# Semantic context effects of picture and word distractors in overt translation:

# RT and EEG data

Svetlana Gerakaki

Donders Institute for Brain, Cognition and Behaviour

Radboud University Nijmegen

The Netherlands

Supervisors: Ardi Roelofs, Ton Dijkstra, Vitória Piai

Master’s programme in Cognitive Neuroscience

Student number 4013832

Radboud University

Nijmegen, The Netherlands

August 2011

Abstract

Two studies involving Dutch-English bilinguals explored the impact of word and picture distractors on overt backward (English to Dutch) translation of single words, with the aim to contribute to the discrete-cascade debate in language production. First, two behavioral reaction time (RT) experiments attempted to replicate the findings of Experiment 1 by Bloem and La Heij (2003). They manipulated semantic relatedness for target-distractor pairs to demonstrate a complete reversal of context effects in the overt backward translation task dependent on distractor modality. In line with these authors, we demonstrated facilitatory effects of related distractor pictures, but, contrary to them, we did not find any evidence of interference by related distractor words. We argue that picture distractors have a robust (facilitatory) impact on language production during overt backward translation, whereas word distractors have a much less stable effect by inducing effects going from no interference at all to even small but significant facilitation. Second, in an electrophysiological (EEG) experiment, we considered semantic context effects of picture distractors rather than word distractors in overt translation. An N450 component showed a larger negative deflection in the semantically unrelated than in the related condition. This finding is indicative of a response level facilitation effect. It thereby supports a cascade view on language production and positions the locus of the semantic facilitation effect at the lexical level.


*Keywords:* translation, bilinguals, semantic interference and facilitation, overt language production, N450, cascade and discrete processing

## Introduction

All bilinguals, even small children, are able to translate words from their native language into their foreign language (forward translation) or back (backward translation). As such, this would appear to be a very simple task. However, bilinguals need to employ significant attentional control in order to perform this task (Roelofs et al, in preparation). Following work by Kroll and colleagues (2010) as well as La Heij and colleagues (1996), it now seems generally accepted that after having reached some degree of second language (L2) proficiency, bilinguals engage their conceptual system in translating between their first (L1) and second (L2) languages. However, disagreement exists about how the conceptual information is mapped onto words during the translation process.

According to La Heij and colleagues (2003, 2004) this mapping involves a discrete step in processing. For example, in translating the written English word RABBIT into Dutch “konijn”, the concept RABBIT(X) as well as related ones such as DOG(X) and CAT(X) become activated, but only RABBIT(X) activates the corresponding lemma: This is theoretical position is referred to as the *discrete view* on mapping conceptual information onto words. In contrast, the *cascade view* on mapping conceptual information onto words, proposed by Roelofs and colleagues (2006, 2007a, in preparation), holds that the concept RABBIT(X) as well as related ones such as DOG(X) and CAT(X) activate the lemma level.

The debate between the proponents of the two positions was clearly outlined in Bloem’s and La Heij’s work (2003). In their study, they looked into the processing levels of word translation by having Dutch-English bilinguals overtly translate

English target words presented alongside distractor words or pictures. On the basis of the results of this Stroop-like task of backward translation they proposed the so-called Conceptual Selection Model (CSM) of word production. In support of their discrete position, La Heij and colleagues (i.e., Bloem & La Heij, 2003, Experiment 1) demonstrated that in vocally translating English words into Dutch (backward translation: e.g., English RABBIT -> Dutch “konijn”), semantically related pictures (e.g., a pictured dog) decrease the vocal translation response time (RT) compared with unrelated pictures (e.g., a house), whereas semantically related Dutch words (e.g., the word HOND) increase the translation RT compared with unrelated words (e.g., HUIS).

To explain this difference in polarity in the semantic effects of picture and word distractor contexts, La Heij et al. argued that semantically related pictures help concept selection, but do not spread activation to the lemma level, hence they help the translation response. In contrast, semantically related words do activate their lemmas, and thereby hinder the translation response. Thus, by assuming different loci of effects (i.e., the conceptual level for distractor pictures and the lemma level for distractor words), La Heij et al. explained why distractor pictures yield semantic facilitation, whereas words yield semantic interference. Bloem and La Heij ( 2003) implemented their ideas about the different loci of the effects in a computer simulation of the Conceptual Selection Model (CSM, Figure 1) and successfully simulated their findings on the difference in polarity of semantic effects between picture and word distractors ((Bloem & La Heij, 2003; Bloem, van den Boogaard & La Heij, 2004).

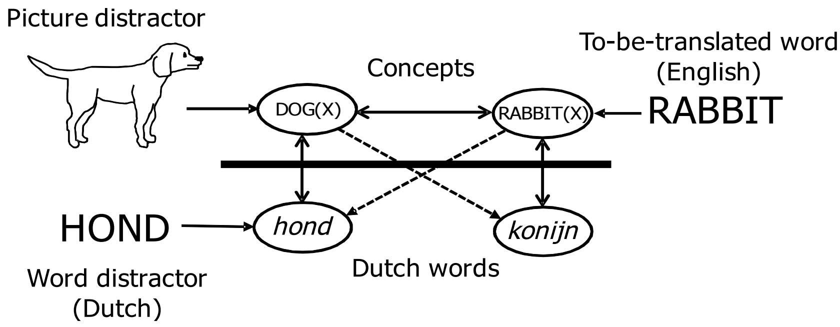



*Figure 1.* Illustration of the network of the discrete-flow model of Bloem and La Heij (2003). Figure adopted from Roelofs and colleagues (in preparation).

However, Roelofs (2007, pp. 1283-1284, in preparation) demonstrated through computer simulations using WEAVER++ (Roelofs, 1992) that implementing a no-threshold continuous flow view and assuming a lemma level locus for the context effects of both pictures and words could also account for the difference in polarity of semantic effects between picture and word distractors. In WEAVER++, lexical access follows the principle of spreading activation and language selectivity is achieved by condition-action rules which are set by the task (goals). In simulating the Bloem and La Heij (2003) findings, Roelofs and colleagues (2006, in preparation) assumed that activation spreads freely from the conceptual to the lexical level (continuous flow). Not only the target concept but also the distractor concept activates its lemma. Semantic facilitation and semantic interference all originate in the lexical level. Figure 2 depicts the cascade view.

To illustrate, suppose that a participant must translate, the target word RABBIT into *konijn* (meaning *rabbit* in Dutch). First, the target word (RABBIT) activates the corresponding word node *rabbit* (word level); this activation spreads freely through the network reaching also the concept node (RABBIT(X)). At this point the condition action rules are applied, resulting in higher activation of the target concept and selection of the Dutch equivalent to the English target word. In these simulations a semantically related distractor picture was seen as also sending activation to the target word and in this way facilitate lexical access. Contrary to this situation, a related distractor word, even though also activating the target word, introduces competition and results in semantic interference. The interference introduced at the lexical level by this competition seems to outweigh the facilitation provided to the target word activation by the distractor word.

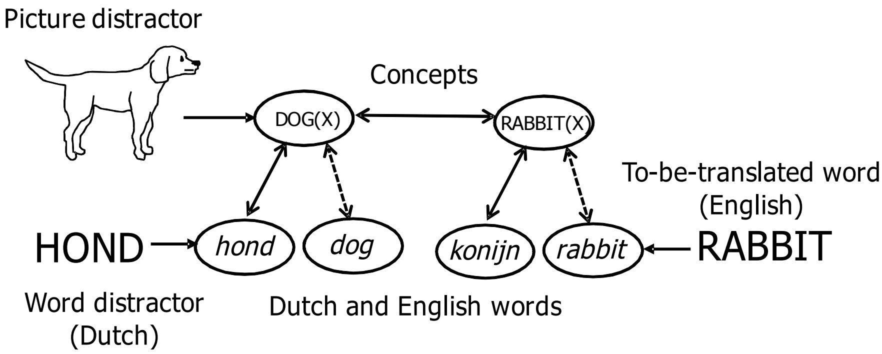



*Figure 2.* Illustration of a fragment of the lexical network of the continuous-flow model of Roelofs (1992, 2003). Figure adopted from Roelofs and colleagues (in preparation).

In what follows, we describe a series of experiments that further investigate the impact of word- and picture- distractors on overt backward (English to Dutch) translation of single words. These experiments intend to shed a new light on the discrete – cascade debate described above.

The first part of this manuscript is devoted to two behavioral reaction time (RT) experiments (behavioral study) in which we attempt to replicate the findings of Experiment 1 in the study by Bloem and La Heij (2003). Our initial objective was to test the materials used in this study in order to use it for an EEG study aimed at looking into the brain signature of semantic context effects of pictures and words in the overt backward translation task. A pretesting of the material was necessary, since some of the display parameters of the original study had to be adapted to the EEG procedure needs. To our surprise, we did not find any evidence of interference induced by related distractor words, while we obtained evidence on a facilitatory effect of related distractor pictures. The findings of the behavioral study (Experiment 1 and 2) suggest that picture distractors have a more robust (facilitatory) impact on language production during overt backward translation, while word distractors seem to have a much less stable effect on such a task, by inducing effects going from no interference at all to even small facilitation. The discussion parts of the two behavioral experiments offer some insight on possible factors (display parameters, language proficiency) modulating the direction and size of the effect of distractor words.

