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Investigating the interplay between semantic and phonological distractor effects in picture naming

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Abstract

In this paper, we investigate the interplay between phonological facilitation and semantic interference effects in picture naming. We use a double distractor variant of the classic picture–word interference paradigm to investigate whether the reported interaction between these effects is dependent on the two types of related information being presented by the same distractor word or not. While prior studies using single mixed distractors such as *pigeon* for the target PIG have reported an interaction between phonological facilitation and semantic interference, we find additivity when the two types of related information come from two different distractor words. Possible implications of this result for how activation is transmitted within the speech production system are discussed.

1. Introduction

Theories of speech production distinguish three types of information relevant to speech production processes: semantic, syntactic, and phonological/phonetic. While all theories make reference to these three distinct types of information, the assumptions on how semantic, syntactic, and phonological encoding processes are interrelated differ greatly. Serial discrete models (e.g., Levelt, Roelofs, & Meyer, 1999) argue that the conceptually mediated selection of the target lexical entry (the lemma) must be completed before phonological processing can begin. Interactive models argue for continuous (and bi-directional) transmission of activation between semantic/syntactic and phonological representations (e.g., Caramazza, 1997; Dell, 1986; Starreveld & La Heij, 1995). In this paper, we investigate the interplay between semantic and phonological distractor effects using a *double distractor* variant of the picture–word-interference paradigm (Abdel Rahman & Melinger, submitted).

The picture–word interference paradigm (hereafter PWI) has been used extensively to investigate speech production processes (e.g., Glaser & Düngelhoff, 1984; Lupker, 1979; Schriefers, Meyer, & Levelt, 1990). In this task, target pictures are presented for a naming response in combination with a visual or auditory distractor word. Two robust effects have been observed with this task. Semantically related distractor words (i.e., category members) induce slower response times (RTs) relative to unrelated distractor words (e.g., Glaser & Düngelhoff, 1984; La Heij, 1988; Lupker, 1979, 1988; Rosinski, 1977; Underwood, 1976) and phonologically related distractors induce faster RTs relative to unrelated distractor words (Briggs & Underwood, 1982; Lupker, 1982; Rayner & Springer, 1986; Underwood & Briggs, 1984).

Another robust finding with the PWI paradigm is that mixed distractor words that are semantically *and* phonologically related to the target picture (e.g., distractor: *pigeon*; target: PIG) produce interactive effects (Damian & Martin, 1999; Starreveld & La Heij, 1995, 1996). In these studies, picture naming times were compared when semantic, phonological and mixed distractors were paired with target pictures. The results showed that pictures with mixed distractors were named as fast as pictures with pure phonologically related distractors. Thus, it appears that the phonological relationship attenuates the semantic interference effect. As the authors suggest, such an interaction between

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semantic interference and phonological facilitation effects is naturally accounted for by interactive models in which activation flows bi-directionally between different processing components. Serial discrete models can also account for the interaction, but in a different manner. Specifically, Roelofs, Meyer, and Levelt (1996) argue that distractor words activate not only their own lemma representations but also phonologically or orthographically related lemmas. According to this proposal, the mixed distractor *pigeon* also activates the target lemma (pig), thereby attenuating the interference effect. Thus, form features of the distractor word may influence lemma selection without feedback from the word-form level.

Mixed distractor words introduce two separate types of information into the production system. It is unclear whether this one-to-many source-information mapping is a necessary or crucial component of the observed interaction. For example, it is possible that the combined effects of semantic and phonological relatedness might not interact in the same way when the different types of information are introduced by separate distractor words, producing multiple one-to-one mappings (e.g., the distractor word *dog* introduces a pure semantic relationship and the distractor word *pill* introduces a pure phonological relationship). An investigation addressing this issue would provide additional insights into the underlying mechanisms of the PWI task as well as into how information flows within the speech production system. Thus, in this paper, we investigate the manner in which the presentation of multiple distractor words with different types of related information influences target picture naming.

