THE INFERENTIAL BASIS OF PERCEPTUAL PERFORMANCE

By

JASON P. LEOBE, M. A.

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AUTHOR: Jason P. Leboe, M. A. (Simon Fraser University)

SUPERVISOR: Dr. Bruce Milliken

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Abstract

Prior exposure to a stimulus often speeds responding to that stimulus on a future occasion. Moreover, under some conditions, a previous encounter with a stimulus actually leads to slower responding to that stimulus. These "positive" and "negative" repetition effects are frequently interpreted as directly reflecting the activation state of abstract representations of knowledge (e.g., Paap & Noel, 1991; Tipper, 1985). This view has been challenged by other research suggesting that the effect of repetition depends on the appropriateness (or inappropriateness) of prior processing for meeting current task demands (e.g., Jacoby, 1983; Neill & Mathis, 1998). In a series of experiments, I demonstrate that inferences people make about the source of fluent processing can also modulate the effect of repetition on perceptual performance. These findings establish that the same inferential process that is known to guide decision-making in other cognitive task domains, such as memory and categorization, contributes to performance on simple perceptual tasks as well.
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Chapter 1: Introduction

A common approach to perception research is to assume that responses to stimuli are guided directly by abstract mental representations acquired through multiple prior exposures to a stimulus. It is this view that provides a popular way of explaining how prior exposure to an identical or related stimulus can affect current perceptual processing. Specifically, faster processing due to repetition or relatedness is thought to derive from an increase in the activation state of underlying representations. Conversely, slowed responding due to stimulus repetition or relatedness is assumed to reflect lowered activation or “inhibition” of these representations. I propose that a major flaw in this theoretical approach to perception research is its emphasis on the role of previously acquired knowledge in guiding perceptual performance. This focus on the effect of past learning neglects the profound effect that processes specific to the present can have on perceptual processing. In particular, I propose that inferences people make about the source of current processing provide an important modulating influence on the effect of prior learning on current perception.

In the remainder of this Introduction, I will suggest that assuming performance in perceptual tasks to be a direct reflection of stable representations of acquired knowledge is an example of a pervasive bias in cognitive psychology. To illustrate, I will discuss this assumption as also highly influential in guiding theoretical approaches to research in human memory and categorization. I propose that, in each of these domains, this
assumption is erroneous to the extent that processing unique to the current situation also contributes to performance on cognitive tasks.

The Fundamental Attribution Error in Social Cognition

A well-documented bias in social cognition is people’s tendency to interpret the behaviour of others as originating from stable aspects of their personality. Implicit in this bias is the assumption that such dispositional features will cause the same individual to behave the same way across a broad range of contexts. For example, after witnessing a fellow driver respond with rage (e.g., horn-blowing, cursing, offensive gestures, etc.) after being delayed at green stoplight, one might infer that the driver is chronically ill-tempered, generally impatient, and easily frustrated. In other words, one might expect the driver to behave similarly in other situations involving the presence of obstacles to their current goals, such as while waiting in line at the amusement park, while attempting to open a particularly stubborn jar of pickles, and after landing on “Go to Jail” during a game of Monopoly.

Although relying on dispositional explanations of other people’s behaviour may lead to accurate inferences in some cases (sometimes ill-tempered drivers are chronically ill-tempered people), erroneous conclusions are very likely to occur as well. For example, there are often a number of other potential causes, peculiar to present circumstances, that could explain another person’s behaviour, but that would not be present in another context. For instance, the cause of a driver’s violent reaction to your inattentiveness while waiting behind you as the light turns from red to green may be
related to anxiety about being late for work on this particular day. The same driver under similar circumstances, but without any concern about arriving at work on time, may be quite happy to wait patiently until you become aware of the green light. This failure to appreciate the role of situational factors in giving rise to another’s behaviour and the excessive tendency to attribute a dispositional cause for that behaviour is typically referred to as the “fundamental attribution error” (e.g., Heider, 1958; Ross, 1977).

