Impact of distraction and memory on grammaticality judgment in a patient with aphasia.

Background

Aphasia has recently been described as a cognitive processing deficit attributed to resource allocation or restriction, rather than a deficit in linguistic structure itself (Haarman, Just & Carpenter, 1997; Murray, Holland & Beeson, 1997a, 1997b; Hula & McNeil, 2008). Models of cognitive and linguistic processing differ in their degree of "oversight" of specific linguistic functions. Some models assume an overall executive which allocates resources all tasks (Just & Carpenter, 1992) or to linguistic domains (Baddeley, 2003). Other models assume processing capacities that are related to not only specific linguistic functions but also to experience (MacDonald & Christianson, 2002) or to the influence of individual difference in executive functioning (Engle, 2002). Regardless, exceeding processing capacity or misallocation of resources leads to breakdown in performance. Processing deficits may manifest themselves as reductions in speed and/or accuracy in completion of various linguistic and nonlinguistic tasks. While models are developed to provide theoretical explanations for observed linguistic behavior on a more global scale, examination of isolated patients can be helpful in attempting to address the applicability of a particular model to a pattern of behavior. Sentence processing is one dimension of linguistic performance that can be examined.

Grammaticality judgment is a metalinguistic task, and it is one method of examining sentence processing. Many patients with aphasia are able to judge grammaticality of sentences that they are unable to comprehend, suggesting that there are several levels of processing involved in interpreting sentences (Linebarger, Schwartz & Saffran, 1983; Wulfeck, 1988; Wilson & Saygin, 2004). Therefore, theories describing aphasia as a processing deficit can explain patients' generally better metalinguistic skills than can theories suggesting linguistic structural deficits (Hula & McNeil, 2008). Processing models of aphasia would suggest that cognitive variables such as attention and short term memory might differentially influence speed and/or accuracy of grammaticality judgment in patients with aphasia.

Auditory distraction is one means of varying attentional requirements. Factors affecting normal subjects' abilities to complete cognitive linguistic tasks in the face of various types of distraction have been a subject of ongoing study (Jones, 1999; Goff et al., 2006). Prior study of auditory grammaticality judgment by persons with aphasia showed disruptions in both aphasic and normal controls in a dual-task environment (Murray et al, 1997a). Cross-modality interference effects differ from those in a single modality, at least in part assuring that disruptions cannot be attributed to a sensory deficit (Tun & Wingfield, 2002). The purpose of this study was to compare the effects of auditory distraction on speed of grammaticality judgment of visually presented sentences varied by reversibility and short term memory requirements. The task was performed by a patient with aphasia and results compared to data for normal older adults.

Method

Development of stimuli: Consider the following sentence pair (nonreversible, SAD):

The electrician is fixing the radio
*The electrician is fix the radio.

In order to increase short term memory demands, extraneous words (6-8 total syllables) were placed outside the grammatical constraint; that is, outside the words which could theoretically constitute an error (Baum, 1989). Extra words (6-8 syllables) were similarly placed between the constraint and the error (or potential error) (the outside condition), as follows.

In his fancy repair shop, the electrician is fixing the radio. (outside, good)
The electrician is *quickly and effectively* fixing the radio.. (inside, good)

* *In his fancy repair shop*, the electrician is fixing the radio. (outside, bad)
* The electrician is *quickly and effectively* fixing the radio. (inside, bad)

Sets of reversible sentences were also constructed:

The tiger is hunting the lion.
The tiger is *confidently and gracefully* hunting the lion.
In the middle of the jungle, the lion was hunted by the tiger.
*The tiger is hunt the lion.
*The tiger is *confidently and gracefully* hunt the lion.
**In the middle of the jungle*, the tiger is hunt the lion.

The grammatical structure of the padding does differ in the inside and outside conditions; a self-paced reading task in normal younger and older participants showed no difference in reading speed for the two types of padding.