Several studies in various domains have investigated how multiple primes of the same type influence target processing (cf. Balota & Paul, 1996; Brodeur & Lupker, 1994; Klein, Briand, Smith, & Smith-Lamothe, 1988; Schmidt, 1976; Stanners, Neiser, & Painton, 1979; Stanovich & West, 1983 for investigations of word recognition, and Brown, Roos-Gilbert, & Carr, 1995; Kahneman & Chajczyk, 1983; MacLeod & Hodder, 1998; Yee & Hunt, 1991, MacLeod & Bors, 2002, for investigations of color stroop interference). The multiple prime method has recently been extended to the PWI task whereby two distractor words are simultaneously presented with the target picture (Abdel Rahman & Melinger, submitted). These prior studies have demonstrated that the use of two distractor words does not interrupt the normal PWI processes—the classic effects, namely semantic interference and phonological facilitation, are observed. Furthermore, both distractors contribute to the observed effects; the magnitude of the respective effects increases when two words with the same relationship to the target are coupled (e.g., Distractors: *dog* and *beer*; Picture: PIG). To our knowledge, the multiple prime method has never been used to investigate the combined effects of different types of prime–target relationships. Here, we use this method to investigate whether the effects of phonological facilitation and semantic competition interact when the two types of information are introduced by two separate sources.

Drawing concrete predictions for multiple distractors from the different types of existing models is more complex than for single distractor words. Here, we present one possible way in which the number of distractors could influence the manner in which different effects interact. Consider the interactive two-stage model which includes feedback from the word-form level to the semantic/syntactic level (Dell, 1986, 1988). Continuous flow of activation coupled with feedback from the word-form level may result in different outcomes when two distractor words are presented rather than one (see Fig. 1). Specifically, for single mixed distractors, the activated word-form and lemma representations correspond to the same word and thus can mutually activate each other (see left column in Fig. 1). The word-form representation of *pigeon* can benefit from the higher activation level of its lemma (due to its semantic relationship with the target). The lemma *pigeon* can benefit, in turn, from the higher activation level of its corresponding word-form (which receives activation from the word-form of the target, assuming continuous flow of activation). Representations activated by two separate distractors cannot benefit from this sort of activation resonation within the system since the phonologically related word-form does not correspond to the semantically related competing lemma (see right column in Fig. 1).

In the current experiment, the double distractor variant of the picture–word interference paradigm was employed to investigate the interplay between semantic interference and phonological facilitation when the respective effects are introduced by separate sources (two

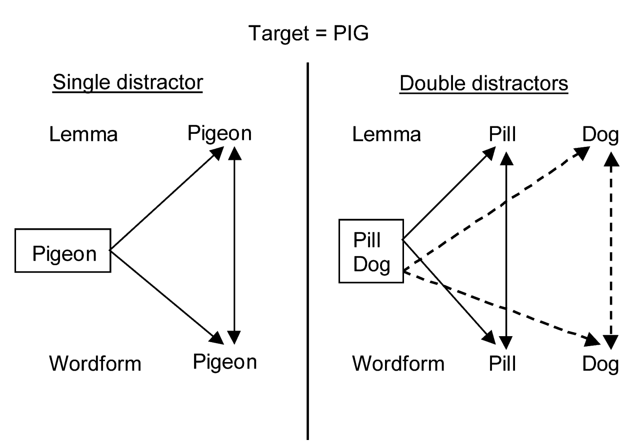

Fig. 1. Example of activation flow between distractors, lemmas, and lexemes in an interactive activation model (e.g., Dell, 1986, 1988) when one vs. two distractor words are presented.

words) rather than from a single source. The combined sets of conditions will be used to test whether the individual effects of the distractors interact or produce additive effects in picture naming. The former finding would suggest that the conditions underlying semantic interference and phonological facilitation are insensitive to the source of the effect. The latter result would suggest that how and whether the effects interact is dependent on how the relevant information is being introduced into the system.