Research on the fundamental attribution error has revealed people’s bias to attribute behaviour to a range of stable traits, including strongly-held beliefs (e.g., Jones & Harris, 1967; Jones, Worchel, Goethals, & Grumet, 1971) and dispositional constructs that have served as the traditional basis for theories of personality, such as introversion/extroversion (e.g., Miller, Jones, & Hinkle, 1981). The primary emphasis in this thesis, however, will be on the contribution of the fundamental attribution error to people’s assumptions about skills and knowledge rather than personality traits.

The idea that performance under a constrained set of circumstances can be used to estimate general level of ability is a pervasive one in Western culture. For example, this notion serves as the rationale for using performance on examinations to assign grades in university courses. Moreover, measures of underlying ability from performance on standardized tests, such as IQ, SAT, and GRE, are commonly used to predict an individual’s future academic or occupational success. On a less global scale, a tendency to infer pre-existing skills and knowledge based on observed mastery also represents a potential source of bias on people’s social cognitions. People will be sensible in accepting a Jeopardy champion as more knowledgeable than the average person.
However, this basis for inferring breadth of acquired knowledge can also lead to systematic error. For example, observers will rate another person as generally knowledgeable after witnessing his or her ability to answer a set of trivia questions despite awareness that the same person also generated the questions (The Quizmaster Effect, Ross, Amabile, & Steinmetz, 1981). The point is that the role of the fundamental attribution error extends beyond inferences people make about stable traits and attitudes to inferences about another’s learning history. The argument I intend to develop here is that a similar manifestation of the fundamental attribution error frequently plays a role in guiding the thinking of scientists devoted to the study of human cognition.

A Fundamental Attribution Error in Memory Research

Throughout much of the history of experimentation in human memory, researchers viewed memory as a “storehouse” of information about the past, and “remembering” as the act of locating that information and bringing it into consciousness (Roediger, 1980). Consistent with this view, the majority of memory studies have involved presenting participants with a list of stimuli (usually words) and measuring the quantity of those stimuli that participants were able to report after some amount of delay (Ebbinghaus, 1885/1998; Neisser, 1991; Koriat & Goldsmith, 1996; Koriat, Goldsmith, & Pansky, 2001). Success in reporting stimuli in this paradigm was interpreted as directly reflecting the ease of retrieving those stimuli from memory storage. Failure to retrieve a stimulus was seen as reflecting an influence of the contents of memory as well, either through interference from other, similar stimuli (e.g., Jenkins & Dallenbach, 1924;
Underwood & Freund, 1968; Martin, 1970; Murnane & Shiffrin, 1991) or through a failure to adequately encode that stimulus (e.g., Craik & Lockhart, 1972; Jacoby & Dallas, 1981). By this view, it is the “distinctiveness” of a prior experience with a stimulus that determines successful remembering in the future. This common historical approach to the study of memory can be thought of as an instance of the fundamental attribution error; that is, performance on remembering tasks was attributed solely to the nature of stable representations of prior experience. However, this approach is only valid to the extent that aspects of the current situation do not also contribute to memory performance.

A wide array of memory studies reveals this historical approach to be untenable. In particular, successful remembering is now widely considered to obey the principle of transfer-appropriate processing (Morris, Bransford, & Franks, 1977). That is, a number of studies have revealed that successful performance in both recall (e.g., Fisher & Craik, 1977; Leboe & Whittlesea, 2002) and recognition (e.g., Light & Carter-Sobell, 1970; Morris, et al., 1977; Tulving & Thompson, 1973) tests of memory is determined by the extent to which current processing matches processing engaged in during a prior encounter with a stimulus. Such evidence demonstrates that remembering performance can be seen as largely a consequence of processing demands associated with the current situation in interaction with prior experience, rather than directly reflecting the properties of underlying memory representations.