Failure to fully replicate Bloem's and la Heij's (2003) findings lead to a decision to focus our scheduled electrophysiological (EEG) Experiment (study 2) on looking only at semantic context effects of picture distractors and not of word distractors, in the overt translation task. Our aim for study 2 was twofold: 1) to explore the nature of information flow in the language production system during such a demanding task (discrete vs. cascade processing), and 2) to provide electrophysiological evidence regarding the level of the language production system at which distractor pictures operate. In other words, do pictures activate their names and thus interfere with the to be translated target word? At what point in time does the semantic relatedness effect show up in the EEG signal? We considered a well known ERP component, the N450 (see for example Liotti, Woldorff, Perez III, & Mayberg, 2000) to explore our hypothesis on the locus of the facilitation effect triggered by semantic relatedness. A modulation of the N450 amplitude was only expected if the facilitation effect arises from the lexical level and not if it is the result of earlier processes at the conceptual level.

## Behavioral study

### Experiment 1

The first experiment was a close replication of Experiment 1 in Bloem and La Heij (2003).

### Method

*Participants*

Twenty students from the Radboud University participated in this experiment for paid compensation or credit points. They were native Dutch (L1) speakers with good knowledge of English (L2) . All participants had normal or corrected-to-normal vision. Their L2 proficiency level was tested using a self rating questionnaire in which participants had to list the languages they speak, their proficiency level in terms of comprehension and production, as well as answer questions regarding their experience with English, the age of L2 acquisition and settings of L2 use.

*Materials*

Our study used the exact same 32 high frequency English words from Bloem and La Heij (2003, Experiment 1, see Appendix A), with the exception of only one distractor item, namely *sla* (Dutch for *lettuce*), which we found to have a rather vague picture display. This distractor item was replaced by *aubergine* from the same line drawings database (Snodgrass & Vanderwart, 1980). The words had no clear phonological or orthographic relationship to their Dutch translation equivalents (thus, no cognates were used). Each target word was paired with a semantically related concept. This related concept was used as the distractor in both word- or picture-form. Re-shuffling of the target distractor pairs resulted in the unrelated condition item set. As stated in Bloem and La Heij (2003, p. 471) *" ... The Dutch translation equivalents of the English target words and the Dutch context words were of similar mean language frequency (log frequencies of 1.87 and 1.73, respectively; CELEX database, Burnage, 1990)".*

Maximum size of the pictures was the same as in the original study and special care was taken so that the target words, which were superimposed on the picture distractor, did not hide essential features of the picture. The distractor word was always presented below the target word. Target words as well as distractor words were presented in font size 36. Viewing distance was around 80 cm.

At this point it is critical to fully describe the display setting differences between our experiment and that of Bloem and La Heij (2003). While in Bloem and La Heij (2003), the English target word that had to be translated into Dutch was presented in black lower-case letters against a white background, we used green lower-case letters against a black background. Moreover, the context word was presented in red letters and the context picture in gray line drawing against white background in the original study, while we used white letters for the context word and a white line drawing for the context picture with a black background. These changes were the result of our efforts to balance the salience of our target-distractor pairs. In the Bloem and La Heij (2003) study it can be argued that word distractors were more salient than picture distractors, since they were presented in red font, as opposed to the gray color of the distractor pictures. This might have differentially affected the amount of attention give to each type of distractor (word and picture), thereby mediating the results obtained. Facilitation and interference could be the result of both modality effects (picture – word) and attentional factors related to the ability to suppress the distractor stimulus and focus on the target. To avoid such additional sources of effects we tried to balance the salience of word- and picture-distractors by presenting distractors in the same color (white for pictures and words) and targets always in green for all distractor types. By doing so, we might have made the target more salient, but at the same time we keep the distractor strength constant, with respect to color-characteristics.

*Procedure*

Participants were tested individually in a quite testing room at Radboud University. First, participants read the instruction leaflet and the experimenter made sure they understood what they had to do. Subsequently they were asked to read through the target list that indicated exactly how the English target words should be translated into Dutch. They had to inform the experimenter if there were any target words of which the meaning was new to them. Their task was to translate the English target word presented on screen in green font into Dutch, as fast and as accurately as possible, while ignoring the distractor word or picture. Before the testing session, participants went through a practice session in which they became familiar with the task. None of the materials used in the practice session were used in the actual task. In the original study the practice included the target words that were also used in the testing session, with only the distractor items differing. The practice session consisted of 32 trials, involving a block of picture- and a block of word-distractors.

After the practice session the testing phase begun. Three blocks of target words with picture distractors and another three blocks of target words with word distractors for each participant, resulted in a total of 384 trials per participant. The order of appearance of block type (picture- or word-distractor) was counterbalanced across participants. A picture-distractor block, for example, consisted of 64 trials in total, made up by 32 semantically related target-distractor pairs and 32 semantically unrelated target-distractor pairs. Thus each target word appeared twice in a block; once in a related and once in and unrelated combination. Stimuli in each block were randomized using the mix software (van Casteren & Davis, 2006) resulting in a different order of appearance between blocks but also between participants. Extra care was taken not to have the same target word appear sooner than three trials ahead.

Each trial started with a fixation cross that stayed on screen for 500 ms, followed by a blank screen for 250 ms. Finally the target word and the distractor (picture or word) were presented on screen simultaneously for 750 ms, followed again by a blank screen for 1750 ms. The original study (Bloem & La Heij, 2003) involved the presentation of a fixation cross for 500ms, followed by the stimulus, which remained on display until response, or for a maximum time of 2000 ms. The intertrial interval was 500 ms. We opted for a different display, because presenting the stimulus for too long on screen would probably result in too many eye movements, which might be a problem for the upcoming EEG study. A voice-key registered response latency for each trial, with a 1 ms accuracy. The presentation of stimuli was controlled by Presentation Software (Neurobehavioral Systems, Albany, CA).

**Results**

Incorrect responses and voice key malfunctions as well as responses equal to or faster than 300 ms were excluded from the analyses (4.72% of the data). Means per participant and per item were computed for each experimental condition. Two participants had to be excluded from analysis because of too slow responses relative to the other participants, resulting in a total sample of 18 participants.

The data were submitted to analyses of variance (ANOVA) both by participants ($F_1$) and by items ($F_2$). Relatedness (related versus unrelated target – context pairs) and context modality (picture distractor versus word distractor) were entered as within-participant factors. The analyses showed a main effect of relatedness in the by subjects analysis, $F_1(1, 17) = 29.662$, $p = .000$ and in the by items analysis $F_2(1,31) = 16.690$, $p = .000$. There was also a significant interaction between semantic relatedness and context modality in the analysis by subjects, $F_1(1, 17) = 14.062$, $p = .002$ but only a marginally significant interaction in the analysis by items $F_2(1,31) = 3.191$, $p = .075$. The significant interaction in the analysis by subjects supports that the semantic relatedness of target and distractor did indeed affect performance in a different way for pictures and words. Semantic relatedness induced a facilitation effect of 22 ms for word distractors and almost double facilitation (49 ms) for picture distractors. Thus, the direction of the effect did not reverse from facilitation to interference for distractor words, in contrast to the original study of Bloem and La Heij (2003). Paired-samples t tests on the participant means ($t_1$) indicated that the facilitation effects were significant both for picture-distractors, $t_1(17) = 5.992$, $p = .000$, and word-distractors, $t_1(17) = 3.197$, $p = .005$. The number of errors was to small to allow for a meaningful analysis.

In order to exclude some factors that might have affected our findings, we conducted some additional analysis. According to one theoretical interpretation the different pattern of results in our study and the one by Bloem and La Heij (2003) might be a consequence of difference in the English proficiency level of the participants in the two experiments. This cannot be directly tested here, since the proficiency background questionnaire we used was not used in Bloem and La Heij (2003), in which the only information given is that participants had received more than five years of English education in high school. As an indirect assessment of whether the English proficiency level of participants matters, we performed a median split of participant data based on their performance in the Language Background Questionnaire and examined the mean interference/facilitation effect in each group. As can be seen in Figure 3 there was a facilitation effect for word and picture context, with the facilitation being bigger for low (words = +25.28, pictures = +67.98) compared to high proficiency participants (words = +17.20, pictures = +30.56).