2. Method

2.1. Participants

Twenty-three native Dutch participants from the Max-Planck Institute for Psycholinguistics subject pool were paid for their participation.

2.2. Materials

We selected 36 black and white line drawings of common objects (3×3 cm), equally distributed between six semantic categories (animals, furniture, musical instruments, vegetables, tools, and clothing; see Appendix A). Each picture was paired with six different distractor conditions (see Fig. 3 below). Three single distractor conditions were constructed consisting either of a semantically related word paired with a row of x's (SX—Distractor: *dog xxx*; Picture: PIG), a phonologically related word paired with a row of x's (PX—Distractor: *pill xxx*; Picture: PIG) or an unrelated word paired with a row of x's (UX—Distractor: *harp xxx*; Picture: PIG). Additionally, three double distractor conditions were constructed consisting of one semantically related word plus an unrelated word (SU—Distractor: *dog onion*; Picture: PIG), a phonologically related word and an unrelated word (PU—Distractor: *pill sock*; Picture: PIG) or one semantically related word paired with one phonologically related word (SP—Distractor: *beer pin*; Picture: PIG).[1]

In order to balance the number of presentations for each distractor word within the study, the words used in the mixed SP condition were not those used in the respective single conditions. While this pairing may not be optimal for direct comparisons of the magnitude of the effect, this design component is analogous to that used in prior mixed distractor studies (Damian & Martin, 1999; Starreveld & La Heij, 1995, 1996). Phonologically related distractors always shared minimally the first two segments with the target picture name. Since Dutch orthography is relatively shallow, there were few cases where the orthography and phonology diverged. However, they can diverge in the representation of vowel length. There were four items in which the orthographic length of the target vowel did not match the orthographic length of the distractor and two items where the phonological length of the vowels was not matched. The semantically related and unrelated distractors for the semantically related set were taken from the set of picture names. The phonologically related words and the unrelated words from the PU condition were not picture names.

Distractor pairs were arranged one above the other. The position of the related word (with respect to the row of x's or the unrelated word) was balanced such that it appeared in the upper position for half of the trials and in the lower position in the other half. The words were arranged such that they had maximal integration with the image without obscuring it. For a given picture, word position remained constant across experimental conditions. Words were presented in red and the image was in black on a white background.

2.3. Procedure and design

Each trial began with a fixation cross displayed in the center of the screen. After 500 ms, the fixation cross was replaced by a picture–word pair which was displayed for 2000 ms, resulting in an ISI of 2500 ms. Participants were instructed to name the picture as fast and accurately as possible. No instructions were provided regarding the words. Vocal response times were measured from the onset of picture presentation. The entire experiment lasted approximately 30 min.

Prior to the beginning of the experiment, participants named each picture once and were corrected if necessary. Each picture was presented two times in each condition. The trial presentation was pseudo-randomized such that no picture was repeated in consecutive trials.

The experimental design included the two within-subjects factors prime type (semantically related, phonologically related, and unrelated) and number (single vs. double).

3. Results and discussion

Only correct naming trials and trials between 200 and 2000 ms were included in the analysis. Trials which included incorrect naming, stuttering, mouth clicks, and vocal hesitations were considered errors. Errors

[1] Four other conditions were additionally included in this experiment: a control condition consisting of two rows of x's and three double distractor conditions in which both distractor words held the same relation to the target picture. Namely, we included two semantically related words, two phonologically related words, and two unrelated words. As none of these conditions is relevant to the current discussion or analyses, they will not be described further in this paper.

