PURE MEDIATED PRIMING

by

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ABSTRACT

Mediated priming refers to the activation of a target (e.g., STRIPES) by a prime (e.g., LION) that is related indirectly via a connecting "mediator" (e.g., tiger). In previous mediated priming studies (e.g., McNamara & Altarriba, 1988), the mediator was associatively related to the prime. In contrast, *pure* mediated priming entails no association between prime and mediator (e.g., SPOON → soup) nor between mediator and target (e.g., soup → CAN). This study investigates the existence of pure mediated priming and assesses which semantic priming model (spreading activation, expectancy, compound-cue, or semantic matching) accounts for the results. Experiments 1 – 3 demonstrate the occurrence of mediated priming in a double LDT (Experiment 1) and a standard LDT (Experiments 2 and 3) using a stimuli set consisting of an instrumental relation between prime and mediator (e.g., a spoon *is used to eat* soup) and an integrative relation between mediator and target (e.g., a can that *contains* soup). Experiments 4 and 5 also exhibited mediated priming using a different set of stimuli with integrative relations for both links. Overall, results indicate that retrospective semantic matching provides the best explanation of pure mediated priming.

INDEX WORDS: mediated priming, semantic priming, associative priming, semantic matching, spreading activation, compound-cue theory

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CHAPTER 1

INTRODUCTION

Mediated priming refers to the activation of a target (e.g., CHEESE) by a prime (e.g., CAT) that is related indirectly via a connecting "mediator" (e.g., mouse).[1] Note that this example (CAT → mouse → CHEESE) involves strong associations between the prime (CAT) and the mediator (mouse). That is, in response to the prime, the majority of people would generate the mediator in a free association task. No previous study has found reliable mediated priming in the absence of a strong prime-mediator association. Whether mediated priming can occur when a semantic but weakly associated (i.e., "pure" – cf. McNamara, 2005, p. 83) relation exists between prime and mediator (e.g., WIND → kite) has implications for several major semantic priming theories: spreading activation theory (Anderson, 1983a, 1983b; Collins & Loftus, 1975), semantic matching (Neely, 1977), the verification model/expectancy theory (Becker, 1980) and compound-cue theory (Ratcliff & McKoon, 1988). The current study aimed to investigate whether "pure" mediated priming occurs, and if so, to determine which semantic model best explains it.

Pure mediated priming was operationally defined as activation of a target (e.g., BEAN) by an initial prime (e.g., MORNING) via an intervening concept (e.g., coffee), with not more than a weak association between prime and mediator or between mediator and target. The finding of pure mediated priming (e.g., WIND → kite → STRING) would contribute to the discussion in the semantic priming literature over the importance of association in concept activation (for reviews

[1] Throughout this paper, concepts shown in SMALL CAPS indicate those presented to participants (e.g., prime or target concepts), and concepts in lowercase type indicate the non-presented mediating concepts.

see Hutchison, 2003 and Lucas, 2000). First, however, it is necessary to establish exactly what is meant by "association."

Broadly defined, association refers to any meaningful relation between two thoughts, ideas, or events (Audi, 1999, p. 58). Whether or not association is required for the accessibility of a given concept has been a central issue in cognition dating back to at least Aristotle's four Laws of Association (Hothersall, 2004, pp. 26-27). The Law of Similarity bases accessibility on the commonality between two objects, and thus may include synonyms (e.g., INSTRUCTOR – TEACHER) or category co-members (e.g., WOLF – DOG). The Law of Contrast states that a given idea (e.g., DAY) will increase the accessibility of that idea's opposite (e.g., NIGHT). The Law of Contiguity specified that things occurring together in time and space (i.e., frequent co-occurrence in spoken or written language) are recalled together. For example, if given the word SALT, an increased accessibility in memory for PEPPER should likely occur. The Law of Frequency states that accessibility is increased for things more frequently experienced. So then for most people, the animal DOG would be more accessible in memory than would the animal ZEBRA. Aristotle's four association laws are represented in today's association norms. For example, Hutchison (2003, Table 1) found that 14.1% of the Palermo-Jenkins Association Norms consisted of synonyms (e.g., AFRAID – SCARED; thereby reflecting the Law of Similarity), 24.3% were antonyms (e.g., DAY – NIGHT; Law of Contrast), 11.6% were forward phrasal associates (e.g., BABY – BOY; Law of Contiguity), and 5.6% were supraordinate (e.g., DOG – ANIMAL; Law of Frequency).

For semantic priming researchers, association is defined on the basis of association *strength* rather than by the presence of a meaningful relation (Fischler, 1977; Thompson-Schill, Kurtz, & Gabrieli, 1998). That is, association is defined on a quantitative rather than a qualitative basis. Semantic priming researchers have typically measured association based on the free-association task, wherein participants list the first word that comes to mind for a given concept and the proportion of people providing a given associate serves as the association strength. For example, .695 of people listed PENCIL as an associate for PEN (cf. Nelson, McEvoy, & Schreiber, 1998). Hutchison (2003) established four levels of association strengths: "no association" refers to concepts having a mean association strength < .01; "weak association" refers to an average strength between .01 and .10; "moderate association" for average strengths between .10 and .20; and "strong association" for average strengths > .20. Throughout this paper, "pure" refers to any meaningful connection between two concepts having no association or only a weak association, and "associated" refers to only concepts sharing a strong association (> .20).

According to spreading activation models (Anderson, 1983a, 1983b; Collins & Loftus, 1975), association strength is critical for concept activation, because there is a minimal threshold required for activation. For example, although one could conceivably form a meaningful connection between SNACK and DOG, SNACK would not likely increase activation of DOG above some minimal threshold. In contrast, BONE would likely increase activation of DOG due to their strong association (i.e., .255, cf. Nelson et al., 1998). Thus, "strong associations will be activated to threshold faster than weak associations" (Lorch, 1982, p. 469). As will be discussed further in the next chapter, the role of association in *direct* semantic priming has been a central issue in the semantic priming literature over the past thirty years (e.g., Fischler, 1977; Lupker, 1984; Moss, Ostrin, Tyler, & Marslen-Wilson, 1995) with several studies finding stronger priming effects for associative pairs than pure semantic pairs (see Hutchison, 2003 and Lucas, 2000 for reviews). The primary purpose of this study was to investigate whether association is required for *mediated* priming.

Spreading activation theories (e.g., Anderson, 1983a; Collins & Loftus, 1975) have been proposed as the most promising explanation of mediated priming (e.g., Bennet & McEvoy, 1999; McNamara, 2005; but see McKoon & Ratcliff, 1992 for alternative proposal). However, spreading activation may not be the only underlying mechanism of mediated priming. As will be discussed in Chapter 2, several semantic priming models predict direct priming for concept pairs lacking in association. Pure semantic priming has obtained between prime and target category coordinates that are sufficiently similar but non-associated (McRae & Boisvert, 1998; Thompson-Schill, Kurtz, & Gabrieli, 1998), as well as for instrumental relations (Moss et al., 1995) and integrative relations (Estes & Jones, in preparation). Instrumental relations refer to those in which “the intended function of the prime was to perform some action on the target” (Moss et al., 1995, p. 867; e.g., HAMMER → NAIL). Integrative relations refer to those which enable the linking of prime and target into a sensible combination (Estes & Jones, in preparation, e.g., COMPANY → CAR, a CAR that is *owned by* a COMPANY). (Both of these semantic relation types will be discussed further in the next chapter.) This study investigates the occurrence of pure mediated priming using both instrumental relations (Experiments 1 – 3) and integrative relations (Experiments 1 – 5), because these two types of semantic relations have reliably shown robust pure semantic priming effects.

In lexical decision tasks (LDTs), participants decide whether a given letter string is a real word in the English language. Typically, half the items consist of real words and require a “yes” response, with the remaining items consisting of pronounceable non-words (e.g., brupe). LDTs are perhaps the most commonly used measure of concept activation in semantic priming studies. If a concept is activated above and beyond the activation produced from its presentation, then the binary (yes/no) responses for these letter strings (e.g., BREAD) should be faster than when the concept has not been activated. The current study used two types of LDTs, which varied in their susceptibility to strategic processing. In the *double* LDT (used in Experiments 1 and 4), both prime and target are displayed simultaneously, and participants indicate whether both are real words. This double LDT is the most strategic, because the prime-target pairings are most explicit to the participants. That is, because the prime is still perceptually available upon target presentation, participants are able to check for a relation between prime and target. The *standard* LDT (used in Experiments 2, 3, and 5), wherein participants respond to only the target following presentation of the prime, also makes the prime and target pairings explicit to participants. This standard LDT paradigm offers the advantage of controlling the stimulus onset asynchrony (SOA) between prime and target to assess the time course of target activation. Overall priming effects are measured by subtracting the mean response time (RT) for the related prime-target pairs from the unrelated pairs' mean RT. For example, Meyer and Schvaneveldt (1971) found that RTs in a double LDT were 80 ms faster for related pairs (NURSE → DOCTOR) than for unrelated pairs (BREAD → DOCTOR). However, this overall priming effect could reflect not only the facilitation (i.e., increase in activation) of the target (e.g., DOCTOR) by the related prime (e.g., NURSE), but also the inhibition (i.e., decrease in activation) of the target following the unrelated prime (e.g., BUTTER). Therefore, to better pinpoint whether a given semantic relation facilitates target activation, a neutral baseline condition, such as asterisks, Xs, or a repeated word like "BLANK," is often used as the control prime. The current study uses unrelated primes (i.e., words sharing no meaningful relation with their targets; e.g., RAKE → STOVE) in Experiments 1, 3, and 4 and neutral non-word primes in Experiments 2 and 5.

To summarize, this study addresses the following methodological and theoretical research questions regarding mediated priming:

- Is association of the prime or target with the mediator required for mediated priming to occur? This question has implications for whether semantic models other than spreading activation models (Anderson, 1983a, 1983b; Collins & Loftus, 1975) can account for mediated priming.
- Is pure mediated priming mostly prospective, (i.e., activation of the mediator is predicted by the source node prior to target presentation, Becker, 1980) or is it retrospective (i.e., increased activation for a given node follows target presentation, e.g., Neely, 1977)? Some of the semantic priming theories discussed in Chapter 3 involve prospective processing with the other theories incorporating retrospective processing. Therefore, an investigation of the timing of activation in pure mediated priming sheds light on which semantic priming theory best accounts for the phenomena.

It must be emphasized that the purpose of this study is not to discount spreading activation as a viable mechanism of *associative* mediated priming. Rather the aim is to investigate whether the scope of mediated priming can be extended to include concepts that lack a strong association with the mediating concept (e.g., WIND → sting → KITE; MORNING → coffee → BEAN), and if so, to assess which semantic priming model best accounts for *pure* mediated priming.

CHAPTER 2

PURE SEMANTIC PRIMING

Before examining how and whether pure *mediated* priming can occur, it is first necessary to examine the semantic priming literature on pure *direct* priming. Semantic relations generally refer to any meaningful relationship between two concepts such as a category and exemplar (e.g., FRUIT and PEAR), category co-members (e.g., CAT and DOG), or instrument and object (e.g., BROOM and FLOOR). In contrast, associative relations are defined by the free-association task used to measure the proportion of people providing a given concept (e.g., DOG) when given another concept (e.g., CAT) and are therefore assumed to reflect word use more than word meaning (Thompson-Schill et al., 1998). “Semantic priming” has more generally referred to an improvement in speed or accuracy in responding to a stimulus that is related in *meaning* to a preceding stimulus.

The existence of direct priming without association (i.e., pure semantic priming) has been called into question over the last three decades. However, reliable and even robust priming has been found in the absence of an associative relation for some types of semantic relations (see Hutchison, 2003; Lucas, 2000 for reviews). Moreover, several studies (e.g., den Heyer, Briand, & Smith, 1985; Perea & Rosa, 2002; see Neely, 1991 for review) have found processing differences between associative and semantic priming. As will be discussed further in the next chapter, these processing differences suggest that different theoretical models may underlie associative and pure semantic priming.

Fischler (1977) found robust priming effects in a double LDT for both associative (e.g., ARM LEG; *M* = 99 ms) and pure (e.g., TABLE STOOL; *M* = 84 ms) pairs. Moreover, for the associative items, he found a reliable correlation (*r* = .31) between the size of the priming facilitation and semantic similarity ratings, but a negative correlation (*r* = - .38) between the facilitation size and association. Fischler concluded that "the spread of activation through the semantic space is more pervasive than previously thought" but that "further research with a greater variety of semantically related pairs would be necessary to explore the boundary conditions of the priming effect" (p. 338). However, as discussed in the next chapter, other semantic priming models are thought to provide a better explanation of *pure* semantic priming than spreading activation models.

