The Influence of Verbal Ability on Mediated Priming

Kay Livesay (livesay@cassandra.ucr.edu)
Department of Psychology
University of California, Los Angeles, 90095

Curt Burgess (curt@doumi.ucr.edu)
Department of Psychology
University of California, Riverside, 92521

Abstract

A set of analyses are presented that replicate the mediated priming effect (e.g., *lion-stripes*) using a naming latency task, and demonstrate that the mediated priming effect is influenced by individual differences in sensitivity to this priming effect. Previous research (Livesay & Burgess, 1998) has shown that stimulus differences are a major factor in whether or not mediated priming is obtained. The present research explores the influence of verbal ability on this effect. The primary finding is that individuals with low verbal ability are not sensitive to mediated word relationships, whereas, individuals with high verbal ability manifest a robust mediated priming effect.

Mediated, or two-step priming (MP; Balota & Lorch, 1986; McNamara & Altarriba, 1988), occurs for prime-target pairs which, on the surface, do not appear to be directly related (e.g., *lion-stripes*). Traditionally, the MP effect has been explained using a spreading activation theory of memory. Spreading activation involves of a set of interconnected nodes where activation spreads from one node to related nodes. Thus, according to spreading activation theory, MP occurs because activation spreads from the prime (*lion*) through the mediating item (*tiger*) to the target (*stripes*), thereby facilitating the response to the target word.

An alternative explanation for the MP effect has been suggested by McKoon and Ratcliff (1992), using the compound cue theory of retrieval. According to McKoon and Ratcliff, MP is not "mediated," but, instead, any priming is due to weak, but direct, relationships in memory. Thus, priming between prime-target pairs, either direct or mediated, occurs because of previous experience of the prime-target pair in context.

Livesay and Burgess (1997, 1998) found that stimulus differences contributed to the lability of the MP effect. According to these researchers, there are two kinds of stimuli used to demonstrate mediated priming: contextually consistent stimuli (CC) and contextually inconsistent stimuli (CI). The CC stimuli were mediated prime-target pairs that were judged as likely to be experienced in a common context (e.g., *bat-bounce*, common context is *ball*), CI stimuli were mediated prime-target pairs that were judged as not as likely to be experienced in a common context (e.g., *day-dark*, common context *night*). When stimuli were separated into these categories and the data reanalyzed, the CC items carried the mediated priming effect, while the CI items did not. It is difficult to reconcile these results with a simple localist view of memory (e.g., spreading activation) because there should be priming regardless of contextually consistency, given the clear, direct relationship between the prime and the mediating item and the mediating item and the target.

Contextual consistency with any two items hinges on the likelihood that items consistently occur in similar contexts which is a function of the relationship between objects in the environment and the mapping of those relationships to language use. The role of experience may play another role in whether or not a person experiences mediated priming. Sensitivity to these variations in contextual sensitivity could be a product of a person's verbal ability. If so, contextual consistency and verbal ability could both predict the presence of mediated priming. According to a spreading activation theory of memory both high and low scorers should show mediated priming and direct priming. This is predicted because the connections in two-step priming should be strong, thus facilitating reaction times for both. From a compound cue view only those individuals who have had experience with the mediated prime-target pairs (or direct prime-target pairs) should get priming. And finally, from an experience mediated meaning representation argument, it is more likely that individuals with high verbal ability (high language experience) will display a mediated priming effect because they will have richer representations for the

words, while individuals with low verbal ability will be less likely to display a mediated priming effect, because they will have a more impoverished representation (compared to the high ability representations).

We analyzed mediated and direct priming results based on participants' performance on the following three individual differences measures, the Nelson-Denny Reading Comprehension Test, the Print Exposure measure, and Daneman and Carpenter's (1980) working memory span test. For each analysis the participants were separated into high scorers and low scorers based on their scores on the individual difference measure being analyzed.

