ON THE SUITABILITY OF THE CROSS-MODAL SEMANTIC PRIMING TASK

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ABSTRACT

In auditory word recognition, multiple word candidates are assumed to be activated before one candidate is selected. Sentence context is supposed to increase the activation of the appropriate word candidate, even before it is selected. Results from one particular cross-modal semantic priming study (Zwitserlood 1989) are often advanced as positive evidence for both claims. Other priming studies, however, report inconsistent results regarding multiple activation and the role of context. The present study was set up to test the validity of the cross-modal priming task for the study of early stages of word recognition. This was done by replicating the original study by Zwitserlood, with several improvements. However, the results did not show any early priming effects. Consequently, the influence of context on the activation of word candidates cannot be established. Our tentative conclusion is that cross-modal semantic priming is not suitable for studying the early stages of word recognition.

1. INTRODUCTION

Current models of auditory word recognition agree that the initial stages of word recognition involve activation of multiple word candidates and subsequent selection of one word candidate. Activation of the word candidates increases or decreases when more acoustic information becomes available or when semantic context starts to play a role. In order to investigate whether sentence context has an early effect on auditory word recognition (i.e. during lexical access or selection) or a late effect (i.e. only during the integration stage), Zwitserlood [1] set up a cross-modal semantic priming study (cf. section 2). Her study showed multiple activation as a result of the partial presentation of words, and that lexical access is autonomous and selection is guided by sentence context.

However, there is reason to doubt the consistency of the effects found in [1]. In this study, a between-subjects design was used. The data were then normalised for subject differences by subtracting each subject's mean reaction time from his data and by subsequently adding the overall mean reaction time. Note that, in case of a between-subjects design, each subject's mean lexical decision time is a result of the specific conditions he has been presented with. Thus, the effect of the experimental conditions cannot be separated from the effect caused by the subjects [2]. As the results of [1] are often cited, it might be useful to replicate [1] with a statistically safer within-subject design to find out whether similar results can be obtained.

Other cross-modal priming studies have yielded inconsistent results with respect to multiple activation and the effect of context. Few studies have succeeded in obtaining significant priming effects during lexical access or selection. As a result, the question whether sentence context affects the activation of word candidates during these early stages remained unanswered. Even at relatively late stages in the process of word recognition, the role of context could not be established. This raises questions about the validity of the priming paradigm for investigating early stages of word recognition.

First, the cross-modal priming paradigm and Zwitserlood [1] will be discussed, and a brief overview of other priming literature will be given. Secondly, an experiment was carried out to test the validity of the cross-modal priming task, by replicating [1] with several improvements. The results of this experiment, together with the findings of other priming research, will be used to evaluate the validity of the priming paradigm.

2. THE LITERATURE

2.1. Cross-modal semantic priming and Zwitserlood (1989)

Zwitserlood [1] used the cross-modal semantic priming paradigm (henceforth CMSP) to study the activation of word candidates by presenting fragments of prime words. She constructed pairs of words which were phonemically identical up to a certain point: the members of the Dutch word pair *kapitein/kapitaal* ('captain/capital') are identical up to /t/. Before the two word candidates (called actual word and competitor) start to diverge phonemically, the activation of both candidates can be studied with the CMSP technique. To this end, an auditory prime fragment (e.g. *kapi-*) was presented, followed by a visual probe related to either of the word candidates *(schip* ('ship'*)* or *geld* ('money'*)*, related to *captain* or *capital*, respectively). The prime words were embedded in three sentence contexts: carrier phrases, neutral phrases and biasing phrases. A gating pre-test showed how much stimulus information was needed in each sentence context to isolate the actual word. This information was assumed to indicate where in the word the several stages of recognition had to be located, and the gating results were therefore used to determine the cut-off points for the primes in the priming study.

Zwitserlood's study [1] showed that both word candidates were activated on the basis of a short prime fragment in all three types of sentence context. Even in the sentence context which biased the actual word, there was activation for the contextually inappropriate competitor. When more of the prime fragment was made audible, both word candidates were activated in the semantically neutral contexts. In the biasing phrase context, however, only the actual word was facilitated relative to a control condition: the competitor was deactivated. Zwitserlood [1] concluded that the activation of word candidates can be measured with the CMSP paradigm and that sentence context starts to have an effect during lexical selection. As said, the between-subjects design and the data normalisation cast some doubt on the reliability of these results.