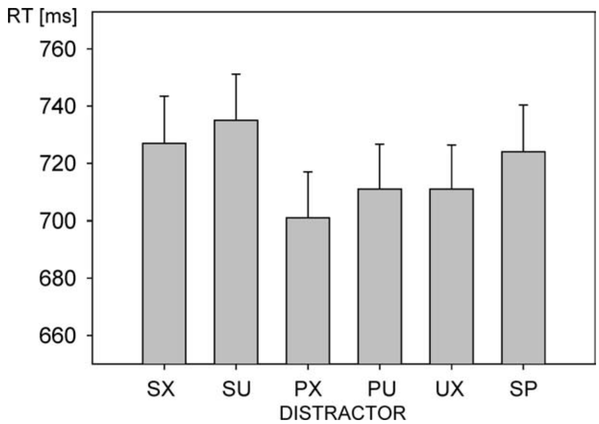

Fig. 2. Mean pictures naming latencies (with standard errors) for six distractor conditions.

occurred on fewer than 3% of trials. Furthermore, trials which were 2.5 standard deviations from a participant's mean were also excluded from the analysis. Fig. 2 presents the naming times for each of the six conditions.

The data were subjected to a 3 (prime type) × 2 (number) within-subjects and items ANOVA. The analysis yielded main effects of prime type, $F_1(2,44) = 25.4, p < .001, Mse = 274; F_2(2,70) = 7.3, p < .001, Mse = 1657$, and number, $F_1(1,22) = 9.11, p < .007, Mse = 400; F_2(1,35) = 5.1, p < .03, Mse = 1447$. The interaction between prime type and number was not significant, $F_1(2,44) = .42, p = .66, Mse = 185; F_2(2,70) = .34, p = .712, Mse = 1187$.

Separate comparisons of the single word conditions revealed the classic interference effect for semantically related words compared to unrelated words, $Mdiff = -15.8$ ms, $t_1(22) = 3.63, p < .001$, which is marginal by items, $t_2(35) = 1.88, p < .07$. We also observe the classic facilitatory effects of phonologically related compared to unrelated words which was significant by subjects, $Mdiff = 9.7$ ms, $t_1(22) = 2.27, p < .05$, but not by items, $t_2(35) = 1.13, p = .26$. This latter fact can be attributed to one item which produced a reversed effect. If this item is removed (one of the items not matched for phonological vowel length), the facilitation effect becomes significant by items, $t_2(34) = 2.1, p < .05$. Thus, we successfully replicate the two most robust effects found in the production literature. This replication forms the basis for further investigation.

To evaluate how the presentation of two distractors influenced target processing, we made the following comparisons: First, to determine the size of the simple effects, we calculated the difference in RTs between the SX and the UX conditions, providing a measure of the semantic competition effect, and between the PX and the UX conditions, providing a measure of the phonological facilitation effect. Second, to identify the cost associated with adding a second unrelated distractor word, we determined the effect of combining a semantically related word with an unrelated word (SU − SX) and the effect of combining a phonologically related word with an unrelated word (PU − PX). The respective differences between the single and double conditions were not significantly different in the semantic condition compared to the phonological condition, 1 ms, t's < 1, suggesting that the processing costs associated with adding an unrelated word in the two conditions was essentially the same. Thus, the SU and PU conditions provide measures of the simple interference and facilitation effects plus the additional cost associated with processing a second unrelated distractor word which appears to be independent of the relatedness condition.

Given these measures, we can formulate the two equations in Fig. 3 to test for additivity (cf. Balota & Paul, 1996). On the left-hand side of these equations, the calculations for the simple effects produced in the single conditions are presented (SX, PX, and UX). On the right-hand side, the effects of the related distractor combined with an unrelated distractor word (SU and PU; RTs here include potential costs of the second word) are subtracted from the mixed (SP) condition (i.e., the effect of combining a semantically related distractor with a phonologically related distractor). If the effects of