Methods

Participants. Seventy-three University of California, Riverside undergraduates participated as part of a course requirement. All participants were right-handed, native speakers of English with normal or corrected-to-normal vision.

Materials. Forty-eight prime-target pairs were taken from Balota and Lorch (1986). Each test list consisted of 54 items, 16 mediated trials, 16 unrelated trials, 16 directly related trials and 6 warmup trials. Unrelated prime-target pairs were generated by quasi-randomly pairing targets with primes from the 48 original pairs. For example, the prime *lion* in the mediated pair *lion-stripes* was replaced with *breeze* to form the unrelated pair *breeze-stripes*; *breeze* was originally paired with *blow*. The prime words were counterbalanced; a target preceded by a mediated prime on list 1 would be preceded by an unrelated item on list 2 and a directly related item on list 3.

Procedures. The stimuli were presented on a computer monitor; participant responses were collected via a microphone connected to the computer by a Digitry CTS system. Each trial began with a fixation cross presented for 500 ms. Following the fixation cross, a prime word was presented for 350 ms, immediately followed by a target word; the target word remained on the screen until participant answered or 2500 ms had elapsed. Participants simply had to name the word that appeared on the screen. If a participant failed to respond, or did not speak loud enough for the microphone to detect their voice the computer would beep and the word time-out would appear on the screen. The participants were then instructed to speak louder on the next trial.

Results

For these analyses the participants were separated into high scorers and low scorers based on their scores on the individual difference measure being analyzed; high scorers were defined as the eight highest scores on each list, low scorers were defined as the lowest eight scores on each list. Participants were chosen this way in order to assure equal representation from each list. The number eight represents the lowest and highest one-third of each list. We analyzed each set of data using the CC/CI categorization. As discussed previously, this categorization has shown a separation of the mediated priming effect in previous research (Livesay & Burgess, 1997, 1998).

Overall Priming Results

One-way ANOVAs were calculated separately for the CC and CI pairs. Both subject (F_1) and item (F_2) analyses were calculated.

Contextually Consistent Pairs. There was a priming effect for both direct and mediated pairs. Mediated pairs were responded to faster (557 ms) than unrelated pairs (570 ms), $F_1(1, 72) = 9.11$, $p = .0035$; $F_2(1, 23) = 4.57$, $p = .043$. Directly related pairs were also responded to faster (546 ms) than unrelated pairs (570 ms), $F_1(1, 72) = 36.79$, $p = .0001$; $F_2(1, 23) = 9.73$, $p = .0048$.

Contextually Inconsistent Pairs. There was not a priming effect for the mediated pairs, $F_s < 1.0$ (mediated, 563 ms, unrelated, 565 ms). However, there was a direct priming effect. Directly related pairs, were responded to faster (550 ms) than unrelated pairs (565 ms), $F_1 (1, 72) = 10.10$, $p = .0022$; $F_2 (1, 22) = 5.45$, $p = .02$.

Individual Differences

For each individual differences measure one-way ANOVAs were calculated for high scorers and low scorers examining priming effects, separated by CC and CI pairs. Figures 1 and 2 illustrate magnitude of mediated and direct priming separated by contextual consistency (CC/CI), group (high/low) and measure.

Nelson-Denny Reading Comprehension Test

The Nelson-Denny reading comprehension test is a two-part test consisting of a reading comprehension test and a vocabulary test; participants receive two scores, a reading comprehension score and a vocabulary score. Therefore, two different analyses will be computed, one for the reading comprehension scores and one for the vocabulary scores.

