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Research Report

Reduced late positivity in younger adults, but not older adults, during short-term repetition

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ABSTRACT

Although word repetition was generally associated with enhanced amplitude of late positive complex (LPC), it seemed to yield attenuated LPC when words were repeated over short enough lags. However, this issue and its corresponding age effects have not been examined directly. For this purpose, EEG was recorded when young and elderly participants were required to make animacy decision during an incidental word repetition paradigm with words repeated after one, six, or nine intervening words. The results revealed that with one intervening word lag LPC decreased for nonliving words which supposed to be related to higher semantic activation levels reflected by larger N400, unchanged for living words associated with lower semantic incongruity activation levels, and increased in relatively longer lags (with six or nine intervening words) in the young group. Whereas, enhanced LPC was observed in the elderly in all conditions. Furthermore, significant age-related LPC repetition differences were revealed only with one intervening word lag for nonliving words. The results suggested that (1) how LPC changes after repetition is influenced by the initial incongruity activation levels of items and their thereafter maintenance in short-term memory; (2) the age-related differences result from the declining of short-term memory maintenance rather than from initial lower incongruity activations among elderly adults.

1. Introduction

Incidental repetition has generally been used to investigate implicit memory by not requiring participants to discriminate between words presented for the first and second time (Rugg et al., 1988). Across a variety of tasks to which the repetition of words was incidental (e.g. lexical judgment, semantic categorization), repetition effects are associated with more accurate, faster responses and generally positive-going ERP shifts relative to initial ERP waveforms 300–900 ms after stimulus onset (Bentin and Peled, 1990; Friedman et al., 1992; Mecklinger, 2000; Nagy and Rugg, 1989; Rugg, 1995).

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This ERP repetition effect is often interpreted as a modulation of an early component (an attenuated N400) and a later component (an enhanced "late positive complex"–LPC).

As an indirect manifestation of memory, word repetition effects sparked enormous interest and have become one of the most thoroughly studied topics since the 1990s. The literature has suggested that the N400 attenuation repetition effect was consistently established across a broad range of studies using pure word lists for semantic categorization tasks (Besson et al., 1992; Friedman et al. 1993; Friedman, et al., 1992; Hamberger and Friedman, 1992; Karayanidis et al., 1991; Matsumoto et al., 2001; Misra and Holcomb, 2003; Rugg et al., 1994; Rugg, et al., 1997; Swick and Knight, 1997). In these experiments, repetition related LPC increment was generally reported. But on careful inspection of these data, it seemed that if the repetition lag was short enough (0, 1), a decreased LPC (and/or unchanged LPC) could occur. For example, an obvious LPC attenuation trend with immediate repetition (lag=0) could be seen in the younger participants in Swick and Knight et al. (1997), but the authors neglected this phenomenon and concluded that the younger participants generated repetition effects only in the 300–500 ms interval (attenuated N400). Rugg et al. (1997) also reported that a trend toward decreased LPC in response to words repeated over short lag (lag=1) could be seen only in their younger participants. Additionally, unchanged LPC was observed in younger adults with immediate masked repetition (Misra and Holcomb, 2003). These data implied that in contrast with the general trend of LPC increment found in longer delay repetitions, LPC decrement was observed in short-term repetitions (lag=0,1).

We found the functional significance of LPC proposed by Van Petten et al. (1991) was best to explain the opposite LPC repetition effect on shorter and longer lags. Van Petten et al. (1991) proposed that LPC indexes the demand on retrieving information from long-term memory to update working memory. According to this proposal, if the word is still held temporarily in an active form in working memory when it is repeated, less retrieval will be directed at their current occurrences giving rise to a reduced LPC. Otherwise, an increased LPC will be produced. According to this proposal, the initial word activation level and the repetition lag together would determine the direction of LPC repetition effect (increase/decrease). In other words, if the initial words were repeated with a short-enough lag for the initial presentation of the words to maintain in working memory, the probability of retrieval from long term memory upon subsequent presentations being necessary will be decreased resulting in a reduced LPC.

Furthermore, the long-standing view of word repetition has suggested that the incidental repetition is an implicit task, which is intact in older adults. This view was supported by several studies using relatively longer lags, which revealed that the repetition-induced LPC increase observed in longer lags did not differ between younger and older participants, though LPC latency was prolonged in the elderly (Frienman et al., 1992; Karayanidis et al., 1991). However, the LPC repetition effect over short enough lags differed between older and younger participants. Swick and Knight (1997) found an increased LPC in their older counterparts when LPC attenuation was observed in younger participants (lag=0). The trend toward decreased LPC in response to words repeated over short lag (lag=1) in Rugg et al. (1997) was also only seen in their younger participants. These data implied that the age effects on LPC repetition effect were also likely to differ depending on lag.

Although implied, the existence of LPC decrement and corresponding age effects have not been reported directly in word repetition studies using pure word list. In the present study, we adopted nonliving/living animacy judgment task and expected repetition-induced LPC decrement to occur on nonliving words, since nonliving words were usually associated with greater N400 in ERPs implying greater activation level than living words. Therefore, the present study was designed to address two questions regarding LPC repetition effects and any corresponding age effects by varying lag (1, 6, 9): to confirm whether word repetition yielded opposite LPC effects at longer lag versus shorter lag and explore whether animacy affected the LPC effects in younger adults, and to evaluate whether older adults would manifest LPC repetition effects differently than younger adults in short lag repetition.

2. Results

2.1. Behavioral results

The performance of the participants was shown in Table 1. Accuracy and reaction time were analyzed by means of repeated-measures ANOVA with repetition (first presentation, repetition), lag (1, 6, 9), and congruity (congruous/living, incongruous/nonliving) as within-group factors and age group (young, old) as a between-group factor. η_p^2 indicated partial eta-squared effect size.

The ANOVAs on accuracy only revealed a significant repetition × lag interaction [$F(2,56)=4.628$, $p<.05$, $\eta_p^2=0.142$], reflecting improved accuracy with repetition given lag 9 [$F(1,29)=8.44$, $p<.01$]. The ANOVAs on RT showed a significant main effect of Age on RTs [$F(1, 28)=5.821$, $p<.05$, $\eta_p^2=0.172$], significant interactions of lag × congruity [$F(2,56)=7.119$, $p<.01$, $\eta_p^2=0.203$] and repetition × congruity [$F(1,28)=4.259$, $p<.05$, $\eta_p^2=0.132$] and main effects of repetition [$F(1,28)=39.468$, $p<.001$, $\eta_p^2=0.585$] and congruity [$F(1,28)=56.235$, $p<.001$, $\eta_p^2=0.668$]. For the lag × congruity interaction, simple effect analyses revealed that RTs for nonliving words exceeded those for living words in each lag condition (all ps $<.001$). The difference between RTs of nonliving words and living words was reliably greater in the lag 1 condition than in the lag 6 ($p<.05$) or lag 9 condition ($p<.01$) as indicated by *Post hoc* Tukey tests. For the repetition × congruity interaction, simple effect analyses showed that RTs for both living and nonliving words were faster after repetition [living: $F(1,29)=26.38$, $p<.001$; nonliving: $F(1,29)=27.85$, $p<.001$], and the repetition-induced RT decrement was greater for nonliving words ($t=2.10$, $p<.05$). The absence of any significant effects involving repetition × age suggested that although the older adults had slower RTs on animacy judgment task, they had normal repetition effect compared to the young adults, either on accuracy or RTs.

In sum, nonliving words were associated with slower responses and the RT difference between nonliving and living