More recent studies have also found some support for pure semantic priming. Using a continuous LDT, Moss and colleagues (1995) found semantic priming for instrumental pairs, in which the prime is used to [fill in verb] the target (e.g., BROOM → FLOOR; sweep). However, consistent with the results of Shelton and Martin (1992), an association between prime and target was required for category coordinates to produce priming. That is, priming obtained for associated natural and artifact category pairs (e.g., DOG → CAT; TABLE → CHAIR), but not for non-associated pairs (e.g., PIG → HORSE; BED → DESK). But McRae and Boisvert (1998) noted that neither Shelton and Martin (1992) nor Moss et al. (1995) based their selection of categorical items on the similarity between prime and target. For example, Shelton and Martin's items were only slightly above the midpoint on their similarity scale (3.56 on 5-point scale ranging from very dissimilar to very similar) and included several questionable items that did not seem similar (e.g., DUCK – COW). McRae and Boisvert tested whether highly similar (e.g., GOOSE → TURKEY) and less similar (e.g., ROBIN → TURKEY) category co-members would yield reliable semantic priming effects at both short (250 ms) and long (750 ms) SOAs. Using a standard LDT, they found reliable priming at both SOAs for the highly similar items, but only at the long SOA for the less similar items. Thompson-Schill and colleagues (1998) went a step further with their finding that semantic relatedness was necessary and sufficient for automatic priming. To assess the relative effects of associative relations, they used asymmetrically associative pairs, which were associatively related in one direction (e.g., COTTAGE → HOUSE), but not in the other (HOUSE → COTTAGE). To assess the relative effects of pure semantic relations, these asymmetric items were also either semantically related (i.e., shared common features; e.g., COTTAGE → HOUSE) or not (e.g., COAT → RACK). Priming effects for the semantically related items were equivalent in both the associative forward (e.g., COTTAGE → HOUSE) *and* the non-associative backward (e.g., HOUSE → COTTAGE) directions. However, for the semantically unrelated items no priming occurred in either the associatively related forward (e.g., LIP → STICK) or the non-associatively related backward (e.g., STICK → LIP) directions. Thus, these studies collectively indicate that not only does pure semantic priming exist, but also that semantic similarity is perhaps a better predictor of semantic priming for categorically related prime-target pairs than is association.

The five experiments in this study use integrative relations, defined as any type of semantic relation that links two concepts together to produce a more specific entity (e.g., the *temporal* relation in WINTER HOLIDAY specifies the season in which the holiday occurs). The integrated combination (e.g., CAGE MOUSE) represents a particular subclass of the head noun (e.g., MOUSE) that is defined by the relation (i.e., a CAGE MOUSE differs from a FIELD MOUSE or a LAB MOUSE based on its habitat). These integrative relations differ from the more frequently used categorical co-members or synonyms in that the two concepts are lacking in featural similarity.

But as discussed next, integrative relations and other semantic relations share the same general time course of activation; one which is distinct from associative relations.

The time course of activation (i.e., the extent of facilitation) differs between associative and semantic relations. At short (i.e., < 300 ms) or medium (approximately 300 to 800 ms) SOAs, both associatively and semantically related primes cause faster response times (i.e., facilitation). But at longer SOAs (i.e., typically ≥ 1000 ms), semantic priming effects are reduced or eliminated, whereas associative priming effects remain stable or increase. den Heyer, Briand, and Smith (1985) found an identical facilitation of 28 ms (cf. Neely, 1991, Table 5) for both associatively related antonyms (e.g., OLD → NEW) and pure semantically related category-exemplars (e.g., METAL → COPPER) at the 200 ms SOA. However, at the longer 1000 ms SOA the associative antonyms exhibited reliable facilitation (30 ms), whereas the pure category-exemplars exhibited an unreliable 12 ms facilitation.

Perea and Rosa (2002) conducted a similar study comparing the priming effects for a mixture of associatively related antonyms, synonyms, and category co-members (e.g., SUCCESS → FAILURE) and a mixture of purely semantic antonyms, synonyms, and category co-members (e.g., LUXURY → POVERTY) at a short 200 ms SOA and a long 1750 ms SOA. Results were remarkably similar to those of den Heyer et al. (1985). At the 200 ms SOA, both the associative and the semantic items showed reliable facilitation (both priming effects = 21 ms). However, at the 1750 ms SOA, only the associative items were reliably facilitated (23 ms effect); the 7 ms facilitation for the semantic items was not reliable. Moreover, in further analyses, they found that results for each type of semantic relation (antonyms, synonyms, and category co-members) resembled the overall pattern of results. Perea and Rosa suggested that the lack of pure semantic priming at the 1750 ms SOA may have been due to a more rapid decay of activation produced by the purely semantic relation.

Priming effects for integrative semantic relations, like their categorical and synonymous semantic relation cohorts, are also reduced at longer SOAs. Estes and Jones (2006, in preparation) compared the time course of pure integrative items (e.g., BEACH → HOUSE) with that of associative items (e.g., MORTGAGE → HOUSE) across a medium SOA of 500 ms, a long SOA of 1000 ms, and a longer SOA of 2000 ms. Facilitation was equivalent between the associative and integrative conditions at the 500 ms SOA (41 ms and 42 ms, respectively) and the 1000 ms SOA (43 ms and 37 ms). But at the 2000 ms SOA, the increased facilitation for the associative items (64 ms) was reliably greater than the reduced (and no longer reliable) facilitation found for the integrative items (22 ms). Thus, across three different studies using a variety of semantic relations, associative but not pure semantic priming occurred at long SOAs.

In summary, *direct* priming exists for many types of pure prime-target relations (i.e., instrumental, highly similar category co-members, synonyms, antonyms, and integrative relations). Moreover, the time course of activation differs between associative and semantic *direct* priming. The next chapter describes five predominant semantic priming models that have served as explanations of the different activation patterns between pure semantic and associative priming: Becker's verification (a.k.a. expectancy) model (1976, 1979, 1980), Collins and Loftus' (1975) spreading activation model, Anderson's ACT* model (1983a, 1983b), Neely's (1977) semantic matching model, and Ratcliff and McKoon's (1988) compound cue theory. Each of these semantic priming models could be (and/or has been) used to explain part or all of the underlying processes involved in mediated priming. Most mediated priming studies (e.g., Balota & Lorch, 1986; Bennet & McEvoy, 1999; McKoon & Ratcliff, 1992; McNamara, 1992a, 1992b, 1994; McNamara & Altarriba, 1988; Ratcliff & McKoon, 1994; Shelton & Martin, 1992) have focused primarily on two of these semantic priming models, namely, spreading activation and compound-cue (but see Chwilla, Kolk, & Mulder, 2000). If mediated priming can occur in the absence of associative links with the mediator, then the next step would be to determine which of these five semantic priming models best explains pure mediated priming.

CHAPTER 3

POTENTIAL ACCOUNTS OF PURE MEDIATED PRIMING

The models described in this section can be subdivided into two processing categories. The prospective models, Becker's (1980) verification model (henceforth referred to by its more commonly used name "expectancy model") and the Collins and Loftus (1975) spreading activation model, posit that activation occurs *prior to* target presentation. The retrospective models – Anderson's (1983a, 1983b) ACT* model, Neely's (1977) semantic matching model, and Ratcliff & McKoon's (1988) compound-cue model – describe target activation as occurring *after* target presentation. In general, prospective models account for associative priming. Retrospective models explain not only pure semantic priming but also backward associative priming for pairs that have a strong associative link from target to prime but not from prime to target (e.g., BABY → STORK; Chwilla, Hagoort, & Brown, 1998; Hutchison, 2002; Kahan, Neely, & Forsythe, 1989; Koriat, 1981; Peterson & Simpson, 1989; Seidenberg, Waters, Sanders, & Langer, 1984). For each model, a description is presented followed by an explanation of whether or not the model could potentially explain pure mediated priming.

Becker's Expectancy Model

According to Becker's (1976, 1979, 1980) verification model, during a semantic priming task people form predictions about what words will follow a given prime. This "expectancy set" can vary in size based in large part on the consistency of relations used within a list. That is, if just one type of relation (e.g., antonyms) is used within the list, participants should be better able to predict the related word that will follow a prime. Moreover, primes (e.g., DOCTOR) that have only one or two strongly associated targets (e.g., NURSE) should yield a smaller expectancy set. Thus, the generation of an expectancy set is prospective, meaning that target activation increases *prior to* its actual presentation. The formation of an expectancy set takes at least 200 ms (Becker, 1980), and requires even longer (typically an SOA of 2000 ms) to fully develop (de Groot, 1984; den Heyer, Briand, & Smith, 1985; Estes & Jones, 2006, in preparation; Lorch, 1982; McNamara, 2005; Neely, 1977, 1991; Perea & Rosa, 2002). Recall from the last chapter that priming effects for associative items remained stable or increased at long SOAs. Expectancy generation, then, could have accounted for the associative priming effects at these longer SOAs.

It is unlikely that expectancy can explain pure mediated priming, because the weak association between prime and mediator would yield a low probability of the inclusion of the mediator in the expectancy set. The weak association between mediator and target would further reduce the probability of the target being activated by the prime via a two-step expectancy process.

Collins and Loftus's Model of Spreading Activation

The Quillian (1967) model of semantic priming represents concepts as nodes in a network, with labeled relational links from the node to other concept nodes. These links can have different "criterialities," meaning that links vary in how essential they are to the meaning of the concept. Collins and Quillian (1969) similarly described these links as varying in accessibility (i.e., strength). For example, the shared property "emergency vehicles" link between FIRE ENGINE and AMBULANCE might be weaker than the "locale" link between FIRE ENGINE and STREET. The overall semantic relatedness between two nodes is based not only on the strength of the link, but also on the amount of interconnections between the two concepts. Thus, CHERRIES, FIRE ENGINES, and ROSES would not be strongly related because they share only the common property "red." In contrast, CHERRIES, APPLES, and PEARS would be more strongly related because they share the stronger link "fruit," and because the presentation of any one fruit would activate many other fruit concepts. Collins and Loftus (1975) made the following assumptions about the spread of activation.

1) When a concept is processed (e.g., read, spoken, or rehearsed), activation is decreased as it is divided among the network paths emerging from that concept. The decrease in the initial activation is inversely proportional to the path's link strength.
2) The longer a concept is continuously processed, the longer activation will be released from that concept. Activation can start from only one concept at a time, but the spread of activation will continue in parallel from other nodes that are encountered during spreading activation from the originating node.
3) Activation decreases over time and/or intervening activity. This assumption, therefore, predicts that direct priming (BONE → DOG) should be more robust than mediated priming (BONE → cat → DOG; de Groot, 1983) due to the increase in both time between prime and target and the additional intervening (albeit related) concept.
4) Activation arriving at a given node from multiple nodes summates at that node. For example, activation of PET would be stronger when the originating node activated CAT, and then activation spread in parallel both from DOG and CAT to PET.

Because the decrease in activation is inversely proportional to the link's strength, prospective spreading activation (Collins & Loftus, 1975) is an unlikely explanation for *pure* mediated priming. That is, the weak association between prime and mediator would permit only a small fraction of the prime's activation to spread to the mediator. In turn, if the mediator and target are also only weakly associated, then the spread of the already small amount of activation from mediator to target may not provide any discernable increase in target activation prior to the target's presentation.

Anderson's ACT* Model of Spreading Activation

The spreading activation process proposed in the original *A*daptive *C*ontrol of *T*hought (ACT) theory did not differ substantially from the Collins and Loftus (1975) model (see Anderson, 1976, p. 125). For example, one performance limitation of ACT stated that activation was "affected by the strength of the links [in a memory structure] relative to other links" (Anderson, 1976, p. 138). These links varied in strength based on how frequently they were used (Anderson, 1983b). The updated ACT theory (i.e., ACT*; Anderson, 1983a, 1983b) shifts the focus of activation from link strength to node strength. Whereas in ACT the associative links are stored and retrieved, in ACT* *cognitive units* (e.g., images, propositions, concepts, other chunks of information) serve as the basic unit of storage. A node (e.g., LION) will be a source of activation (i.e., the source node) if it is perceptually available (e.g., presented as the prime concept in a LDT) or if it is retrieved from long-term memory as a consequence of some production (e.g., relation check) in working memory. To summarize, the following assumptions of Anderson's ACT* theory (1983a, 1983b; Anderson & Pirolli, 1984) pertain to spreading activation:

1) *Node Strength*. Each node has an associated strength that is derived from its frequency of exposure (Anderson, 1983a, p. 266). Each link emanating from a node has a strength associated with it (Anderson, 1983a, Table 1.3). The total proportion of activation spreading from a node to its surrounding network is generally given a value of .80 (McNamara, 2005). The connection strength between two nodes is determined by the relative strength of association between these two nodes as compared to the

association between the source node and its other immediate neighbor nodes. For example, the activation spreading from the source node CAT would be divided among three immediate neighbor nodes (e.g., DOG, MOUSE, and KITTEN) according to their relative association strengths.