2.2. Other cross-modal semantic priming studies

In her description and evaluation of the paradigm, Tabossi [3] remarked that the CMSP paradigm relies on the "robust" phenomenon of semantic priming. Nevertheless, other CMSP studies have shown inconsistent results regarding multiple activation and the role of context (a more detailed overview of the CMSP literature is given in [4]).

Chwilla [5] showed that there were no early priming effects before the recognition point for primes presented in isolation. Zwitserlood and Schriefers [6] found that a short prime fragment only yielded a priming effect when extra processing time was available. Connine, Blasko and Wang [7] found considerable priming effects before the isolation point. The fact that their lexical decision times are relatively long, however, raises questions about the on-line nature of these effects. Moss, McCormick and Tyler [8] found a significant priming effect at the isolation point for their normalised data, but this effect was only marginally significant in the raw data.

CMSP studies on the role of sentence context also show inconsistent results. Tabossi and Zardon [9] showed that context had an effect on the activation of the two meanings of an ambiguous word at a point before the uniqueness point. Yet, as the prime was not cut off but remained audible during lexical decision, one cannot be certain that the paradigm has actually tapped into early processing. Jongenburger [10] and Brown [11], on the other hand, found no effects of sentence context at all. Although Brown [11] (using phonological (instead of semantic) priming) found multiple activation in semantically neutral conditions, he found no effects of semantic context.

Summing up, few CMSP studies have convincingly shown activation of multiple word candidates. Those studies which did obtain priming effects before the recognition point ([6,8]) did not measure the activation of competitor words, and, consequently, could not show multiple activation. It may be the case that word candidates are not activated highly enough themselves during lexical access and selection to spread a detectable amount of activation to semantically related probes. Furthermore, the studies [5,6] showed that there may be a relation between the length of the lexical decision times and the presence or absence of early priming effects. It may be clear that, if the CMSP paradigm does not show robust early priming effects in semantically neutral conditions, the early effect of context on the activation of word candidates cannot be established. It is therefore useful to test the validity of the CMSP paradigm.

3. TESTING THE PARADIGM'S VALIDITY

Zwitserlood [1] provides a solid framework to put the CMSP paradigm to a test. There are some aspects about the design and material in [1], however, which can be improved. These aspects will be discussed in section 3.1.

We investigate the hypothesis that the CMSP paradigm is sensitive enough to measure the activation of multiple word candidates and to measure the effect of sentence context on the activation of word candidates. We predict, on the contrary, that this hypothesis will have to be rejected.

3.1. Method

3.1.1. Recordings. The sentence material was recorded on DAT tape with a Sennheiser ME 30 microphone. A male native speaker of Dutch was selected to pronounce the sentence material at a normal speaking rate.

3.1.2. Cut-off points and Competitors. A gating study was carried out to select appropriate competitor words and to find out where the primes had to be cut off in order to study a particular stage of recognition. With the aid of a speech editor the actual words from the carrier phrases were copied and these substituted for the actual words in the biasing phrases, so that the same acoustic tokens were used in the two sentence conditions. Twenty-four actual words were presented to two groups of subjects: one group of 12 subjects heard the items in the carrier phrase condition; the other group of 12 subjects heard the items in the biasing phrase condition. Subjects first heard the phrase with the final (actual) word cut off after the first 20 ms. On subsequent presentations, the fragment length of the actual word was increased with 35 ms steps until the entire word was made audible, and on each presentation subjects were asked to write down what they thought the word was going to be. In order to study multiple activation, one early probe position was chosen to tap into lexical access, and one position was chosen to tap into the selection stage. The third position, where the full prime was presented, served as a baseline for the partial priming effects at probe positions 1 and 2. The isolation points (defined as the mean point at which subjects first came up with the actual word without subsequently changing their response at later gates) of the items in the biasing and in carrier phrase condition served as probe positions 1 and 2 respectively.

Zwitserlood [1] did not select the competitors on the basis of the gating data, but used the criterion of auditory overlap of at least two word-initial segments. In the present study the competitor choice was based on competitors named in the carrier phrase condition in the gating task. Although the gating task involves guessing strategies, the results do give some insight into the range of the best matching competitors. If the wrong competitors are chosen, which would hardly be activated, the competition that the actual word still has will be underestimated and selection will seem to be completed too early.

3.1.3. Visual probes. An association test was carried out for a number of reasons. First, as far as competitors were different from those in [1], different visual associates had to be selected. Secondly, in [1], some probes were related to two different prime words. In the present design, each subject was presented with the entire set of visual probes, and for some actual words or competitors, the second best probe had to be found. A third reason to carry out an association test was that Zwitserlood relied on two association studies [12,13]. As the present study was carried out some twenty years after the publication of these association norms, some of the associates had become dated.