For each base sentence, then, four stimulus sentences were constructed, half grammatical, half ungrammatical; half with padding inside the grammatical constraint and half with padding outside the constraint, for a total of 60 sentences. Sixty similarly constructed passive voice sentences were included, for a total of 120 items. Thirty distractor items were included.

Participants: Participants included a patient with aphasia (see Table 1; background testing is incomplete), and fifteen subjects over the age of 60. All control participants reported normal or corrected hearing, passed a computerized reading screening prior to the experiment and were judged within normal limits on the MMSE.

Task: Participants were asked to silently read sentences presented on a computer screen and indicate as quickly as possible if each sentence was good (grammatical, permissible in English) or bad (ungrammatical, not permissible in English) by pressing a key on the keypad. Participants completed the task in quiet (no distraction) or in one of two types of auditory distraction (cafeteria noise or narrative [Anne of Green Gables, downloaded from Gutenberg.org).

Apparatus: Participants completed the experiment on either a Gateway or a Dell computer running Windows XP using SuperLab experimental software. Sentences were presented in black font on a white background and were randomized for presentation with a break given after every 40 presentations. Distraction was presented via iTunes using ancillary speakers at an intensity of approximately 70dB measured with a sound level meter. Reaction times (RTs) were measured by SuperLab.

Preliminary Results

Correct and incorrect responses were analyzed for reaction time and compared using chi-square analyses. Outliers were replaced with the value of two standard deviations from the mean. The PWA made more proportionally more errors than the normal controls, and had longer RTs for the incorrect responses (Table 2).

Correct responses were further analyzed using an analysis of variance using SPSS. RTs by the PWA were slowed in distraction, unlike the pattern in the normal older controls. The PWA also had slower RTs in the Inside condition, whereas the normal controls had no difference in RT in either of the padding (inside, outside) conditions. Both groups had slowed RTs in the Reversible condition, but far more so for the PWA.

RTs for the PWA were particularly slowed in the Talk distraction in the Inside condition, as well as in the Talk distraction for Bad sentences. Of note is that there was little difference in relative RTs for active vs. passive sentences. For the PWA, distraction, particularly the Talk distraction, prolonged processing in conditions where memory was further taxed (inside condition) or in ungrammatical (Bad) sentences. This differs from the response to distraction by normal controls, where distraction somewhat speeded processing (hypothesized by improved attention to the GJ task). A set of preliminary figures are attached. Further analysis and discussion of the PWA's performance related to cognitive models of aphasia are in process as further background testing is conducted.

References

Baddeley, A.D. (2003). Working memory*:* Looking back and looking forward. *Nature Reviews Neuroscience*,4, 829-839.

Baum, S (1989) On-line sensitivity to local and long-distance syntactic dependencies in Broca's aphasia. *Brain and Language*, 37 (2), 327-38;

Caramazza A, & Zurif, E (1976) Dissociation of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. *Brain and Language*, 3, 572-582.

Engle, R.W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, 11:1, 19-23.

Goff R, LaPointe L, Hancock A, Stierwalt J, Heald G (2006) *Quality and intensity of cognitive distraction: cafeteria noise and babble in younger vs. older adults*. Annual convention of the American Speech-Language-Hearing Association, Boston, MA.

Haarmann, H. J., Just, M. A., & Carpenter, P. A. (1997). Aphasic sentence comprehension as a resource deficit: A computational approach. *Brain and Language, 59,* 76-120.

Hula, W.D. & McNeil, M.R. (2008). Models of attention and dual-task performance as explanatory constructs in aphasia. *Seminars in Speech and Language*, Aug;29(3):169-87.

Jones, D. (1999) The cognitive psychology of auditory distraction: The 1997 BPS Broadbent Lecture. *British Journal of Psychology*. 90:2, 167-187.

Just M, Carpenter P. (1992) A capacity theory of comprehension: individual differences in working memory. *Psychological Review*, 99:122–149.