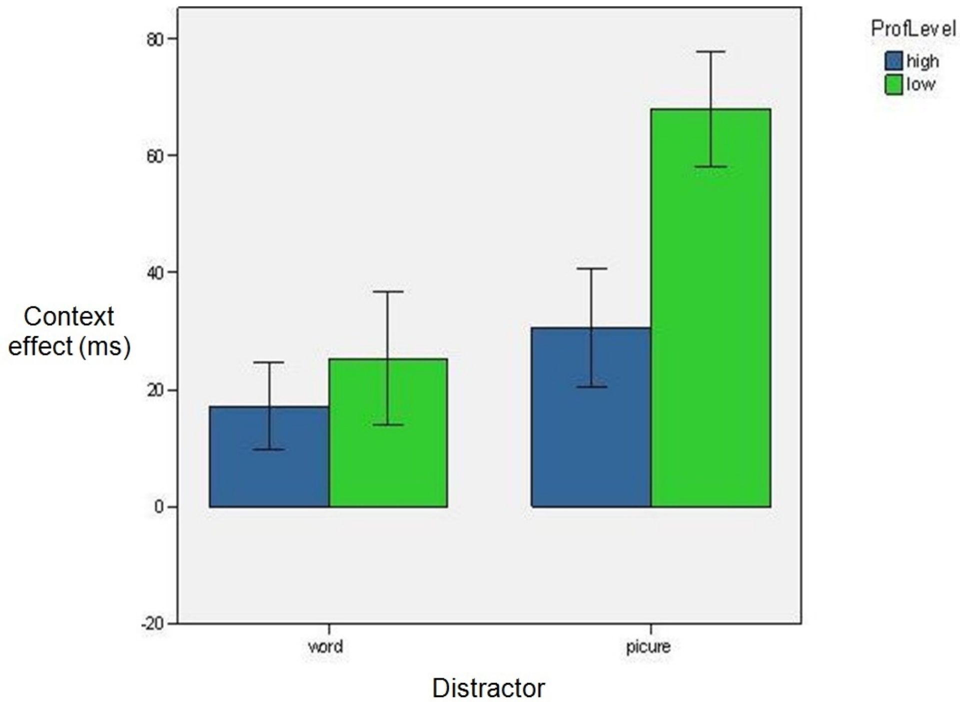
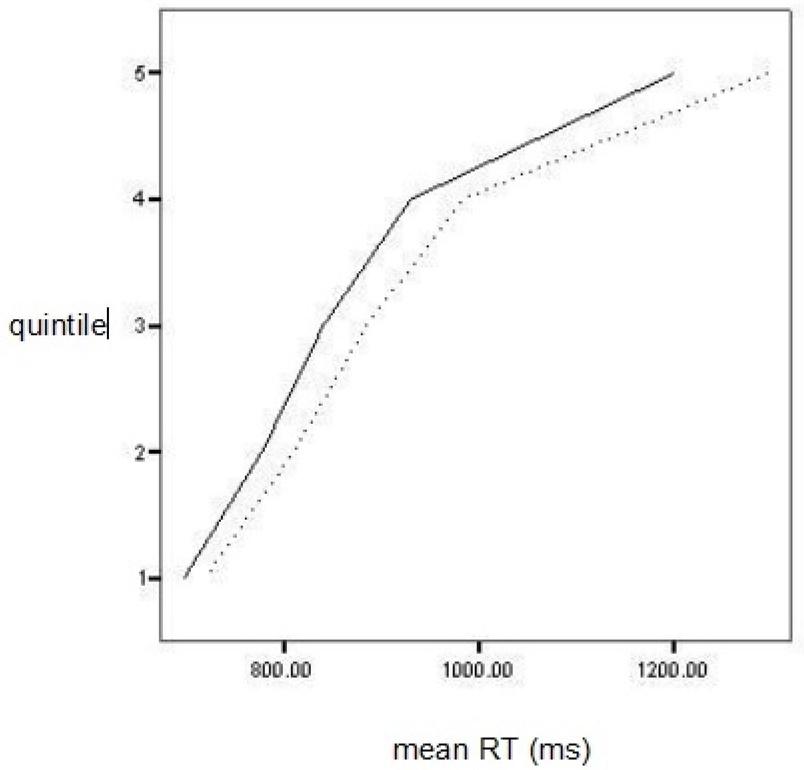



*Figure 3.* Mean facilitation effect by context type and proficiency level. The error bars stand for +/- one standard error.

Moreover the number of trials was larger in our experiment than in the original one. This may have resulted in some kind of training effect that made the original effect of interference disappear. To study this possibility we conducted a separate analysis in which we only included the first block of picture distractors and the first block of word distractors. Because the participants saw the stimuli in blocks of three (three picture blocks and three word blocks, or the opposite), this analysis is not equal to the analysis of the original study (one picture block and one word block, or the opposite), but it may be indicative. This analysis by subjects ($F_1$) revealed a main effect of condition $F_1(1, 17) = 16.575, p = .001$ but no significant interaction of condition by distractor [$F_1(1, 17) =.789, p = .387$]. The inspection of the means already reveals a facilitation for both words (+34.61 ms) and pictures (+46.24 ms).

One final concern was that participants might have adopted different strategies to carry out the task. As such there might be a difference between slow and fast responders; in this respect the overall mean RT might be misleading. To consider this possibility we conducted a Vincentile analysis to examine the shape of the RT distribution (for more information on Vincentile analysis see Balota and colleagues, 2008, p. 498). For each participant response times were rank-ordered and divided into 20% quantiles. Quantile means were computed for each condition (related and unrelated), separately for word context and picture context. These quantiles were then averaged across participants. Figure 4A shows the Vincentised cumulative distribution curves for the semantic relatedness effect (facilitation here) in a picture context. The related condition (solid line) clearly yielded a bigger facilitation effect than the unrelated condition (dotted line) across the whole distribution. Thus the RT distribution analysis indicates that the relatedness effect (facilitation) is present throughout the distribution. The same holds for the semantic relatedness effect in word context (Figure 4B).

A.




B.

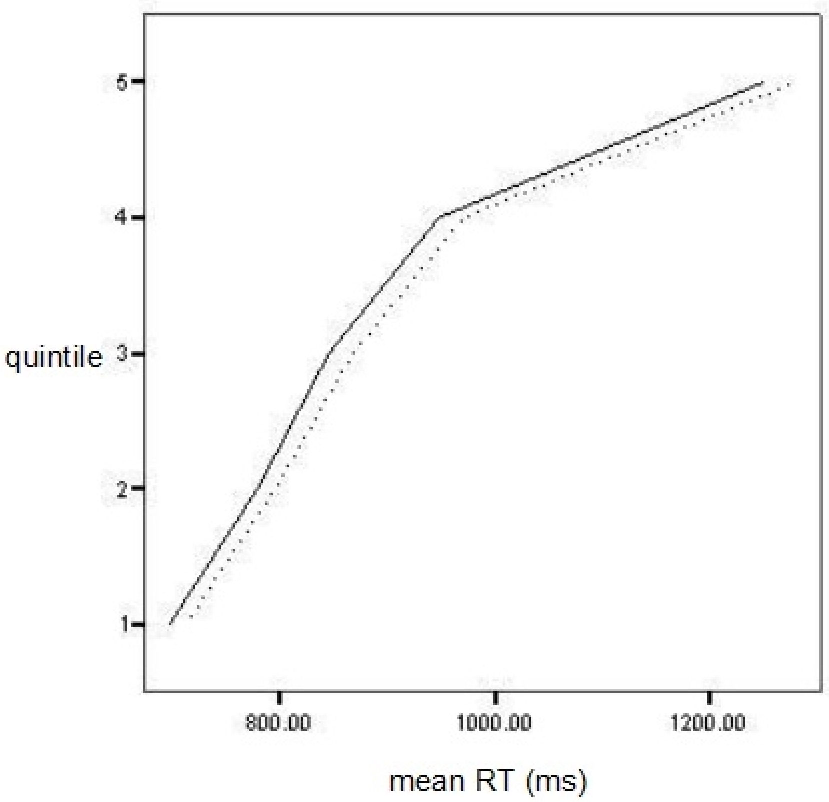



Figure 4. Vincentised cumulative distribution curves for A) related (solid line) and unrelated (dotted line) condition in picture context, and B) related (solid line) and unrelated (dotted line) condition in word context. The X- axis represents reaction time in milliseconds and the Y-axis represents quintiles.

## Discussion

Experiment 1 did not fully replicate the findings of the original study. Bloem and La Heij (2003) reported a reversal of the relatedness effect from facilitation for distractor pictures to interference for distractor words. We did not observe such a pattern. Even though the facilitation obtained from related word distractors was almost half the size of the facilitation obtained from related pictures, the paired-samples t-test still confirmed that this faciliation was significant both for words and pictures. The interaction of relatedness and context modality arose because picture distractors generated almost twice as much facilitation as word distractors. Backward translation of a target word was facilitated by a related context picture, but also by a related context word. Taking into account the nature of the modifications we made to the display parameters of the original study, we conclude that the effect reported by Bloem and La Heij is not very robust.

Which factors might drive the reported reversal of effects in the original study? We note that allocating our participants to high and low proficiency groups did not affect the direction of the effects: Facilitation arose for all of them. Moreover, the number of trials in the experiment was probably not an important factor either, because a consideration of only the first block of each context type revealed the same pattern as the overall analysis in terms of the direction of the effects (facilitation for all). We also explored whether the observed effects depend on the relative RT of our participants, in terms of slow and fast responses. Here, the Vincentile analysis confirmed that the relatedness effect of facilitation was present throughout the whole RT distribution.

