Executive Attention deficits in aphasia: case studies

Many features of language impairments in people with aphasia (PWA) suggest that they have problems with executive functions that control language use (Hula and McNeil, 2008). An outstanding question is the extent to which the executive functions affected in PWA apply in other cognitive domains (Murray, 2012) or are specific to language (Jefferies and Lambon Ralph, 2006; Hoffman et al., 2013). The Executive Attention model (Engle and Kane, 2004) provides a framework for examining this question. It claims the central executive consists of two interacting components: task maintenance, the ability to use task goals to exert proactive control that reduces interference, and conflict resolution, the ability to resolve conflicts generated by interference during goal-directed processing.

It is proposed that task maintenance is a domain-general capacity, and that conflict resolution is at least partially encapsulated, with specialized functions responsible for modality-specific interference. Therefore, PWA with task maintenance deficits should be affected in all cognitive areas, whereas PWA with conflict resolution impairments should be affected only in language functions, where they should show increased interference effects even in contexts of minimal task maintenance demand. Hypotheses were tested in two case studies.

Methods

PWA: PWA1 is a 70 year-old, high-school educated male with moderate-to-severe fluent aphasia. PWA2 is a 49 year-old, college educated male with moderate-to-severe nonfluent aphasia. Both experienced aphasia following LCVA in 2010 (see table 1 for testing).

Control Subjects: Tasks were given to 8 young controls (YC) ages 18-25 (average education: 15 years). Given age/education differences, 2 matched controls (MC) were also tested on all tasks.

Experimental Tasks:

Four measures of executive attention were administered. Two tasks— Word-Picture Interference (WPI) and Semantic Sustained Attention to Response Task (SSART)— were semantic, while two— Spatial Stroop (SpStroop) and Perceptual Sustained Attention to Response Task (PSART)— were nonverbal. In the WPI and SpStroop tasks, interference effects were based on stimulus-internal properties, while in the SART tasks they were based on inhibiting habituated motor response. All responses were via key press.

Word-Picture Interference (WPI). Based on Lim (2011). This task required participants to classify written words (animal vs. non-animal) embedded in a picture (congruent, neutral, or interfering). In the high executive attention demand condition (High-EA), incongruent stimuli were 24% of trials, neutral 24%, and congruent 52%. In the low executive attention demand condition (Low-EA), incongruent stimuli were 76% of trials and neutral 24%. Task maintenance was measured by RT/accuracy differences on incongruent trials in Low-EA vs. High-EA. Conflict resolution was measured by comparing incongruent vs. neutral trials in Low-EA.

Semantic Sustained Attention to Response Task (SSART). Based on McVay and Kane (2012). This task required participants to respond to visually presented words in a go/no-go design. Animals were presented on 89% of trials, and foods on 11%. In the Low-EA condition, a key press was required only for the infrequent category, while in the High-EA condition it was required only for the frequent category. Stimuli were presented quickly (300ms), with a total response window of 1200ms. Task maintenance was measured by comparing infrequent category accuracy in Low-EA vs. High-EA contexts.

Spatial Stroop (SpStroop). Based on Hamilton & Martin (2005). This task required participants to determine whether an arrow was pointing left or right while presented in a neutral, congruent, or incongruent location on the screen. It was otherwise identical to WPI.

Perceptual Sustained Attention to Response Task (PSART). Based on Smallwood et al. (2006) This task required participants to respond to letter strings, with frequent ‘O’ strings and infrequent ‘X’ strings. It was otherwise identical to SSART.

Results

YCs had decreased accuracy and increased RT in the High-EA conditions for all tasks (p’s < .05). MCs’ performances were within YC range (Crawford and Howell, 1998) except for longer SpStroop RTs in the High-EA condition in MC2.

PWA were compared individually against the YC group (Tables 2 and 3).

PWA1 was in normal range on SpStroop for accuracy, but impaired for all measures of RT. He was also impaired in all conditions of PSART, with the exception of the High-EA infrequent category condition. He was in normal range on WPI for accuracy, but impaired for all measures of RT. He was unable to complete the SSART.

PWA2 was in normal accuracy range for PSART, SpStroop, and WPI. He showed abnormally long RTs for incongruent trials in both SpStroop and WPI on the High-EA but not Low-EA conditions. He responded to only 1.5% of trials in Low-EA version and to 40% of trials in the High-EA version of the SSART.

Discussion

In most tasks, PWA1 was equally impaired on Low-EA and High-EA conditions, and therefore did not demonstrate the predicted amodal task maintenance deficit. Although this could be interpreted as a basic conflict resolution deficit in multiple domains, a simpler explanation is that PWA1 has significant psychomotor slowing, as evidenced by his PSART performance and very high RTs.

PWA2’s better performance in the High-EA compared to Low-EA conditions of SpStroop and WPI is evidence for an amodal task maintenance deficit. His clear understanding of the instructions in the SSART, his ability to perform the task “off-line” during training and his normal PSART performance point to delayed lexical access, not general psychomotor slowing, as the reason for his inability to perform the SSART.

These results provide preliminary support for the presence of amodal executive attention deficits in task maintenance, but not for domain-specific deficits in conflict resolution, in PWA. Additional case and group studies are needed to see if other deficits predicted by the Executive Attention model exist in PWA, and whether current predictions about the domain specificity of such deficits are correct.

