1. INTRODUCTION

In the present study, the Cross-Modal Lexical Priming (CMLP) task will be used. This task was developed by Swinney et al. (1979) and has been used extensively to shed light on on-line ambiguity resolution (Prather & Swinney, 1988; Swinney, 1979) and on-line interpretation of sentences with non-canonical word orders (Clahsen & Featherston, 1999; Love & Swinney, 1996; Nagel, Shapiro, & Navy, 1994; Nicol, Fodor, & Swinney, 1994; Osterhout & Swinney, 1993). In the CMLP variant that is used in this dissertation, spoken sentence processing is combined with a visual lexical decision task (LDT). The visual targets (words and non-words) that are presented can be either associatively related to a word (prime) in the spoken sentence or unrelated, but matched to the related targets on important characteristics. Reaction times (RTs) to the related targets are compared with RTs to matched control targets. If the RTs show facilitation (i.e., are shorter) for the related targets relative to the unrelated targets this is an indication for priming. This priming effect is taken to suggest that the meaning of the prime word in the spoken sentence was activated.

As far as the terminology is concerned, four different variables are relevant for measuring the priming effect. First of all, the prime, which (in the CMLP paradigm) is always a word that is part of the spoken sentence. Then, three types of targets are visually presented: a word related to the prime (related probe), an unrelated control word (control probe), and non-word targets. In most CMLP designs the related and control probes are matched on important characteristics, such as word length and frequency of occurrence.

Since its introduction in 1979, a couple of variants of the task have been developed: Cross-Modal Naming (where the Lexical Decision Task has been replaced by a Naming task: Love & Swinney, 1996), Cross-Modal Picture Priming (where binary decisions have to be made for pictures instead of words: Love, 1998), Cross-Modal Identity Priming (where identical words are used instead of associatively related words: Clahsen & Featherston, 1999; Featherston, 2001; Muckel & Pechmann, 2002), Cross-Modal Interference (where the focus is on processing load instead of activation of word meaning: Nagel et al., 1996; Shapiro, Gordon, Hack, & Killackey, 1993a), and Cross-Modal Integration (used to study the integration of particular words into spoken sentences: Ahrens, 2003).

As the CMLP task is the leading figure in this dissertation, this chapter is completely dedicated to the paradigm, its background, criticisms and potential pitfalls. After a discussion of the two tasks of the paradigm, a number of issues are presented that must be
taken into account with respect to probe selection, various ways to match the materials, and factors relevant for the choice of the exact probe positions. Finally, an important methodological discussion in the CMLP literature, starting with KcKoon and Ratcliff (1994) will be presented.

1.1. The Lexical Decision Task

In the CMLP paradigm, activation of word meanings is demonstrated via associative priming\(^1\) effects. These effects are measured with the visual lexical decision task (LDT). Therefore it is important to consider several issues relevant to this task. Associative priming is most commonly explained with a spreading activation model, like the one proposed by Collins and Loftus (1975). Spreading activation theories propose that the lexicon consists of a network of interconnected nodes, each node or set of nodes representing a particular concept. Processing a word involves activating the concept node corresponding to its meaning. This activation is assumed to spread along links to other, related concepts, thereby increasing the activation levels of these nodes. When, subsequently, a word corresponding to one of these pre-activated representations is presented, it can be recognized relatively fast. This faster recognition of the related word is called priming.

By contrast, compound-cue theories (e.g., Ratcliff & McKoon, 1994) propose that, when processing a word, semantic memory is accessed using a cue consisting of the word conjoined with the context in which it occurs (e.g., the preceding word). As related words co-occur more frequently than do unrelated words, the compound cues for related words tend to have greater familiarity than do those for unrelated words. Greater familiarity, in turn, gives rise to faster and more accurate processing, resulting in priming. In this explanation of priming there is no anticipatory activation of the probe, rather the RTs for related probe are facilitated by high familiarity values for the compound cue\(^2\).