Altering the display parameters, in particular changing the color of the target item from black against a white background into green against a black background, and at the same time changing the distractor color from red to white for the word and from gray to white for the picture could also have affected our results. These changes most likely made the target more salient than the distractor, whereas in the original study the distractor appeared to be more salient. In addition, we displayed the stimuli for a maximum of 750 ms, while the original study had them on display until response or for a maximum of 2000 ms. All these differences might have affected our findings.

In regard of these possibilities we decided to conduct a second experiment, in an attempt to replicate the Bloem and La Heij (2003) study as closely as possible.

## Experiment 2

The second experiment can be seen as an almost full replication of Experiment 1 in Bloem and La Heij (2003). We attempted to keep display parameters and timing as close to the original as possible.

## Method

*Participants*

Twenty students from Radboud University, Nijmegen, who did not take part in the previous experiment, participated in this experiment for paid compensation or credit points. They were native Dutch speakers with good knowledge of English. Their proficiency level was tested using the same language background questionnaire as in Experiment 1. All participants had normal or corrected-to-normal vision.

*Materials*

The exact same stimuli as in Experiment 1 were used. Distractors were again displayed under the target word and the size of the stimuli was identical to that in our first experiment. Only now, we set display parameters identical to the Bloem and La Heij (2003) study. Thus, following the original study distractor words were presented in red font, distractor pictures in gray line drawing, and target words in black font, all against a white background.

*Procedure*

The procedure was identical to Experiment 1. The timing of stimuli display was adapted towards matching the Bloem and La Heij study, but the number of trials remained identical to our first experiment. This was the only difference between Experiment 2 and Bloem's and La Heij's original study (2003). Thus, each trial started with a fixation cross that stayed on screen for 500 ms, followed by a blank screen for 250 ms. The target word and the distractor (picture or word) were presented on screen simultaneously until a response was given, or for a maximum time of 2000 ms. The intertrial interval was 500 ms. A voice-key registered response latency for each trial, with a 1 ms accuracy. The presentation of stimuli was controlled by Presentation Software (Neurobehavioral Systems, Albany, CA).

**Results**

Incorrect responses, voice key malfunctions and responses equal to or faster than 300 ms were excluded from the analyses (5.5% of the data). Means per participant and per item were computed for each experimental condition. The data from three participants had to be excluded from the analyses because they responded extremely slowly or made too many errors, resulting in a total data sample for 18 participants.

An analysis of variance (ANOVA) both by subjects ($F_1$) and by items ($F_2$) was conducted, with relatedness (related versus unrelated target – context pairs) and context modality (picture distractor versus word distractor) as within-participant factors. Contrary to Experiment 1, the analysis revealed no main effect of relatedness by subjects, $F_1(1, 16) = 2.891$, $p = .108$, nor by items, $F_2(1,31) = .717$, $p = .398$. As in our first experiment, the analysis showed a significant interaction between semantic relatedness and context modality in the analysis by subjects, $F_1(1, 16) = 5.33$, $p = .035$

but not in the analysis by items $F_2(1,31) = .605, p = .437$. The analysis by items also revealed a main effect of context type [$F(1,32) = 9.349, p = .005$], with word context (both semantically related and unrelated) yielding on average a 29 ms faster response (806 ms) than picture context (835 ms). The by subjects analysis revealed no main effect of context type, $F_1(1,16) = 2.761, p = .116$. Paired-samples t tests on the participant means ($t_1$) indicated that the facilitation effect induced by related pictures was significant $t_1(16) = 2.865, p = .01$. The relatedness effect for word distractors was not significant $t_1(16) = 0.149, p > .05$. The number of errors was to small to warrant a meaningful analysis.

The same additional analysis steps were undertaken in the second experiment, to look into some parameters that might have affected our findings. First, we explored the hypothesis that the direction of the effects might be related to the proficiency level of the participants. In order to get an indirect idea on the role of proficiency in this, we performed a median split of our participants based on their performance in the Language Background Questionnaire and looked at the mean interference/facilitation effect[1]. As can be seen in Figure 5 there seems to be a difference in the direction of the effects, with high proficiency participants experiencing facilitation in both picture (+29.33 ms) and word (+10.52 ms) contexts, while low proficiency participants seem to experience a small facilitation for related picture (+3.28 ms) context, but interference in the related word ( - 10.97 ms) context. Thus, our low proficiency participants seem to show the pattern of results of Bloem and La Heij (2003).

1 To do this we had to eliminate one more participant in order to split up the participant group in equal parts (high-low).

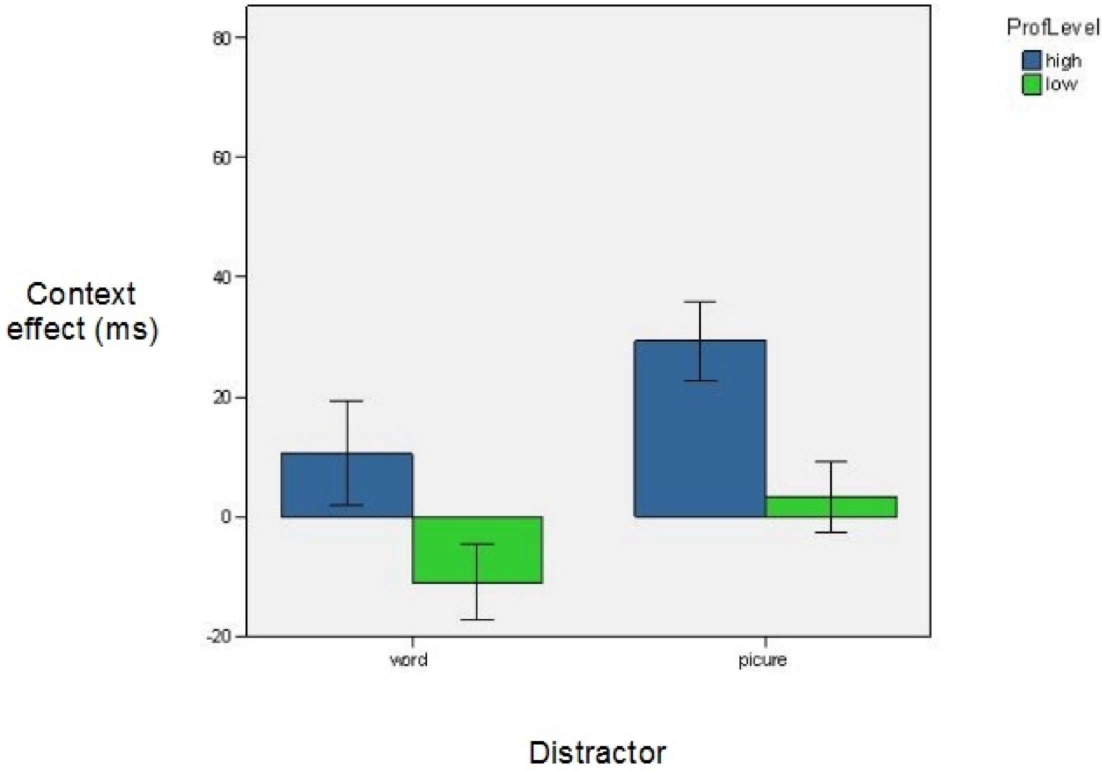



*Figure 5.* Mean facilitation/interference effect by context type and proficiency level. The error bars stand for +/- one standard error.

Next, we tested for the possibility that our findings are the result of far more stimuli blocks than Bloem and La Heij (2003) used. To this end we did a separate analysis in which we only included block one of picture distractors and block one of word distractors. This by subjects ($F_1$) analysis revealed no significant interaction of condition by distractor, $F_1(1, 15) = .025, p = .877$. The inspection of the means already reveals a very small facilitation for both words (+ 2.54 ms) and pictures (+5.19 ms). Even though not directly comparable to the original study, this small facilitation effects for related words, show a contrasting pattern relative to Bloem and La Heij (2003).

Finally we explored the possibility that participants might have adopted different strategies to carry out the task, resulting in a difference between slow and fast responders that is occluded by the overall mean RT. Following the same procedure like in Experiment 1, we conducted a Vincentile analysis to examine the shape of the RT distribution. Figure 6A shows the Vincentised cumulative distribution curves for the semantic relatedness effect (facilitation here) with picture context. The related condition (solid line) clearly yields shorter RTs than the unrelated condition (dotted line), except for the tail of the distribution. Thus the RT distribution analysis shows that the relatedness effect (facilitation) is present for faster but not for slower responses. For the word context, since there was no significant facilitation we did not expect to see the two RT distributions to diverge from each other at any point (Figure 6B).