Table 1. Test scores.

	CCT	PALPA 48: Written WPM	PNT-short(A)	CLQT: composite severity
PWA1	33/64	17/40	10/30	2.6/4
PWA2	38/64	21/40	2/30	1.6/4

Table 2. SART Accuracy

Condition	YC Mean(SD)	95% cutoff	MC1	MC2	PWA1	PWA2
PSART						
LowEA/frequent	1.00(.04)	0.93	0.99	1	**0.44***	0.98
LowEA/infreq	0.99(.10)	0.79	1	1	**0.52***	0.88
HighEA/frequent	1.00(.06)	0.88	1	1	**0.87***	0.96
HighEA/infreq	0.72(.45)	-0.19	0.84	0.96	0.24	0.48
SSART						
LowEA/frequent	1.00(.06)	0.87	0.98	1	**NA**	0.97
LowEA/infreq	0.99(.10)	0.79	1	1	**NA**	**0.00***
HighEA/frequent	1.00(.06)	0.87	0.99	0.99	**NA**	**0.37***
HighEA/infreq	0.57(.50)	-0.42	0.32	0.64	**NA**	0.6

Table 3. SpStroop and WPI Accuracy and RT

Condition	YC Mean(SD)	95% cutoff	MC1	MC2	PWA1	PWA2
SpStroop Accuracy						
LowEA/Incongruent	0.97(.16)	0.66	1	1	0.99	0.98
LowEA/Neutral	0.97(.16)	0.65	1	1	1	0.98
HighEA/Incongruent	0.91(.28)	0.34	0.97	1	0.9	0.93
HighEA/Neutral	0.99(.11)	0.77	1	1	1	0.98
HighEA/Congruent	0.99(.09)	0.82	1	1	0.98	0.99
WPI Accuracy						
LowEA/Incongruent	0.97(.16)	0.65	1	1	0.97	0.99
LowEA/Neutral	0.97(.18)	0.61	1	0.99	0.97	0.98
HighEA/Incongruent	0.92(.28)	0.36	0.97	1	0.85	0.97
HighEA/Neutral	0.98(.14)	0.69	1	1	0.89	1
HighEA/Congruent	0.99(.10)	0.78	1	1	0.98	1
Sstroop RT(s)						
LowEA/Incongruent	0.502(.27)	1.034	0.609	0.767	**4.718***	0.692
LowEA/Neutral	0.498(.25)	1.008	0.568	0.723	**3.965***	0.658
HighEA/Incongruent	0.546(.12)	0.785	0.742	**0.806***	**4.659***	**0.913***
HighEA/Neutral	0.476(.09)	0.648	0.63	**0.713***	**3.743***	**0.796***
HighEA/Congruent	0.483(.11)	0.694	0.64	**0.704***	**3.531***	0.68
WPI RT(s)						
LowEA/Incongruent	0.684(.27)	1.235	0.791	0.772	**3.034***	0.95
LowEA/Neutral	0.657(.23)	1.124	0.754	0.755	**2.820***	0.887
HighEA/Incongruent	0.754(.21)	1.183	0.867	1.025	**6.740***	**1.332***
HighEA/Neutral	0.693(.21)	1.112	0.795	0.867	**4.812***	**1.144***
HighEA/Congruent	0.662(.25)	1.163	0.739	0.837	**3.544***	**1.063***

Literature Cited:

Crawford, J. R., & Howell, D. C. (1998). Comparing an individual's test score against norms derived from small samples. *The Clinical Neuropsychologist* (Neuropsychology Development and Cognition Section D), 12(4), 482– 486.

Hamilton, a C., & Martin, R. C. (2005). Dissociations among tasks involving inhibition: a single-case study. *Cognitive, affective & behavioral neuroscience*, *5*(1), 1–13.

Hoffman, P., Jefferies, E., Haffey, A., Littlejohns, T., & Lambon Ralph, M. A. (2013). Domain-specific control of semantic cognition: A dissociation within patients with semantic working memory deficits. *Aphasiology*, 1–25.

Hula, W., & McNeil, M. (2008). Models of attention and dual-task performance as explanatory constructs in aphasia. *Seminars in speech and language*, *29*(3), 169–187.

Jefferies, E., & Lambon Ralph, M. A. (2006). Semantic impairment in stroke aphasia versus semantic dementia: a case-series comparison. *Brain: a journal of neurology*, *129*(Pt 8), 2132–47.

McVay, J. C., & Kane, M. J. (2012). Drifting from slow to "D'oh!": working memory capacity and mind wandering predict extreme reaction times and executive control errors. *Journal of experimental psychology. Learning, memory, and cognition*, *38*(3), 525–49.

Murray, L. (2012). Attention and Other Cognitive Deficits in Aphasia: Presence and Relation to Language and Communication Measures. *American Journal of Speech-Language Pathology*, *21* (May), 51–65.

Smallwood, J., Riby, L., Heim, D., & Davies, J. B. (2006). Encoding during the attentional lapse: accuracy of encoding during the semantic sustained attention to response task. *Consciousness and cognition*, *15*(1), 218–31.