Whereas the previous accounts assume that priming occurs without intention or conscious awareness, is fast-acting and can run in parallel with other mental activities, Posner and Snyder (1975, in Canas, 1990) propose another possible explanation for facilitation of reaction times to related words. This conscious, slow-acting process with limited capacities is called the expectancy-based priming mechanism. In this process, participants

\(^1\) Associative priming can be compared to semantic priming. In semantic priming, facilitation occurs within a certain semantic category (for example, *dog* would prime *cat*). Associative priming is based on relations between words that are established during everyday language use and experiences in daily life (for example, *dog* could prime *bone*). Associative relations are established with an Association Task, where participants are asked to react on each target word with the first word that comes to mind. Associatively related word pairs are often also semantically related.

\(^2\) Therefore, according to this account, priming does not indicate what would happen if the probe were not presented.
use the prime to generate a possible set of targets that might follow the prime. If the probe that actually appears is a member of this expectancy set, the lexical decision will be faster. If the probe that actually appears is not a member of the expectancy set, however, the lexical decision will be inhibited. The chance that this process is triggered is influenced by the relatedness proportion, that is, the probability (in a specific experiment) that a word target is semantically related to its prime. The expectancy-based strategy seems to be more useful when the relatedness proportion is higher, that is, when the number of related words is higher than the number of unrelated words. The magnitude of priming increases as the proportion of related pairs increases, which is called the relatedness proportion effect.

Apart from the prospective prime-generated expectancy process, another attentional process was proposed by Neely, Keefe, and Ross (1989). This process is called the retrospective target/prime semantic matching process and it is influenced by the non-word ratio, the proportion of non-words relative to all unrelated targets. It is suggested that this retrospective process takes place after lexical access has occurred, but before the overt response is given. The basic idea is that if the semantic matching process indicates that prime and target are related, the subject will be biased toward a ‘word’ response, which causes a facilitation of the response. If, however, the prime and target are unrelated, the subject will have a ‘non-word’ bias, which takes time to overcome before the correct ‘word’ response can be given.

Since the present experiments aim to measure priming as an indication of some underlying, unconscious process (activation of word meaning), it is important to control for factors that might produce strategic effects on the RT results to be able to gain a clean view of the more automatic processes underlying lexical-semantic processing during sentence comprehension. The most important conclusion from the short overview above is that a low relatedness proportion and a low non-word ratio are of importance. In the experiments presented in this dissertation, the relatedness proportion is approximately .40 and the non-word ratio (the probability that an unrelated target is a non-word) approximately .65. These ratios are similar to those in other CMLP experiments (e.g., Love & Swinney, 1996; Shapiro, Hestvik, Lesan, & Garcia, 2003; Swinney, Ford, Frauenfelder, & Bresnan, 1988).

1.2. Sentence comprehension

The primary question in CMLP studies involves spoken sentence processing. Hence, it must be ascertained that, first of all, participants do indeed listen to the sentences, and second, that sentence comprehension occurs as naturally as possible without any interfering
processes. In CMLP experiments, participants are commonly tested for comprehension throughout the experiment. Participants are asked to paraphrase or to answer questions about a subset of the sentences randomly throughout the experiment. This comprehension task is mainly inserted to make sure that participants pay attention to the sentences. Often, the results are used to exclude participants post-hoc from further analyses if they fail on a pre-established number of questions.

Baumgaertner and Tompkins (2002) discussed the effects of the difficulty of the comprehension questions on depth of sentence processing. They argue that as the lexical decision task gets more difficult and the comprehension questions get easier, the participants may only attend to the sentences superficially. In line with this, Friedrich, Henik, and Tzelgov (1991) did not find semantic priming effects in a task at the word level where participants had to do a letter search task on a prime word. This effect can be interpreted to indicate that the participants processed the prime words superficially, which was not enough to allow semantic priming to occur. Finally, Norris, Cutler, McQueen, and Butterfield (2006) were unable to find priming effects in a series of CMLP experiments, whereas effects were found using the same items in an isolated words condition. Probably this can be explained (at least partially) by the fact that their ‘control’ task did not induce comprehension of the sentences. Rather, in part of the experiments recognition was tested and in some others an immediate sentence repetition task was used. Presumably, questions (or other ‘control’ tasks) that do not focus on semantic aspects of the materials, but rather on phonological or physical aspects encourage people to process the materials in a shallow, superficial way. Associative priming at the sentence level might have less chance to occur if a control task does not force people to process the sentences deeply, but rather reinforces shallow processing of the materials. Therefore, attention should be paid to the complexity level of the comprehension questions. If these questions are too easy, the possibility arises that participants do not pay enough attention to the contents of the sentences.