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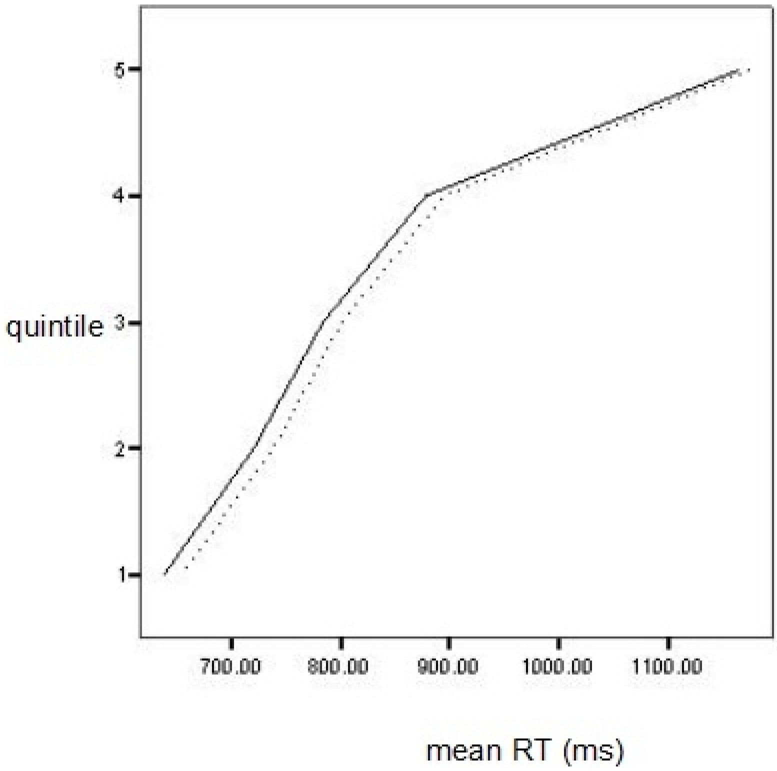
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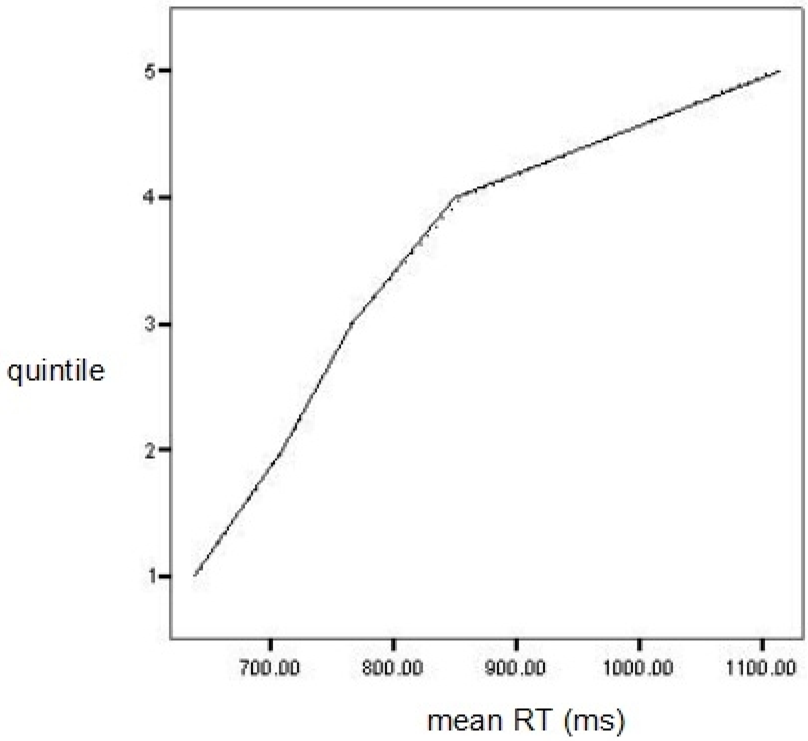
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mean RT (ms)

*Figure 6, Panels A&B.* Vincentised cumulative distribution curves for A) related (solid line) and unrelated (dotted line) condition in picture context, and B) related (solid line) and unrelated (dotted line) condition in word context. X- axis represents reaction time in milliseconds and Y-axis represents the quintiles .

**Discussion**

In Experiment 2, like in Experiment 1, the semantic relatedness of target and distractor affected performance in a different way for pictures and words. Semantic relatedness induced no effect (0 ms) for word distractors, but a significant 15 ms facilitation for picture distractors. This observed difference in effects deviates strongly from the relatedness effect of -28 ms interference for words, in the original study. It is also noteworthy that the facilitation from related pictures was almost half the size of the facilitation in Experiment 1. In fact, facilitation from related pictures in Experiment 2 (15 ms) was smaller than the facilitation we obtained for related words in Experiment 1 (21 ms).

In Experiment 2, we tried to stay as close as possible to the settings and procedure of the original study of Bloem and La Heij (2003). Nevertheless, we were still unable to replicate significant aspects of their data patterns. Experiment 2 aimed at eliminating some of the factors that might have affected performance in Experiment 1, in particular, the salience of presented words or pictures. Such display parameters of target and distractors in comparison to display timing were indeed found to affect performance.

The two experiments of our behavioral study made clear that replication of the Bloem and La Heij findings (2003) is not straightforward. In both Experiment 1 and Experiment 2 the interference-relatedness effect induced by context words was particularly hard to replicate. Table 1 lists the mean RT per condition and context type for all experiments (data from the EEG experiment of study 2 are also included). Contrary to the original study which obtained an interference effect for related words, we found a significant facilitation effect (Experiment 1) and a null effect (Experiment 2). A robust finding in all three experiments was the induction of a facilitation effect by related distractor pictures. Related pictures did speed up target translation, relative to unrelated pictures.

*Table 1.* Mean RTs (in ms) in the various experimental conditions of the original study (Bloem and La Heij, 2003), Experiments 1 and 2 (study 1), as well as the EEG experiment (study 2).

| Experiment | Context type | Semantically related | Semantically unrelated | Relatedness effect (RT unrelated – RT related) |
|---|---|---|---|---|
| Bloem & La Heij (2003), Experiment 1 | word | 793 | 765 | -28 |
| | picture | 769 | 797 | 28 |
| Behavioral study, Experiment 1 | word | 903 | 925 | 22 |
| | picture | 889 | 938 | 49 |
| Behavioral study, Experiment 2 | word | 809 | 808 | -1 |
| | picture | 829 | 844 | 15 |
| EEG study, EEG Experiment | word | - | - | - |
| | picture | 934 | 959 | 25 |

As in the first experiment, several assumptions were explored regarding factors that might drive the reported reversal of effects in the original study and why we were not able to replicate this finding. It was interesting to see that, separating our participants into high and low proficiency groups did affect the direction of the effects, with low proficiency participants showing effects similar to Bloem and La

Heij (2003). Thus, English proficiency level seems to play a role in the effects seen, even though no safe conclusions can be drawn by the present experimental setup. Moreover, number of trials was also not an important factor for our findings, since only considering the first block of each context type revealed a similar pattern as the overall analysis in terms of the direction of the effects (small facilitation for all), with the extremely small overall interference effect of related words, turning into an equally small facilitation for this first word block. We also explored the idea of whether the observed effects depend on the relative RT of our participants. The Vincentile analysis showed that indeed slow responses do not show much facilitation by related pictures.

## EEG study

In the light of our difficulty in fully replicating the original findings of Bloem and La Heij (2003) in the behavioral study, we decided to focus only on picture context for the scheduled EEG study. Thus, we opted for a more powerful design by zooming in on the related picture facilitation effect, which constitutes, after all, the main point of theoretical divergence between the discrete and continuous flow view.

The aim of the EEG Experiment was twofold: 1) to explore the nature of information flow in the language production system during such a demanding task (discrete vs. cascade processing), and 2) to provide electrophysiological evidence regarding the level of the language production system at which distractor pictures operate.

As an EEG indicator for the locus of the semantic relatedness effect, we used the N450 event related component, a negative deflection that occurs between 350 to 500 ms post stimulus onset with a peak around 450 ms. This component has been related to response level effects (conflict monitoring or inhibition) in Stroop-like tasks (e.g., Greenham, Stelmack, & Campbell, 2000; Hirschfeld, Jansma, Bölte, & Zwitserlood, 2008; Liotti, Woldorff, Perez III, & Mayberg, 2000; Swick & Turken, 2002). Overt backward translation in a distractor -word and picture- context has been labeled a Stroop-like task. Roelofs (2003) has linked the response selection level in models of Stroop task performance to the lexical selection level in language production. Thus, evidence of a Stroop-like response selection effect in the backward translation task can be seen as a lexical selection level effect. If we obtain an N450 component in our Stroop-like backward translation task, then we have some evidence that the facilitation effect arises at the lexical (response level) and not at the conceptual level. If on the other hand, no such effect is seen meaning that the N450 is not modulated by semantic relatedness, then we can conclude that the facilitation does not arise at response level processes. In other words, if the facilitation arises during conceptual access, as the CSM would predict, then we should observe no modulation of the N450 component which reflects response level stages of language production. If, on the other hand, activation spreads freely from the conceptual to the lexical level as Weaver++ would predict, then we should see an N450 modulation in accord with a locus of the effect during lexical selection.

## EEG Experiment

In this experiment we recorded EEG while participants performed the overt backward translation task. Only picture context was used, since word context did not result in stable outcomes in the behavioral study.