Linebarger M.C., Schwartz M.F., & Saffran E.M. (1983) Sensitivity to grammatical structure in so-called agrammatic aphasics. *Cognition*, 13:361-92.

Murray, L. L., Holland, A. L., & Beeson, P. M. (1997a). Grammaticality judgments of mildly aphasic individuals under dual-task conditions. *Aphasiology, 11*, 993-1016.

Murray, L. L., Holland, A. L., & Beeson, P. M. (1997b). Auditory processing in individuals with mild aphasia: A study of resource allocation. Journal of Speech, Language, and Hearing Research, 40, 792-809.

Swinburn, K; Porter, G. & Howard, D (2004) *Comprehensive Aphasia Test*. Psychology Press.

Tun, P. A., O'Kane, G., & Wingfield, A. (2002). Distraction by competing speech in younger and older listeners. *Psychology and Aging*, 17, 453–467.

Wilson, S. M. & Saygın, A. P. (2004). Grammaticality judgment in aphasia: Deficits are not specific to syntactic structures, aphasic syndromes, or lesion sites. *Journal of Cognitive Neuroscience* 16, 2 (Mar. 2004), 238-252.

Wulfeck, B (1988). Grammaticality judgments and sentence comprehension in agrammatic aphasia. *Journal of Speech and Hearing Research*, 31, 72-81.

Table 1. PWA Background Information

Age: 62	Onset: 11/01	Lesion: L temporal/parietal	Gender: F
Hemiparesis: None		Education: HS graduate	
Documented visual disturbance: None		Occupation: Homemaker	
Pure tone average		(R/L) 10/10	
Speech reception threshold		(R/L) 15/10	
Picture description example: "The little boy is watching the cat; he's doing something with the fish. He's gonna eat that fish. There's a lot of radio stereo equipment. There's a plant of the shelf up there. That's a newspaper. There too on the table."			
Comprehensive Aphasia Test – Subtests and T scores[1]			
Memory		62	
Comprehension of Spoken Language		47	
Comprehension of Written Language		59	
Repetition		59	
Naming		50	
Spoken picture description		75	
Oral reading		61	
Writing		57	
Written picture description		75	
Auditory Comprehension			
Words		49	
Sentences		48	
Paragraphs		60	
Reading Comprehension			
Words		53	
Sentences		60	
Proportion of reversible sentences correct (CAT)			
Auditory		.2	
Reading		.7	
Proportion of nonreversible sentence correct (CAT)			
Auditory		1	
Reading		1	
GJ on *Philadelphia Comprehension Battery* (PCB) – A' = .85 to .95			
Lexical tasks: Proportion correct			
Boston Naming Test		.92	
Peabody Picture Vocabulary Test		.91	
CAT – Auditory Word Comprehension		.8	
CAT – Reading Word Comprehension		.9	
Synonymy Triplets (PCB)		1.0	

[1](M = 50; SD = 10); T-score of 60 = 68th percentile; T-score of 70 = 96th percentile.
[2]Pt exhibits an auditory syntactic deficit evidenced by significant difference between auditory and written sentence comprehension scores on the CAT (Z = 12/5.23 = 2.29) (Swinburn et al., 2004; p. 71, 113).

Table 2. Error analysis for PWA; *denotes p<.05

Variable		Proportion of Error Responses	X^2
Distraction	Quiet	.08	3.519; p = .172
	Noise	.14	
	Talk	.08	
*Sentence	SAD	.15	6.993; p = .008
	Passive	.06	
Grammaticality	Bad	.09	.124; p = .724
	Good	.10	
Reversibility	Reversible	.12	2.303; p = .158
	Nonreversible	.07	
*Padding	Inside	.14	8.061; p = .018
	Outside	.003	
	None	.11	