2) *Spread of Activation*. Activation flows from a source node that has been presented perceptually or is the result of a production in working memory. Activation spreads very quickly (≈ 1 ms per link). In the Collins and Loftus (1975) model, the target is in a pre-activated state after activation spreads from the prime, whereas in ACT* both prime and target must be sources of activation (i.e., attention) for heightened activation of the target to occur (McNamara, 2005). The simultaneous activation of both prime and target is aided by *reverberation*, in which activation can spread back from a target node to its source node and then back from the source node to the target until an asymptotic level of activation is reached.
3) *Maintenance of Activation*. A maximum of 10 nodes can be part of the "Active List" (i.e., held in WM; Anderson, 1983a, Table 1.3). However, WM capacity will vary with the familiarity of these nodes. These temporary structures in WM originate from the environment (e.g., presented word on a computer screen), from the activated portion of LTM, or from computations in WM (e.g., combined node consisting of a presented concept and concept from LTM).
4) *Decay of Activation*. Activation decays with the distance it travels. When attention to a source node (e.g., the prime) ceases, the pattern of activation emanating from that node rapidly decays.

It is because of the reverberation of activation between the prime and target that the ACT* model is not only prospective, but also retrospective. Moreover, due to this reverberation, a link's strong backward association could compensate for that link's relatively weak forward association (McNamara, 1992b). Thus, the ACT* model predicts that asymptotic target activation "is determined by associations in the forward and backward directions" (McNamara, 1992b, p. 1177). Therefore, backward association along with forward association must be considered when evaluating the likelihood of spreading activation as an explanation for pure mediated priming.

Spreading Activation and Mediated Priming

Although spreading activation is not likely to account for *pure* mediated priming, prior studies have supported spreading activation as the likely explanation of *associative* mediated priming (i.e., when the mediator shares associations with each concept). McNamara (1992a, 1992b, 1994, 2005; McNamara & Altarriba, 1988) argued that both the spreading activation model (Collins & Loftus, 1975) as well as Anderson's ACT* model (1983a, 1983b) of spreading activation could explain multi-step associative priming (i.e., mediated priming). Specifically, both prospective (Collins & Loftus, 1975) and retrospective (ACT* model; Anderson, 1983a, 1983b) spreading activation models predict that priming should decrease as distance (e.g., the number of nodes, links, or associative steps between prime and target) increases (McNamara & Altarriba, 1988). Consequently, the priming between directly associated prime (e.g., TEA) and mediator (e.g., coffee) nodes should be greater than the priming between the indirectly associated prime (e.g., TEA) and target (e.g., BEAN) nodes, which would in turn be greater than the priming between the unrelated prime (e.g., CAT) and target (e.g., BEAN) nodes. The decrease in activation over intervening nodes has been demonstrated in several earlier mediated priming studies (e.g., deGroot, 1983; McNamara & Altarriba, 1988; McNamara, 1992a; McNamara, 1992b). Priming effects for directly associated pairs (e.g., TIGER → STRIPES) had robust priming effects (i.e., > 30 ms), whereas priming effects for two-step mediated items (e.g., LION → tiger → STRIPES) averaged 15 ms, and three-step mediated priming (e.g., MANE → lion → tiger → STRIPES) had weaker priming effects averaging 10 ms (McNamara, 1992a).

To better determine the role of association in previous mediated priming studies, I assessed the association strengths for the stimuli sets in the two most predominant mediated priming studies – Balota and Lorch (1986) and McNamara and Altarriba (1988). These two studies were chosen because they represent the two most frequently cited mediated priming studies (Balota & Lorch, 1986 = 94 citations in PsycINFO and McNamara & Altarriba, 1988 = 60 citations). Moreover, materials in subsequent studies (e.g., McKoon & Ratcliff, 1992; McNamara, 1992b) were based on these two studies' items. I assessed the forward and backward association values for each link using the University of South Florida Free Association Norms (Nelson et al., 1998). For the Balota and Lorch items, both forward (M = .29, SE = .03) and backward (M = .24, SE = .03) association values were greater for the prime-to-mediator link than for the mediator-to-target link (forward: M = .10, SE = .02; backward: M = .16, SE = .03), $t_{frwd}(47) = 5.21$, $p < .001$ and $t_{bkwd}(46) = 2.08$, $p < .05$. In contrast, for the McNamara and Altarriba items, forward association values were equivalent between the prime-mediator (M = .28, SE = .04) and mediator-target (M = .27, SE = .03) links, $t(30) = .22$, $p = .83$. However, the backward association was much greater for the mediator-target link (M = .23, SE = .03) than for the prime-mediator link (M = .05, SE = .02), $t(38) = 5.18$, $p < .001$. For these items, the strong backward association from the target (e.g., CAKE) to the mediator (e.g., BIRTHDAY) may have contributed to the mediator's activation. If so, then the mediated priming found in the McNamara and Altarriba study would better support the ACT* model (Anderson, 1983) than the Collins and Loftus (1975) model.

Neely's Semantic Matching Model

Semantic matching refers to a search for a meaningful relation between prime and target (Neely, 1977; Neely, Keefe, & Ross, 1989). In a LDT, participants check for a relation between prime and target following presentation of the target. Participants are biased to respond that the stimulus is a word if a semantic relation is present and to respond that it is a non-word if a relation is not present. Thus, semantic matching is a retrospective process that can occur only after target presentation.

The time course of semantic matching has not been completely established. Neely and Keefe (1989) argued that facilitation does not occur for pure semantic items at short SOAs because participants are not able to pre-access the meaning of the prime prior to target presentation. However, as discussed in the previous chapter, reliable semantic priming occurs at short SOAs of 200 ms or less (e.g., den Heyer et al., 1985; Estes & Jones, in preparation; Perea & Rosa, 2002; see also Perea & Grotor, 1997).

But at what SOA is pure semantic priming reduced or eliminated? The answer to this question favors either a prospective or retrospective processing model as the explanation of pure semantic priming. In addition to the studies discussed in the last chapter comparing the time course of priming facilitation for associative versus semantic items (den Heyer et al., 1985; Estes & Jones, in preparation; Perea & Rosa, 2002), several other studies have demonstrated a consistent pattern of activation for pure semantic priming. Neely (1977) found a reliable 33 ms priming effect for category-exemplar (e.g., BIRD → ROBIN) items at a short 200 ms SOA, but only a non-reliable 14 ms effect at the much longer 2000 ms SOA. Smith, Briand, Klein, & den Heyer

(1987) found that activation was maintained for category-exemplar items with priming effects of 28 ms at a short 200 ms and 40 ms at the "long" SOA of 1000 ms. Together, the Neely (1977) and Smith et al. (1987) studies suggest that SOAs longer than 1000 ms may be needed to eliminate semantic priming effects.

Earlier results from our lab support this supposition. We (Estes & Jones; in preparation) investigated the time course of activation for integrative semantic relations (e.g., APARTMENT → DOG) compared to other semantic relations (i.e., category co-members, e.g., FOX → DOG) across four SOAs: 100 ms, 500 ms, 1500 ms, and 2500 ms. At the short 100 ms SOA, reliable priming effects of 20 ms and 18 ms obtained for the integrative items and the category co-members, respectively. Asymptotic activation occurred for the integrative and categorical relations at the medium SOA of 500 ms with priming effects of 49 ms and 43 ms. For the category co-members, this activation decreased only slightly with a priming effect of 36 ms at the 1500 ms SOA, but was eliminated at the 2500 ms SOA, which had an unreliable priming effect of 15 ms. The integrative items also decreased in activation with reliable priming effects of 25 ms and 23 ms at the 1500 ms and 2500 ms SOAs. To summarize, pure semantic priming effects tend to increase and then stabilize from short SOAs (i.e., 200 ms or less) to medium or long SOAs (i.e., between 500 and 1500 ms) and then decrease at very long SOAs (typically > 1500 ms).

As discussed further in the last chapter, semantic matching has been described as an interfering process in spreading activation accounts of mediated priming (e.g., de Groot, 1983; McNamara & Altarriba, 1988; Neely, 1991). That is, a search for a plausible relation between a seemingly unrelated prime (e.g., LION) and target (e.g., STRIPES) could prevent any multi-step activation spread. However, if the search for a "relation" could be expanded to also include a search for a plausible mediator (e.g., tiger), then semantic matching could conceivably account for pure mediated priming.

Chwilla, Kolk, and Mulder (2000) found that post-lexical integration (i.e., semantic matching) processes occurred during mediated priming. Event-related potential studies have established that the N400 effect reflects semantic matching but not spreading activation. This N400 priming effect is represented by smaller amplitudes 400 ms after stimulus onset when a word immediately follows a related word than when it follows an unrelated one (Chwilla et al., 2000). Using a standard LDT, Chwilla and colleagues found an N400 effect for mediated targets (e.g., LION → tiger → STRIPES), thus indicating that retrospective semantic matching occurred during mediated priming.

Compound-Cue Theory

The compound-cue theory (Ratcliff & McKoon, 1988) assumes that a prime (e.g., COFFEE) and target (e.g., BEAN) are combined within a short-term buffer to form a compound (e.g., COFFEE BEAN). The familiarity of this compound is then assessed by summing the strengths between the cue and all images in long-term memory. Familiarity, then, is based on the extent to which the prime and target are "directly connected to each other in memory or are directly connected to one or more common images" (Ratcliff & McKoon, 1988, p. 386), and higher familiarity leads to faster target response times.

Are such free association probabilities the best measure of a "direct connection" between prime and target? McKoon and Ratcliff (1992) suggested that primes and targets of mediated pairs may be weakly but directly connected in accordance with their frequency of co-occurrence in natural language. Moreover, they claimed that spreading activation theory's prediction of mediated priming relied on an association between the prime and mediator and between mediator and target. Thus, they predicted that "if spreading activation is measured by free association, then according to spreading activation theories, there should be facilitation only for pairs with mediators, not for pairs without mediators" (p. 1157). In contrast, the compound-cue theory predicts that "the presence or absence of mediating concepts is irrelevant" (McKoon & Ratcliff, 1992, p. 1170). Rather priming should occur only when two concepts are either directly connected to each other or are separated by no more than one associate (Ratcliff & McKoon, 1988). If the familiarities of the mediated and non-mediated pairs are equivalent, then the amount of target facilitation should also be equivalent. Hence, as described next, the existence of mediated priming serves to discriminate between compound-cue and spreading activation theories. In the past, the familiarity of the prime-target compound was typically measured via the free association task as the probability of producing the target word in response to the prime word. However, familiarity encompasses not only association but also co-occurrence. Therefore, reliable universal measures of these two factors are necessary to equate familiarity between the mediated and non-mediated (i.e., control) prime-target pairs. The online University of South Florida association norms (Nelson et al., 1998) and the online Latent Semantic Analysis (LSA) scores for co-occurrence now enable researchers to truly equate familiarity (Landauer, Foltz, & Laham, 1998), and consequently, researchers are better able to test whether compound-cue theory can explain mediated priming.

A Brief Review of Mediated Priming Studies

Although the current study limits its investigation to *pure* mediated priming, a review of the prior associative mediated priming studies offers important methodological and theoretical considerations for any mediated priming investigation. Earlier mediated priming studies (e.g., Balota & Lorch, 1986; de Groot, 1983; McNamara & Altarriba, 1988) used triads that lacked an associative link between prime and target, but had associative links between prime and mediator (e.g., BULL → cow → MILK). Although direct (i.e., one-step) priming (e.g., THREAD → NEEDLE) occurred in all three studies, mediated priming was nonexistent (de Groot, 1983) or occurred only under limited conditions (Balota & Lorch, 1986; McNamara & Altarriba, 1988).

In a series of LDT experiments (de Groot, 1983), target latencies did not reliably differ between the mediated (BULL → cow → MILK) and the neutral (i.e., the word "blank" → MILK) conditions. de Groot (1983) speculated that a post-access check (i.e., semantic matching attempt) may have contributed to the lack of a reliable target RT facilitation by the mediated primes. To test this explanation, she conducted three masked prime experiments, wherein the prime was presented for only 20 ms and was immediately replaced with a mask for 200 ms. Associatively related pairs were used in the first two of these experiments, and mediated pairs were used in the third masked prime experiment. Although reliable facilitation (neutral mean RT minus related mean RT) of 30 and 31 ms occurred for the directly related pairs (Experiments 5 and 6, respectively), no priming effect occurred for the mediated items (e.g., MOON → sun → BURN) used in Experiment 7. Based on the results from these seven experiments, de Groot suggested that spreading activation could not account for multi-step priming. Although activation may have spread from the prime to the closest neighbor node (i.e. the mediator), this activation may have decayed to the point of not having the minimal amount of activation necessary to spread further from the mediator to the target (de Groot, 1983, p. 432).

However, considering the small mediated priming effect size (15 ms), the lack of reliable facilitation in de Groot's (1983) Experiment 7 may have been due to the lack of power (Balota & Lorch, 1986); there were only 18 participants and just 21 items in the experiment. Balota and Lorch suggested that another possible explanation for de Groot's null finding in Experiment 7 may have been the short 220 ms SOA used. Because activation must spread across an additional link between prime and target, more time may be needed. To test this possibility, Balota and Lorch included a 500 ms SOA condition (n = 32) in addition to a 250 ms condition (n = 32) in their LDT experiments. However, there were no main effects or interactions for SOA. Directly related items (e.g., TIGER → STRIPES) produced a robust 37 ms facilitation effect, but no facilitation occurred for the mediated items (LION → STRIPES). Thus, their LDT results also failed to support multi-step activation (mediated priming).