Fifty-two subjects were asked to give three associates to the actual words and competitors in question. Subjects were instructed to write down the three words that first came to mind on reading the test items. Whether a certain word was given as the first, second or third associate determined its weight factor, and the weight factor, and the number of subjects that named a particular associate, were used as criteria to select the best associate.

3.1.4. Control conditions. Zwitserlood [1] included two fragments, short and long, of unrelated control words, combined with the visual probes to control for possible effects of fragment length. Zwitserlood's control phrases were all meaningful sentences, and thus, there was no control condition comparable with the carrier phrase context. In the present study, the control prime words were carefully chosen such that the control word was comparable to the actual word/competitor pair, in terms of number of syllables, stress pattern, phonological structure, and word frequency (based on the CELEX database). The control sentences were constructed so that the visual probes were presented following unrelated sentences (control 'biasing' or carrier phrases) and unrelated 'prime' words. Lastly, the control biasing phrase had to equal the biasing phrase of the actual word in informational value up to the actual word (cf. [6] and [14]). The control words were cut off at approximately the same fragment lengths as the corresponding test primes.

3.1.5. Experimental design. In [1] there were more test conditions (36) than there were test items (24). As a result, a between-subjects design had to be used. For the present study a reduced number of test conditions allowed a within-subject design, which is statistically safer. The design was set up so that the 12 test conditons (2 contexts x 3 probe positions x 2 probe types) and the 12 control conditions were rotated over 12 lists: the same subject was presented with the actual word probe in a test condition and the probe related to the actual word's competitor in a comparable control condition.

3.2. Procedure

The visual probe was presented at the acoustic offset of the prime word or the prime fragment and remained visible for 50 ms. Subjects were instructed to listen carefully and to give a lexical decision response to the visual probe as fast and at the same time as accurately as possible. The "yes" button was always under the subject's dominant hand. Reaction times were measured from the onset of the presentation of the visual probe until one of the response buttons were pressed. In the test part of the experiment, there were 58 filler items in addition to the 48 test and control items. The entire experimental set was balanced for words and nonwords. There was a practice session of 12 sentences. Before the actual test session started, a warming-up list of 18 filler sentences was presented to the subjects after which they proceeded seamlessly to the test session. If subjects had not responded within 3 seconds from the onset of the probe presentation, they proceeded to the next sentence.

Subjects were warned in advance that they were supposed to pay attention to the entire sentences, as they would have to fill in a regular recall test afterwards (by ticking the sentences they had heard). To make sure that subjects also paid attention to the prime fragments themselves, an extra task was added to the test. After approximately 15% of the items, after subjects had given their lexical decision response, a message appeared on the screen: *Repeat the last word you heard.* Subjects could choose to simply repeat the fragment or to repeat and finish the fragment. Because subjects might be distracted by the repeat command, at least one filler sentence (without the repeat command) followed before the next test or control stimulus was presented. Apart from this restriction, the order of the stimuli was randomised. Another way to avoid that subjects would not pay enough attention to the auditory information was to vary the cut-off point throughout the sentences. Therefore, a number of the filler items were cut off halfway or at the beginning of the sentences.

The accuracy and speed with which subjects performed the task was transformed into a score. During the experiment, the subjects were not informed about their score: the total score only appeared on the screen when the experiment was finished. Subjects were informed in advance that the subject with the highest score would receive a bonus of Dfl.25.

3.3. Subjects. 10 subjects were randomly assigned to each of the 12 lists, so that a total of 120 subjects participated in the experiment. The subjects were students at Utrecht University and were paid Dfl.10 for their participation. The subjects had not participated in any of the previous pilot experiments or pretests.

3.4. Results

All incorrect lexical decisions were considered as missing values. The mean raw lexical decision times for test conditions and control conditions are shown in figure 1.

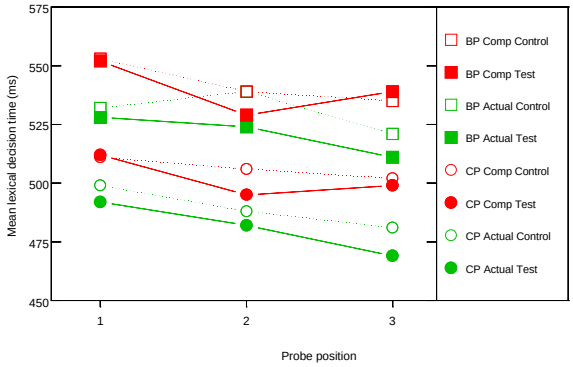

Figure 1. Mean raw lexical decision times to actual word and competitor probes in carrier phrase (CP) condition and biasing phrase (BP) condition at three probe positions. Solid and dotted lines represent test and control conditions, respectively.