Nelson-Denny Comprehension

High Scorers

Contextually Consistent Pairs. There was a priming effect for both mediated and directly pairs. Mediated prime-target pairs were responded to faster (533 ms) than unrelated prime-target pairs (550 ms), $F_1(1, 22) = 6.09$; $p = .022$, $F_2(1, 23) = 3.13$, $p = .090$. Directly

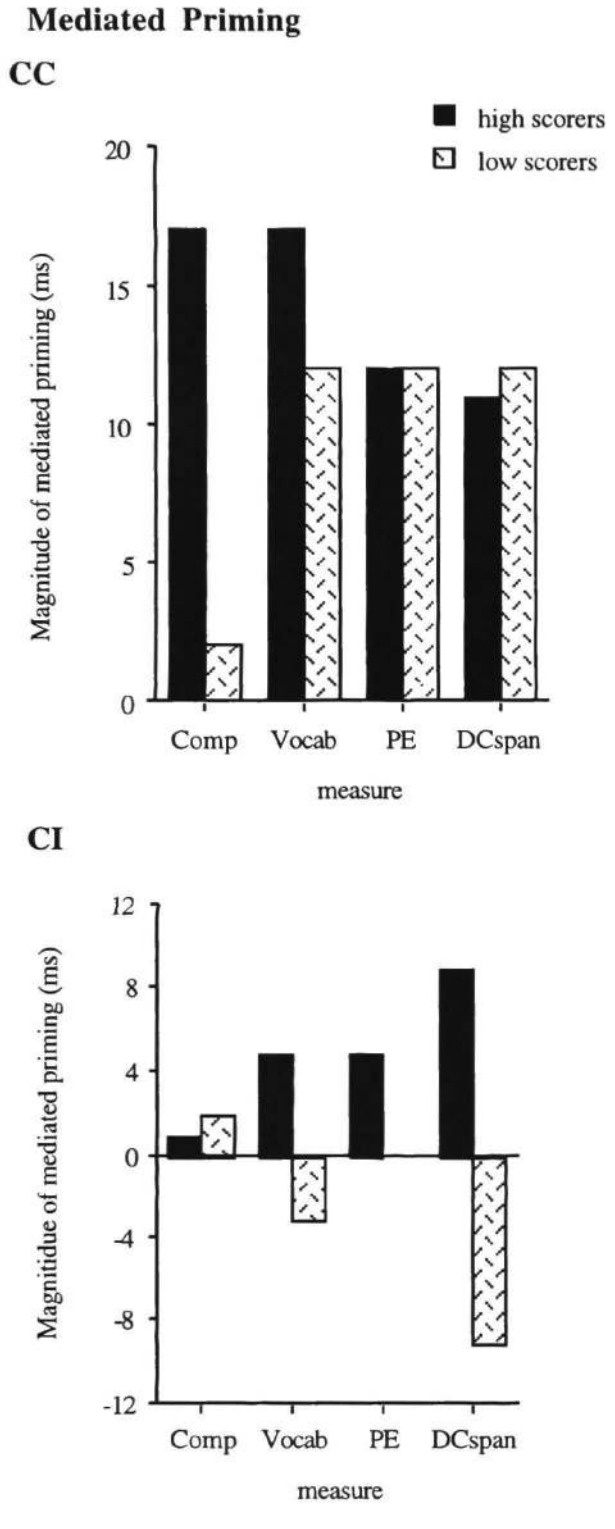

Figure 1. Magnitude (ms) of mediated priming plotted by contextual consistency (CC/CI), high/low scorers and measure.

related pairs (533 ms) were responded to faster than unrelated pairs (550 ms), $F_1(1, 22) = 6.92$, $p = .015$; $F_2(1, 23) = 2.75$, $p = .110$.

Contextually Inconsistent Pairs. There was not a priming effect for the mediated pairs, $F_s < 1.0$ (mediated, 540 ms, unrelated 541 ms). In addition, there was no priming for the directly related pairs, $F_1(1, 22) = 2.39$, $p = .136$; $F_2(1, 22) < 1.0$ (directly related, 533 ms, unrelated 541 ms).