McNamara and Altarriba (1988) argued that the subtlety of the mediated relation may have been overshadowed by the inclusion of directly related items within the same LDT experiment, thereby partially accounting for the null effects of de Groot (1983) and of Balota and Lorch (1986) in their LDT experiment. McNamara and Altarriba tested this potential methodological explanation by providing one group (n = 60) with only mediated experimental items (e.g., LION → STRIPES) and another group (n = 60) with both mediated and directly related (e.g., TIGER → STRIPES) items. They used a double LDT in their first experiment, wherein participants judged whether both the prime and target words were real words. In the mediated only group, the mediated items were a reliable 21 ms faster than the unrelated control items (e.g., BEACH → STRIPES). But in the mediated-and-direct group, response latencies were nearly equivalent between the mediated and control items. Chwilla and Kolk (2002, Experiment 1) replicated this result using different stimuli. They found a priming effect of 41 ms in a mediated only list and no effect in the “mixed” (mediated plus direct) list. This mediated only *vs*. mixed list effect (cf. Chwilla & Kolk, 2002; McNamara & Altarriba, 1988) suggests that mediated priming utilizes strategic processes (e.g., noticing the stronger associative relation and using that relation to guide the lexical decisions). Recall that strategic processing was explicitly proposed by two of the semantic priming models, namely, the expectancy model and the semantic matching model. Therefore, this list effect may support strategic models as an explanation of pure mediated priming over spreading activation models, which posit automatic processing.

However, because the lexical decision is made on the prime-target combination, a double LDT lends itself to strategic processing to a greater extent than does a standard LDT. Therefore, the simultaneous occurrence of the prime (e.g., LION) and the target (e.g., STRIPES) may facilitate the detection of a plausible mediator (e.g., TIGER), and in turn, speed response latencies for the target (e.g., STRIPES). Thus, in the double LDT paradigm, mediated priming effects are heavily affected by the inclusion of more strongly related items (e.g., directly associated items).

McKoon and Ratcliff (1992) argued that facilitation could occur for prime-target pairs that had neither direct nor mediated associations. Such facilitation indicates that either spreading activation theories "are wrong" or "free association does not provide an infallible index of associative links" (p. 1157). Using Balota and Lorch's (1986) mediated items (e.g., CAT → mouse → CHEESE), McKoon and Ratcliff replaced the original target word with a new target to create non-mediated items (e.g., MEAT replaced CHEESE). These new targets were non-associated with the mediator, but still had the same basic semantic relation (*things animals can eat*). Using a continuous LDT they compared the priming effects between their non-mediated items and McNamara and Altarriba's mediated items. Their results showed reliable and equivalent priming effects of 13 ms and 14 ms for the non-mediated and mediated pairs respectively. They replicated this non-mediated priming effect in a second experiment using a standard LDT. Because compound-cue theories predict that priming depends on familiarity, a measure is needed that assesses the frequency with which the prime and target have been encountered together in the past. According to McKoon and Ratcliff, the closest approximation to prime-target familiarity measures the frequency of co-occurrence in large samples of written language. Using a continuous LDT, they tested whether prime-target co-occurrence could produce priming for non-mediated items. Consistent with the compound-cue theory, pairs that had a high co-occurrence value (e.g., HOSPITAL → BABY) were a reliable 21 ms faster than were the unrelated pairs. In contrast, the 17 ms priming effect for the low co-occurrence items (e.g., ROOM → BABY) was not reliable. However, note that the absolute priming effect difference between the high and low co-occurrence conditions was negligible (4 ms), suggesting that co-occurrence may not systematically affect priming. Therefore, the compound-cue theory as an explanation of mediated priming was not strongly supported by these results.

McNamara (1992a) argued that co-occurrence is not a reliable predictor of priming, as it is directly related to temporal contiguity (e.g., two words in the same sentence), which has been shown to not affect priming. Using a continuous LDT, McNamara (1992b, Experiment 1) demonstrated a small but reliable three-step mediated priming effect (MANE → lion → tiger → STRIPES; 10 ms), which could not be explained by compound-cue theory. Chwilla & Kolk (2002, Experiment 2) also found a reliable three-step mediated priming effect of 33 ms using a double LDT. Furthermore, McNamara (1992b) created potential mediators for McKoon and Ratcilff's (1992) non-mediated stimuli (e.g., DEER → animal → farm → GRAIN) that had associative links between prime and mediator and between mediator and target. Thus, the reliable priming effect found for these "nonmediated control" items (McKoon & Ratcliff, 1992) may have been caused by two-step or three-step mediated priming rather than a direct (yet weak) association (i.e., co-occurrence) between prime (DEER) and target (GRAIN) as McKoon and Ratcliff had argued.

According to McKoon and Ratcliff (1992), the debate over the existence of mediated priming rested largely on whether co-occurrence or association served as the best measure of conceptual distance. They found that free-association probabilities, as calculated using Anderson's (1983a, 1983b) ACT* model, did not predict priming effects. Thus, both spreading-activation and compound-cue models need to examine semantic relatedness in addition to co-occurrence and free association as potential causes of semantic priming (McKoon & Ratcliff, 1994).

Although no mediated priming studies have manipulated or controlled the underlying type of semantic relationship (e.g., instrumental, categorical, etc.), a few studies (e.g., Chwilla & Kolk, 2002; Livesay & Burgess, 1998) have assessed whether global co-occurrence can account for mediated priming. Using the Hyperspace Analogue to Language (HAL) model of memory (Burgess & Lund, 2000), Livesay and Burgess assessed the co-occurrence of the mediated and control items originally used by Balota and Lorch (1986). They found that the co-occurrence was higher for the unrelated primes and targets than for the mediated prime-target pairs. Moreover, Livesay and Burgess found that the magnitude of mediated priming was not related to lexical co-occurrence ($r = .013$). Chwilla and Kolk used LSA to assess co-occurrence. Unfortunately, however, their mediated (two-step or three-step) items were much higher in co-occurrence than were their unrelated control items for both Experiment 1 (.186 *vs.* .082) and Experiment 2 (.115 *vs.* .072). Thus, Chwilla and Kolk's (2002) findings do not rule out compound-cue theory as a plausible explanation of mediated priming. The experiments reported within the current study use stimuli that are equivalent in co-occurrence between the mediated and control conditions. Therefore, if mediated priming were to occur, it could not be attributed to higher co-occurrence for the mediated items, thus making the compound-cue theory a less plausible explanation of mediated priming.

To summarize, the studies discussed in this section illuminate several methodological concerns. First, the presence of directly related prime target pairs within the same experimental list may overshadow the presumably weaker mediated relations (McNamara & Altarriba, 1988). Second, double LDTs evoke more strategic processing than standard LDTs. Consequently, it is important to use both LDT paradigms in any semantic priming study to determine whether strategic processing can occur in the absence of the continued prime presentation. Finally, as discussed above, both prime-target association *and* co-occurrence need to be equated between the experimental and unrelated control conditions. In addition to association and co-occurrence, a third important factor – namely semantic relatedness – needs to be considered (McKoon & Ratcliff, 1992; McNamara, 1994). The three experiments reported in the next chapter serve to isolate the effect of semantic relatedness within mediated priming by controlling association and co-occurrence.

CHAPTER 4

EVIDENCE OF PURE MEDIATED PRIMING

Overview of Experiments 1 - 3

Evidence of pure mediated priming (e.g., SPOON → soup → CAN) would have several implications for the semantic priming models discussed in the last chapter. Because prime-target familiarity is equated between the experimental and unrelated control items, the mere existence of pure mediated priming would challenge the compound-cue theory. Similarly, because the forward and backward associations between prime and mediator and between mediator and target are weak (≤ .10), both the Collins and Loftus (1975) and the ACT* (Anderson, 1983a, 1983b) models of spreading activation are less viable explanations for any obtained mediated priming. The first three experiments examine whether pure mediated priming exists and thus, focus primarily on whether spreading activation or compound-cue models can explain pure mediated priming. Experiments 4 and 5, in the next chapter, investigate whether pure mediated priming is prospective (as predicted by the expectancy model) or retrospective (as predicted by the semantic matching model).

Experiments 1- 3 used pure instrumental relations (e.g., SOAP and shower; Moss et al., 1995) between the prime and mediator and integrative relations between mediator and target (shower and CURTAIN; Estes & Jones, in preparation). Both of these semantic relationships have been shown to yield robust (i.e., priming effects > 30 ms) pure direct priming effects. If mediated priming is caused by spreading activation from prime to target via the mediator (SOAP → shower → CURTAIN), then priming should not occur in the absence of either a forward or backward association between the mediator and each concept. Hence, as shown in Table 1, the stimuli set used in Experiments 1-3 had weak forward and backward associations between prime and mediator and between mediator and target. Three different priming paradigms were used to investigate the existence of mediated priming. Experiment 1 used a double LDT paradigm modeled after McNamara and Altarriba (1988, Experiment 1) to investigate whether both words in a mediated pair (PIPE BALLOON) were recognized faster than the words in the co-occurrence-controlled unrelated pair (POLE BALLOON). Experiment 2 used a standard LDT in which lexical decisions were made for only the target following either a mediator or a baseline (i.e., ********) prime. Moreover, short (200 ms) and long (1000 ms) SOAs were compared in order to investigate the time course of pure mediated priming and more specifically to determine whether priming could occur rapidly. As discussed further in the introduction to Experiment 2, this manipulation of SOA has important implications for many semantic priming models. Experiment 3 replicated Experiment 2 to ensure that the mediated priming in Experiment 2 was not an artifact of the nonword baseline condition (i.e., ********; see Neely, 1991, pp. 278-280). For each target, the unrelated primes used in Experiment 1 (MULE → CURTAIN) replaced the baseline primes (******** → CURTAIN).

Experiment 1

Because both the prime and the target are displayed on the screen when the lexical decision is made, the double LDT used in Experiment 1 provides a more sensitive (albeit less stringent) first test of pure mediated priming. Because the mediated (e.g., GRILL → THIGH) and control prime-target pairs (e.g., SPOON → THIGH) are equated for both association (i.e., with all association values = 0) and co-occurrence, the compound-cue model predicts no difference in response times. Because the forward and backward associations between prime and mediator and between mediator and target were weak (all < .10), neither the spreading activation models nor the expectancy model could account for any obtained mediated priming effects. Given these controls, any resulting mediated priming would best be explained by semantic matching models.

Method

Participants. For each of the following experiments, all participants were undergraduates at the University of Georgia, all participated for partial course credit, and all were native speakers of English. Thirty-seven undergraduates participated in Experiment 1. A total of 74 additional undergraduates participated in the norming tasks and post-test (described below).

Materials. The complete set of items used in Experiments 1-3 is shown in Appendix A. The association and co-occurrence (i.e., LSA) stimuli norms are shown in Table 1. Thirty initial prime-mediator pairs sharing a non-associative instrumental relation were sampled from Moss et al. (1995) or created using the same criteria (i.e., the prime can be used to [fill in verb] the mediator; e.g., a GRILL can be used to cook a CHICKEN). Targets were created by forming a conceptual combination consisting of the mediator and target.

To test the likelihood of activating the author-generated mediators, participants (N = 36) were presented with the prime and target words separated by a blank line (cf. de Groot, 1983) and then typed a word that "connected the first word to the last word" (e.g., grill ____________ thigh). For each prime-target pair, the modal response served as the mediator (range = .17 to .83; M = .41) in the final item set. One of these pairs (e.g., PLOW-FORT) lacked a modal response and was deleted prior to analyses making a final set of 29 experimental items. Note that this mediator frequency proportion (.41) is much lower than de Groot's mediator proportion (.90). This difference is likely due to the strong forward association values between prime and mediator (.47) and between mediator and target (.24) in de Groot's first stimuli set.

Note that a few of the instrumental prime-mediator relations used in this study (see Appendix A; e.g., MICROWAVE popcorn, OVEN bread, HORSE carriage) could also be described as integrative relations. For example, both microwave popcorn and oven bread could be said to have a *locale* relation (head noun located in modifier). However, items like these have a fundamental yet subtle difference from most integrative items in that the better integrative relation would most likely consist of an action verb (i.e., popcorn that is *cooked* in a microwave). This subtle qualitative difference was supported by an integration rating task (adapted from Solomon & Perlmutter, 2004), in which participants (N = 32) rated the extent to which two concepts could be "linked together to produce a sensible phrase" on a scale from 1 (not linked) to 7 (tightly linked). Participants provided integration ratings for the prime-mediator pair (e.g., OVEN-bread) and the mediator-target pair (e.g., bread-BASKET) for all 29 items. Trial order was randomized across participants. Integrative ratings were reliably lower for the instrumental prime-mediator link ($M = 4.72$, $SE = .20$) than for the integrative mediator-target link ($M = 5.39$, $SE = .17$), $t_p(31) = 3.82$, $p < .001$ and $t_i(28) = 2.83$, $p < .01$.