Equally problematic for the notion that successful remembering reflects the “accessibility” of a prior experience is the growing body of data demonstrating the error-
prone nature of the remembering process (see Roediger, 1996, for a review). For example, in some studies, participants have reported details about a prior event that never actually occurred (e.g., Bartlett, 1932; Deese, 1959; Loftus & Palmer, 1974; Loftus, Miller, & Burns, 1978; McCloskey & Zaragoza, 1985; Owens, Bower, & Black, 1979; Roediger & McDermott, 1995; Zaragoza & Lane, 1994). In other studies, participants sometimes have difficulty distinguishing memory for real events from memory for events that were merely imagined (Johnson, Taylor, & Raye, 1977; Read, 1996; Suengas & Johnson, 1988). Experimenters have even been successful in inducing participants to report detailed false memories of childhood experiences (Hyman & Pentland, 1996; Hyman, Husband, & Billings, 1995; Loftus & Pickrell, 1995; Pezdek, Finger, & Hodge, 1997).

Such findings have led a number of theorists to propose that it is a fundamental error to consider acts of remembering as reflecting direct access to previously acquired memory representations. Instead, memory theorists have begun to favour an alternative view that remembering is a way of experiencing the quality and content of information that “comes-to-mind” during attempts to remember (e.g., Johnson, 1997; Johnson, Hashtroudi, & Lindsay, 1993; Leboe & Whittlesea, 2002; Whittlesea, 1997; Whittlesea & Leboe, 2000). If thoughts about what occurred during a prior event are generated particularly easily and are rich in perceptual detail, people will tend to infer that those aspects of the event actually occurred. The implication of this inferential basis of remembering is that what people believe occurred in their prior experience will only be indirectly related to the true nature of their personal history. To the extent that
representations of prior experience stored in memory alone sponsor the easy and vivid "coming-to-mind" of details about those events, people will be accurate when they make statements about their past. On the other hand, if highly accessible and vivid thoughts about the past "come-to-mind" for reasons other than the re-enactment of processing that occurred during a prior event, errors in remembering will readily occur. In this sense, remembering can be said to have an inferential basis. In combination with evidence that the relation between past and present conditions is critical for remembering performance, support for an inferential basis of remembering is ruinous for the view that the "accessibility" of memory representations is exclusively responsible for guiding remembering. Instead, it is increasingly clear that processes specific to the current situation also play an important role in contributing to remembering performance.

A Fundamental Attribution Error in Categorization Research

Beyond the remembering domain, the idea that pre-existing knowledge structures alone control decision-making remains prevalent. For instance, research into the processes that underlie categorization judgments has been dominated by the assumption that such decisions are guided by making direct contact with stored representations of categorical knowledge. A number of theorists have suggested that categorization involves the comparison of objects in the world to abstract mental representations (or prototypes) that preserve the most typical feature values possessed by members of a category (e.g., Posner & Keele, 1970; Rosch, 1978; Rosch & Mervis, 1975). This approach derives empirical support from observations that members of a category
possessing the most typical features of that category are also those that are categorized most quickly (e.g., Rosch, Simpson, & Miller, 1976; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) and are generated first in response to a category cue (Mervis, Catlin, & Rosch, 1976). Such evidence is usually classified under the general heading of “typicality effects”.

A similar perspective has prevailed in the literature on implicit learning of artificial grammars. In the typical artificial grammar learning experiment, people are presented with a list of stimuli generated by a complex rule, ostensibly in preparation for a later memory test. At the end of this initial study phase, participants are informed of the rule-following nature of the stimuli encountered previously. During the subsequent test phase, participants are presented with novel stimuli, half of which conform to the rules of the training set and half of which violate the rules in some way. The participant’s task in the test phase is to judge which stimuli are “legal” and which are not. Although participants deny any knowledge of the rules that distinguish “legal” from “illegal” items, they display above-chance accuracy in categorizing test stimuli. This finding is commonly referred to as implicit learning because people exhibit knowledge of what distinguishes “legal” from “illegal” stimuli in their categorization judgments without expressing any conscious knowledge of what allows them to do so (see Dienes & Berry, 1997, and Neal & Hesketh, 1997, for reviews). A common explanation of this result is that, during the study phase, participants unconsciously extract and preserve some knowledge of the rules constraining the structure of “legal” stimuli and rely on this
knowledge to guide their classification judgments during the test phase (e.g., Knowlton & Squire, 1994; Reber, 1993; Reber & Allan, 1978).