Low Scorers

Contextually Consistent Pairs. There was no priming for mediated pairs, $F_s < 1.0$ (mediated pairs, 577 ms, unrelated pairs, 579 ms). There was, however, direct priming, $F_1(1, 23) = 7.71$, $p = .011$, $F_2(1, 22) = 6.20$, $p = .020$, directly related pairs were responded to faster (562 ms) than unrelated pairs (579 ms),

Contextually Inconsistent Pairs. There was not a priming effect for the mediated pairs, $F_s < 1.0$ (mediated, 569 ms, unrelated pairs, 571 ms). There was also no direct priming effect, $F_s < 1.0$ (directly related pairs, 565 ms, unrelated pairs, 571 ms).

Nelson-Denny Vocabulary

High Scorers

Contextually Consistent Pairs. There was a priming effect for mediated pairs. Mediated pairs were responded to faster (528 ms) than unrelated pairs (545 ms), $F_1(1, 23) = 5.29$, $p = .030$, $F_2(1, 23) = 3.58$, $p = .071$. There was also a priming effect for the directly related pairs, $F_1(1, 23) = 8.51$, $p = .0078$; $F_2(1, 22) = 3.69$, $p = .067$; directly related pairs (525 ms) were responded to faster than unrelated pairs (545 ms).

Contextually Inconsistent Pairs. There was not a priming effect for either mediated or directly related pairs, $F_1 < 1.0$; $F_2(1, 22) = 1.11$, $p = .303$ (mediated pairs, 536 ms, unrelated pairs, 541 ms). Directly related pairs, $F_1(1, 23) = 2.79$, $p = .108$; $F_2(1, 23) = 1.57$, $p = .223$ (direct pairs, 527 ms, unrelated pairs, 541 ms).

Low Scorers

Contextually Consistent Pairs. There was no priming effect for mediated pairs, $F_1(1, 23) = 2.42$, $p = .133$; $F_2(1, 23) = 2.90$, $p = .102$ (mediated 576 ms, unrelated, 588 ms). There was, however, direct priming, $F_1(1, 23) = 11.12$, $p = .0029$; $F_2(1, 23) = 9.92$, $p = .0045$, directly related pairs were responded to faster (564 ms) than unrelated pairs (588 ms).

Contextually Inconsistent Pairs. There was not a priming effect for the mediated pairs, $F_s < 1.0$ (mediated 584 ms, unrelated 581 ms). There was also no direct priming effect, $F_1(1, 23) = 2.07$, $p = .164$;

