

Introduction: The cognitive skill of attention has previously been found to be impaired in persons with aphasia (PWA) relative to control participants (e.g., Murray, 2012). However, no study to date has examined the degree to which attention fluctuates from day to day in PWA, despite the fact that other neurologically impaired populations, such as Alzheimer's and Parkinson's patients, have been found to exhibit a greater degree of day-to-day variability in attention than controls (Burton, Strauss, Hultsch, Moll, & Hunter, 2006). We suggest that day-to-day *intra-individual* variability (DTD-IIV) in attention is an important area of investigation in aphasia, and furthermore that *inter-individual* differences in DTD-IIV in attention may be critical in reliably predicting treatment outcomes. The expectation that an individual will improve her skills over time as a function of treatment is based on the assumption that she is able to pay attention consistently *during each session*. If an individual is in fact able to attend consistently each day, this assumption is fair; however, if her attention fluctuates from day to day, it seems unlikely that she will show rapid or steady improvement. With this in mind, the goal of this study was to systematically assess five types of non-linguistic attention in both PWA and control participants, using a novel computerized task and repeated sampling design. Analyses examined reaction times as well as DTD-IIV.

Methods: Eighteen persons with aphasia (PWA) all presenting with chronic aphasia (mean age 60.3, age range 47-74; various aphasia types/severity), as well as five age-matched neurologically unimpaired control participants, completed a novel experimental non-linguistic attention task four different times, on four different days. The task contained five conditions, for a total of 20 conditions administered to each participant. Each condition lasted approximately four minutes and involved non-linguistic visual stimuli (single black dots on either the left or right side of the screen) and/or non-linguistic auditory stimuli (simple tones presented through headphones in either the left or right ear). During each condition, participants were instructed to attend to a series of target stimuli, each following a fixation, and press one of three buttons depending on whether the target was on the left, on the right, or absent. The five conditions were designed to differ minimally from one another so that performance could be directly compared from one condition to another.

- Condition 1: Sustained visual attention (only visual stimuli present)
- Condition 2: Sustained auditory attention (only auditory stimuli present)
- Condition 3: Selective visual attention (visual & auditory stimuli both present, but participant told to respond only to visual stimuli)
- Condition 4: Selective auditory attention (visual & auditory stimuli both present, but participant told to respond only to auditory stimuli)
- Condition 5: Auditory/visual integrational attention (visual & auditory stimuli both present; participant told to respond to "sameness", i.e. indicate whether the two stimuli are both on the left, both on the right, or on different sides from each other)

Sustained attention (Conditions 1 and 2) is generally thought to be simpler than selective attention (Conditions 3 and 4). Auditory/visual integrational attention (Condition 5) has not previously been identified as a type of attention. The order of administration of Conditions 1 and 2 was counterbalanced across participants, as was the order of administration of Conditions 3 and 4.

Results: Accuracy on the experimental task was generally high for both PWA and controls. Two sets of analyses were performed, one examining reaction times (RT) for each condition, and the

other examining DTD-IIV in RTs across the four administrations of each condition, using the coefficient of variation (COV, or standard deviation over the mean; a higher COV indicates a higher degree of day-to-day variability).

Set 1: First, reaction times (RTs) were transformed into z-scores for each PWA, and a 1x5 ANOVA examining the effect of Condition on RT z-scores for Time 1 was performed; similar ANOVAs were also performed for Times 2, 3, and 4 (see Figure 1). In each instance a significant main effect of Condition was observed (e.g., for Time 1, $F(4,90) = 57$, $p < .001$). Post-hoc Tukey analyses also revealed two interesting trends. First, a clear complexity effect emerged, such that RTs were significantly slower ($p < .01$) for each *selective* attention condition than for its corresponding *sustained* attention condition (i.e., slower on Condition 3 than Condition 1 and on Condition 4 than Condition 2). Additionally, a modality effect emerged, such that RTs were significantly slower ($p < .05$) for each *auditory* attention condition than for its corresponding *visual* attention condition (i.e., slower on Condition 2 than Condition 1 and on Condition 4 than Condition 3). Interestingly, RTs for Condition 4 and Condition 5 were generally comparable.

A corresponding set of 1x5 ANOVAs was also performed to examine the effect of Condition on RT z-scores for the control group (see Figure 1). Each of these four ANOVAs showed a significant main effect of Condition (e.g., for Time 1, $F(4,25) = 23$, $p < .001$). Post-hoc Tukey analyses revealed few robust trends for this group, likely because of the smaller sample size and resulting lower statistical power.

Set 2: Next, in order to examine DTD-IIV, a COV was calculated for each participant and each condition. A 1x5 ANOVA revealed a main effect of Condition across PWA ($F(4,90) = 4.02$, $p < .01$, see Figure 2). A Tukey post-hoc analysis for this group showed that COVs were significantly lower for Condition 1 than Condition 4 ($p < .05$); similarly, COVs were significantly lower for Condition 1 than Condition 5 ($p < .01$). A similar 1x5 ANOVA for control participants, however, showed no such complexity effect.