The mediated triads (e.g., SPOON → soup → CAN) were divided into two lists and control items were created for each subset by re-pairing the primes (e.g., SPOON) with different targets (e.g., THIGH) within that subset such that the co-occurrence (i.e., LSA value) of the unrelated prime-target pair matched that of the mediated prime-target pair as closely as possible. A paired-samples t-test confirmed that LSA scores were equivalent between the mediated ($M = .139$, $SE = .023$) and control ($M = .138$, $SE = .020$) pairs, $t(28) = .12$, $p = .91$. Thirty filler items were also included consisting of 15 nonword-word (e.g., FEAP-THUMB) and 15 word-nonword (e.g., DINNER-ELLION) prime-target pairs.

Procedure. The procedure was modeled closely after the double LDT used by McNamara and Altarriba (1988, Experiment 1). The prime (e.g., GRILL) was presented for 100 ms in 18-point red font on a black background and was horizontally centered just above the vertical midpoint of the screen. Next the target word (e.g., THIGH) was presented in the same font just below the prime (i.e., vertically and horizontally centered). Both prime and target remained on the screen while participants indicated whether both words were real words in the English language by pressing the <J> key for "yes" or the <F> key for "no."

Results and Discussion. Paired-samples t-tests were used in analyzing both response times (RTs) and accuracies. In this and all subsequent experiments, RTs from incorrect trials were excluded from all analyses, as well as response times greater than 1500 ms, and any remaining RTs more than 2.5 standard deviations above or below each participant's condition mean. In each experiment, results were analyzed separately with participants (t_p, F_p) and items (t_i, F_i) as the random variable.

Results provided support for the existence of pure mediated priming. The mediated pairs (e.g., SOAP CURTAIN; $M = 880$, $SE = 25$) were recognized 43 ms faster than the unrelated pairs (e.g., MULE CURTAIN; $M = 923$, $SE = 27$), $t_p(36) = 2.66$, $p = .012$ and $t_i(28) = 2.53$, $p = .017$. Accuracies were at ceiling (both *M*s = .99) and did not differ between conditions (*p*s > .75), thus indicating that there was no speed-accuracy tradeoff. Thus, these results are the first evidence of mediated priming that cannot be attributed to a direct weak link between the prime and the target. That is, because the familiarity (i.e., co-occurrence and association) of the prime-target compound cue was equated between the control and mediated items, results challenge the compound-cue theory. Furthermore, because both the forward and backward association values were weak for each link, neither the Collins and Loftus (1975) nor Anderson's (1983a, 1983b) ACT* spreading activation model can account for the obtained mediated priming.

Recall that the proposed semantic matching model account for pure mediated priming requires a check for an interconnecting node (i.e., mediator) that is related to both prime and target. Hence, evidence of mediator activation is required to support a mediated priming semantic matching account. If both the prime and target are crucial to the activation of the mediator as is claimed by the semantic matching model, then offline mediator activation should be greater when both the prime and target are provided in comparison to when only the prime is provided. In support of this claim, the mean production frequency for these mediators was ten times higher when both the prime and target were provided (i.e., during the norming task; M = .41) than the production of the mediator in response to only the prime (as indicated by the Nelson et al. (1998) free association norms; M = .04). Thus, both the prime and target seem to activate a plausible mediator. Note that, the ACT* model would also predict greater mediator activation due to the bidirectional activation spread from the target to the mediator and from the prime to the mediator. However, the low association values for the stimuli used in this experiment render the spread of activation unlikely. For example, it is unlikely that enough activation would spread from SPOON to the weakly associated mediator soup or that activation from the target CAN would reverberate back to the weakly associated mediator soup. Therefore semantic matching, which entails a check for a relation, seems to provide the most promising explanation for pure mediated priming.

Could these results simply reflect integrative priming? It's possible that some of the prime-target pairs (e.g., MICROWAVE BAG, SPOON CAN, OVEN BASKET) could be interpreted using a *locale* relation. To test this alternative explanation, participants (N = 18) provided integrative ratings on a scale from 1 (not linked) to 7 (tightly linked) in a post-test for these 29 mediated prime-target pairs. The correlation between these integrative ratings (M = 3.19, SE = .18) and the mediated RTs was not reliable (r = -.10, p = .59), thereby suggesting that results were due to mediated rather than to integrative priming.

Note that in the double LDT used in Experiment 1, the prime is still *perceptually* available. Recall that pure semantic priming does not require the continued display of the prime inherent in the double LDT. Thus, the remaining experiments used a more stringent standard LDT in which prime and target presentation did not overlap. Importantly, the standard LDT allows for SOA to be manipulated in order to assess the time course of pure mediated priming. That is, because participants respond to only the target, the duration between prime and target presentation is easily controlled. A second critical advantage in using the standard LDT is that it allows a direct test of facilitation by using a neutral prime rather than an unrelated prime.

Experiment 2

Experiment 2 used a standard LDT in which participants made their lexical decisions for only the target word. Specifically, the prime appeared for 150 ms followed by a blank screen, and then the target appeared until the participant provided a response. When primes are not perceptually available to continuously activate their targets (in this case the potential mediators), overall levels of mediator activation are lower (Anderson, 1983b). Moreover, because the target is not immediately available to select from the set of potential mediators, a larger set of potential mediators must be maintained in working memory. Thus, one purpose of Experiment 2 was to determine whether mediated priming would occur even in the standard LDT. Recall that the standard LDT is less influenced by strategic processes than is the double LDT. However, as demonstrated in previous studies (e.g., McRae & Boisvert, 1998; Moss et al., 1995; Thompson-

Schill et al., 1998), pure direct priming can occur in a standard LDT, most likely via a retrospective semantic matching process. Thus, pure mediated priming might also occur if the prime can be maintained in WM long enough for a semantic match to occur between prime and target (via a search for a common mediator).

A second purpose of Experiment 2 was to investigate whether mediated priming was caused by facilitation (i.e., related primes increase target activation) or by inhibition (i.e., unrelated primes decrease target activation). In order to assess whether any type of semantic priming is the result of facilitation or inhibition, a neutral condition is needed. Using a row of Xs as the neutral condition, Neely (1976) found that the semantic priming effect was mostly due to facilitation (i.e., related RTs – neutral RTs = 38 ms). In contrast, de Groot (1983, Experiment 4) found that the overall 19 ms mediated priming effect was due to inhibition. That is, the mediated RT did not differ from the neutral RT, but was 19 ms faster than the unrelated RT. If the mediated priming found in Experiment 1 is simply due to inhibition caused by slower RTs for the control items (e.g., MULE CURTAIN), then no mediated priming should occur in Experiment 2. However, if the mediated priming found in Experiment 1 reflected facilitation of the target, then RTs should be faster for the targets following the mediated primes (e.g., soap → curtain) than for those following the baseline neutral primes (e.g., ******** → curtain).

The third purpose of Experiment 2 was to provide an initial investigation of the time course of mediated priming. Recall that Balota and Lorch (1986) speculated that de Groot's (1983, Experiment 7) failure to obtain mediated priming may have been due to the short 220 ms SOA used, because more time may have been needed for activation to spread across multiple links. Thus, any mediated priming found in this study at the 200 ms SOA further challenges the Collins and Loftus (1975) spreading activation model but not Anderson's (1983a, 1983b) ACT* model, which posits fast spreading activation of approximately 1 ms per link. Also, recall that pure semantic priming studies found reliable semantic priming even at short SOAs of 200 ms or less. However, assuming for a moment that semantic matching explains pure mediated priming, the search for an intervening *node* (i.e., a mediator) may take longer than a search for a plausible relation. Hence, SOA was varied between a short SOA (200 ms) and a medium-long SOA (1000 ms) to determine whether mediated priming could occur rapidly. Given the results of previous pure semantic priming studies (e.g., Estes & Jones, in preparation; Smith et al., 1987), a 1000 ms SOA was expected to be sufficiently long to produce mediated priming.

To summarize, then, Experiment 2 examined whether mediated priming could occur in a standard LDT, and if so whether it reflected a facilitation of the target by the indirectly related prime and whether the facilitation occurred at both a short (200 ms) and medium-long (1000 ms) SOA.

Method

Participants. One-hundred eleven undergraduates were divided between the short SOA (n = 57) and the long SOA (n = 54).

Materials and Design. The mediated items were identical to those used in Experiment 1. The primes for the unrelated items were replaced with a row of 8 asterisks (i.e., ********). Thirty additional filler items having non-word targets were used. Fifteen of these filler items had a real word prime (e.g., BARN → LURMOR), the rest had a neutral prime (e.g., ******** → tabe). A mixed design was used with SOA (short = 200 ms, long = 1000 ms) between-participants and Relation (mediated, neutral) within-participants. Relation was counterbalanced across two lists, such that each item was presented with a mediated and a neutral prime on separate lists.

Procedure. To begin each trial, participants were instructed to press the spacebar. A blank screen appeared for 200 ms followed by a red 18-point fixation plus sign, which was centered on a black screen for 500 ms. Next the prime appeared for 150 ms, followed by a blank screen for either 50 ms in the short SOA condition or for 850 ms in the long SOA condition. The target then appeared in white font until participants provided a response. The <J> key was used to indicate that the target was a real word and the <F> key was used to indicate a non-word. Participants completed 10 practice trials prior to the experiment. For the 60 experimental trials, trial-order was randomized across participants.

Results and Discussion. For the participant analysis, a mixed ANOVA was used with Relation as a within-factor and SOA as a between-factor. For the item analysis, a repeated-measures ANOVA was used with both Relation and SOA as within-factors. Accuracies were at ceiling (.980 < all *M*s < .987) and there were no reliable main effects or interactions in either the participant analysis (all *p*s > .20) or in the item analysis (all *p*s > .05). Mean response times for each of the four Prime-type × SOA conditions are shown in Figure 1.

Results provided further support for pure mediated priming. Condition means are shown in Figure 1. RTs were 24 ms faster for the mediated ($M = 638$, $SE = 10$) than for the neutral ($M = 662$, $SE = 11$) items, $F_p(1, 109) = 13.65$, $p < .001$ and $F_i(1, 28) = 13.59$, $p = .001$. Moreover, follow-up t-tests revealed that mediated priming occurred for both the short SOA, $t_p(56) = 2.06$, $p < .05$ and $t_i(28) = 2.03$, $p = .05$, and the long SOA, $t_p(53) = 3.08$, $p < .01$ and $t_i(28) = 3.20$, $p < .01$. Although the priming effect size was somewhat larger in the long SOA (29 ms) than in the short SOA (18 ms), the Relation × SOA interaction was not reliable, $F_p(1, 109) = .97$, $p = .33$ and $F_i(1, 28) = 1.15$, $p = .29$. Mean RTs were nearly equivalent between the short ($M = 653$, *SE*

= 13) and long (*M* = 646, *SE* = 14) SOAs, $F_p(1, 109) = .12$, $p = .73$ and $F_i(1, 28) = 2.06$, $p = .16$, with nearly identical response times for the baseline condition (*M*s = 662 and 661, respectively).

Experiment 2 provides even stronger support for pure mediated priming by using a less strategic standard LDT rather than the double LDT. The lack of an interaction between SOA and Relation along with the planned comparison results demonstrate that pure mediated priming can occur at both short and long SOAs, suggesting a rapidly occurring process that is not subject to rapid decay consistent with the semantic matching model (Neely, 1977) and counter to the Collins and Loftus (1975) spreading activation model. Because the stimuli had only weakly associated links, the ACT* model (Anderson, 1983a, 1983b) is unlikely to account for the pure mediated priming. Rather a semantic matching process, whereby a retrospective search for a plausible mediator (i.e., related to both prime and target) can account for these results. Finally, the priming effect (i.e., neutral – mediated) of Experiment 2 suggests that pure mediated priming is due to facilitation by the indirectly related prime as opposed to inhibition from unrelated primes (used in Experiment 1).

However, there is one other alternative explanation to account for the priming effect found in Experiment 2. Since Neely introduced the neutral baseline in 1976, several researchers (e.g., Antos, 1979; Jonides & Mack, 1984) have criticized the non-linguistic nature of non-word neutral stimuli (e.g., XXXXX's; see Neely, 1991, pp. 278-280, and McNamara, 2005, pp. 58-62 for reviews on this controversy). Thus, Experiment 3 served to replicate Experiment 2 to ensure that the mediated priming was not an artifact of the non-word baseline condition.

Experiment 3

The faster target response times in Experiment 2 for the mediated relation than for the baseline relation may have simply been the result of a real word prime (e.g., SOAP) rather than the mediated relation between prime and target. That is, target RTs may be faster when following a real word prime (e.g., SOAP) than when following a non-word prime (e.g., ********), regardless of whether or not that word prime is related. Hence, the purpose of Experiment 3 was to replicate the mediated priming effect found in Experiment 2 using the unrelated primes (e.g., MULE → CURTAIN) that were used in Experiment 1.

Method

Participants. One-hundred twenty-three undergraduates were divided between the short (200 ms; n = 63) and long (1000 ms; n = 60) SOAs.

Materials. The mediated items were identical to those used in Experiments 1 and 2. The primes for the unrelated items were the same as those used in Experiment 1 (e.g., MULE → CURTAIN). All thirty filler items consisted of real word primes followed by non-word targets (e.g., BARN → LURMOR; MEMORY → TABE).