On the other hand, making the questions too difficult has important pitfalls as well: memory processes might interfere with natural comprehension and, as also mentioned by Baumgaertner and Tompkins (2002), participants may pay too much attention to the sentences and therefore not react properly to the probes.

3 Although their argument is mainly posed against the influence of context in lexical ambiguity studies, it can be extended to other types of sentences too. In experiments with lexical ambiguities a biasing context is often used, which means that on the basis of the context one meaning of an ambiguous word is favored over the other. Baumgaertner and Tompkins (2002) claim that if sentences are processed more superficially, the chances that participants do not pay enough attention to the sentence contexts increase. If this is the case, context may influence the lexical access of ambiguous words to a lesser extent than it does in natural comprehension. According to the authors, this might be an alternative explanation for the fact that, despite context, both meanings of an ambiguous word are always reported to be activated in CMLP studies on lexical ambiguities (e.g., Prather & Swinney, 1988; Swinney, 1979).
In the experiments described in this dissertation, part of the instructions for the participants is that they should be able to answer the questions if they merely listen to the sentences attentively. It is explicitly emphasized that they should not try to memorize the sentences. This instruction is meant to minimize the chance that memory processes interfere with natural sentence processing. The procedure discussed before, where participants are excluded from data analysis if they fail to meet a certain preset criterion on the number of correctly answered comprehension questions, minimizes the risk of including in the analyses data from participants who engaged in shallow processing of the sentences.

2. **Probes**

2.1. **Selection**

A possible pitfall in selecting the probes is the complexity of the secondary (probe) task. In a pilot study with students, run to pretest materials for a Cross-Modal Picture Priming (CMPP) study with children, no effects were found (Swinney & Prather, 1989). In the CMPP-task the visual probe is a picture instead of a word and children (or, in the pilot, students) make a yes/no decision to each picture (for example: “Is it edible or not?”). In explaining the null-results of the pilot study, the authors claim that floor effects (minimal reaction times) were obtained. Since it is physically impossible for the participants to respond faster, facilitation (priming) of related words (or pictures) cannot be expected.

There are different ways to encourage participants to perform at an optimal, but not maximal, level. Only when the optimal level is not as high as the maximal level, priming effects (that is: better performances in some circumstances but not in others) can be observed. This can be influenced at three levels - the three stages of the lexical decision process (see e.g., Nicol et al., 1994): visual processing, lexical access and decision making and motor response.

Swinney and Prather (1989) influenced the first stage to avoid floor effects: they made the task slightly more difficult by manipulating the visibility of the pictures (they presented the pictures with the lights in the experimental room on). In this manipulated condition, the expected effects indeed appeared.

Shapiro, Brookins, Gordon, and Nagel (1991) manipulated the first and the second stage of the lexical decision process in a Cross-Modal Interference (CMI) task. In a response to Schmauder, Kennison and Clifton (1991) who could not replicate some main

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4 Note that this is relevant for the results in the LDT as well: if sentence parts or specific words are repeated for memorizing purposes, this could result in continuous priming effects for these particular words.
findings of Shapiro and colleagues (Shapiro, Zurif, & Grimshaw, 1987, 1989; Shapiro & Levine, 1990), Shapiro et al. (1991) showed that the main reason for this replication failure was the choice of their probes. They claimed that the probe set that was used by Schmauder et al. (1991) was too homogeneous. The probes that were used by Schmauder et al. (1991) were all monosyllabic, four to five letter words, within a small range of frequency. According to the interpretation of Shapiro et al. (1991), this would encourage participants to form expectations, which would make the LDT less effortful to perform. This being the case, no significant trade-off between the primary (understanding the spoken sentences) and the secondary task (LDT) could be expected to occur: the primary task could not cause a decrease in response times on the LDT since, presumably, the performance on the LDT task was already maximal. To test this hypothesis, heterogeneity of the probe set was increased in two ways. In the first experiment the probes that were used had a length of five to nine letters (average length = 6.85) and two or three syllables (average = 2.33). The frequency of the words ranged from 56 to 312 (average = 159) per million. In the second experiment, a perceptually altered version of Schmauder’s probes was used. In all words both uppercase and lowercase characters were used. The data revealed a replication of the original results of Shapiro et al. (1987, 1989, 1990) when the same sentences were used with a different probe set.