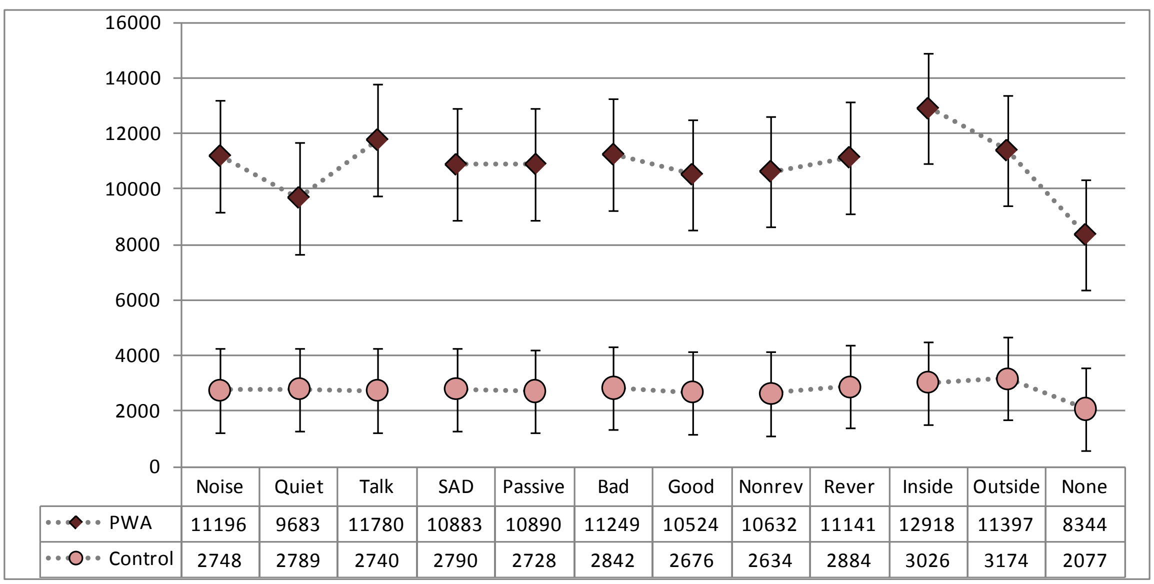
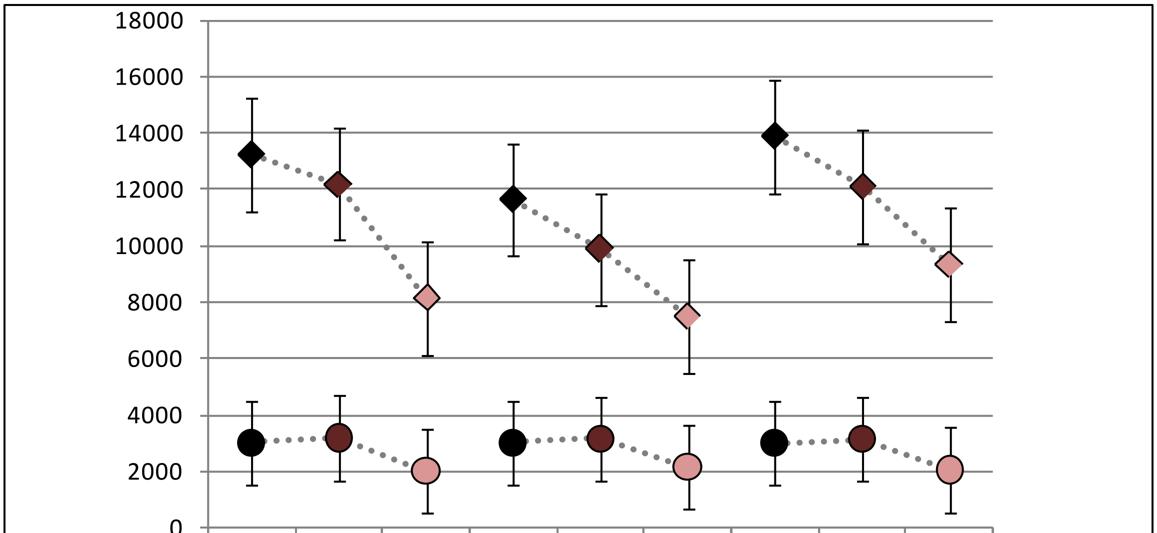
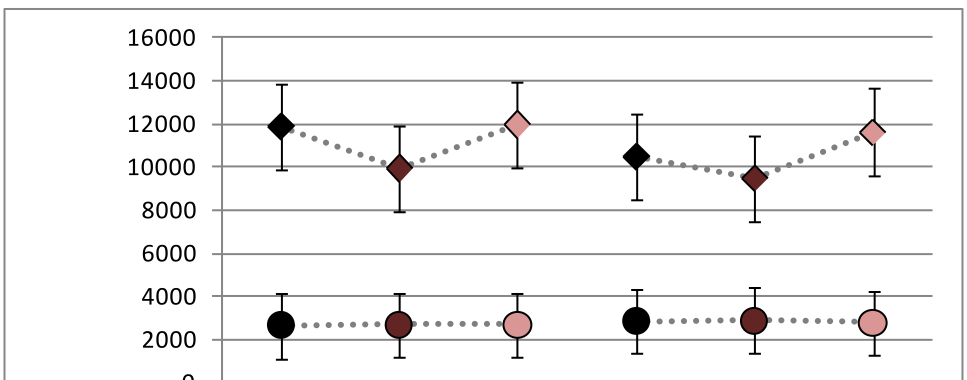