Procedure. The procedure was the same as in Experiment 2.

Results and Discussion. As in Experiment 2, analyses consisted of repeated-measures 2 (SOA) × 2 (Relation) ANOVAs and planned comparisons within each SOA. Results replicated those of Experiment 2, thereby further supporting mediated priming. That is, the mediated priming effect in Experiment 3 indicated that the mediated priming found in Experiment 2 was not just an artifact of the non-word neutral condition. There were again no reliable main effects or interactions for the accuracy measure (ps > .05 by participants and ps > .15 by items), so only the RTs are reported below. All four condition RT means are shown in Figure 2. Response times were again nearly identical between the short (M = 644, SE = 15) and long (M = 649, SE = 16) SOAs, $F_p(1, 121) = .04$, $p = .84$ and $F_i(1, 28) = .41$, $p = .53$. Target response times were a reliable 17 ms faster following mediated primes (M = 638, SE = 11) than following unrelated primes (M = 656, SE = 12), $F_p(1, 121) = 12.13$, $p = .001$ and $F_i(1, 28) = 7.95$, $p < .01$. As in Experiment 2, there was no Prime-type × SOA interaction, $F_p(1, 121) = .07$, $p = .79$ and $F_i(1, 28) = .18$, $p = .67$. Moreover, planned t-tests revealed reliable mediated priming within both the short SOA, [$t_p(62) = 2.65$, $p = .01$, though not in the item analysis, $t_i(28) = .82$, $p = .42$] and the long SOA [$t_p(59) = 2.34$, $p = .02$, though marginal by items $t_i(28) = 1.77$, $p < .10$].

The pattern of results duplicated that of Experiment 2, thus providing further evidence for pure mediated priming. Moreover, the mediated priming effect was again equivalent across the 200 ms and 1000 ms SOAs. Hence, the results of Experiments 2 and 3 individually and collectively demonstrate that pure mediated priming occurs rapidly. The next chapter describes two additional experiments that use a different item set to further evaluate pure mediated priming.

CHAPTER 5

MORE EVIDENCE OF PURE MEDIATED PRIMING

The previous three experiments found mediated priming using a non-associative instrumental relation between prime (e.g., SOAP) and mediator (e.g., shower) and a non-associative integrative relation between mediator and prime (e.g., shower – CURTAIN). Recall that this robust instrumental relation was chosen because Moss et al. (1995) showed reliable pure semantic priming for this relation. However, in part to demonstrate that the proposed model generalizes to other types of semantic relations, Experiments 4 and 5 used items that shared an integrative relation (e.g., CAGE → mouse → CHEESE) between prime and mediator rather than the instrumental relation used in Experiments 1 – 3.

Overview of Experiments 4 – 5

Experiment 4 used the highly strategic double LDT to ensure that mediated priming can occur for items sharing an integrative prime-mediator relation. Experiment 5 used the less strategic standard LDT to assess the extent of mediated priming at a very long SOA of 2000 ms in order to provide a more stringent test of prospective processing. Also, in Experiment 5, a different neutral condition (i.e., a pronounceable non-word) replaced the row of asterisks used in Experiment 2.

Integrative priming reliably occurs in direct priming experiments (e.g., Coolen, van Jaarsveld, & Schreuder, 1991; Estes & Jones, 2003, 2006, in preparation) that allow for retrospective relatedness checking. Integrative mediated priming is most likely to occur in the relatively strategic double LDT (Experiment 4), because retrospective relatedness-checking is facilitated by the maintained prime presentation during the lexical decision.

Experiment 4

Method

Participants. Forty-five undergraduates participated in the stimulus norming task described below. Thirty-nine additional undergraduates participated in the experiment.

Materials and Design. The final set of 30 experimental items is shown in Appendix B. Stimuli construction consisted of the following steps. An initial set of 40 associative prime-mediator-target triads (e.g., TEA → coffee → BEAN) were sampled from Balota and Lorch (1986) and McNamara and Altarriba (1988), as well as created by the author. Next, the primes for these associative items were replaced with primes that could be integrated with the mediator to form the 40 integrative triads (e.g., TEA was replaced with MORNING). Then these items were normed for mediator production using the "missing word" task described in Experiment 1 (de Groot, 1983). That is, participants (N = 45) typed in the missing word that best connected the presented prime and target pair (e.g., MORNING ________ BEAN). As before, the most frequently provided mediator was chosen as the proposed mediator. The ten items with the lowest mediator frequency proportions were eliminated to create the final set of 30 integrative items, which had a mean mediator frequency of .46 (*SE* = .05). Control items were created by re-pairing the primes with different targets to create unrelated non-mediated prime-target pairs that were equated on co-occurrence with the mediated items. The forward and backward association values as well as the prime-target LSA values are shown for each condition in Table 2. Relation (mediated or unrelated) was within-participants and within-items.

Procedure. The double LDT procedure was the same as in Experiment 1.

Results and Discussion. Accuracies and response times were analyzed using a paired samples t-test with participants and items as the random factor. Consistent with the results of Experiment 1, a main effect of Relation obtained for the RTs, $t_p(38) = 4.22$, $p < .01$ and $t_i(29) = 2.22$, $p < .05$. RTs were a robust 51 ms faster for the mediated ($M = 876$, $SE = 28$) than for the unrelated condition ($M = 927$, $SE = 31$). A Relation main effect also obtained for the accuracy measure; with higher accuracies for the mediated ($M = .997$, $SE = .002$) than the unrelated ($M = .979$, $SE = .007$) items, $t_p(38) = 2.36$, $p < .05$ and $t_i(29) = 2.58$, $p < .05$. Hence, Experiment 4 provided further evidence of pure mediated priming using an integrative prime-mediator link. As in the three previous experiments, the weak forward and backward associative links for these items suggest that semantic matching provides a better explanation than the spreading activation or ACT* models.

Experiment 5

Experiment 5 further investigated whether semantic matching underlies mediated priming by comparing a very long 2000 ms SOA to a 1000 ms SOA, which was found to produce reliable pure mediated priming in Experiments 2 and 3. Recall that retrospective semantic matching was found to be reliable at short SOAs (e.g., den Heyer et al., 1985; Estes & Jones, in preparation; Perea & Rosa, 2002), and seemed to reach asymptotic activation at medium or medium-long SOAs (i.e., between 300 and 1500 ms) before declining at very long SOAs (> 1500 ms). In contrast, prospective priming predicted by the expectancy theory (Becker, 1980) predicts that priming effects will either remain stable or increase at very long SOAs. Thus, an interaction between SOA and Relation in Experiment 5, such that mediated priming occurred at the 1000 ms SOA but not at the 2000 ms SOA, would support a retrospective semantic matching account of pure mediated priming. In order to test this prediction, planned comparisons will be conducted within each SOA to determine whether mediated priming occurred. Given the previous mediated priming results of Experiments 2 and 3, reliable mediated priming was again expected for the 1000 ms SOA. Recall that direct integrative priming effects (e.g., BIRD → BATH) were reduced for longer SOAs ≥ 2000 ms (Estes & Jones, in preparation). Therefore, at the 2000 ms SOA, mediated priming was predicted to be non-existent or smaller than that found at the 1000 ms SOA.

Method

Participants. Sixty-one undergraduates were randomly assigned to either the 1000 ms (n = 30) or the 2000 ms (n = 31) SOA condition.

Materials and Design. The same materials used in Experiment 4 were used, except that the primes for the neutral control condition consisted of pronounceable non-words (e.g., FISK, MILG, CABE). Recall that using neutral primes in place of unrelated primes tests whether mediated priming effects reflect facilitation rather than inhibition. Accuracies and response times served as the dependent measures. A 2 (SOA: 1000 ms, 2000 ms; between-participants) × 2 (Relation: mediated, neutral; within-participants) design was used. Both factors were within-items.

Procedure. The standard LDT used in Experiments 2 and 3 was used. For the short 1000 ms SOA condition, the prime was presented for 150 ms followed by an 850 ms blank screen. For the long 2000 ms condition, the prime was presented for 150 ms followed by a 1850 ms blank screen.

Results and Discussion. Figure 3 shows the means for each of the four SOA × Relation conditions. A 2 (SOA) × 2 (Relation) ANOVA was conducted with accuracies and RTs as the dependent measures. Planned comparisons were also conducted to assess whether mediated priming occurred within each SOA.

As before no main effects or interactions obtained for the accuracies (all *p*s > .35). Consistent with previous pure direct priming studies (e.g., Estes & Jones, in preparation; Perea & Rosa, 2002; Neely, 1977), priming effects varied with SOA. Specifically, a marginal SOA × Relation interaction obtained for the RTs, $F_p(1, 59) = 3.00$, $p = .09$ and $F_i(1, 29) = 3.89$, $p = .06$. Moreover, planned t-tests revealed reliable mediated priming within the 1000 ms SOA, $t_p(29) = 2.27$, $p < .05$ and $t_i(29) = 2.07$, $p < .05$, but not within the 2000 ms SOA, $t_p(30) = .06$, $p = .95$ and $t_i(30) = .52$, $p = .61$. Probably due to the lack of mediated priming within the 2000 ms SOA, the overall main effect of Relation was nonsignificant, $F_p(1, 59) = 2.71$, $p = .11$ and $F_i(1, 29) = 2.47$, $p = .13$. The main effect of SOA was also nonsignificant (both *p*s > .75). The lack of a mediated priming effect at the 2000 ms SOA is inconsistent with the expectancy model, which posits that priming effects should be maintained or should increase at longer SOAs due to the increased time it takes to generate an expectancy set (Becker, 1980; Estes & Jones, in preparation). The occurrence of a mediated priming effect at the 1000 ms SOA has several important methodological and theoretical implications. First, the inclusion of a different neutral prime (i.e., the pronounceable non-words rather than the asterisks used in Experiment 2) further demonstrates that mediated priming is due to facilitation rather than inhibition. Second, the weak association between the mediator and each concept reduces the likelihood that spreading activation can explain these results. Finally, as will be discussed further in the next chapter, the finding of mediated priming for the 1000 ms SOA and not for the 2000 ms SOA is consistent with pure direct semantic priming studies and supports a semantic matching account of pure mediated priming.

CHAPTER 6

IMPLICATIONS FOR SEMANTIC PRIMING

In all five experiments, the prime-mediator and mediator-target links were only weakly associated. Experiments 1 – 3 used stimuli having an instrumental relation between prime (e.g., SPOON) and mediator (e.g., soup), and an integrative relation between mediator and target (e.g., CAN). Mediated priming was demonstrated for this instrumental prime-mediator link in Experiments 1 – 3, each using a different LDT paradigm and/or neutral condition. Experiment 1, using a double LDT, yielded a robust 43 ms mediated priming effect. Experiment 2, using a standard LDT with a neutral baseline condition (i.e., ********), demonstrated that pure mediated priming was likely due to facilitation by the mediated prime rather than inhibition from the unrelated prime. Moreover, Experiment 2 demonstrated that pure mediated priming occurred rapidly with statistically equivalent priming effects at the 200 ms and 1000 ms SOAs. Experiment 3 replicated this effect using the same unrelated primes as in Experiment 1.

Experiments 4 and 5 used a different set of items that had an integrative relation between prime (e.g., CAGE) and mediator (e.g., mouse). Experiment 4 again found a robust priming effect (i.e., 50 ms) in a double LDT, thereby establishing that integrative prime-mediator relations could also produce pure mediated priming. Experiment 5 further investigated the time course of pure mediated priming using a 1000 ms SOA and a very long SOA of 2000 ms. Consistent with the results of Experiments 2 and 3, mediated priming again occurred at the 1000 ms SOA, but no mediated priming occurred at the 2000 ms SOA.

In summary, pure mediated priming occurred in five experiments, across two different sets of stimuli and two different LDT paradigms (double and standard). Thus, this study is the first to use weak associative relations between prime and mediator, and therefore expands the applicability of mediated priming to a broader range of semantic relations, namely integrative and instrumental.

Which Semantic Priming Model Explains Pure Mediated Priming?

Recall that the models can be categorized as either prospective (i.e., target activation by prime occurs prior to target presentation) or retrospective (i.e., target activation by prime occurs following target presentation). Hence, I first consider whether results reflected prospective or retrospective processing. Next, I consider whether retrospective spreading activation could account for the current pure mediated priming results. Within the discussion of these three critical questions, all but one of the semantic priming models described in Chapter 3 are determined to be unlikely explanations of pure mediated priming. Finally, the one remaining semantic priming model is discussed in further detail.

Is Pure Mediated Priming Prospective or Retrospective?