Although Shapiro et al. (1991) emphasize the heterogeneity of the newly created probe sets, the results can also be interpreted in terms of the factors mentioned earlier. In the first experiment, the set used by Shapiro et al. (1991) consisted of longer words and therefore seems to be more demanding with respect to the second stage of the lexical decision process: lexical access and decision making. Indeed, the response times were considerably longer (the averages in the Schmauder et al. (1991) study ranged from 604 to 611 ms, the averages in Shapiro et al. (1991) ranged from 640 to 717 ms). In the second experiment, the demands for the first stage, visual processing, were enhanced. Average response times increased even more in this condition, ranging from 683 to 743 ms.

The conclusion of this section is that caution should be exercised in the selection of probes: the probes should generate enough processing load to ensure that priming effects can be found. This can be accomplished by using probes that are not too ‘easy’ to process (i.e., short, high in frequency), and by creating a heterogeneous probe set, in order to prevent participants from forming expectations.

2.2. Matching

Priming can be defined as the facilitation of a response to an item relative to the baseline response time for that same item. In the CMLP paradigm, the design that is most often used is the matched probe design. In this design the response time (RT) to the related
probe is compared to the RT to a probe that showed the same RT in a baseline LDT, but is unrelated to the prime word in the sentence. This design has proven to be successful and is relatively easy to use (e.g., it is easier to match a pair of single words than it is to match a pair of sentences). McKoon, Ratcliff, & Ward (1994), however, argued that this design is inappropriate. Their arguments will be discussed below.

In the matched probe design the RT to a specific probe at a specific point in a specific sentence is compared with the RT to a different probe at the same point in the same sentence. Two other possibilities are theoretically valid to measure priming effects at different positions in a sentence. The first is to compare the RT of a specific probe at a specific point in a specific sentence with the RT to the same probe at a different point in the same sentence. The second option is to compare the RT to a specific probe at a specific point in a specific sentence with the same probe at the same point in a different sentence.

The first possibility, in which the probe point is the variable that is changed to get adequate baselines, is virtually impossible. It is known from previous studies that at different points in a sentence one can expect different processing loads. Therefore it is difficult to directly compare RTs across a sentence. Nagel et al. (1994) found a trend for differences in RTs for the control probes at different positions in the sentence. Differences in processing load as a function of sentence position were also observed with another methodology (Granier, Robin, Shapiro, Peach, & Zimba, 2000). Granier et al. (2000) used a visuomotor tracking task as a secondary task during sentence comprehension and found that performance on this secondary task was poorer, and thus processing load higher, both during the beginning and the end of sentences (first and last 500 ms), as compared to the middle of sentences.

The second possible design is called the matched sentence design. A main problem with this design is that it is very difficult to create two different sentences that are completely matched except for the prime. This is especially true because there might be unknown variables that affect sentence processing.

McKoon et al. (1994) argued that the matched probe design is unreliable, and that the switched probe design should be used instead. In this design the related probe for a particular sentence is used as control probe for another sentence. This means that the related and control probe, although matched per probe group, are not matched per pair or per sentence. Therefore, the sentence cannot be used as the main level of analysis.

The issue of design type is part of an interesting discussion on the methodology of the CMLP paradigm between McKoon and Ratcliff on the one hand (McKoon & Ratcliff, 1994; McKoon et al., 1994; McKoon, Allbritton, & Ratcliff, 1996) and Love, Swinney and colleagues on the other hand (Love & Swinney, 1996, 1998; Nicol, Swinney, Love, & Hald, 2006; Nicol et al., 1994, see also Hestvik, Nordby, & Karlsen, 1999). McKoon et al. (1994) ran a series of experiments on gap-filling in object-relative sentences that represented a
number of different variants of the CMLP paradigm. The studies differed on three characteristics. First, some experiments used the ‘standard’, rather complex, types of sentences with many adjectives used in typical CMLP experiments (see example sentence (1)), and some used simpler sentences (see sentence (2)). Second, in some experiments the sentences were presented aurally and in others they were presented visually (i.e., in the same modality as the probe). Finally, some experiments used a matched probe design and others a switched probe design. Most experiments included two probe positions (though there was never more than one probe in a given trial): a control probe position that was placed directly before the verb (indicated as [1] in the example sentences), and an experimental probe position, [2], that was placed directly after the verb.