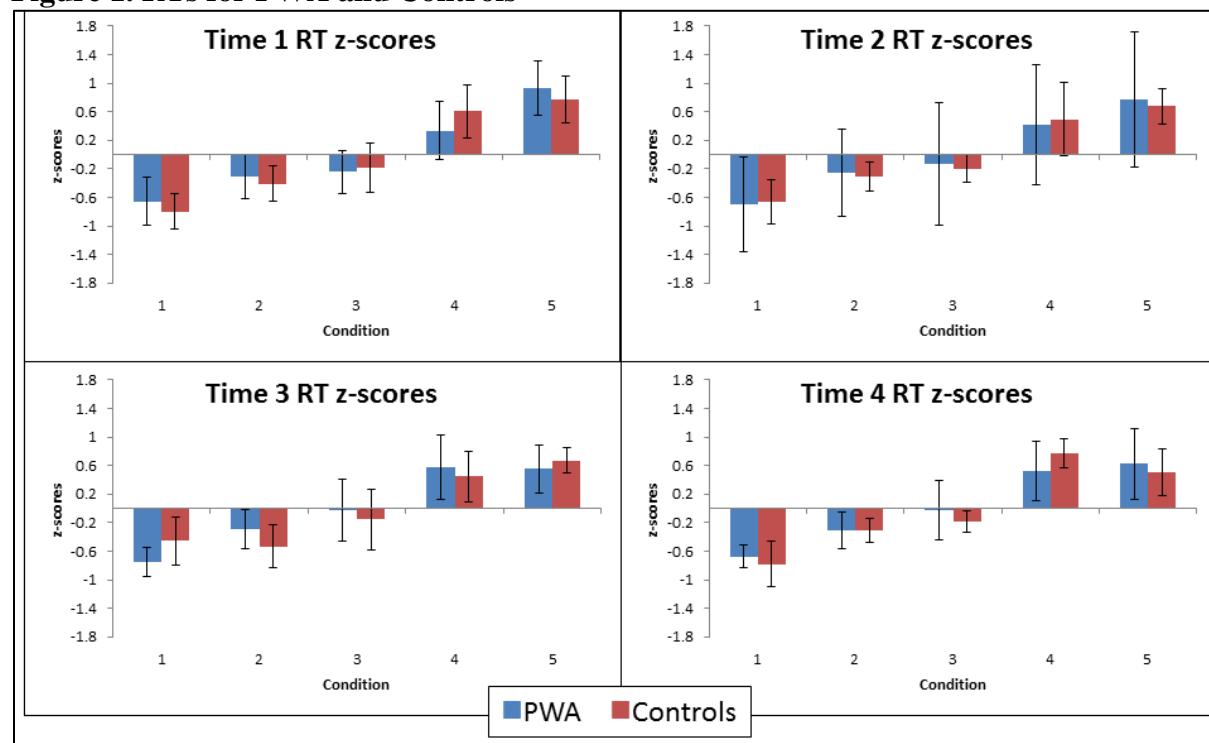
Interestingly, in addition to the across-PWA trends, inter-individual differences were also evident, such that some PWA showed high COVs relative to controls on several conditions, while others exhibited control-like COVs across all conditions. Neither age nor aphasia severity (as assessed by the Western Aphasia Battery, Kertesz, 1982) were correlated with COV for any condition.

Discussion: Based on these results, it appears that when non-linguistic attentional demands are higher, PWA exhibit not only slower RTs, but also increased DTD-IIV in RT. Conditions 4 and 5 in particular – which require participants to attend to auditory stimuli in the face of a visual distractor, and to integrate auditory and visual stimuli together, respectively – elicited not only slow reaction times, but also a high degree of DTD-IIV. This finding suggests that when PWA are asked to attend simultaneously to visual and auditory stimuli – as is often the case during a therapy session – they may have difficulty maintaining consistent attentional levels from day to day. Additionally, there seems to be inter-individual variability in performance even within the PWA group; we hypothesize that inter-individual differences in DTD-IIV in attention could help account for inter-individual differences in response to treatment. Future research should investigate the nature of the association between treatment gains and DTD-IIV in attention.

References

- Murray, L. L. (2012). Attention and other cognitive deficits in aphasia: Presence and relation to language and communication measures. *American Journal of Speech-Language Pathology*, 21(2), S51.
- Burton, C. L., Strauss, E., Hultsch, D. F., Moll, A., & Hunter, M. A. (2006). Intraindividual variability as a marker of neurological dysfunction: A comparison of Alzheimer's disease and Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology*, 28(1), 67-83.

Figure 1. RTs for PWA and Controls



The four portions of this figure illustrate eight ANOVAs (four for PWA, four for controls) examining the effect of Condition on RT z-scores within given administrations (“Times”) of the experimental task. For PWA, Tukey post-hoc analyses revealed significant differences between Conditions 1 and 2 ($p < .05$), Conditions 3 and 4 ($p < .001$), Conditions 1 and 3 ($p < .01$), and Conditions 2 and 4 ($p < .001$).

Figure 2. COVs for PWA by Condition