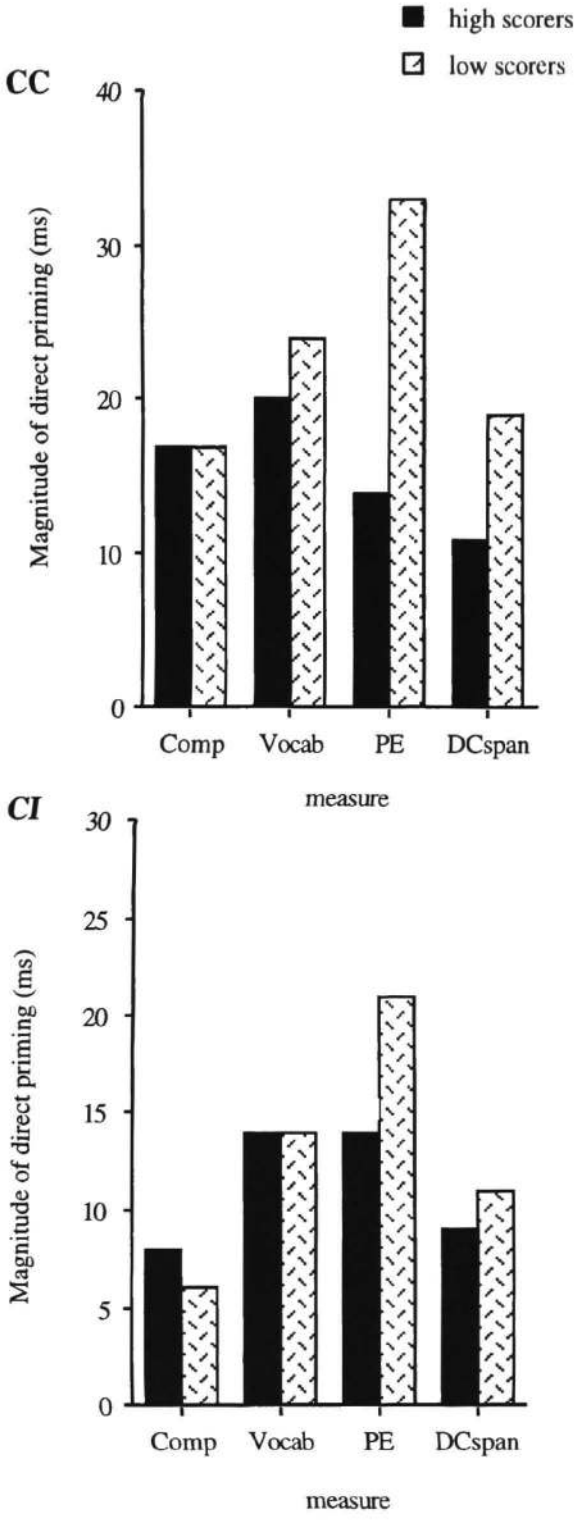

Figure 2. Magnitude (ms) of direct priming plotted by contextual consistency (CC/CI), high/low scorers and measure.

F_2 (1, 22) = 2.63, p = .119 (directly related, 567 ms, unrelated 581 ms).

Print Exposure

The print exposure measure is composed of three tests, the author recognition test (ART), the magazine recognition test (MRT) and the newspaper recognition test (NRT). The score for each measure is totaled to give an overall index of print exposure. These measures were originally developed by Stanovich and Cunningham (1993; see also, Stanovich & West, 1989) and have been correlated with actual exposure to print and reading comprehension ability. The tests used in this paper were modified versions of the original test, updating the author, magazine and newspaper names. The general procedure is to give a participant a list of names, half real names, half foil names, their task is to circle those names that are either author names (on the ART), magazine names (on the MRT) or newspaper names (on the NRT). A score is calculated as the number hits minus the number of false alarms.

High Scorers

Contextually Consistent Pairs. There was a priming effect for both mediated and directly related pairs. Mediated pairs were responded to faster (535 ms) than unrelated pairs (547 ms), $F_1(1, 23) = 5.54$, p = .027, $F_2(1, 23) = 2.90$, p = .102. Directly related pairs (533 ms) were responded to faster than unrelated pairs (547 ms), $F_1(1, 23) = 5.09$, p = .03; $F_2(1, 23) = 3.15$, p = .089.

Contextually Inconsistent Pairs. There was not a priming effect for the mediated pairs, $F_s < 1.0$ (mediated pairs, 541 ms, unrelated pairs, 546 ms). There was, however, a priming effect for the directly related pairs, $F_1(1, 23) = 4.74$, p = .040; $F_2(1, 23) = 4.89$, p = .037, directly related pairs (532 ms) were responded to faster than unrelated pairs (546 ms).

Low Scorers

Contextually Consistent Pairs. There was not a priming effect for mediated pairs, $F_1(1, 22) = 1.86$, p = .186; $F_2(1, 22) = 2.62$, p = .119 (mediated pairs, 575 ms, unrelated pairs, 587 ms). There was, however, direct priming, $F_1(1, 22) = 20.87$, p = .0002; $F_2(1, 22) = 13.75$, p = .0012, directly related pairs (554 ms) were responded to faster than unrelated pairs (587 ms),

Contextually Inconsistent Pairs. There was not a priming effect for mediated pairs, $F_s < 1.0$ (mediated pairs, 580 ms, unrelated pairs, 580 ms). However, there was a marginal direct priming effect, $F_1(1, 22) = 3.88$, p = .061; F_2 (1, 22) = 3.75, p = .065, directly related pairs (559 ms) were responded to faster

than the unrelated pairs (580 ms).