(1) Two instructors held the skier that the waitress in the lobby [1] blamed [2] for the theft.

McKoon et al. (1994) found no priming at either of these probe positions when a matched probe design was used. When a switched probe design was used, however, they found priming at both probe positions. The authors therefore conclude that ‘the choice of control word was critical in determining the results’ (p. 1224). The next discussion will reveal that the supposed superiority of the switched probe design as opposed to the matched probe design was based on unreliable results.

3. PROBE POSITIONS

3.1. Control probe position

To verify adequate matching of probes, one should include a control probe position at which no priming is expected. If priming is found at ‘experimental’ probe positions but not at the control probe position, one can assume that the related and control probes were adequately matched. The findings at the control probe position revealed the weakness of the McKoon et al. (1994) arguments. Nicol et al. (1994) pointed out that with both the matched and the switched probe design, the pattern of results obtained by McKoon et al. was the same: in both experiments there were no differential effects between probe positions. The only difference was that in the matched probe design a significant difference was found between related and control probes both at the control probe position and the probe position of interest (the gap), whereas in the switched probe design no significant differences were found at either probe position. In both cases, because of a lack of
differential effects between probe positions, no conclusions can be drawn about the probe position of interest.

Indeed, Nicol et al. (1994) showed some evidence suggesting that the significant differences found at both probe positions in the matched probe experiment of McKoon et al. might have been caused by inherent differences in reaction time between the related and the control probes. In a baseline LDT, using the related and control probes of McKoon et al., they found that the mean response times for the related probes were significantly faster than for the control probes. This strongly suggests poor matching in the matched probe experiment by McKoon et al. (while matching occurs automatically in the switched probe design).

3.2. Number and placement of probe positions

An important methodological disadvantage of the CMLP task, as opposed to, for example, self-paced reading tasks or ERP, is that CMLP allows a response to be taken at only one particular position per sentence at a time. The complexity of the research design and resulting statistical analyses increase exponentially with the number of extra probe positions that are included. In most experiments, two or three probe positions are used; four seems to be the maximum given typically available sample sizes. Furthermore, this limited number of probe positions cannot consist of only experimental probe positions; at least one must be a control probe position (see section 6.1). In addition to this quantitative limitation to the range of possible moments during a sentence at which the CMLP task can measure language processes, there are two other restrictions: probes are preferably not placed at the very beginning or the very end of a sentence.

3.2.1 Early probes

Words that appear early in a sentence have been found to be ‘bad’ primes (i.e., show no priming effects) by a couple of researchers (Shillcock, 1982; D.A. Swinney, personal communication, 2002; Zwitserlood & Schriefers, 1995), suggesting that at least a minimal amount of preceding context or time is necessary for priming to occur.

3.2.2 End-of-sentence effects

At the end of a sentence, the processes of interest (i.e., automatic on-line processes) may interfere with a more general processing effect: the end-of-sentence wrap-up effect (Balogh, Zurif, Prather, Swinney, & Finkel, 1998, see also Ben-Shachar, Palti, & Grodzinsky, 2004; Hagoort, 2003). In response to Blumstein et al. (1998), Balogh et al. (1998) demonstrated that in sentences like (3), priming of the noun professor was found not only directly after its
occurrence (probe position [1]), and at a position where it is expected to occur due to structural factors (see Chapter 3) but also at the end of the sentence (probe position [4]).


Although an extra control probe position after probe position [3] and before [4] is missing, and therefore reactivation cannot be proved unequivocally, the distance between [3] and [4] is long enough to suggest that activation has returned to baseline before [4]. The distance between [3] and [4] was always longer than the distance between [1] and the control probe position [2], where no priming was found. Since no residual activation was found at [2], it is reasonable to expect no residual activation at the last probe position as well. The conclusion that the priming effect at the end of the sentence reflected an additional, different process thus seems warranted.

