THE EFFECT OF THE DEGREE OF ACOUSTICAL DISTORTION ON LEXICAL ACCESS BY YOUNGER ADULTS

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1. INTRODUCTION

Comprehension of spoken language is dependent on the accurate transmission of the acoustic speech signal. If the signal becomes distorted, then comprehension becomes more difficult and the specific nature of language processing may be altered. As discussed in our companion paper [1], it has been suggested that some types of acoustic distortions, such as low-pass filtering, may disrupt the early stages of lexical access (encoding and activation of lexical-semantic information), whereas other types of distortion, such as time compression, may disrupt later stages of lexical access (word selection and integration) [2]. However, previous research investigating this hypothesis [1, 2], has confounded the type of distortion with the amount of distortion.

The goal of the present study was to investigate how the speed of processing a sentence-final target word is influenced by varying the degree of acoustic distortion applied to three different types of sentence contexts: semantically congruent, semantically incongruent, and semantically neutral. The effects of acoustic distortion and semantic context on the speed of a lexical decision were measured. The results on the lexical decision task were interpreted as evidence of semantic priming, encompassing both facilitation and inhibition effects [3]. Facilitation of lexical access by the preceding sentence context is evidenced by faster reaction times (RT) in response to targets preceded by a semantically congruent sentence context relative those preceded by a neutral context [4]. Inhibition is reflected in increased RT's to targets preceded by incongruent contexts, relative to a neutral context [4].

2. METHOD

2.1 Participants

Two experimental groups, each composed of 36 undergraduate students, participated in the experiment: Group 1 (mean age = 19.11 years, *SD* = 1.56) and Group 2 (mean age = 19.06 years, *SD* = 1.47). Each participant had normal audiometric thresholds (≤ 25 dB HL) at frequencies below 4 kHz. Participants in Group 1 obtained a mean score of 11.78/20 (*SD* = 2.73) on the Mill Hill vocabulary test, while participants in Group 2 obtained a mean score of 11.94/20 (*SD* = 2.47).

2.2 Stimuli

The experimental stimuli consisted of six lists, where each list contained 48 sentence contexts, 24 in which the sentence-final target word was a real word and 24 in which the target was a non-word distractor. The non-word distractors were phonologically permissible strings, had no meaning, and generally resembled the real word targets in length, number of syllables, and phonetic content.

Within each list of 48 sentence contexts, 24 sentences remained acoustically unaltered and 24 sentences were acoustically distorted using low-pass filtering. All sentence-final word targets remained unaltered. Both unaltered and altered sentence contexts were equally divided into 3 semantic categories forming 6 experimental conditions: Congruent-altered, incongruent-altered, neutral-altered, congruent-unaltered, incongruent-unaltered and neutral-unaltered. The acoustically altered sentence contexts were low-pass filtered using Praat [5]. Participants in Group 1 received altered contexts low-pass filtered at 1000 Hz and those in Group 2 received altered contexts filtered at 1750 Hz. It was determined during pilot testing that these degrees of low-pass filtering yielded word recognition scores of 50% and 76%, respectively, for the standard NU6 word lists used in speech audiometry (see companion paper [1]).

2.3 Procedure

Within each group, each participant was randomly selected to be presented one of the six lists, with the lists counterbalanced across participants. The stimuli were presented to participants binaurally over Sennheiser 265 headphones at 70 dB SPL in a double-walled sound-attenuating booth. Participants were instructed to listen to each sentence context and the accompanying sentence-final (non-)word and to make a word/non-word lexical decision by pressing the YES or NO button, respectively, on the response box as soon as the light was illuminated to cue the beginning of the response period. Button order (Y/N vs. N/Y) on the response box, corresponding to the hand participant used to press the response button, was counterbalanced across participants.

3. RESULTS

3.1 Analysis

Inclusion of a participant's data in the final analysis was determined based on the criterion that the participant correctly answered 90% of the test trials. RT's for a word were eliminated if no response was entered or if the response entered was incorrect. An independent samples t-test comparing the mean RTs for words and non-words was significant (Group 1: $t(70) = -3.79$, $p = 0.00$; Group 2: $t(70) = -7.16$, $p = 0.00$). Only the RT's for real word targets were considered in subsequent analyses.

3.2 Reaction Time

Initially, button order was analyzed as a between-subjects factor; however, since no significant effects of button order emerged, this factor was dropped from further analyses. Semantic context and acoustic distortion (altered or unaltered) served as within-subjects variables for the separate analyses conducted for each group. A repeated measures analysis of variance (ANOVA) revealed significant main effects of semantic context (Group 1: $F(2, 68) = 67.60$, $p < 0.005$; Group 2: $F(2, 68) = 92.19$, $p < 0.005$). There were no significant main effects of distortion for either experimental group. For Group 1 only, there was a

significant interaction of distortion and context (F (2, 68) = 12.20, $p < 0.005$). No other interactions were significant.