Thus, successful classification performance in implicit learning experiments is often interpreted as arising from direct access to information about the deep structure of stimuli encountered in the study phase. Likewise, from the perspective of prototype theory, direct contact with knowledge of the most typical features possessed by members of a category is directly responsible for typicality effects. In both cases, it is assumed that people extract and preserve knowledge about the abstract structure of categories and that this knowledge is applied in making categorization judgements. However, once again, this idea represents a fundamental attribution error to the extent that processing unique to the current situation plays a role in guiding categorization judgments.

As an alternative to this Abstractionist approach, a number of theorists have proposed that categorization performance does not proceed directly from knowledge about the structure of categories. Instead, categorization judgments are seen as guided by making contact with representations of specific prior encounters with stimuli that possess similar features (Brooks, 1978, 1987; Hintzman, 1986; Medin & Schaeffer, 1978; Nosofsky, 1991; Whittlesea, 1987). From this perspective, it is the structural similarity between a novel stimulus and representations of prior "instances" that permits access to information about category membership.

Based on this Instance Theory of categorization, typicality effects occur because category members that possess the most typical features are often those that people encounter most frequently. As a result, more representations of prior "instances" are
available to guide categorization performance. This approach to categorization also offers an explanation of participants’ success in distinguishing “legal” from “illegal” stimuli in implicit learning experiments. In those experiments, “legal” test stimuli not only follow the rule used to construct the training set, but are also more structurally similar than “illegal” test items to stimuli encountered in the study phase. As a result, participants could discriminate somewhat between “legal” and “illegal” test items by accessing their memory for specific study items and judging the similarity between those items and items presented in the test phase (Dulany, Carlson, & Dewey, 1984; Perruchet & Pacteau, 1991; Vokey & Brooks, 1992). The critical point is that, in the case of Instance Theory, performance in categorization tasks is seen as directly controlled by knowledge about the structure of category members preserved in memory. Thus, both Instance and Abstractionist theories of categorization can be seen as examples of the fundamental attribution error to the extent that processing occurring in the present plays a role in guiding categorization judgments.

A number of findings demonstrate that, separate from what people know about features possessed by category members, the processing requirements of the current situation can also determine the way people categorize novel stimuli (e.g., Whittlesea, Brooks, & Westcott, 1988; Whittlesea & Dorken, 1993). For example, in an experiment conducted by Whittlesea and Dorken (1993), participants were presented with two sets of nonsense words that were each constructed from a different complex rule. Participants were instructed to spell items from one of the categories and to pronounce items from the other category. In the test phase, participants were presented with novel stimuli and were
asked to assign those stimuli to one of the two study categories. At test, half of the test items from the Spell category were spelled, whereas the other half were pronounced. Conversely, half of the items from the Pronounce category were pronounced at test, whereas the other half were spelled. The critical result was that participants were more likely to assign test items to the correct category when the way they processed those test items matched the way that they had processed the studied items from that category. Such evidence suggests that categorization performance can be seen as governed by the same principle of transfer-appropriate processing that contributes to performance on remembering tasks.

Moreover, other evidence demonstrates that inferential processes control performance in categorization tasks in the same way that they control performance on remembering tasks (Whittlesea & Leboe, 2000). For example, reliance on a judgment of similarity as a basis for treating a novel stimulus as a member of some category can itself be considered an inferential process. Reliance on this “resemblance heuristic” will often lead to accurate judgments because members of a category often share common attributes. However, this same inference will lead to systematic error if such a comparison is based on features that are not diagnostic of category membership. For instance, merely taking into account physical resemblance may lead people to incorrectly categorize a whale as a fish and a wolf as a dog.