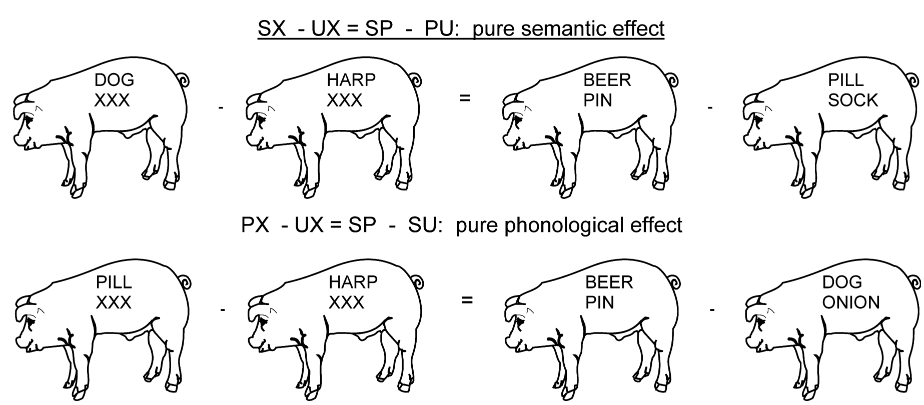

Fig. 3. Two equations (with examples from the relevant distractor conditions) to test for interactions between semantic interference and phonological facilitation effects.

semantic interference and phonological facilitation are additive when the respective types of information stem from separate distractor words, then the two sides of the equation should be equal. If the effects of the two distractors in the mixed presentation interact, then the two sides of the equation should differ.

Neither of these equations yielded a significant difference, suggesting that the two factors do not interact. When the PU condition was subtracted from the mixed SP condition, RTs were not significantly different from the simple semantic interference effect, 2.8 ms, t's < 1. Likewise, when the SU condition was subtracted from the mixed SP condition, RTs were not significantly different from the simple phonological facilitation effect, 1.0 ms, t's < 1.

The results for the present experiment demonstrate that the double distractor procedure successfully replicates the classic effects found repeatedly using picture–word interference. We found significant semantic interference and phonological facilitation in the respective single conditions. Furthermore, combining an unrelated word with these two types of related distractors has the same effect in both cases. Finally, our tests for interactions between the two different distractor effects failed to reveal a significant interaction. Each equation tests whether the RTs for the mixed SP condition are predictable from the sum of its parts. Neither equation provided any evidence for an interaction. Rather, the reaction times were exactly as predicted by the size of the individual effects and the cost of processing two distractors rather than one.

4. General discussion

In this paper we extended the investigation of the interplay between different distractor type effects by investigating how multiple distractors influence target processing. Specifically, we asked whether the reported interaction between semantic competition and phonological facilitation (Damian & Martin, 1999; Starreveld & La Heij, 1995, 1996) is dependent on the two types of related information being presented by a single distractor word. This question was addressed using the double distractor variant of the classic picture–word-interference paradigm. Our results suggest that the respective PWI effects are sensitive to how the information is introduced into the system. We demonstrated that when two distractor words with different relationships to the target picture are presented, namely one semantically and one phonologically related, the naming latencies for the target picture are as expected by the sum of the contributing components. Thus, unlike for single mixed distractor words, semantic interference and phonological facilitation effects do not interact when two distractors are presented.

Despite the presence of significant semantic interference and phonological facilitation in the single distractor conditions, we failed to find an interaction between these factors. The absence of an interaction cannot be attributed to characteristics of the SU and PU conditions. For example, it could be argued that the combined presentation of a related word with an unrelated word already alters processing of the visual input such that the respective effects are not "purely" semantic or "purely" phonological. We tested this alternative explanation by comparing the difference between these two conditions (SU and PU) and their respective single conditions (SX and PX). This test revealed no significant difference. One could also argue that the PU condition does not exhibit a phonological facilitation effect since it is not faster than the UX condition. This observation is misleading, however. The processing cost of presenting a second distractor word results in RTs approximately 10 ms longer than for one word. The PX condition produced a 10 ms facilitative effect. Thus, these two effects cancel each other out, resulting in equivalent PU and UX conditions. If the phonologically related words in the PU condition were not producing a facilitative effect, then the PU condition should be longer than the UX. We can thus conclude that all the relevant conditions and effects required to reveal an interaction were present. Our calculations demonstrate that the naming latencies in the double mixed condition were exactly as predicted by the sum of the component parts. Thus, although it is difficult to base strong theoretical claims on the absence of an interaction because the finding of additivity could be interpreted as a null effect, our results show a clear difference between the effects of presenting a single mixed distractor word and two words providing mixed semantic and phonological information.