Daneman and Carpenter Working Memory Span Test

The stimuli for this test were taken from the Daneman and Carpenter (1980). The standard procedures were used. Participants read aloud sentences presented one at a time on a computer screen and were then asked verbally to recall the sentence final word from each sentence read. The number of sentences presented increased from two to six sentences (for a more detailed description of the procedures see, Daneman & Carpenter, 1980). High scores had spans of 3.5-5, low scorers had spans of 1.5-3.0 (span increases occur in steps of .5).

High Scorers

Contextually Consistent Pairs. There was not a priming effect for mediated pairs; $F_1(1, 22) = 2.34$, $p = .141$; $F_2(1, 23) = 2.93$, $p = .100$ (mediated pairs, 550 ms, unrelated pairs, 561 ms). There was marginal priming for directly related pairs, $F_1(1, 22) = 1.38$, $p = .253$; $F_2(1, 23) = 3.67$, $p = .068$ (directly related pairs, 550 ms, unrelated, 561 ms).

Contextually Inconsistent Pairs. There was no priming for either mediated or directly related pairs, $F_1(1, 22) = 1.50$, $p = .234$; $F_2(1, 22) = 1.11$, $p = .303$ (mediated pairs, 553 ms, unrelated pairs, 562 ms); directly related pairs, $F_1 < 1.0$; $F_2(1, 23) = 2.44$, $p = .132$ (directly related pairs, 553 ms, unrelated pairs, 562 ms).

Low Scorers

Contextually Consistent Pairs. There was a marginal priming effect for mediated pairs and a reliable priming effect for directly related pairs. Mediated pairs (558 ms) were responded to faster than unrelated pairs (570 ms); $F_1(1, 23) = 3.69$, $p = .067$; $F_2(1, 23) = 3.47$, $p = .075$. Directly related pairs (551 ms) were responded to faster than unrelated pairs (570 ms); $F_1(1, 23) = 5.20$, $p = .036$; $F_2(1, 23) = 4.16$, $p = .053$.

Contextually Inconsistent Pairs. There was not a priming effect for the mediated pairs, $F_s < 1.0$ (mediated pairs, 584 ms, unrelated pairs, 576 ms). There was not a direct priming effect either, $F_1(1, 23) = 1.08$, $p = .313$; $F_2 < 1.0$ (directly related pairs, 564 ms, unrelated pairs 576 ms).

Discussion

A general pattern of results is apparent. For the most part, both high and low scorers are sensitive to direct priming, however, high and low scoring subjects differ on their sensitivity to subtle, mediated priming effects. With the exception of the working memory span measures, low scorers showed no mediated priming effect for either CC pairs or CI pairs. However, low scorers did show a direct priming effect in the CC condition. These findings suggest, that low scoring participants may not have the representation of the information needed for mediated priming available during processing, unlike the high scorers.

These results support the experience mediated view of representation where differences in experience with language may have structural effects on the lexicon. These results are problematic for the spreading activation model of memory for two reasons. Associative norming results have shown that each step in the "mediated" priming chain are strong associates -- *tiger* is a strong associate of *lion* and *stripes* is a strong associate of *tiger*; thus, according to spreading activation theory, all pairs should get priming. However that is not the case, only the CC items get mediated priming. In addition, all participants should get mediated priming because the spread of activation is considered to occur quickly, and automatically. Even if there was a limited amount of activation available, activation should spread immediately because the prime and mediator and target are all strong associates and should robustly participate in the spreading activation process.

A possible explanation for these results is that low scorers have a slower spread of activation and therefore, given the 350 ms SOA, do not have enough time for activation to spread from prime to target. This has not been empirically tested and remains to examined in a timecourse experiment.