Pure direct priming studies collectively suggest that target activation occurs immediately (at short SOAs < 300 ms; e.g., den Heyer et al., 1985; Estes & Jones, in preparation; Neely, 1977; Perea & Rosa, 2002; Smith et al., 1987). This activation increases or is maintained through longer SOAs (i.e., 1000 ms; Estes & Jones, in preparation; Smith et al., 1987) and then is eliminated or at least is reduced by very long SOAs (i.e., SOAs > 1500 ms; Estes & Jones, in preparation; Neely, 1977; Perea & Rosa, 2002). Thus, the pattern of results exhibited in this study is highly consistent with that of other pure direct priming studies reflecting retrospective priming. More specifically, results demonstrated reliable target activation not only within the strategic double LDT paradigms (Experiments 1 and 4), but also in the standard LDT at short SOAs of 200 ms as well as “long” SOAs of 1000 (Experiments 2, 3, and 5). Finally, the mediated priming effect was eliminated at the very long SOA of 2000 ms (Experiment 5). Whereas prospective priming models predict a maintenance or increase in priming effects at longer SOAs (Becker, 1980; Neely, 1991, Table 6), retrospective priming models predict a decay at very long SOAs (typically ≥ 1500 ms; Neely, 1991, Table 4; Estes & Jones, in preparation). Therefore, the prospective models – the Collins and Loftus (1975) spreading activation model and Becker’s (1980) expectancy model – are unlikely to account for pure mediated priming.

Is there Spreading Activation in Pure Mediated Priming?

Recall that the ACT* model has a retrospective component whereby target activation is increased following target presentation due to the reverberation from target back to the source node (i.e., the mediator). Theoretically, then the increased activation of the mediator by the target would have enabled further spread of activation from the mediator to the target. Although there is no established minimal threshold of association that would produce such reverberation, previous mediated priming studies suggest a minimal threshold of greater than .20, or a strong association by Hutchison’s (2003) criteria. Balota and Lorch (1986, LDT Experiment) failed to find mediated priming for stimuli that had weakly or moderately associated mediator-target links (Balota & Lorch, 1986: forward = .10, backward = .16). In contrast, McNamara and Altarriba (1988) found mediated priming using stimuli having strong mediator-target associations (forward = .27, backward = .23). So then, for the current study, given that the backward association from target to mediator was weak (.099) in Experiments 1 – 3 and moderately weak (.101) in Experiments 4 and 5, it is highly unlikely that this reverberation from target to mediator would have occurred.

Previous studies on backward priming lend support to the view that a sufficient level of backward association is required for backward priming to occur. Hutchison (2002) failed to find reliable backward priming for items (e.g., BABY → STORK) having a weak (.01) backward association (i.e., from target to prime), whereas Kahan et al. (1999) found reliable backward priming for compounds (e.g., HOP → BELL) having a moderate backward association of .17 and non-compounds (e.g., WOOD → TERMITE) having an association of .10. Given the additional steps described by Anderson's (1983a, 1983b) ACT* model, the minimal backward association value needed for target-to-mediator spreading activation to occur is likely even greater for mediated priming than for backward priming.

Can Co-occurrence Explain Mediated Priming?

Experiments 1, 3, and 4 used unrelated control items that were matched for co-occurrence using LSA. Thus, the compound-cue theory is not a viable explanation of the current pure mediated priming results. However, familiarity is a viable explanation of mediated priming in general. Therefore, future mediated priming studies should control for this co-occurrence confound.

The Semantic Matching Account of Mediated Priming

The results of these five experiments point to the retrospective semantic matching model as the best explanation of pure mediated priming. To reiterate, the time course of mediated priming effects in Experiments 2, 3, and 5, demonstrated priming at both a short SOA of 200 ms and a "long" SOA of 1000 ms, but no mediated priming at the 2000 ms SOA, and thereby suggested a retrospective model. The weak association between both links and especially from target to mediator greatly reduces the possibility that the ACT* model could account for these results. Finally, the compound-cue model does not provide a viable explanation for these results due to the equated co-occurrence between the mediated and unrelated items in Experiments 1, 3, and 4.

However, one cannot effectively argue that one model (i.e., semantic matching) provides the most promising explanation solely by eliminating the other semantic priming models as viable candidates. Fortunately, though, there is further basis for selecting the semantic matching model as the most promising explanation of pure mediated priming. First, recall that whereas semantic matching refers to a *search for a relation* from the target back to the prime (McNamara, 2005), the ACT* model proposes a *spread of activation* from target to prime. Second, the semantic matching model differs from the ACT* model in that the former posits strategic processing whereas the latter describes an automatic (i.e., nonvolitional) process. Mediated priming effects in the double LDTs (43 ms in Experiment 1 and 51 ms in Experiment 4) were more robust than in the standard LDTs (priming effects ranging from 17 to 29 ms for the 200 ms and 1000 ms SOAs in Experiments 2, 3, and 5). This difference between the LDT paradigms may have reflected the easier ability in the double LDT to strategically check for a mediator that is related to both prime and target.

Finally, recall that retrospective semantic matching entails a search for a relation between *prime* and *target* (Neely, 1977). In fact, Neely (1991) stated that a semantic matching process between a seemingly unrelated prime (e.g., CAGE) and target (e.g., CHEESE) would curtail any mediated priming. So then how could retrospective semantic matching explain pure mediated priming? The answer to this question requires broadening the search for a relation to also include a search for intervening concepts. Beginning with the Collins and Loftus (1975) spreading activation model, most semantic network models posit that links between concepts can include other conceptual nodes (e.g., soup as an intervening node between SPOON and CAN) or relational nodes (e.g., *contained in* as a relational node between soup and CAN). So then following target presentation, a search would begin for a conceptual node (i.e., a mediator) that was related to both prime and target. In other words, rather than the search for a *relation* (e.g., categorical, instrumental, integrative) between prime and target as is currently proposed by the semantic matching model, the search would be for an intervening *concept*.

Associative priming posits decay in activation with increased distance – a prediction that has been supported by McNamara's (1992a) finding of more robust priming for associatively related prime-target pairs (30 ms) than for associative mediated pairs (15 ms; also de Groot, 1983; Shelton & Martin, 1992). However, there is no reason to suspect that semantic matching for a relation should be any faster than semantic matching for a concept. So then, the search for a plausible relation that links a directly related mediator and target (e.g., shower → CURTAIN; a CURTAIN *located in* a shower) should not require any more time than the search for a plausible mediator (e.g., shower) that links the indirectly related prime and target (e.g., SOAP → CURTAIN).

Fifty-three additional undergraduates participated in a post-test to examine this hypothesis. The direct priming effects between the mediators and targets used in the first set of items (see Appendix A) were compared to the mediated priming effects found for these items in the 1000 ms SOA condition of Experiment 3. Direct priming was found for these items' mediator-target pairs in a standard LDT using this same 1000 ms SOA. The directly related mediator-target pairs (e.g., shower → CURTAIN; $M = 618$, $SE = 13$) were 23 ms faster than the unrelated control pairs (e.g., FOOD → CURTAIN; $M = 641$, $SE = 13$), $t_p(52) = 2.70$, $p < .01$ and $t_i(28) = 2.91$, $p < .01$. More importantly, a 2 (Priming: direct, mediated) × 2 (Relation: related, unrelated) interaction confirmed that the priming effects were equivalent between the mediated priming found in Experiment 3 (20 ms; n = 60) and the direct priming (23 ms), $F_p(1, 111) = .07$,

$p = .79$ and $F_i(1, 28) = .01$, $p = .93$. Although a null interaction should be interpreted with caution, these equivalent priming effects for the direct and mediated relations further distinguish pure mediated priming from the associative mediated priming predicted by spreading activation models.

Implications for Integrative Priming

In Experiments 1 – 3, integrative relations linked the mediator and target (e.g., chicken → THIGH; *part of* relation), and in Experiments 4 and 5, these relations linked the prime and mediator (e.g., CAGE → mouse; *inhabits* relation) as well as the mediator and target (e.g., mouse → CHEESE; *consumes* relation). The occurrence of *mediated* integrative priming extends the *direct* integrative priming results of Estes and Jones (in preparation) and Coolen et al. (1991).

Future Directions

As discussed previously, some types of semantic relations are stronger than others (Lucas, 2000; Hutchison, 2003). For example, the instrumental relation used between prime and mediator in Experiments 1 – 3 produces robust priming effects, even when non-associated (Moss et al., 1995; see also Lucas, 2000). The integrative relation used for one or both links throughout all five experiments is also very robust (Estes & Jones, in preparation). The next step then will be to examine additional semantic relations (e.g., associative, categorical) and factors related to these semantic relations (e.g., similarity) in order to determine whether semantic matching or some other mechanism produces mediated priming for these other semantic relations. Recall from Chapter 3, that associative priming has been explained by the ACT* model, spreading activation model, and the expectancy model, whereas pure semantic priming is typically attributed to retrospective models (e.g., compound-cue model, semantic matching). Furthermore, not all semantic relations have reliably exhibited reliable pure direct priming, so it is important to explore which semantic relations will and will not yield pure mediated priming.

Re-examination of Associative Mediated Priming

Could semantic matching also account for associative mediated priming, wherein strong associations exist between the prime and mediator and/or the mediator and target? Recall that Balota and Lorch (1986) as well as de Groot (1983) failed to find mediated priming in a LDT. However, upon closer examination of their items, only the prime-mediator links had a strong associative relation. The mediator-target links had only a weak association. Thus, spreading activation may have been initiated for the prime-mediator links and then may have been halted upon the lack of an associative relation between mediator and target. Although the current study demonstrates reliable pure mediated priming in five studies, a retrospective semantic matching process may not occur once spreading activation has been initiated. To assess the relative roles of spreading activation and semantic matching within associative mediated priming, the associative strengths will be varied separately within each link and compared to a control condition of items having strong associative relations for both links (as is the case for the McNamara & Altarriba, 1988 items).

The Effect of Similarity on Categorical Mediated Priming

McRae & Boisvert (1998) found reliable priming for highly similar category co-members (e.g., GOOSE – TURKEY) at both short (250 ms) and long (750 ms) SOAs, but priming occurred for less similar category co-members (e.g., ROBIN – TURKEY) at only the 750 ms SOA. Thus, because pure direct priming is more robust for the highly similar items, perhaps mediated priming for categorical relations is facilitated by or requires a sufficient level of featural similarity between prime and mediator. To examine this question, pure PRIME-mediator-TARGET triads will be created that consist of primes and mediators taken from the same basic-level category (e.g., birds). To prevent simple direct categorical priming, targets cannot also consist of another category member. So instead, targets will consist of some featural characteristic of the mediator. If featural similarity facilitates categorical mediated priming, then priming effects should be stronger for triads having a high similarity between prime and mediator (e.g., SPARROW → canary → YELLOW) than for those having a lower similarity (e.g., PENGUIN → canary → YELLOW). Note that the prime-target similarity, association, and co-occurrence would have to be equated between the high and low Prime-Mediator similarity conditions, and primes would need to be matched for typicality.

Conclusion

Previous mediated priming studies used stimuli having only associative relations between prime and mediator, thereby concluding that mediated priming was either a function of multi-step spreading activation (e.g., Balota & Lorch, 1986; de Groot, 1983; McNamara, 1992a, 1992b; McNamara & Altarriba, 1988) or the formation of a weakly related (via co-occurrence) compound (e.g., McKoon & Ratcliff, 1992; Ratcliff & McKoon, 1994). The current study demonstrates the first occurrence of pure mediated priming across five experiments, which use two different stimuli sets, thereby extending the previous scope of mediated priming to include non-associated relations. Moreover, these results suggest that an expanded version of Neely's (1977) retrospective semantic matching model best accounts for pure mediated priming.