## Method

*Participants*

Seventeen right-handed students from the Radboud University, who did not participate in any of the behavioral study-experiments, took part in the EEG experiment for paid compensation or credit points. As was the case for the behavioral study, participants were all native Dutch speakers with good knowledge of English. Their proficiency level was tested using the same language background questionnaire as in the behavioral study. All participants had normal or corrected-to-normal vision and gave written informed consent to their participation. The experiment was conducted according to the Helsinki declaration (World Medical Association, 1996).

*Materials and Design*

The stimuli of the behavioral study were again used in this experiment. Only now there was only one independent variable (relatedness) with two levels (semantically related vs. unrelated picture context), because we did not use word context. Nonetheless, number of trials remained the same in total (384) because we replaced the word context trials (192) with additional picture context trials (192).

*Procedure*

Since the largest facilitation effect from picture context was obtained in Experiment 1 of the behavioral study, we decided to use this display settings for the EEG experiment. The procedure was identical to that of the behavioral study. The testing phase included a total of six blocks of target words with picture distractors. Participants were tested individually in an electrically and acoustically shielded booth at Radboud University, Nijmegen. The experimenter gave clear instructions regarding participant's eye-blinking, advising them to only blink during the time interval between their response and the appearance of the fixation cross. As soon as the fixation cross appeared on screen, they had to stop blinking. These guidelines helped minimize artifacts in the signal.

To allow for sufficient blinking time and thereby making blinking more natural we doubled the display time of the fixation cross and the intertrial interval. Each trial started with a fixation cross that stayed on screen for 1000 ms, followed by a blank screen for 250 ms. Finally the target word and the context picture were presented on screen simultaneously for 750 ms, followed again by a blank screen for 1750 ms. The intertrial interval was 1000 ms. A voice-key registered response latency for each trial, with a 1 ms accuracy. The presentation of stimuli was controlled by Presentation Software (Neurobehavioral Systems, Albany, CA).

*EEG Acquisition*

Sixty scalp electrodes mounted equi-distantly in an elastic cap were used for the recording with the Acticap system, amplified with BrainAmps DC amplifiers ( 500 Hz sampling rate). The signal was filtered on-line using a 0.016 - 100 Hz band-pass filter. Each electrode was referred on-line to the left mastoid, and re-referenced off-line to averaged mastoids. Electrode impedance was kept below 5 kΩ. The horizontal EOG was measured by electrodes on the outer canthus of each eye. The vertical EOG was measured by electrodes on the infra-orbital and the supra-orbital of the left eye.

One channel (P7) of one participant was excluded from subsequent analyses due to large amount of noise in the data. The recorded EEG signal was analyzed using the BrainVisionAnalyzer software (v.1.05.0005, Brain Products GmbH, Germany) .

*ERP analysis*

Responses faster than 700 ms were excluded from the analysis to avoid contamination of the EEG data with artifacts from articulation onset (8 % of the data). Error-trials were also excluded from the analyses.The recorded single waveforms were filtered with a bandpass filter of 0.1 to 30[2] Hz. The waveforms were then segmented into stimulus time-locked epochs made up by the signal 200 ms pre- to 700 ms post- stimulus onset. The average EEG activity 200 to 0 ms pre-stimulus was also used as the baseline to perform baseline-correction. Trials that contained eye movements, electrode drifting, or muscular artifacts within the epoch were rejected.

After further segmenting the signal following the two levels of the independent variable (relatedness,) at least 60 trials remained in each level, for each participant. Average waveforms per participant for each level of relatedness (semantically related-unrelated) were computed. ERP correlates of the facilitation effect were explored by a quadrant analysis approach. Each quadrant mean (left anterior, left posterior, right anterior, and right posterior) was computed by grouping ten channels in each of the four quadrants (see Figure 8). A sliding 50 ms time-window analysis of the signal, starting at 0 ms (stimulus onset) and reaching until 700 ms, was performed by computing the respective average microvoltages for each time-window, by quadrant, per participant. A semi-automatic approach was adopted for N450 peak-detection in each participant per relatedness (semantically related, unrelated condition).

The data were submitted to repeated measures ANOVA for each time-window, with site (anterior, posterior), hemisphere (left, right) and relatedness (semantically related, unrelated) as factors. If the repeated measures ANOVA revealed a significant effect of the independent variable (relatedness) in more than one

2 For one participant the filter was set to 26Hz to avoid exclusion of too many segments.

consecutive time-windows, then an overall average of the microvoltages recorded during the particular time-interval was computed and subjected to repeated measures ANOVA. Should the quadrant analysis reveal an interaction between the experimental factor (relatedness) and one of the factors site and/or hemisphere, a follow up analyses was conducted by collapsing over two quadrants. The factor site collapsed over anterior-posterior and the factor hemisphere over left-right.

**Results**

*Naming Latency Data*

The same rating procedure was used for the reaction time data as in the behavioral study. Errors, voice key malfunctions and RTs equal or faster than 300 ms were excluded from the analysis (3 % of the data). Data from one participant had to be removed because he did not meet the study requirements (L1 was German). A paired-samples t-test analysis revealed that on average participants experienced significant facilitation when translating in the context of semantically related pictures ($M$ = 934, $SE$ = 21.3) compared to when translating in the context of unrelated pictures ( $M$ = 959, $SE$ = 21.1), $t_1(14) = 3.696$, $p = .005$. This was also the case in the by items analysis, $t_2(191) = -2.712$, p = .007. Errors were not analyzed due to too low occurrence.

*EEG Data*

Data of two participants were excluded from the EEG analysis. The first one because he was already excluded in the RT analysis and the second one because of too many artifacts in the signal. The repeated measures ANOVA (with no Greenhouse-Geisser correction since no sphericity assumption violation was present in the data) revealed a main effect of relatedness for the time-window from 350-600 ms, $F(1,14) = 13.617$ , $p = .005$ . The respective F values for each consecutive time window can be seen in Table 2.

*Table 2. F* values and *p*-valuses (df = 1,14) per time window for the factor relatedness (related – unrelated).

| *Time Window* | *F* | *Sig.* |
|---|---|---|
| 0-50 | .386 | .544 |
| 50-100 | .187 | .672 |
| 100-150 | .077 | .786 |
| 150-200 | 3.769 | .073 |
| 200-250 | .117 | .737 |
| 250-300 | .615 | .446 |
| 300-350 | 3.352 | .088 |
| 350-400 | 6.27 | .025 |
| 400-450 | 10.13 | .007 |
| 450-500 | 14.93 | .002 |
| 500-550 | 13.76 | .002 |
| 550-600 | 9.42 | .008 |
| 600-650 | 1.793 | .202 |
| 650-700 | .490 | .496 |

The statistically significant deflection started at 350 ms and lasted until 600 ms, with semantically unrelated pictures inducing larger negativity than semantically related pictures.

A paired-samples t-test analysis revealed a larger peak amplitude of the waveform in the unrelated condition (M = -3.83, SE = 0.98), compared to the semantically related condition (M = -2.207, SE = 1.07), $t(14) = 2.724, p = .016$. Peak timing though, did not reveal any significant difference, $t(14) = 1.944, p = .072$ (unrelated M = 437 ms, SE = 7.48; semantically related M = 444 ms, SE = 7.75).

Figure 7 depicts the grand-average waveforms of nine representative channels with their position in the head figure on the top. As can be seen, in all channels a negative deflection starts around 350 ms and lasts until 600 ms, compatible with an

N450 effect (e.g. Greenham, Stelmack, & Campbell, 2000; Hirschfeld, Jansma, Bölte, & Zwitserlood, 2008; Liotti, Woldorff, Perez III, & Mayberg, 2000; Swick & Turken, 2002 ). The unrelated condition elicited a larger negativity relative to the semantically related condition.