Fig 1. Interaction effects:
Group x Distraction, Sentence, Grammaticality, Reversibility and Padding.



	Noise			Quiet			Talk		
	Inside	Out	None	Inside	Out	None	Inside	Out	None
PWA	13227	12205	8157	11641	9882	7525	13887	12102	9351
Control	3036	3198	2010	3033	3174	2160	3009	3149	2062

Fig. 2: Group x Padding x Distraction



	Bad			Good		
	Noise	Quiet	Talk	Noise	Quiet	Talk
PWA	11899	9913	11934	10493	9453	11626
Control	2649	2686	2692	2848	2892	2788

Fig. 3: Group x Distraction x Grammaticality

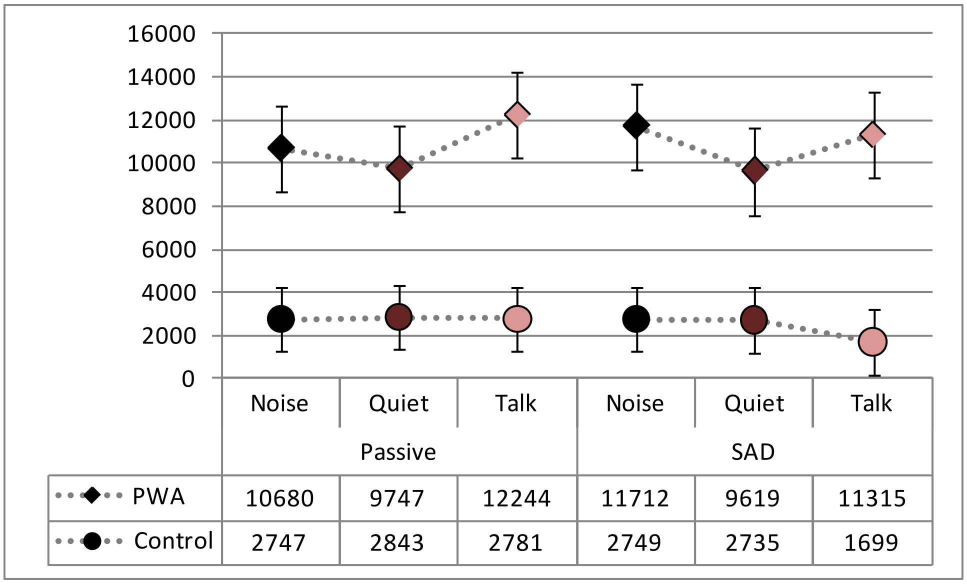


Fig 4. Group x Distraction x Sentence

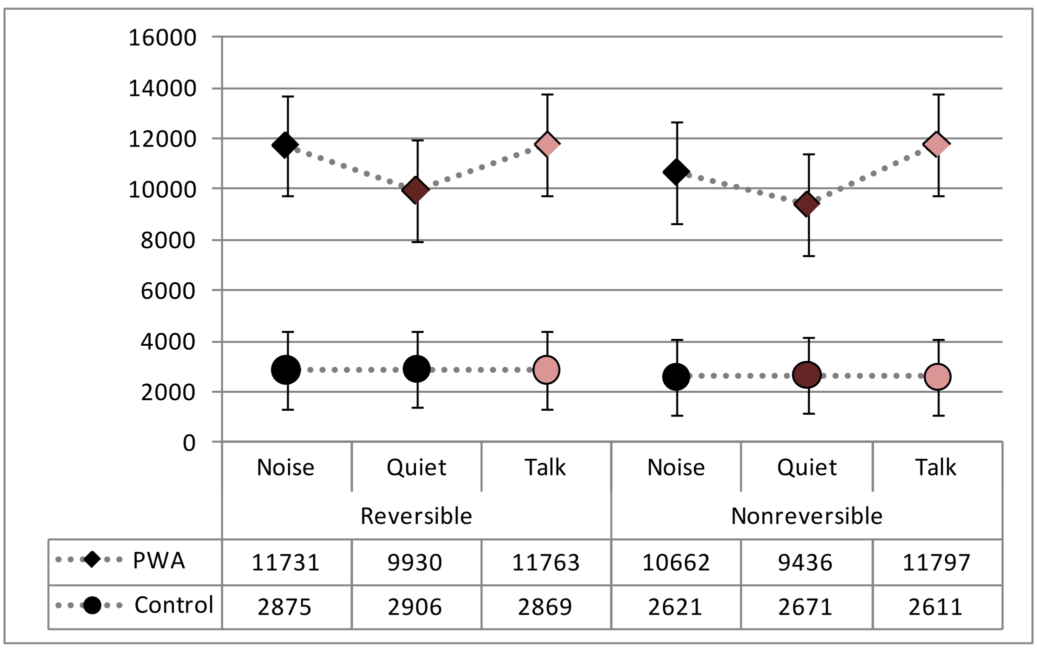


Fig. 5. Group x Distraction x Reversibility

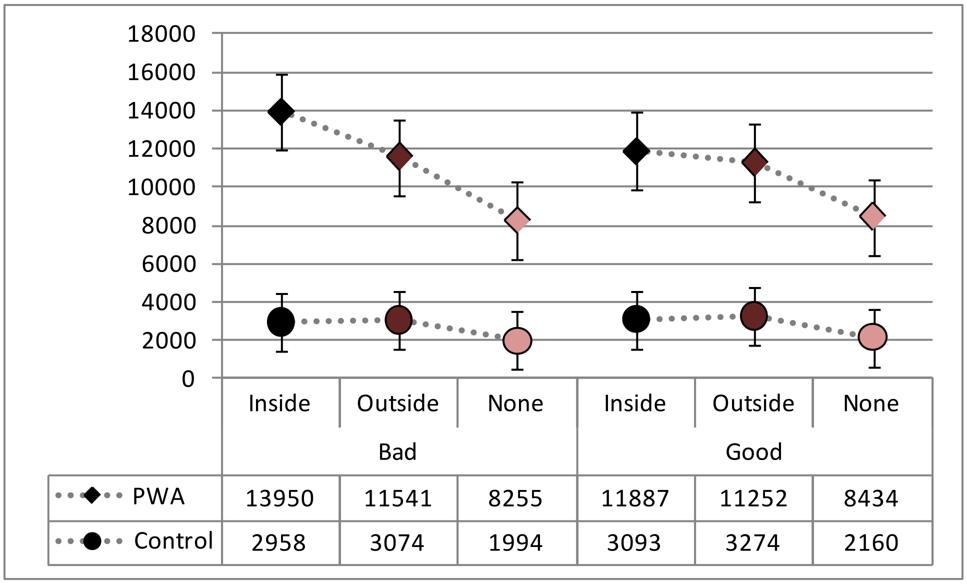