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APPENDIX A

EXPERIMENTS 1 – 3 STIMULI

Instrumental Prime-Mediator

Mediated (Prime – Mediator – Target)	Unrelated (Prime – Target)
BROOM – clean – DRAIN	GRILL – DRAIN
OVEN – bread – BASKET	BROOM – BASKET
SPOON – soup – CAN	TICKET – CAN
FORK – breakfast – BACON	OVEN – BACON
AX – wood – STOVE	RAKE – STOVE
LIBRARY – research – EXPERIMENT	FORK – EXPERIMENT
MICROWAVE – popcorn – BAG	HORSE – BAG
RAKE – plant – SEED	RAZOR – SEED
RAZOR – cut – MUSCLE	MICROWAVE – MUSCLE
TICKET – show – DOG	SPATULA – DOG
SPATULA – pancake – BLUEBERRY	ROAD – BLUEBERRY
ROAD – car – DOOR	RECIPE – DOOR
RECIPE – cake – CRUMB	AX – CRUMB
HORSE – carriage – WHEEL	LIBRARY – WHEEL
GRILL – chicken – THIGH	SPOON – THIGH
NEEDLE – blood – BANK	PIPE – BANK
TRAP – bear – CAVE	KNIFE – CAVE
BUTTON – clothes – CLOSET	ZIPPER – CLOSET
KNIFE – bread – LOAF	FREEZER – LOAF
SOAP – shower – CURTAIN	MULE – CURTAIN
FREEZER – ice – SCULPTURE	SCISSORS – SCULPTURE
MULE – field – FLOWER	WIND – FLOWER
PLATE – food – WEIGHT	BUTTON – WEIGHT
ZIPPER – clothes – HANGER	SOAP – HANGER
PIPE – air – BALLOON	POLE – BALLOON
WIND – kite – STRING	LADDER – STRING
LADDER – tree – NEST	TRAP – NEST
SCISSORS – paper – COLOR	PLATE – COLOR
POLE – fish – POND	NEEDLE – POND

APPENDIX B

EXPERIMENTS 4 AND 5 STIMULI

Integrative Prime-Mediator

Mediated (Prime—Mediator—Target)	Unrelated (Prime—Target)
SEED – bird – BATH	COPPER – BATH
MORNING – coffee – BEAN	CAGE – BEAN
BRICK – church – BELL	BRISTLE – BELL
DIVORCE – peace – QUIET	TAR – QUIET
LAW – school – BUS	DIVORCE – BUS
TAR – cigarette – BUTT	BRICK – BUTT
WOOD – floor – CARPET	MORNING – CARPET
CAGE – mouse – CHEESE	WOOD – CHEESE
POCKET – watch – CLOCK	BOTTLE – CLOCK
BRISTLE – broom – CLOSET	DISPLAY – CLOSET
BOTTLE – water – COOLER	GEOMETRY – COOLER
GEOMETRY – square – DANCE	SEED – DANCE
SUMMER – night – DARK	POCKET – DARK
DISPLAY – window – DOOR	SUMMER – DOOR
COPPER – money – DRAWER	LAW – DRAWER
BEACH – ball – BOUNCE	UNDERGROUND – BOUNCE
TUNA – salad – FORK	NYLON – FORK
TREAT – dog – HOUSE	SPRING – HOUSE
NYLON – rope – LADDER	GRAMMAR – LADDER
DESK – pencil – LEAD	RIVER – LEAD
SEA – oyster – PEARL	CHAPEL – PEARL
RIVER – fish – POLE	LEMON – POLE
SPRING – rain – PUDDLE	LEATHER – PUDDLE
PLOW – horse – RACE	TUNA – RACE
CHAPEL – wedding – RING	DESK – RING
LEATHER – shoe – SOLE	GARDEN – SOLE
LEMON – tree – SQUIRREL	BEACH – SQUIRREL
GARDEN – rose – THORN	SEA – THORN
UNDERGROUND – train – WHISTLE	PLOW – WHISTLE
GRAMMAR – book – WORM	TREAT – WORM

Table 1

Association and Co-occurrence (LSA) Means for the Stimuli of Experiments 1 – 3 Stimuli

PM Frwd. Assoc.	PM Bkwd. Assoc.	MT Frwd. Assoc.	MT Bkwd. Assoc.	PT Med. LSA	PT Unrel. LSA
.037 (.009)	.020 (.013)	.020 (.006)	.099 (.032)	.141 (.023)	.148 (.019)

Note: Standard Errors are shown in parentheses. PM = Prime-Mediator; MT = Mediator-Target; PT = Prime-Target; Frwd. = Forward; Bkwd. = Backward; Med. = Mediated; Unrel. = Unrelated; Assoc. = Association.

Table 2

Association and Co-occurrence (LSA) Means for the Stimuli of Experiments 4 – 5 Stimuli

PM Frwd Assoc.	PM Bkwd Assoc.	MT Frwd Assoc.	MT Bkwd Assoc.	PT Med. LSA	PT Unrel. LSA
.024 (.003)	.001 (.001)	.051 (.008)	.101 .025	.115 (.014)	.114 (.012)

Note: Standard Errors are shown in parentheses. PM = Prime-Mediator; MT = Mediator-Target; PT = Prime-Target; Frwd. = Forward; Bkwd. = Backward; Med. = Mediated; Unrel. = Unrelated; Assoc. = Association.

Figure 1.

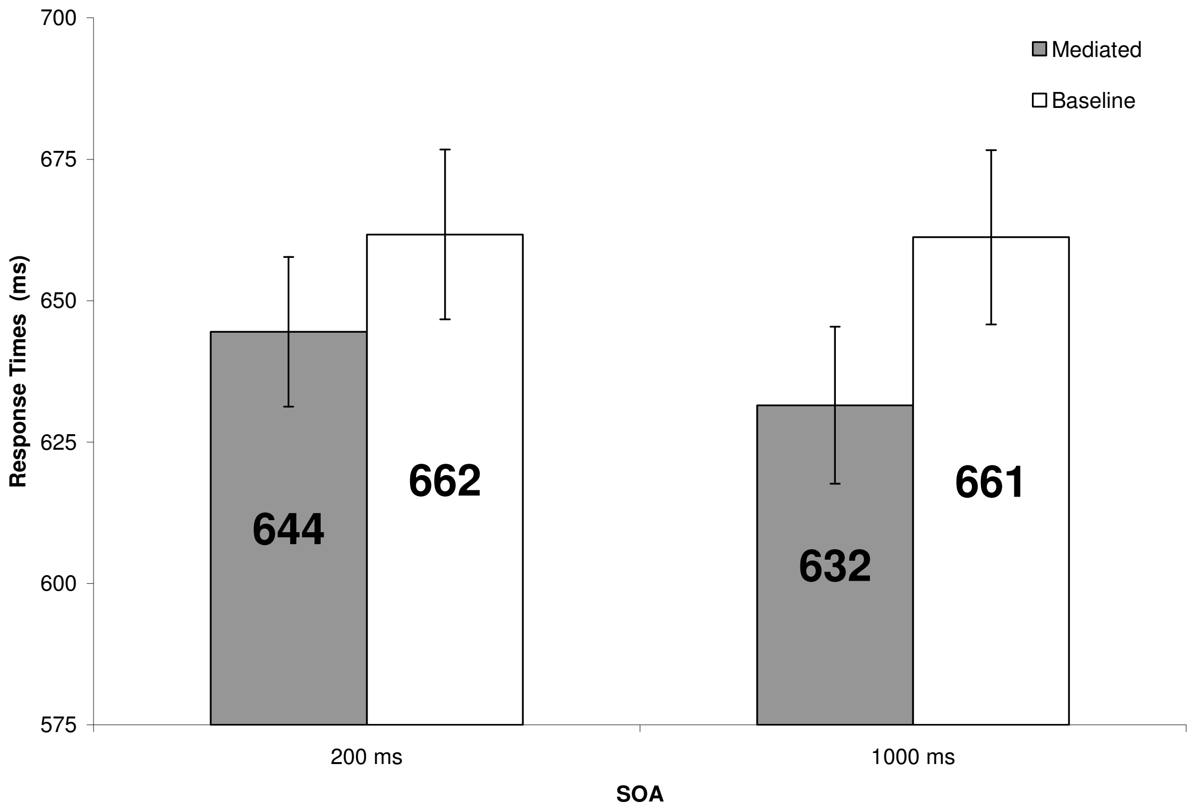

700
675
650
625
600
575
Response Times (ms)
Mediated
Baseline
644
662
632
661
200 ms
1000 ms
SOA

Figure 2.

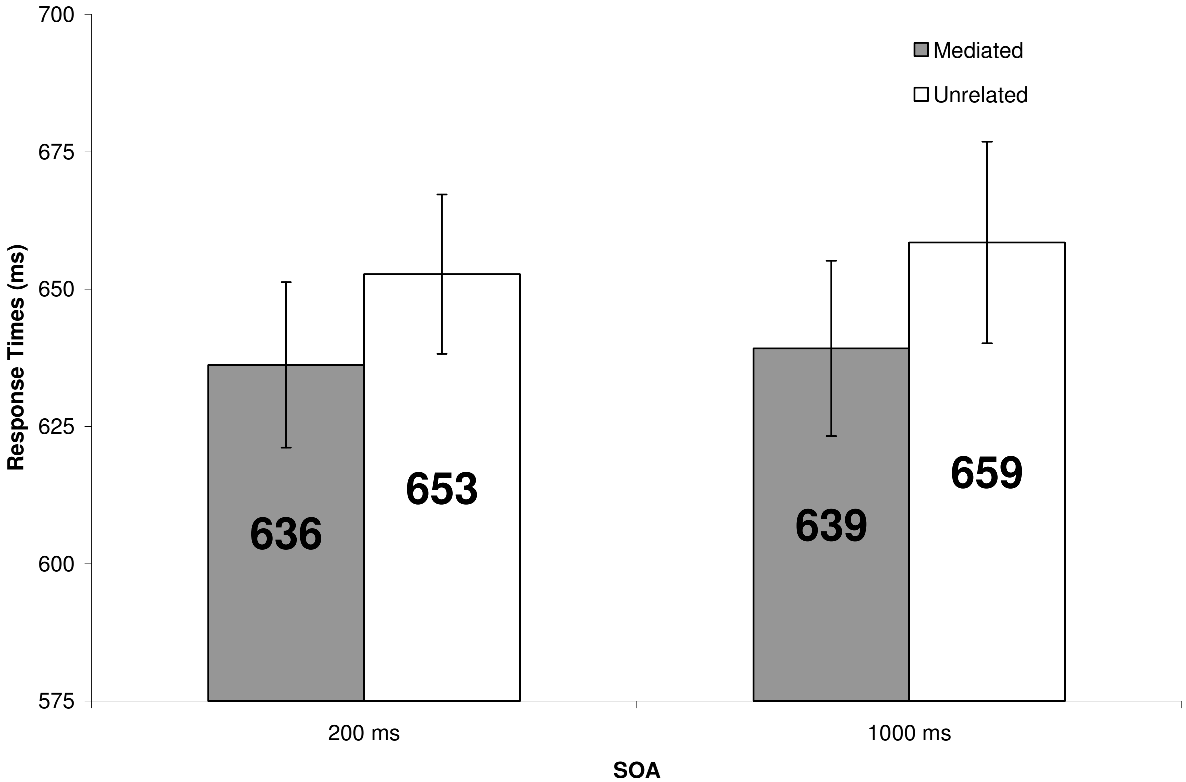
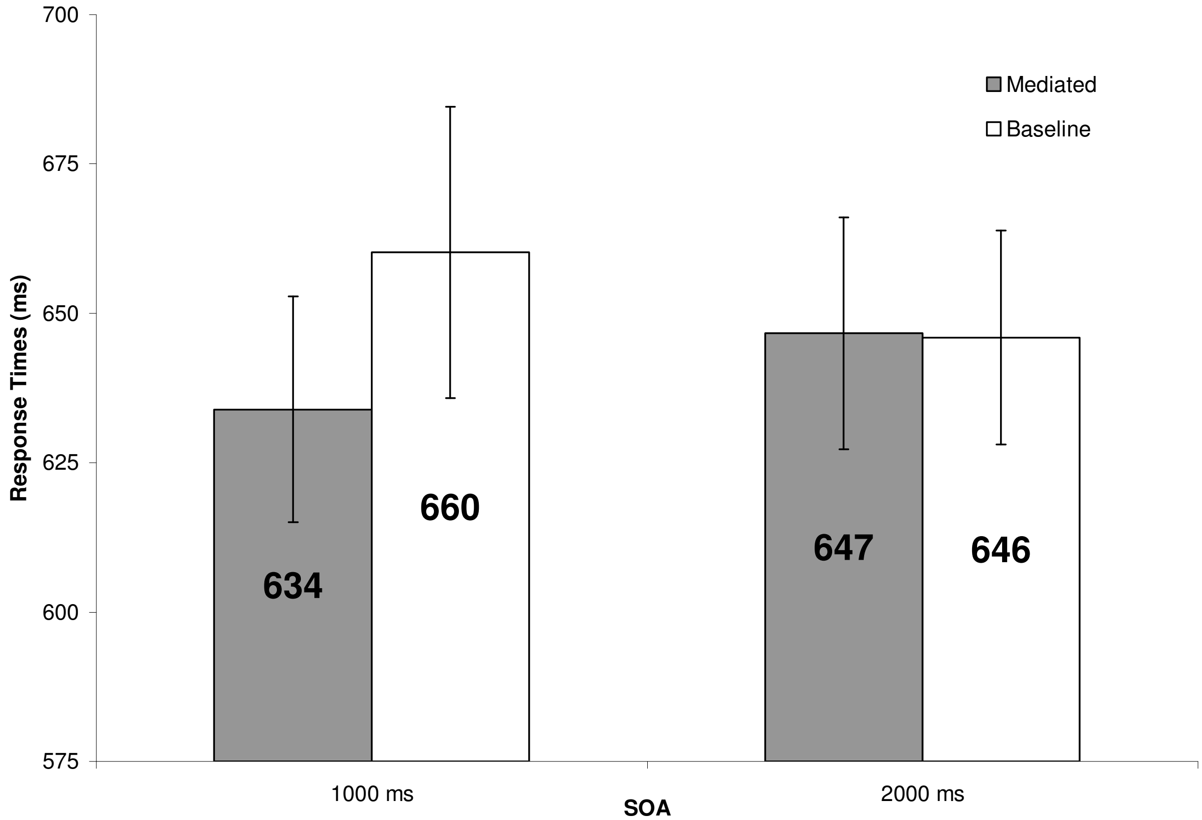

700
675
650
625
600
575
Response Times (ms)
Mediated
Unrelated
636
653
639
659
200 ms
1000 ms
SOA

Figure 3.


700
675
650
625
600
575
Response Times (ms)
Mediated
Baseline
634
660
647
646
1000 ms
2000 ms
SOA