At probe position 1, facilitation for actual word and competitor, relative to their control conditions, is absent in both sentence contexts. At probe position 2, which was assumed to reflect the selection stage, there seems to be a small amount of facilitation for actual word and competitor. In the biasing phrase condition both actual word and competitor seem to be activated. At probe position 3, where the full prime is presented, the activation of the competitor has decreased: the auditory information no longer matches that of the competitor. In the carrier phrase context, the facilitation for the actual word has increased to 12 ms. In the biasing phrase condition, the facilitation for the actual word is smaller than at probe position 2. So, even after the presentation of the full prime, the priming effect is small in both sentence contexts.

Note that all lexical decision times in carrier phrase conditions are *shorter* than those in biasing phrase conditions, regardless of probe position and probe type.

On the basis of our hypothesis, we expect an interaction between the amount of facilitation (test vs control condition), probe type (actual word vs competitor) and probe position. In other words, we expect the facilitation for the actual word to increase with increasing probe position and we expect the facilitation for the competitor to decrease with increasing probe position. If this is the case, then context is expected to enhance the activation of the actual word and to deactivate the competitor, which would translate into a Test/Control x Context x Probe Type (actual word vs competitor) x Probe Position interaction.

The raw data were entered into repeated measures analyses of variance. The main effect of Test/Control was significant only in the analysis on subjects ($F_1(2,118)=19.4$, $p<0.001$; $F_2(10,14)<1$, n.s.). The main effect of Probe Type was marginally significant in the subject analysis ($F_1(2,118)=2.55$, $p=0.08$; $F_2(10,14)=1.43$, n.s.). The main effect of Context was not significant in either analysis ($F_1(2,118)=2.11$, $p=0.13$; $F_2(10,14)<1$, n.s.).

The interaction between Test/Control x Context was marginally significant in the analysis on subjects ($F_1(2,118)=2.64$, $p=0.08$; $F_2(10,14)=1.43$, n.s.). The interaction between Test/Control x Context x Probe Type was also only marginally significant in the analysis on subjects ($F_1(2,118)=2.44$, $p=0.09$; $F_2(10,14)<1$, n.s.). The interaction between Context x Probe position was only significant in the item analysis ($F_1(4,116)=1.46$, n.s.; $F_2(20,4)=6.25$, $p<0.05$). The interaction Test/Control x Probe Type x Probe position was also only significant in the analysis on items ($F_1(4,116)=1.22$, n.s.; $F_2(20,4)=12.3$, $p<0.05$).

4. DISCUSSION AND CONCLUSION

As the interaction Test/Control x Probe Type x Probe Position was not significant in both analyses, the data do not support our hypothesis that the CMSP paradigm can be used to show multiple activation. Although there is a tendency for an increase in facilitation for the actual word and a decrease of facilitation for the competitor with increasing prime fragment length, even the priming effect as a result of the presentation of the full prime is fairly small. It is therefore impossible to establish the role of context during the early stages of word recognition.

In addition we see that lexical decision times in biasing phrases are somewhat longer than those in carrier phrases. This may mean that the longer lexical decision times partly reflect sentence processing or a higher cognitive load, whereas in the carrier phrase condition only the word itself needs to be processed. Zwitserlood [1] included a neutral context which did not contain semantically biasing information, but which was longer than the carrier phrase. The reason why the carrier phrase context was chosen was that it is almost impossible to construct sentences in which both actual word and competitor are equally probable continuations of the sentence. Thus, the effects of sentence length and semantic sentence context are difficult to separate.

The results of [1] are often advanced as evidence for multiple activation and an early effect of context. The objections against the design of [1], combined with the inconsistent results of other CMSP studies cast doubt on the robustness of the results of [1]. We tested the validity of the CMSP paradigm by replicating [1] with some improvements. The results showed that there are no reliable priming effects resulting from the partial presentation of the prime. So far, we have little reason to assume that the CMSP paradigm is suitable to study early stages of auditory word recognition. This implies that the role of sentence context during the early stages of word recognition remains unclear.

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