ERP signs of semantic congruity and word repetition in sentences

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By a number of behavioural and electrophysiological measurements (e.g. Monsell, 1985; Rugg, 1987) it has been shown that the analysis of a word is influenced both by its previous occurrence (i.e. repetition priming) and by its semantic associates (i.e. semantic priming). Most often this influence is facilitatory (e.g. reduced response latencies and error rates in lexical decision and naming tasks). Despite a difference in the time courses of the two effects, it has been suggested that repetition priming can, in part, be accounted for by whatever mechanism underlies semantic priming. However, on the basis of differences in the amplitude, latency and scalp distributions of ERP indices of repetition and semantic priming in word lists, Rugg (1987) concluded that they "involve separate cognitive mechanisms". We also used ERP (i.e. N400, LPC) and behavioural (i.e. cued recall) measures to examine this issue further for words within a sentence context.

Methods

Seventeen right-handed native English speakers (7 males, 10 females, between 18-34 yrs) were paid to participate as subjects; four subjects had left-handed family members.

One hundred and sixty sentences of high contextual constraint (final word cloze probabilities > 0.75) were each presented one word at a time for a duration of 200 ms, once every 500 ms. The inter-sentence interval was 2 s. Half of the sentences ended with an incongruous word; congruous and incongruous words were matched in length and frequency of occurrence in the language. Subjects silently read the

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sentences and tried to memorize the final words. Following 10 practice sentences, experimental sentences were shown in 4 sets of 80 each, the last 160 being repetitions of the first 160. After the first 160 sentences, subjects were given a questionnaire with all the sentence fragments and asked to recall each final word.

EEG was recorded via Ag/AgCl electrodes from 12 scalp sites: 4 midline at Fz, Cz, Pz and Oz and 4 lateral pairs over frontal (F7, F8), fronto-temporal (Broca: Bl: half of the distance between F7 and T3 on the left and Br: between F8 and T4 on the right), centro-temporal over Brodmann's areas 41 (C3' and C4'; 33% of the interaural distance along the interaural line through the vertex) and parietal (Wernicke W1 and Wr; 30% of the interaural distance lateral to Cz, and 12.5% of the inion-nasion distance posterior to Cz), each referred to the left mastoid. Vertical and horizontal eye movements were monitored via an electrode on the lower orbital ridge and via a bipolar montage at the external canthi, respectively.

The EEG was amplified by Grass 7P122 preamplifiers with a 0.01 to 60 Hz (half-amplitude cut-off) bandpass, and digitized at a rate of 250 Hz. The ERPs were averaged off-line for a 2048 ms epoch, beginning 200 ms before onset of the final word of the sentence. Trials with eye movements or muscle artefacts (approx. 15%) were rejected off-line by a computer algorithm based on peak to peak amplitude values and on the absolute value of the differences within a latency range.

Individual subjects' ERPs were measured by computing the mean voltage in selected latency windows (N400 measured between 300-600 ms; post-N400 positivity measured between 600-1300 ms) relative to 200 ms pre-stimulus baseline. Analyses of variance (ANOVA) were carried out with the Greenhouse-Geisser correction as needed; uncorrected dfs and corrected probability are reported.

Results

Overall, Ss recalled an average of 44.7% of the total 160 words (1st presentation: congruous 60%, incongruous 5.7%; 2nd presentation: congruous 86.2%, incongruous 26.6%). A two-way ANOVA with Congruity and Repetition as repeated measurements showed significant main effects of Congruity [$F(1,16) = 402$, $p < .001$)] and Repetition [$F(1,16) = 225.3$, $p < .001$] and a marginally significant interaction between the two [$F(1,16) = 3.7$, $p < .07$].

As shown in Figure 1 for Pz, upon initial presentation there was a significant effect of congruity between 300 and 600 ms, with incongruous words eliciting larger N400s [$F(1,15) = 24.3$, $p < .001$]; this effect had a posterior distribution with a significant right-hemisphere preponderance (mean amplitude at Fz:-1.3, Cz:-2.4, Pz:-2.9, Oz:-2.1, F7:-0.6, F8:-1.6, Bl:-0.3, Br:-1.8, C3':-0.1, C4':-2.4, Wl:-1.3, Wr:-3.1 μV). Repetition effectively eliminated this congruity effect [Congruity x Repetition:

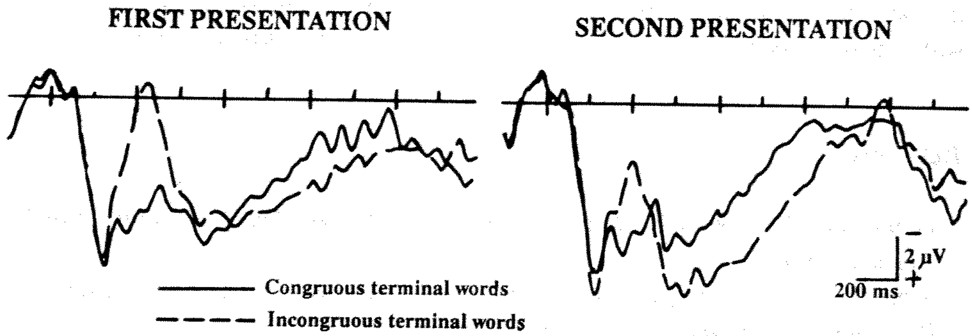

Figure 1

F(1,15) = 5.4, p < .03], primarily by reducing N400s to incongruous words. This N400 repetition effect also had a posterior distribution with a significant right hemisphere bias (mean amplitude at Fz:2.1, Cz:2.5, Pz:3.4, Oz:2.5, F7:0.6, F8:1.3, Bl:0.2, Br:1.0, C3':1.0, C4':1.6, Wl:2.1, Wr:2.6 μV).

The congruity effect was also altered by repetition in the post-N400 region (600-1300 ms), due primarily to an increase in LPC amplitude to incongruous words [Congruity x Repetition: F(1,15) = 8.5, p < .01; main effect of repetition for incongruous words: F(1,15) = 4.4, p < .05]. This late repetition effect had neither a significant anterior/posterior [F(3,45) = 1.6, N.S.] nor a lateralized amplitude gradient [F(1,15) = 0.34 , N.S.]. In addition, we found that this late repetition effect for incongruous words was significantly smaller (0.6 μV) than the earlier one (1.8 μV) [Repetition x Window, F(1,15) = 17.1, p < .001].

Discussion

Our data revealed a biphasic effect of repetition. In the N400 latency range, we found that the congruity effect was significantly reduced by repetition, primarily due to a decrease in N400 amplitude to incongruous words. Subsequent to the N400, repetition enhanced the amplitude of the LPC elicited by incongruous words. The early phase of the repetition effect differed from the later phase both in amplitude and scalp distribution. The early phase was larger and more posteriorly distributed (similar to the congruity effect) than was the later, equipotential phase. This pattern of results is inconsistent with a view in which the N400 reduction with repetition is a spurious result of overlap by a monophasic positivity. Rather, it suggests the view that a similar "activation" process underlies the reduction in N400 amplitude with both semantic congruity and repetition (see also Smith & Halgren, 1989). The fact that both congruous and incongruous words were better recalled following repetition indicates that recall and activation are dissociable. Thus, our results are most in line with a two-component view of repetition (Henderson, 1982; Monsell, 1985).

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