Our proposed locus for the contrast between the observed additive effects and the interaction reported for single mixed distractors in the literature concerns basic differences between presenting mixed semantic and phonological information in one word or in two separate words. As suggested above, it is possible that the presence of an interaction between semantic competition and phonological facilitation crucially depends on the two types of information being introduced by a single distractor word. For example, to explain their observed interaction, Damian and Martin (1999) propose that the target lemma receives additional activation from the word-form level when a mixed distractor is presented. This, in turn, leads to a higher activation level of the target lemma relative to the mixed competitor, resulting in an attenuation of the semantic competition effect. As proposed in Section 1, if the semantic competitor at the lemma level does not correspond to the phonologically related word-form representation, then it is possible that the amount of feedback transmitted to the target lemma would be reduced, allowing the semantic competition effect to emerge.

This is just one possible manner in which the single vs. double distractor manipulation could influence the interplay between the relevant effects. While firm conclusions on exactly how the two situations differ would be premature at this time, the results from our study indicate that they do differ. Further investigations of how these differences emerge will provide valuable insights into speech production processes.

A second potential explanation for the discrepancy between our results and those reported in the literature lies in a potential shortcoming of all studies that have investigated the interplay between semantic and phonological distractor effects, namely that the distractor words used in the various conditions are different. For single distractor word studies, this is an inherent trait. For a given target picture (pig), the word *pigeon* can only be used as in the mixed distractor condition, not also in the pure semantic or phonological condition. For the present study, this design element was adopted to ensure equal number of presentations for each distractor word. However, whenever different words are used in the different relatedness conditions the possibility arises that additive or interactive result patterns are due to the characteristics of the materials. In fact, comparing across studies one finds that observed semantic competition and phonological facilitation effects vary greatly in their magnitude. For example, a limited comparison of two papers reveals a range from 12 to 44 ms for semantic interference and from 20 to 47 ms for phonological facilitation (e.g. Damian & Martin, 1999; Schriefers et al., 1990). This comparison illustrates the potential difficulty of testing for additivity when different distractor words are used.

Ideally, to rule out this alternative explanation one would like to contrast a mixed semantic + phonological effect using the same distractor words that are used to obtain the pure semantic and phonological effects. This, of course, is impossible using the classic picture–word-interference method. However, it is possible with the double distractor method. Future investigations which capitalize on the potential flexibility afforded by the double distractor method can provide a more direct test for additivity than is presented in the current study or in prior investigations because it allows the same words to be utilized for eliciting both the simple effects and the mixed effects.

To conclude, we have extended the investigation of the interplay between semantic competition and phonological facilitation effects in speech production with the double distractor method. Our results suggest that a critical prerequisite for observing an interaction is that the two types of related information be introduced by a single distractor word. In Fig. 1 we presented a potential difference in how activation accumulates as a result of the presentation of one distractor or two. Whether this characterization is in fact the best way of accounting for the contrast in results when one or two distractors are presented must be determined by further research. Clearly, however, using two distractors provides the experimenter with increased degrees of freedom to investigate questions central to speech production research.

Acknowledgments

We thank Willem Levelt for helpful discussion of our data and Philipp Rauch and Esther Vrinzen for collecting the data. We also appreciate the comments received from two reviewers.