Because of its inferential basis, the way that people categorize will be highly flexible across changes in context (Barsalou, 1987; Labov, 1973). For example, one ought to expect the features that people emphasize in their evaluations of resemblance to,
in part, be determined by those features that they are encouraged to attend to in the present (e.g., a wolf encountered in a backyard is dog-like, whereas a wolf hunting in a pack is a wild animal). Taken together, then, demonstrations of a role for transfer effects and inference in guiding categorization decisions confirm that processing specific to present circumstances contributes to categorization performance.

The Fundamental Attribution Error and Perception

The purpose of the preceding discussion was twofold. First, it was meant to highlight the broad role of “dispositional” attributions in guiding theoretical approaches to the study of human cognition. Second, it described how performance in two specific domains of cognitive research has been used (or misused) to make inferences about stored representations of knowledge. The purpose of the remainder of this thesis is to demonstrate an analogous “fundamental attribution error” in the domain of perception.

I will treat “acts of perception” as involving any conclusion people draw about stimuli based on aspects of those stimuli that are physically present. Such conclusions can involve arriving at the identity of a specific sensory pattern (e.g., word or picture identification) or a determination about the physical properties of a stimulus (e.g., judgments of two stimuli as the “same” or “different” based on their physical attributes). This definition of perception distinguishes it from remembering judgments that require a decision about some prior experience. Based on this definition, though, the distinction between perception and categorization may appear somewhat blurry, because they can both involve identification of sensory patterns. Still, different from perception,
categorization involves decisions about how to treat a stimulus as a member of a larger
class, even though members of that class possess different physical properties and
identities. For example, canaries and robins can both be classified as birds, but also have
their own unique labels.

A number of prevailing theories about the way people identify and respond to
external stimulus configurations are founded on the idea that information about stimuli is
represented in an abstract form (e.g., Anderson, 1980; Biederman & Cooper, 1991;
Bowers, Vigliocco, & Haan, 1998; Forster & Davis, 1984; Morton, 1979; Ratcliff &
McKoon, 1997). For example, many models of word recognition suggest that internal
representations of the identity and meaning of words are abstract and separate from the
internal representations that link specific letters and their phonological properties (e.g.,

This assumption that perception is mediated by abstract mental representations
frequently determines the way theorists interpret performance in perceptual tasks. One
domain in which this influence has been especially strong is in tasks that measure the
influence of a recent prior stimulus on perception of an identical or related stimulus. In a
typical study of this type, participants respond to stimuli presented in two successive
displays, often referred to as prime and probe displays, respectively. The result of
interest is the difference between performance on trials in which the prime and probe are
related and performance on trials in which the prime and probe are unrelated. Using this
procedure, many investigators have reported faster and more accurate responding to a
stimulus as a result of prior presentation of an identical stimulus (the phenomenon of
repetition priming; e.g., Forster & Davis, 1984; Bodner & Masson, 1997). Similarly, many studies have shown that people can respond faster to a stimulus after a prior encounter with a stimulus that is related in meaning (the phenomenon of semantic priming; see Neely, 1991, for a review).

The idea that pre-existing abstract knowledge controls perception provides one basis for explaining these effects. To use a neural metaphor, the contribution of abstract knowledge structures to perceptual processing may be a function of the current level of activation of those structures. Because perception is thought to occur once internal representations become activated above some threshold, both repetition priming and semantic priming are often interpreted as reflecting a temporary increase in the activation level of these representations. For the remainder of this thesis, I will refer to this basis for accounting for priming effects as the “Activation” approach (see Bowers, 2000; Tenpenny, 1995 for reviews). According to the “Activation” approach, then, the savings in performance due to repetition (or relatedness) is often interpreted as controlled directly by abstract representations of previously acquired knowledge. An important implication of this view is that processes invoked upon onset of the probe are assumed not to contribute to this savings effect.¹