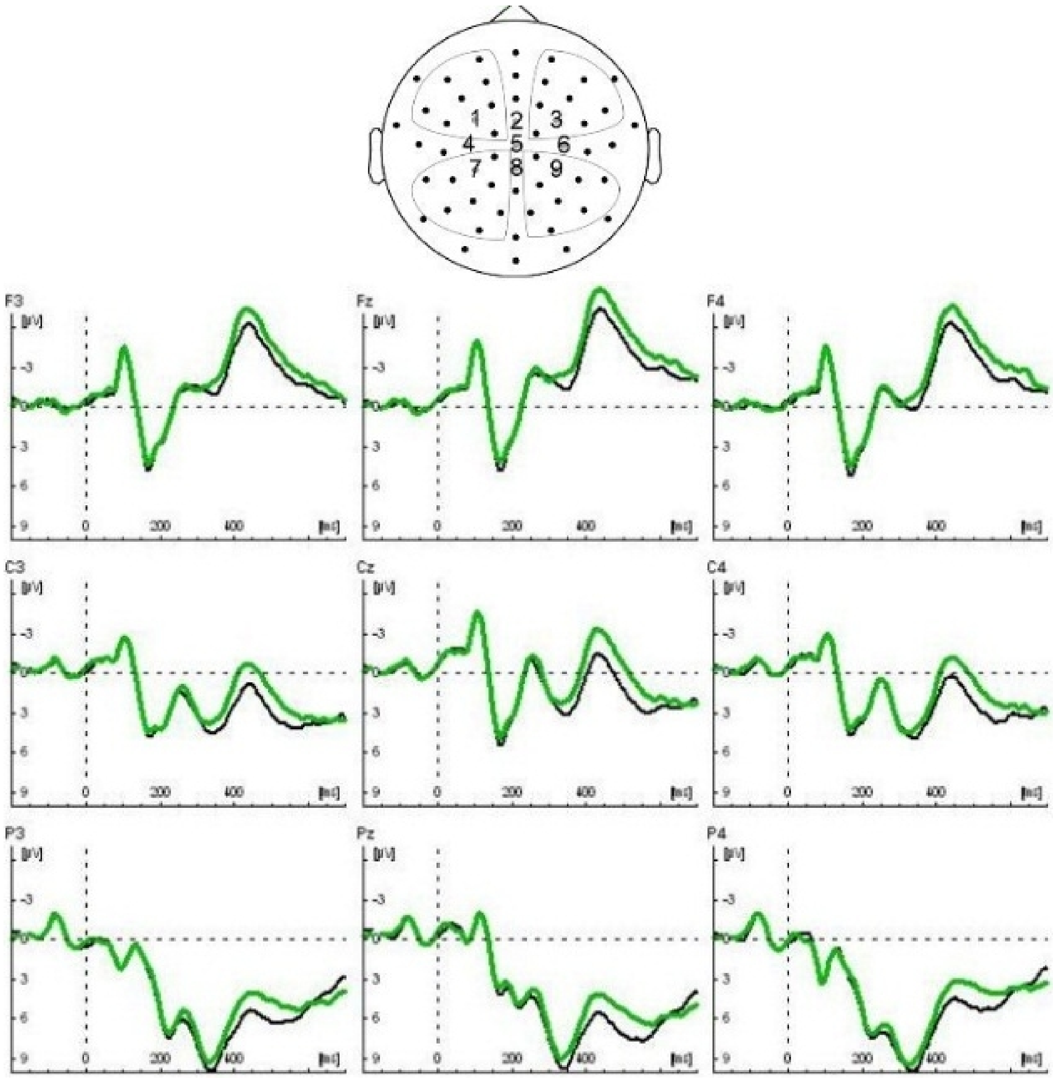


*Figure 7*. Electrode configuration. The four quadrants used in the analyses are encircled (head figure adapted from Piai, Schreuder, & Bastiaansen, submitted). The numbers 1 – 9 indicate which representative channels are depicted and correspond to F3 up to P4, starting at the top left side of the ERP waveform panels (F3). Below, the grand-average ERP responses to the semantically related condition (black line) and the unrelated condition (green line).

The rather broadly distributed topography of the effect and the way it unfolds in time (by a 50 ms time-window) can be seen in Figure 8.

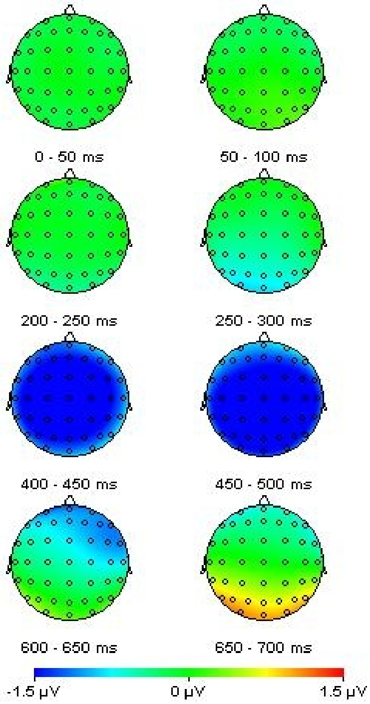


*Figure 8* . Scalp topography of the relatedness effect from stimulus onset to 700 ms.

Moreover a significant interaction of site by relatedness was present at the following time-windows: 50-100 ms, $F(1,14) = 10.369$, $p = .006$; 250-300 ms, $F(1,14) = 5.780$, $p = .031$; 600-650 ms, $F(1,14) = 5.502$, $p = .034$; 650-700 ms, $F(1,14) = 8.048$, $p = .013$. Follow up analyses conducted by collapsing over two quadrants (anterior-posterior) revealed no simple effects of relatedness at posterior sites for all [50-100 ms, $t(14) = -.581$, $p = .571$; 250-300 ms, $t(14) = 1.698$, $p = .112$; 600-650 ms, $t(14) = -.992$, $p = .338$] but the 650-700 time-window. For this time-window a simple effect of relatedness was seen for posterior sites, $t(14) = -3.48$, $p = .005$, indicating that the amplitude was larger at posterior channels for unrelated context pictures ($M =$

2.832, *SE* = .880) compared to semantically related context pictures (*M* = 1.955, *SE* = .929). No simple effects of relatedness were seen in anterior sites for any of the time-windows [50-100 ms, $t(14) = 1.353$, $p = .198$; 250-300 ms, $t(14) = -.137$, $p = .893$; 600-650 ms, $t(14) = 2.097$, $p = .055$; 650-700 ms, $t(14) = .886$, $p = .390$].

Finally, a significant hemisphere by relatedness interaction was seen at the 150-200 ms time-window, $F(1,14) = 6.416$, $p = .024$. Simple effects follow up analysis by collapsing over two quadrants (left and right hemisphere) revealed a simple effect of relatedness on the right hemisphere, $t(14) = 2.486$, $p = .05$, with the semantically related context pictures (*M* = 3.175, *SE* = .568) inducing larger amplitude in the right hemisphere than did unrelated context pictures (*M* = 2.810, *SE* = .579). No simple effect of relatedness was found for the left hemisphere, $t(14) = 1.220$, $p = .242$.

**Discussion.**

The RT data in the present EEG study replicated the facilitation effect from related picture-context found in Experiment 1 of the behavioral study. In size, a smaller facilitation effect was obtained in the EEG experiment (25 ms) than in the behavioral study (49 ms). Doubling the number of the picture context trials to match the 384 trials of picture and word context trials of the behavioral study, may have affected the participants' performance.

The EEG data provided clear evidence of an N450 component in our Stroop-like translation task. Unrelated picture-context elicited a significantly larger negative deflection of the signal in the time-window between 350-600 ms, peaking at 437 ms for the unrelated condition, and at 444 ms for the semantically related condition. Whereas peak amplitude was significantly different between conditions, the peak timing difference was not; indicating that semantically related and unrelated pictures both elicited effects of similar timing. As argued above, our interpretation is therefore that the facilitation effect arose during lexical selection, and not during conceptual selection.

Moreover, the N450 component obtained is indicative of cascade processing with a continuous flow of information from the conceptual- to the lexical- level. In the General Discussion section we further address the implications of this finding in terms of what participants do when a context picture is presented to them.

## General Discussion

In this thesis, two behavioral experiments and one EEG experiment are reported to evaluate the discrete vs. cascade views on the activation flow during word translation. Our data are in line with a cascade view on information flow during language production.

The behavioral experiments investigated the effects of context pictures and context words on production performance in an overt backward translation task. In the first experiment, a significant interaction of relatedness (semantically related vs. unrelated) by context type (word vs. picture) was observed, with related pictures inducing almost double the amount of facilitation relative to related words. Both facilitation effects were significant. Contrary to Bloem and La Heij (2003), we did not find evidence for interference induced by related words. Backward translation of a target word was facilitated by a related context picture as well as by a related context word.

In the second experiment, we again obtained a significant interaction of relatedness by distractor type. Simple effects analysis revealed that only the facilitation obtained from picture context was significant. Backward translation of a target word was significantly facilitated by a related context picture, but not by a related context word. In fact, the mean effect of relatedness for word context was zero. Thus, even though Experiment 2 was a close replication - in terms of display settings - of Bloem and La Heij (2003), no sign of interference induced by related word context was evident in our data. It is interesting to note that the facilitation from related pictures was almost half the size of the facilitation seen in Experiment 1.

The third experiment was an EEG experiment that applied an event related design to search for evidence of response level effects in the backward translation task. The results revealed an N450 component, with unrelated context pictures inducing a significantly larger negative deflection than semantically related context pictures. This main effect of relatedness was significant for the time-window between 350 to 600 ms post stimulus onset. Analysis of the RT data showed a relatedness effect, with related picture context resulting in faster responses than unrelated picture context.

Overall, these three experiments demonstrate that facilitation induced by semantically related pictures is a robust phenomenon, while interference by semantically related words – as found in Bloem and La Heij (2003)- is not that straightforward. The robustness of the picture context facilitation was also tested by Navarrete and Costa (2009). They as well replicated the effect of facilitation (Experiment 2a), and even obtained a facilitation effect  when manipulating the percentage of related trials in the stimuli and reduced the semantic categories (Experiment 2b).