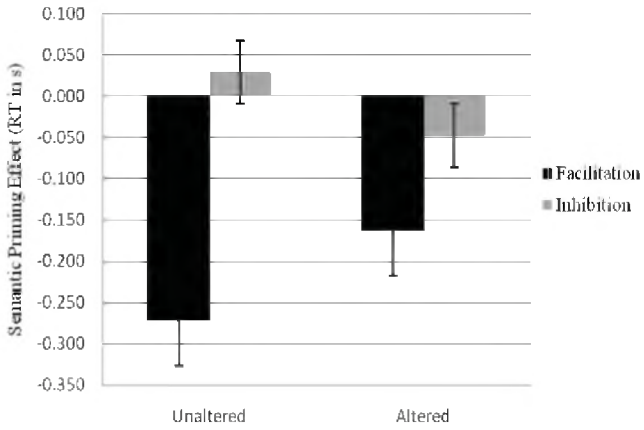

Fig.1. Semantic priming effects for unaltered contexts and contexts altered using low-pass filtering at 1000 Hz. Facilitation is plotted as the difference between mean RT's for congruent and neutral contexts. Inhibition is plotted as the difference between mean RT's for incongruent and neutral contexts. Error bars represent standard errors.

3.3 Facilitation and Inhibition

The finding of a significant main effect of context was explored further by examining facilitation and inhibition of the lexical decision by the semantic context of the sentence. Recall that facilitation is determined by calculating the difference between RT's in the congruent and neutral conditions, whereas inhibition is determined by calculating the difference between RT's in the incongruent and neutral conditions. Figure 1 and Figure 2 show the facilitation and inhibition effects for Group 1 and Group 2, respectively. As expected, the results for both groups are similar in the unaltered condition. Not surprisingly, facilitation was similar in the unaltered and altered conditions when less distortion was applied (Group 2), but facilitation was reduced relative to the unaltered condition when more distortion was applied (Group 1), even though the extent of inhibition was similarly reduced relative to the unaltered condition regardless of the degree of distortion. This illustrates the interaction revealed in the ANOVA above.

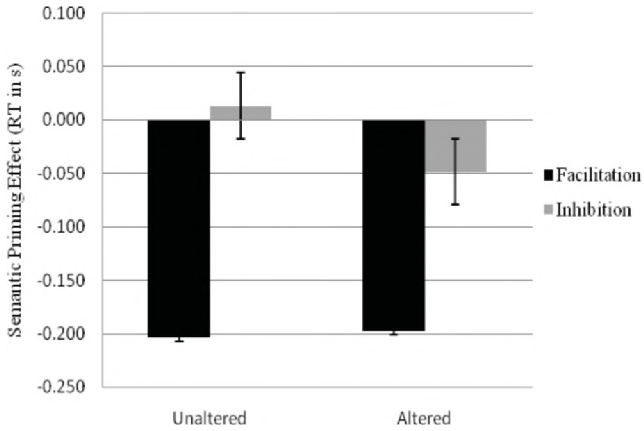

Fig.2. Semantic priming effects for unaltered contexts and contexts altered using low-pass filtering at 1750 Hz.

4. DISCUSSION

Acoustically distorting the semantic context using low-pass filtering disrupts the encoding of linguistic information as evidenced by changes in the speed of lexical decision for a following target word that was spoken without distortion. The extended response times arising from low-pass filtering contributed to a smaller facilitation priming effect that varied with the degree of distortion that was applied. As shown in Figures 1 and 2, this decrease in facilitation was more pronounced for experimental Group 1 as compared to Group 2. Low-pass filtering at 1750 Hz allows more high frequency spectral information, which could account for the smaller decrease in facilitation evidenced by experimental Group 2 as compared to Group 1. Thus, the amount and/or quality of available acoustical information seems to be more important to lexical access and lexical decision operations than is the type of distortion as was initially argued by previous researchers [2]. Further exploration of precisely how different degrees of acoustical distortion alter the speed and nature of lexical processing warrants further study. This research may provide insights into the effort needed to process words heard in non-ideal acoustical conditions that cannot be provided by traditional 'off-line' studies of word recognition because performance remains at ceiling.

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ACKNOWLEDGMENTS

This project was funded by CIHR and NSERC.