Evidence that adults with aphasia rationally adapt to rely more heavily on conceptual cues

Haley C. Dresang,[1,2] Tessa Warren,[1] Michael Walsh Dickey,[1,2] William Hula,[2,1] & Fang-Cheng Yeh[3]

[1]University of Pittsburgh, [2]VA Pittsburgh Healthcare System, [3]University of Pittsburgh Medical Center

HaleyDresang@pitt.edu

Rational adaptation claims that cognitive systems strategically adapt to optimize behavior.[1] Changes in task, context, or neural function can change what kinds of information are most useful for performing a particular behavior; rational adaptation predicts individuals will adjust accordingly. This study tests a key prediction of rational adaptation to neural changes in language disorders: Adults with aphasia will adapt to their language impairments by relying more on conceptual cues (which tend to be less impaired in aphasia) and less on lexical cues (which may be more impaired in aphasia), compared to neurotypical controls. Evidence from off-line comprehension tasks (e.g. interpreting the message of a sentence)[3-4] is consistent with this claim, but the current study tests this prediction in a naming task, for which healthy language users prioritize lexical knowledge of word co-occurrence over conceptual event relatedness information[2].

A primed verb naming task was used in 17 adults with chronic aphasia following a single left-hemisphere stroke and 15 age-matched neurotypical controls. Participants saw noun primes that were associated with a target verb either based on conceptual event relatedness or lexical co-occurrence statistics. Facilitation from each cue type was compared to an unrelated baseline prime condition. For example, for the target verb *WRITE*, a participant would view one of three possible primes: “name,” which is highly likely to co-occur within 4 words of "write” (CoCA[5]); “pencil,” an instrument involved in the event of writing (McRae et al.[6], USF Association norms[7]); or “water,” not lexically or conceptually related to “write”. There were 48 target verbs; prime conditions were counterbalanced and pseudorandomized across 3 lists. All participants completed all 3 lists, interleaved with other experimental tasks.

Participants viewed prime-target pairs, separated by a 500 ms interstimulus interval, on a computer monitor. Participants were asked to read aloud the action word, presented in upper case. Accuracy and latency measurements were recorded by E-Prime and Audacity software. Bayesian multilevel regression models assessed the effects of prime condition on naming accuracy and latency between participant groups. Prime conditions were dummy coded with the baseline condition as the reference level. To address outliers, latency observations above the 95th percentile for each group were trimmed, and only accurate trials were examined in the latency model.

Group reliably predicted trial-level naming accuracy, with participants with aphasia (M=0.79, SD=0.41) performing less well than controls (M=0.99, SD=0.07). Furthermore, group moderately interacted with prime condition in predicting naming accuracy, such that aphasia amplified the facilitation of conceptual cues, but absence of aphasia amplified the effect of lexical cues (Table 1). Group also reliably predicted trial-level primed naming latency, with participants with aphasia (M=0.81 sec, SD=0.27) performing slower than controls (M=0.59 sec, SD=0.13). Interactions between group and prime condition were not robust for latency (Table 2).

These findings offer preliminary evidence that people with aphasia may employ rational adaptation to optimize their ability to accurately retrieve verbs. Participants with aphasia received greater priming from conceptual cues compared to neurotypical controls. These findings contrast with previous evidence that healthy language users receive more priming from lexical co-occurrence cues during naming, and critically extend the rational adaptation literature in aphasia from sentence comprehension to lexical production. This study suggests a potential mechanism by which conceptual event-knowledge underlies efficacious speech-language treatments targeting verbs:[8] If people with aphasia rely on conceptual information to retrieve words, then treatment can capitalize on this mechanism by strengthening conceptually driven activation and retrieval processes.

References

[1] Anderson, 1991; [2] Willits, Amato, & MacDonald, 2015; [3] Gibson, Sandberg, Fedorenko, Bergen & Kiran, 2015; [4] Warren, Dickey, & Liburd, 2017; [5] Davies, 2010; [6] McRae, Hare, Elman & Ferretti, 2005; [7] Nelson, McEvoy & Schreiber, 2004; [8] Edmonds, 2016

Table 1. Primed naming accuracy population-level effects for participants with aphasia and age-matched control participants

	Estimate	Est. Error	Lower 95% HDI	Upper 95% HDI	$\hat{R}$	Bulk ESS	Tail ESS
(Intercept)	1.84	0.54	0.79	2.94	1	1836	3811
Group	5.41	1.22	3.06	7.83	1	3055	4291
Event-related prime	0.3	0.21	-0.14	0.69	1	8274	6879
Lexical co-occurrence prime	0.26	0.26	-0.22	0.80	1	6277	5352
Group : Event prime	-1.32	0.88	-3.13	0.37	1	6724	5599
Group : Lexical prime	1.35	1.51	-1.32	4.46	1	8408	5913

Notes: HDI=Highest density credible interval. $\hat{R}$=The potential scale reduction factor on split chains (at convergence, $\hat{R}$ = 1). ESS=Effective sample size. Although these credible intervals overlap with zero, there is a 95% chance that the interaction between group and event facilitation is less than zero, and an 83% chance that the group and lexical co-occurrence interaction is greater than zero.

Table 2. Primed naming response time population-level effects for participants with aphasia and age-matched control participants

	Estimate	Est. Error	Lower 95% HDI	Upper 95% HDI	$\hat{R}$	Bulk ESS	Tail ESS
(Intercept)	-0.272	0.052	-0.045	-0.009	1	1928	3531
Group	-0.274	0.072	-0.415	-0.133	1	1795	3438
Event-related prime	0.008	0.018	-0.027	0.0431	1	4452	6071
Lexical co-occurrence prime	0.000	0.018	-0.034	0.036	1	4360	6273
Group : Event prime	-0.011	0.015	-0.041	0.016	1	12723	8405
Group : Lexical prime	-0.009	0.014	-0.036	0.019	1	12647	7708

Notes: HDI=Highest density credible interval. $\hat{R}$ =The potential scale reduction factor on split chains (at convergence, $\hat{R}$ = 1). ESS=Effective sample size.