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Brain and Language 95 (2005) 12–13
Brain and Language
www.elsevier.com/locate/b&l

When lexical selection gets tough, the LIFG gets going: A lesion analysis study of interference during word production ☆

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Accepted 8 July 2005
Available online 29 August 2005

Nonaphasic speakers take longer to name a repeated series of pictures from the same semantic category vs. mixed categories, due to semantically mediated competition for lexical selection (Damian, Vigliocco, & Levelt, 2001). Thompson-Schill et al. (1998) argued that damage to the left inferior frontal gyrus (LIFG) compromises selection when competition is high. Consistent with this, anterior (Broca) aphasics showed a larger blocking effect (more errors in semantically homogeneous vs. mixed blocks) compared to posterior aphasics, and this effect linearly increased across repetitions (Schnur, Brecher, Rossi, & Schwartz, 2004). In this study, we analyzed high-resolution structural MRI and CT scans, collected from a subgroup of aphasics reported by Schnur et al., to directly examine the relationship between the LIFG and the semantic blocking effect.

Methods

Participants

Participants were 12 individuals with chronic aphasia secondary to left hemisphere stroke. Mean (and range) for age was 53 years (35–68); education 14 years (10–19); and months post-onset 63 (10–175).

Procedures

Blocked-cyclic naming

Stimuli were 72 line drawings depicting 12 semantic categories, each with six exemplars. From these, 12 semantically homogeneous and 12 mixed-category sets were formed. Participants named each set four times (cycles) before the next set appeared. Response deadline was 5 s. The response-stimulus interval (RSI) was manipulated within participants (1, 5 s).

Lesion analysis

For six participants, T1-weighted magnetic resonance image volumes consisted of 160 contiguous axial slices covering the entire brain (matrix size 192×256; 1 mm voxels). For six participants, CT scans consisted of at least 44 contiguous axial slices covering the entire brain (2.5–3 mm slice thickness; in one case, 32 slices of 9 mm slice thickness).

Using MRIcro (Rorden & Brett, 2000), a trained observer (E.L.) under supervision of an experienced behavioral neurologist (H.B.C.), manually drew lesion boundaries onto a standard MNI template. Using MRIcro's Automated Anatomical Labeling map, we defined two anatomical regions of interest (ROIs): the LIFG (inferior orbitalis, triangularis, and opercularis), and a temporal lobe area (superior and middle temporal gyri; cf. Maess, Friederici, Damian, Meyer, & Levelt, 2002).

Statistical analyses

Analysis 1

(a) To estimate the magnitude and variability of the blocking effect for each participant, we computed a t value of the difference in error rate for every item when it appeared in homogeneous vs. mixed blocks. (b) A split of these t values (range = −1.25 to 3.61) was used to classify participants as showing a HIGH ($t > 1$; mean = 2.31) or LOW ($t < 1$; mean = −.31) blocking effect. (c) For each ROI, a t test was performed to compare percent damage across these two groups.

Analysis 2

(a) To estimate the growth in interference over cycles for each participant (independent of overall magnitude), we calculated the blocking effect for each item (as above) *at each cycle,* then computed linear contrasts of the condition by cycle effect. For each participant, this resulted in a linear contrast f value. (b) A split of these f values (range = 0 to 3.95) was used to classify participants as showing a HIGH ($f > 1$; only positive increases; mean = 2.61) or LOW ($f < 1$; mean = .27) growth effect. (c) Lesions were compared as in Analysis 1.

☆ This research was supported by NIH Grants: RO1 DC00191-22 (M.F.S.); HD007425 (T.T.S.); and MH60414, MH067008 (S.T.S.).
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0093-934X/$ - see front matter
doi:10.1016/j.bandl.2005.07.008

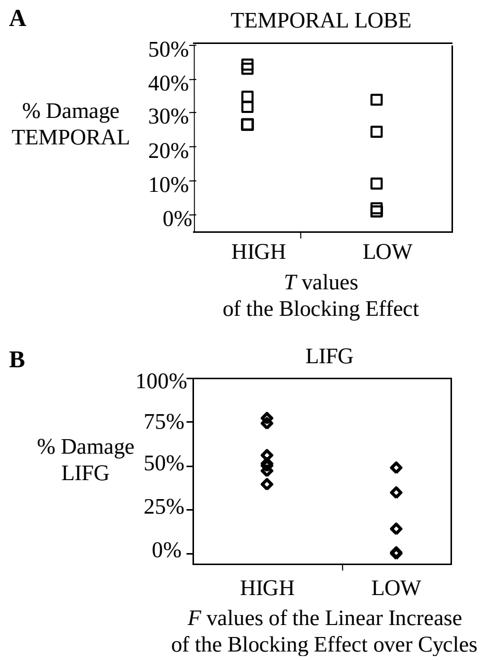

Fig 1. (A) Percent damage to the temporal lobe predicted a HIGH ($n = 5$) vs. LOW ($n = 7$) blocking effect (indexed by t values). (B) Percent damage to the LIFG predicted a HIGH ($n = 7$) vs. LOW ($n = 5$) linear increase in the effect over cycles (indexed by f values).

Results

In Analysis 1, groups differed in percent damage in the temporal ROI (t (1, 10) = 3.82; $p < .01$; see Fig. 1A), but not the LIFG (t (1, 10) = 1.47; $p > .15$).

In Analysis 2, groups differed in percent damage in the LIFG (t (1, 10) = 3.59; $p < .01$; see Fig. 1B), but not the temporal ROI (t (1, 10) = 1.44; $p > .15$).

We performed correlation analyses to assess the contribution of age, months post-onset, and lesion-size in predicting overall blocking effect (t values) and its growth over cycles (f values). The only significant relationship was between lesion-size and t values ($r = .58$, $p < .05$).

Discussion

Previously, we showed that the semantic blocking effect emerges when interference from named competitors grows big enough to overcome various facilitation effects that operate in this paradigm (Schnur et al., 2004). This is more likely at later than earlier cycles. Here, we demonstrate that aphasics with large blocking effects, averaged over cycles and indexed by t values, had a greater amount of damage in left superior and middle temporal gyri (see Maess et al., 2002). Critically, aphasics whose blocking scores increased linearly across cycles, independent of overall magnitude, had a greater amount of LIFG damage. According to Thompson-Schill et al. (1998), the LIFG plays a role in the selection of mental representations primarily or exclusively when competition is high. Our findings support this by showing that damage to the LIFG is reliably associated with the growth of blocking errors across cycles, paralleling the growth of competitor interference.

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