Balogh et al. (1998) indicate that this end-of-sentence wrap-up effect is not well understood. It may reflect a general integration process that allows the listener to combine the new information with general knowledge or to draw some general conclusion from the sentence. It could also reflect a processing mechanism that performs a syntactic check at the end of a sentence, for example to make sure that all arguments slots set up by the main verb have been filled. Or it may even be a task-specific strategy, evoked by the method used, in which sequences of unrelated single sentences are presented. According to some researchers it seems reasonable that the effect has nothing to do with normal, natural sentence comprehension (D.A. Swinney, personal communication, 2002).

Nonetheless, it is impossible to disentangle end-of-sentence wrap-up effects from the on-line effects that are the focus of the study when probes are presented at the end of a sentence. Therefore, probes in the experiments reported here were always presented before the end of the sentence.

Norris et al. (2006) point out that many studies reporting associative priming effects in sentences used end-of-sentence probe positions. Their objection is that this position draws the attention of the listeners to the primes and thus increases the chances to find priming effects. The same argument goes for situations in which the sentences are terminated after the appearance of the prime or when primes appear at major clause boundaries.

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5 For a further discussion of the end-of-sentence wrap-up effect, see Chapter 6.
4. SPURIOUS PRIMING EFFECTS

4.1. Better fit

Before one can infer priming from a RT difference between related and unrelated probes, it has to be ascertained that no other confounding factors could have influenced the RTs of either the related or the control probe in a systematic way. McKoon and Ratcliff (1994) pointed out such a factor in their criticisms of the materials used by Nicol and Swinney (1989). According to McKoon and Ratcliff, the related probes constituted a ‘better fit’ (e.g., semantically, pragmatically or syntactically, that is, were more plausible given the context) with the sentence than the control probes and, moreover, these differences in fit differed between probe positions, thereby possibly accounting for the observed pattern of deactivation and reactivation. Thus, at the probe position of interest, the related probes supposedly fitted better than the control probes, resulting in faster RTs. McKoon and Ratcliff designed an experiment in which they used adapted versions of the sentences used originally by Nicol and Swinney (1989). In the original experiment, sentences like (4) were used, in which reactivation of the direct object boy was expected directly after the verb, that is, at probe position [2]. Therefore faster RTs were expected for the semantically related probe girl than for the control probe body at [2], but not at [1]. The adapted version of the sentence is seen in (5). The original sentence is changed in such a way that the direct object is not encountered before the verb occurs. The same probes were used.

(4) The police stopped the boy that the crowd at the party [1] accused __[2]__ of the crime.

related probe: GIRL
unrelated probe: BODY


‘related’ probe: GIRL
‘unrelated’ probe: BODY

McKoon and Ratcliff presented sentences like (5) on a screen in a word-by-word reading task. For each participant, at either the first or the second probe position, either the ‘related’ or the ‘control’ probe was presented, also visually, to the right of the sentence. A lexical decision had to be made to this probe after which the sentence continued. A significant interaction was found between probe position and probe type, that is, at probe

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6 For the syntactic theory behind this hypothesis see Chapter 3.
position [2] related probes were reacted to faster than control probes, and this difference in reaction times differed significantly from that at probe position [1]. According to McKoon and Ratcliff, the only conclusion can be that the ‘better fit’ of the related probes (a GIRL is more likely to be accused than a BODY) caused the faster RTs.

Although these results might seem convincing at first sight, attention should be paid to the difference in tasks used by McKoon and Ratcliff on the one hand, and Swinney et al. on the other hand. Whereas in the original experiment the probes were presented in a different modality than the sentences (visually versus aurally), in the McKoon and Ratcliff experiment the probes and the sentences were presented in the same modality. Furthermore, in the original CMLP task the (spoken) sentence continues without interruption beyond the presentation of the probe while in the McKoon and Ratcliff task presentation of the rest of the sentence only continued after a response was given to the probe. These two differences will be discussed now.

4.1.1 Modality

Nicol et al. (2006, see also Love & Swinney, 1996; Swinney, Prather, & Love, 2000) directly compared a CMLP-task with a word-by-word reading task in combination with an LDT (called the unimodal sentence interruption paradigm). The latter paradigm was similar to the one adopted by McKoon and Ratcliff (1994). Exactly the same sentences and probes were used in both experiments. An example is given in (6) and (7). The probes were matched per pair on length, frequency and a priori lexical decision times. The congruent probe was a word which provided a good fit with the sentence at the probe position and formed a good continuation at this point (as determined based on off-line pre-test results). Neither probe was predictable from the prior context.

