switching errors (rank)	0.091	-0.057	-0.123
Design Fluency - switching	**0.448**	**0.298**	0.293
Design Fluency - total correct composite	0.274	0.337	0.174
Design Fluency - total set loss	**0.440**	**0.341**	0.306
Design Fluency - total repeated responses (errors)	**0.459**	0.341	**0.466**
Design Fluency - total attempted	-0.253	0.007	-0.330
Design Fluency - total percent accurate	0.427	0.392	0.352

bold indicates $p \leq 0.05$

WCST = Wisconsin Card Sorting Test
Trail-Making and Design Fluency = Delis-Kaplan Executive Function Systems (D-KEFS)