Appendix A

Picture name	Distractor word conditions						
	SX*/ SU		PX*/ PU		UX	SP	
Beer	Hond	*Dog*	Beeld	*Image*	Venkel	Konijn	*Rabbit*
Bear	Venkel	*Fennel*	Vergiet	*Colander*	*Fennel*	Beker	*Baker*
Hond	Konijn	*Rabbit*	Horloge	*War*	Rock	Beer	*Bear*
Dog	Rock	*Suit*	Koffer	*Suitcase*	*Skirt*	Hok	*Sty*
Schilpad	Dolfijn	*Dolphin*	Schilderij	*Painting*	Hark	Kat	*Cat*
Turtle	Hark	*Rake*	Asbak	*Ashtray*	*Rake*	Schip	*Ship*
Dolfijn	Kat	*Cat*	Dokter	*Doctor*	Stoel	Schildpad	*Turtle*
Dolphin	Stoel	*Stool*	Tovenaar	*Magician*	*Chair*	Dobber	*Buoy*
Konijn	Schildpad	*Turtle*	Koning	*King*	Bekkens	Hond	*Dog*
Rabbit	Bekkens	*Cymbals*	Wolk	*Cloud*	*Cymbals*	Komeet	*Comet*
Kat	Beer	*Bear*	Kasteel	*Castle*	Pak	Dolfijn	*Dolphin*
Cat	Pak	*Suit*	Schaal	*Bowl*	*Suit*	Kabouter	*Dwarf*
Bed	Kast	*Cabinet*	Bel	*Bell*	Asperge	Tafel	*Table*

Appendix A (*continued*)

Picture name	Distractor word conditions						
	SX*/ SU		PX*/ PU		UX	SP	
Bed	Asperge	*Asparagus*	Harnas	*Armor*	*Asparagus*	Berg	*Mountain*
Bank	Wieg	*Cradle*	Bakker	*Baker*	Konijn	Stoel	*Chair*
Bench	Konijn	*Rabbit*	Rolstoel	*Wheelchair*	*Rabbit*	Ballon	*Balloon*
Tafel	Stoel	*Stool*	Taart	*Cake*	Baco	Bed	*Bed*
Table	Baco	*Wrench*	Boom	*Tree*	*Wrench*	Taco	*Taco*
Wieg	Bank	*Bench*	Wiel	*Wheel*	Das	Kast	*Cabinet*
Cradle	Das	*Tie*	Zadel	*Saddle*	*Tie*	Wiek	*Sail*
Kast	Bed	*Bed*	Kam	*Comb*	Beer	Wieg	*Cradle*
Cabinet	Radijs	*Radish*	Haai	*Shark*	*Bear*	Kado	*Gift*
Stoel	Tafel	*Table*	Stoep	*Pavement*	Banjo	Bank	*Bench*
Chair	Banjo	*Banjo*	Raket	*Rocket*	*Banjo*	Stoer	*Tough*
Harp	Banjo	*Banjo*	Hart	*Hart*	Komkommer	Tamboerijn	*Tambourine*
Harp	Komkommer	*Cucumber*	Passer	*Compass*	*Cucumber*	Hand	*Hand*
Piano	Tamboerijn	*Tambourine*	Pistool	*Pistol*	Boor	Bekkens	*Cymbals*
Piano	Boor	*Drill*	Dak	*Roof*	*Drill*	Piraat	*Pirate*
Viool	Bekkens	*Cymbals*	Vinger	*Finger*	Hemd	Harp	*Harp*
Violin	Hemd	*Shirt*	Helm	*Helmet*	*Shirt*	Videoband	*Videotape*
Tamboerijn	Piano	*Piano*	Tand	*Tooth*	Hond	Banjo	*Banjo*
Tambourine	Hond	*Dog*	Baard	*Beard*	*Dog*	Tak	*Twig*
Banjo	Harp	*Harp*	Banaan	*Banana*	Kast	Viool	*Violin*
Banjo	Kast	*Cabinet*	Verf	*Paint*	*Cabinet*	Bal	*Ball*
Bekken	Viool	*Violin*	Benzinepomp	*Gas pump*	Tafel	Piano	*Piano*
Cymbals	Tafel	*Table*	Soldaat	*Soldier*	*Table*	Bes	*Berry*
Rok	Das	*Tie*	Rolstoel	*Wheelchair*	Tomaat	Hemd	*Shirt*