A notable exception that appeared among the individual differences results was the fact that only the DCspan measure showed no mediated priming for high scorers. This result seems unusual since all other measures show a mediated priming effect for the high scorers. Perhaps the DCspan is a measure that is not sensitive to these lower, more lexical aspects of verbal ability. Priming is not usually considered to be a resource demanding task and therefore is not likely to overload an individual's capacity, hence, high and low span participants should show similar performance, which they do. However, the results obtained for high and low span participants appear to be contrary to the other measures of individual differences (Nelson-Denny, print exposure). This is an indication that the DCspan measure is not sensitive to these more lexical level effects, while the other measures of verbal ability are sensitive to these effects.

Another distinction that was expected to appear, but did not, was the difference between the Nelson-Denny vocabulary test and the Nelson-Denny comprehension

test. It was assumed that since the vocabulary test is a more lexical level test than the reading comprehension test it would be more sensitive to these lexical level effects. However, both the vocabulary and reading comprehension tests showed the same pattern of results.

As stated earlier, the lack of mediated priming exhibited by low scorers indicates that subtle lexical relationships may not be strongly represented (or represented at all), by low scoring individuals. What is not clear is how this difference in representation would occur.

From a localist, spreading activation view, these low scoring participants appear to be limited in their ability to spread activation, possibly due to an impoverished representation. It is possible this could be attributable to a weak relationship between the directly related and mediated items. This weak relationship between directly related and mediated items could be based on experience with those two words. However, this explanation seems unlikely given that prime, mediators and target words were all rated as strong associates in norming studies.

From a distributed representation view, the differences seen between high and low scorers can be attributed to a difference in contextual experience with these words. Low scorers having less varied contextual experience, thus leading to less enriched representations for those words. The differences seen here could be a consequence of retrieval using semantic representations that are less developed. This is partially suggested given that the print exposure measures appear to be more sensitive to both the mediated and direct priming relationships than the other measures of individual ability.

Previous research (Livesay & Burgess, 1998) has shown that stimuli differences can contribute to differences seen in the mediated priming effect. Present results suggests that verbal ability -- and perhaps more specifically experience -- is also a contributing factor to whether or not the MP effect will be obtained. It appears that print exposure (a measure of language experience) is the most sensitive of the four tests of individual differences to the effects of mediated and direct priming.

Acknowledgments

This research was supported by an NSF Presidential Faculty Fellowship award SBR-9453406 to Curt Burgess.

References

Balota, D. & Lorch, R. (1986). Depth of automatic spreading activation: Mediated priming effects in pronunciation but not in lexical decision. *Journal of Experimental Psychology: Learning, Memory and Cognition, 12,* 336-345.

Daneman, M. & Carpenter, P. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19,* 450-466.

Livesay, K. & Burgess, C. (1997). Mediated priming in high-dimensional meaning space: What is "mediated" in mediated priming? *Proceedings of the Cognitive Science Society* (pp. 436-441). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Livesay, K. & Burgess, C. (1998). Mediated priming does not rely on weak semantic relatedness or local co-occurrence *Proceedings of the Cognitive Science Society* (pp. 609-614). Hillsdale, N.J.: Lawrence Erlbaum Associates.

McKoon, G. & Ratcliff, R. (1992). Spreading activation versus compound cue accounts of priming: Mediated priming revisited. *Journal of Experimental Psychology: Learning, Memory and Cognition, 18,* 1155-1172.

McNamara, T. & Altarriba, J. (1988). Depth of spreading activation revisited: Semantic mediated priming occurs in lexical decisions. *Journal of Memory and Language, 27,* 545-559.

Stanovich, K. & Cunningham, A. (1992). Studying the consequences of literacy within a literate society: The cognitive correlates of print exposure. *Memory and Cognition, 20,* 51-68.

Stanovich, K.& West, R. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly, 24,* 402-433.