Fig 6. Group x Padding x Grammaticality

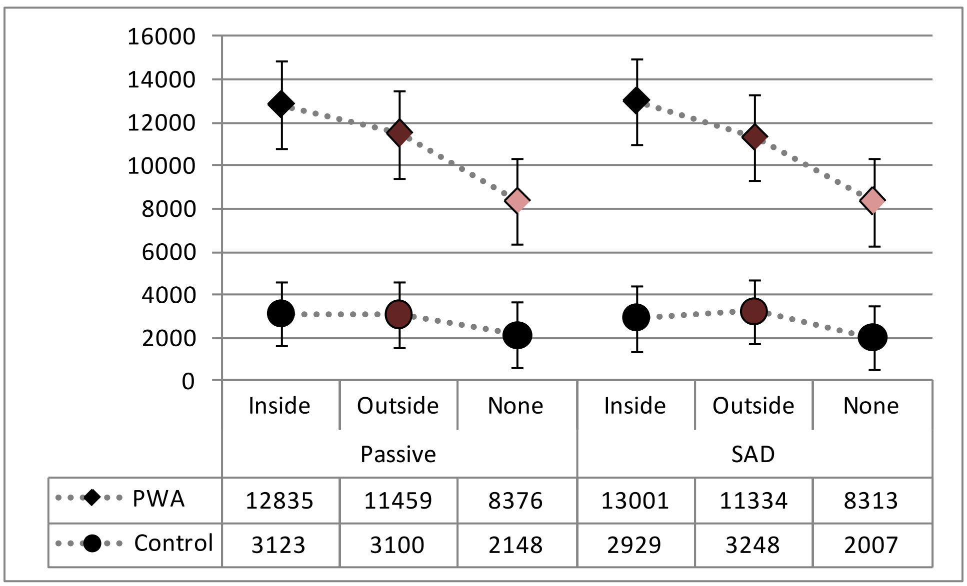
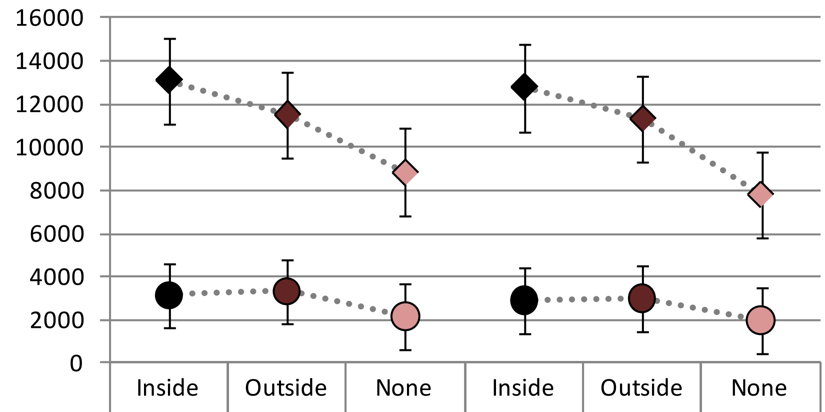


Fig. 7. Group x Padding x Sentence



	Reversible			Nonreversible		
	Inside	Outside	None	Inside	Outside	None
PWA	13079	11479	8867	12757	11314	7823
Control	3144	3342	2165	2908	3006	1989

Fig 8. Group x Padding x Reversibility