Skirt	Tomaat	*Tomato*	Beeld	*Image*	*Tomato*	Rots	*Bad luck*
Vest	Sok	*Sock*	Verf	*Paint*	Kat	Pak	*Suit*
Vest	Kat	*Cat*	Horloge	*War*	*Cat*	Ventiel	*Valve*
Sok	Hemd	*Shirt*	Soldaat	*Soldier*	Zaag	Vest	*Vest*
Sock	Zaag	*Saw*	Dokter	*Doctor*	*Saw*	Sorbet	*Sorbet*
Hemd	Pak	*Suit*	Helm	*Helmet*	Radijs	Rok	*Skirt*
Shirt	Beer	*Bear*	Schilderij	*Painting*	*Radish*	Heks	*Witch*
Das	Vest	*Vest*	Dak	*Roof*	Wieg	Sok	*Sock*
Tie	Wieg	*Cradle*	Koning	*King*	*Cradle*	Dartbord	*Dartboard*
Pak	Rok	*Skirt*	Passer	*Compass*	Tamboerijn	Das	*Tie*
Suit	Tamboerijn	*Tambourine*	Kasteel	*Castle*	*Tambourine*	Parachute	*Parachute*
Schaar	Hamer	*Hammer*	Schaal	*Bowl*	Harp	Boor	*Drill*
Scissors	Wortel	*Carrot*	Bel	*Bell*	*Harp*	*Schaats*	*Skates*
Hamer	Boor	*Drill*	Haai	*Shark*	Sok	Zaag	*Saw*
Hammer	Sok	*Sock*	Bakker	*Baker*	*Sock*	Haan	*Rooster*
Zaag	Hark	*Rake*	Zadel	*Saddle*	Bed	Baco	*Wrench*
Saw	Bed	*Bed*	Taart	*Cake*	*Bed*	Zakenman	*Businessman*
Boor	Zaag	*Saw*	Boom	*Tree*	Wortel	Hark	*Rake*
Drill	Harp	*Harp*	Wiel	*Wheel*	*Carrot*	Boot	*Boat*
Baco	Schaar	*Scissors*	Baard	*Beard*	Dolfijn	Hamer	*Hammer*
Wrench	Dolfijn	*Dolphin*	Kam	*Comb*	*Dolphin*	Baan	*Job*
Hark	Baco	*Drill*	Harnas	*Armor*	Viool	Schaar	*Scissors*
Rake	Viool	*Violin*	Stoep	*Pavement*	*Violin*	Hals	*Neck*
Radijs	Tomaat	*Tomato*	Raket	*Rocket*	Piano	Wortel	*Carrot*
Radish	Piano	*Piano*	Hart	*Hart*	*Piano*	Ramp	*Ramp*
Wortel	Komkommer	*Cucumber*	Wolk	*Cloud*	Hamer	Asperge	*Asparagus*
Carrot	Hamer	*Hammer*	Pistool	*Pistol*	*Hammer*	Worst	*Sausage*

Appendix A (*continued*)

Picture name	Distractor word conditions						
	SX*/ SU		PX*/ PU		UX	SP	
Tomaat	Radijs	*Radish*	Tovenaar	*Magician*	Vest	Venkel	*Fennel*
Tomato	Vest	*Vest*	Vinger	*Finger*	*Vest*	Totem	*Totem*
Asperge	Wortel	*Carrot*	Asbak	*Ashtray*	Bank	Radijs	*Radish*
Asparagus	Bank	*Couch*	Tand	*Tooth*	*Bench*	Astronaut	*Astronaut*
Komkommer	Venkel	*Fennel*	Koffer	*Suitcase*	Schildpad	Tomaat	*Tomato*
Cucumber	Schildpad	*Turtle*	Banaan	*Banana*	*Turtle*	Kok	*Cook*
Venkel	Asperge	*Asparagus*	Vergiet	*Colander*	Schaar	Komkommer	*Cucumber*
Fennel	Schaar	*Scissors*	Benzinepomp	*Gas pump*	*Scissors*	Ventilator	*Ventilator*

*The SX and PX conditions consisted of the top word of each item pair combined with a row of Xs.

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