(6) The butler in the mansion mastered [1] the difficult recipe in moments
congruent probe: TECHNIQUE
incongruent probe: NEWSPAPER

(7) The attendant in the hotel folded [1] the clean towels for the new guests.
congruent probe: NEWSPAPER
incongruent probe: TECHNIQUE

The unimodal sentence interruption paradigm indeed showed a goodness-of-fit effect, that is, faster RTs were found for probes that fit into the sentence than for incongruent probes. However, in the CMLP task, in which the same materials were used, no effect was found. Nicol et al. (2006) therefore concluded that the cross-modal continuous sentence
presentation as used in their study effectively prevents integration and intrusion of visually presented probe words.

4.1.2 Rate of sentence presentation

The second difference between the McKoon and Ratcliff study and the standard CMLP paradigm is that in the latter the sentence is presented without interruption and always continues beyond presentation of the probe. Indeed, when asked to indicate the location of the probe, participants in CMLP experiments typically fail to report the correct location of the probe during the sentence (Love & Swinney, 1996). This contrasts sharply to the McKoon and Ratcliff design where the word was presented almost as part of the sentence (i.e., the sentence stopped and instead the next visual word was the probe). The only difference between presentation of the sentence words and presentation of the probe word was the position on the screen. The sentence was presented word by word in the center of the screen whereas the probe occurred at a position to the right of the sentence words. The sentence continued only after the lexical decision had been made, making it likely that participants integrated the word into the sentence.

An interesting additional finding was that the cross-modal task appeared to be much easier for the participants than the ‘all-visual’ task. In the all-visual condition 61 out of 103 participants (approximately 60%) were excluded for having more than 10% errors on the LDT or more than 25% errors on the comprehension questions. These same criteria resulted in exclusion of 8 out of 46 participants (approximately 17%) in the cross-modal condition. Also, mean RT in the cross-modal condition was 562 ms, as compared to around 700 ms for the all-visual task.

The difference between an uninterrupted and an interrupted design was tested by comparing a ‘standard’ CMLP with a slowed speed CMLP task (Nicol et al., 2006). The basic idea was that when speech is slow, there is more time for intrusion from external factors. In the standard design, sentences were spoken in a natural rate of around six syllables per second. In the slowed speech design the same sentences were spoken at a rate of approximately four syllables per second. This speech was rated by independent judges to sound clear and comprehensible but slow. The results were clear: faster RTs for congruent versus incongruent probes were found in the slowed condition but not in the normal condition. Reaction times and error patterns were comparable for both studies, indicating that the tasks did not differ in complexity.

McKoon et al. (1996) used the same no-gap sentences as McKoon and Ratcliff (1994) in a cross-modal design and reported the same goodness-of-fit effects that were found in the original all-visual experiment. This can be explained by the factor discussed here: rate of presentation. The spoken sentences in McKoon et al. (1996) were presented at approximately 390 ms per word, that is, approximately 2.6 words per second. This is even
slower than the speech rate used by Nicol et al. (2006) in the slowed condition, which was 2.97 words per second (versus 4.2 words per second in the normal condition).

4.2. Backward priming

Glucksberg, Kreuz and Rho (1986) do not agree with the conclusions about context independency of lexical access during the first stage of access in lexical ambiguities. They argue that only the relevant meanings are ever accessed when a lexical ambiguity is accessed and that the findings can be attributed to a methodological flaw in the CMLP paradigm. The surface, acoustical form of the word however is kept in memory for a short period, and when the irrelevant probe word is presented, the two words get connected, and priming occurs. This kind of priming is called ‘backward priming’. The irrelevant meaning of the ambiguous word is thus said to be activated simply and solely because of the characteristics of the CMLP task. However, these effects could not be replicated in cross-modal designs and in sentence contexts (Prather & Swinney, 1988; for further discussion see also Jones, 1989; Swinney & Prather, 1989; Swinney & Osterhout, 1990; Tanenhaus, Burgess, & Seidenberg, 1988).