Situational Influences on Perceptual Performance

The view that the activity level of relevant abstract knowledge alone guides performance in perceptual tasks has encountered one of the same obstacles as related ideas in the domains of memory and categorization. In particular, according to the
principle of transfer-appropriate processing, a wide array of studies have demonstrated that perceptual performance depends on the nature of one’s prior experience in interaction with current task demands (e.g., Allen & Jacoby, 1990; Jacoby, 1983; Jacoby & Dallas, 1981; Jacoby & Hayman, 1987; Kolers & Roediger, 1980; Kolers & Smythe, 1984; Levy, Barnes, & Martin, 1993; Masson, 1986; MacLeod & Masson, 2000; Oliphant, 1983; Vriezen, Moscovitch, & Bellos, 1995; Whittlesea & Brooks, 1988; Whittlesea & Cantwell, 1988). The main implication of these studies is that perceptual judgments do not rely on the simple application of acquired abstract knowledge. If perception depended entirely on the application of such knowledge, one would expect much more consistency in performance across changes in context than is actually observed.

Demonstrations of transfer-appropriate processing in perceptual performance have been extremely valuable for correcting the fundamental attribution error in perception research. However, a more intriguing possibility is that situational influences on perception extend beyond transfer-appropriate processing. In particular, a critical issue in need of study is whether, as is true in studies of memory and categorization, inferential processes also contribute to performance in simple perception tasks. Indeed, although there is increasing empirical support for the idea that the subjective experience of remembering has an inferential basis (e.g., Jacoby, Kelley, & Dywan, 1989; Whittlesea, 1997; Whittlesea & Leboe, 2000; Leboe & Whittlesea, 2002), little research has been conducted on the role of inferential processes in perceptual tasks. The goal of
the experiments reported here is to demonstrate that the way people interpret the cause of their own processing can also contribute to performance on perceptual tasks.

The Widespread Influence of the Fluency Attribution Process

In tests of recognition memory, it has been argued that people can use the fluency of their perceptual processing to make an inference about their prior experience. The logic underlying this argument is that the processing of a prior exposure to a stimulus facilitates processing of that stimulus on a subsequent occasion. Consequently, if a stimulus in a recognition memory test is processed particularly fluently, then a reasonable inference would be that it was one of the items studied before. People’s use of this “fluency heuristic” has been revealed most clearly in studies showing that facilitating the processing of stimuli by means other than prior experience also causes participants to judge those stimuli to be “old” (e.g., Jacoby & Whitehouse, 1989; Leboe & Whittlesea, 2002; Lindsay & Kelley, 1996; Rajaram, 1993; Whittlesea, 1993; Whittlesea, Jacoby, & Girard, 1989). In other words, participants infer that they have had a prior experience with a stimulus when processing of that stimulus is fluent, regardless of whether that fluency is actually caused by a prior experience. Such demonstrations confirm that feelings of familiarity result from an inference that particularly fluent stimulus processing originates from a previous encounter with a stimulus (Jacoby, et al., 1989; Whittlesea & Williams, 2001a, 2001b).

Although research on fluency attribution has focused predominantly on remembering, it is clear that fluency attributions can affect performance in non-
remembering tasks as well. For example, prior exposure to a stimulus has been demonstrated to influence judgments of pleasantness (Zajonc, 1980; Whittlesea & Price, 2001), stimulus clarity (Jacoby, Allan, Collins, & Larwill, 1988; Whittlesea, 1993; Whittlesea et al., 1989), stimulus exposure duration (Mandler, Nakamura, & Van Zandt, 1987; Witherspoon & Allan, 1985), and stimulus well-formedness (Ratcliff & McKoon, 1995; Whittlesea & Leboe, 2000). Such observations reveal that inferences about the source of fluent processing contribute to the way that people experience stimuli in the present, in addition to guiding statements they make about the past. The possibility exists, then, that this same type of inferential process could exert a broad influence on people's ability to make perceptual judgments.