Several possibilities were explored, in order to gain a more clear picture of our findings. With respect to the first experiment, it was shown that, at least for our pool of participants, a separation into high and low proficiency groups did not affect the direction of the effects (facilitation arose for both groups). Nevertheless, the second experiment offered an indication that English (L2) proficiency might play a role in the direction of the effects observed, in that low proficiency participants experienced interference by semantically related words, while highly proficient participants experienced facilitation. Number of trials was not an important factor mediating our findings in both behavioral experiments. A Vincentile analysis confirmed that the relatedness effect of facilitation (picture and word context) was present throughout the whole RT distribution for Experiment 1. This was not the case for Experiment 2, where only a significant facilitation from related picture context was seen and where it was less evident for slow responses. This difference might be related to the different display-timing of the two experiments and will be discussed further below.

The presence of the N450 component in relation with the absence of a peak timing difference between the two relatedness conditions in the EEG Experiment was indicative of the locus of the effect, because it suggests that the facilitation effect arose during lexical selection and not conceptualization. If the facilitation would arise during conceptual selection, then we would not expect to see an N450 component, which was evident in our data. And since this component has been linked to response level effects in Stroop-like tasks, we can conclude that the facilitation is a response level effect. Thus, our findings are in line with the cascade view on information flow, which locates the facilitation induced by related pictures at the lexical selection level and not the conceptual selection level. In particular, the evidence supports a cascade view in processing during overt translation, in which activation spreads freely from the conceptual to the lexical level, rather than is being stopped or passed by a threshold only allowing for the target concept to reach the lexical level.

Further analysis of the EEG showed that in the interval from 650 to 700 ms semantically related context pictures affected activity at posterior channels differently than did unrelated context pictures. This finding is difficult to interpret. This interaction might reflect a different treatment of the related picture context than the unrelated context, but it is difficult to say in what way. Alternatively, because the effect starts rather late (at 650 ms), it might reflect self-monitoring. The significant hemisphere by relatedness interaction between 150-200 ms, with related context pictures inducing larger amplitude on the right hemisphere, matches the Dell'Acqua et al (2010) findings on fast semantic processing. They obtained an early component at about 100 ms, which was attributed to fast semantic access from picture stimuli, which in their case were the target stimuli.

Schwieter and Sunderman (2009) also attempted to replicate the Bloem and La Heij (2003) study. They tried to disentangle issues regarding the locus of language selection in low and high proficient language learners. Their participants were high and low proficiency English-Spanish bilinguals. In accordance with our findings, they did not succeed in demonstrating a significant interference effect induced by related context words, neither for their low proficiency group nor for their high proficiency group. Similar to our Experiments 1 and 2 (behavioral study) they obtained a significant facilitation effect for related picture context, while the interference effect (-17 ms) exerted by related word context was not significant. These findings, combined with our findings suggest that picture facilitation is indeed the most robust effect in this task, with L2 proficiency as another factor mediating the results.

The results from the median split based on proficiency in Experiment 2 (behavioral study), point to a different effect of relatedness on low as compared to high proficiency participants. Following Kroll and colleagues' (2010) assumption that highly proficient bilinguals do engage their conceptual system in translation, while low proficient bilinguals might reside on pure word-to-word associations, one could imagine that our group of low proficiency participants experienced interference from related word distractors because they partly employed this word-to-word association strategy. As a result, the low proficient bilinguals might not have maintained a good control of their two languages (Dutch and English). While trying to translate the English target word, they were confronted with the Dutch context word, which may have distracted them and reduced their association performance. So, even though low proficient bilinguals usually have a good control over their two languages, the nature of the task may have introduced some factors that result in interference.

It is important to mention here that this interference in low proficient bilinguals was not seen in the first experiment (behavioral study). This is again indicative of the lack of robustness of the effect induced by related words, since similar proficiency levels in Experiments 1 and 2 (confirmed by appropriate statistical analysis) resulted in different effects, based on the display settings of the experiment. A second interpretation of the absence of any evidence for interference by related words for low proficient bilinguals in Experiment 1 (behavioral study) might be that the short display-time of the stimulus (750 ms) allowed the participants to suppress this interference by the related word and focus on the associative translation process.

In combining the suppression hypothesis with the display-timing issue, one more difference between Experiments 1 and 2 (behavioral study) becomes relevant: Namely, that the target and distractor stimuli were presented in different colors in the two studies. Perhaps, displaying the target in green and the distractor word in white (Experiment 1) made the participant focus on the target item, while displaying the target in black and the distractor in red (Experiment 2) might have shifted the focus on the distractor item. In combination with longer display duration for Experiment 2 (until response), this may have resulted in larger activation of the distractor and thus greater interference for low proficiency participants in Experiment 2. A differential salience -built up by displaying word and picture context in the same colors in Experiment 1 (both in white), while displaying word and picture context in different colors in Experiment 2 (word context in red, picture context in gray), may also explain why we obtained facilitation even for word context in Experiment 1. Future research should undertake a more systematic variation of the factors potentially affecting the relatedness effect. Such clarification would offer more insight on the questions regarding language proficiency, display settings, and display-timing, thereby reaching more differentiated task and context-dependent conclusions.

## Conclusion

Three experiments were conducted in order to shed more light on the discrete-cascade debate on language production during word translation. Our findings support a cascade view on language processing. Two behavioral experiments highlighted the robustness of the related picture context facilitation effect, while spreading doubt on the robustness of the related word context interference effect. The present study is one of the few extending the literature on the discrete-cascade debate using the overt backward translation task, and adds to the discussion regarding the display parameters of the particular task. In a third study, involving EEG recordings, an N450 component positioned the locus of the facilitation effect at the response selection level, rather than at the conceptual level. Our study is the first to uncover the neural signature of overt backward translation in time, and the first to provide evidence in favor of an

EEG component (N450) supporting the cascade processing on language production during a Stroop-like backward translation task.

## Acknowledgments

I wish to thank my thesis supervisors Ardi Roelofs and Ton Dijkstra for their extremely valuable support and help in completing this project successfully. Special mention goes to Vitória Piai for driving me through all the stages of software presentation processing and EEG data analyses during the whole past year. Last but not least, my gratitude goes to Michalis Moatsos and my family for supporting my dreams and being there for me at all times.

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# Appendix

A.

| nr | Target word | Dutch Translation | Related Word/Picture context | English translation | Unrelated Word/Picture context | English translation |
|---|---|---|---|---|---|---|
| 1 | Pig | Varken | Geit | (goat) | Glas | (glass) |
| 2 | Horse | Paard | Koe | (cow) | Sok | (sock) |
| 3 | Duck | Eend | Kip | (chicken) | Mand | (basket) |
| 4 | Donkey | Ezel | Zebra | (zebra) | Auto | (car) |
| 5 | Dog | Hond | Kat | (cat) | Sla | (lettuce) |
| 6 | Deer | Hert | Buffel | (buffalo) | Blouse | (blouse) |
| 7 | Pigeon | Duif | Zwaan | (swan) | Klok | (clock) |
| 8 | Frog | Kikker | Slak | (snail) | Arm | (arm) |
| 9 | Ant | Mier | Spin | (spider) | Deur | (door) |
| 10 | Shark | Haai | Dolfijn | (dolphin) | Aardbei | (strawberry) |
| 11 | Plane | Vliegtuig | Trein | (train) | Neus | (nose) |
| 12 | Garlic | Knoflook | Ui | (onion) | Jas | (coat) |
| 13 | Lemon | Citroen | Aardbei | (strawberry ) | Dolfijn | (dolphin) |
| 14 | Rabbit | Konijn | Eekhoorn | (squirrel) | Schoen | (shoe) |
| 15 | Cherry | Kers | Appel | (apple) | Zebra | (zebra) |
| 16 | Potato | Aardappel | Aubergine | (aubergine) | Kat | (cat) |
| 17 | Watch | Horloge | Klok | (clock) | Slak | (snail) |
| 18 | Spoon | Lepel | Vork | (fork) | Eekhoorn | (squirrel) |
| 19 | Bottle | Fles | Glas | (glass) | Zwaan | (swan) |
| 20 | Saw | Zaag | Hamer | (hammer) | Appel | (apple) |
| 21 | Knife | Mes | Bijl | (ax) | Bank | (bench) |
| 22 | Trouser s | Broek | Jas | (coat) | Koe | (cow) |
| 23 | Dress | Jurk | Trui | (sweater) | Geit | (goat) |
| 24 | Skirt | Rok | Blouse | (blouse) | Buffel | (buffalo) |

Appendix A continued:

| nr | Target word | Dutch Translation | Related Word/Picture context | English translation | Unrelated Word/Picture context | English translation |
|---|---|---|---|---|---|---|
| 25 | Boot | Laars | Schoen | (shoe) | Spin | (spider) |
| 26 | Leg | Been | Arm | (arm) | Ui | (onion) |
| 27 | Eye | Oog | Neus | (nose) | Bijl | (ax) |
| 28 | Suitcase | Koffer | Mand | (basket) | Vork | (fork) |
| 29 | Window | Raam | Deur | (door) | Trui | (sweater) |
| 30 | Chair | Stoel | Bank | (bench) | Trein | (train) |
| 31 | Glove | Handschoen | Sok | (sock) | Kip | (chicken) |
| 32 | Bike | Fiets | Auto | (car) | Hamer | (hammer) |