To the extent that inferences regarding the cause of fluent processing contribute to performance in perceptual tasks, it is difficult to maintain the view that the effect of repetition or semantic priming is mediated solely through contact with representations of abstract knowledge. Instead, if fluency attribution plays a role in perceptual tasks, then one would expect considerable variability in the effect of prior events on performance in such tasks. That is, the effect of a related prior event on performance in a perceptual task ought to depend on the particular way that people interpret processing fluency in the context of that task. In particular, the involvement of an inferential process allows for either speeded or slowed performance to arise as a consequence of repetition (or relatedness). By this view, whether the effect of a related prior event is positive or negative depends on whether the inference participants make about the source of fluent processing acts in concert or in opposition to the demands of the current task.
An inferential basis to performance in perceptual tasks has similar implications to those discussed earlier for studies of memory and categorization. Judgments that people make on remembering and categorization tasks cannot be used as direct measures of what information is stored in memory because those judgments also reflect inferences that people make about the significance of current processing. For the same reason, performance in perceptual tasks may not reflect the activity level of abstract mental representations.

The purpose of the experiments reported here is to illustrate that performance in perceptual tasks is not a neutral tool for measuring levels of activation in underlying knowledge structures. To this end, the general research strategy was to demonstrate that the influence of related prior events on perceptual performance is considerably less consistent than the “Activation” approach is equipped to explain. Instead, the findings described here are more easily accounted for by the idea that a related prior experience can affect the inferences people make about the source of speeded perceptual processing.
Chapter 2: The Inferential Basis of Judging Same and Different

One of the more well-known examples of an attempt to use performance on a perceptual task to make inferences about levels of activity in underlying mental representations was provided by Posner and Snyder (1975), using a procedure originally developed by Beller (1971). In this procedure, participants are presented with a single letter in a prime display followed shortly after by the presentation of two letters in a probe display. The participant’s task on each trial is simply to indicate whether the two probe letters are the same or different. One critical finding reported by Posner and Snyder (1975) was that same responses were faster when the prime letter matched both probe letters than when the prime mismatched both probe letters. An important property of this result is that it occurred even when the prime and probe letters repeated on a relatively small proportion of trials. In other words, the repetition effect for same responses occurred even when participants had no reason to anticipate stimulus repetition. For this reason, Posner and Snyder suggested that the repetition effect was caused, at least in part, by automatic activation of a memory representation of the prime letter.

Although the repetition effect observed on same responses is entirely consistent with the “Activation” approach, one of the more curious results reported by Posner and Snyder (1975) involved the effect of repetition when a different response was required. On these trials, participants “tend to be faster in rejecting a pair of letters as being identical when they are given a prime that matches neither of them” (Posner & Snyder,
1975, pg. 69). This result is difficult to reconcile with the proposal that repeating an item simply facilitates its perception. If this proposal were correct, then one might expect the facilitation effect to occur for both same and different trials. As such, some consequence of stimulus repetition other than activation of a memory representation of the prime letter must also contribute to repetition effects in this task. In particular, I propose that the paradoxical negative effect of stimulus repetition on different trials is an example of the way in which inferences that people make about the source of current perceptual processing can determine performance on even the simplest of perceptual tasks.
Experiment 1: Misattributing Fluency to “Sameness”

The primary objective of Experiment 1 is to illustrate how an inferential process can contribute to performance in a task similar to the one used by Posner and Snyder (1975). As mentioned above, repetition actually resulted in slower performance when a different response was required. There is no way to explain this type of result if one assumes that repetition effects are the direct consequence of enhanced activation of an abstract memory representation. However, one might be able to account for this observation by allowing for the possibility that repetition effects could also reflect inferences about the source of speeded perceptual processing. Specifically, it is possible that efforts to generate a same/different response are influenced, in part, by reliance on a fluency heuristic.

I assume that the symmetry associated with a probe display consisting of two identical stimuli leads to an experience of greater “coherence” (cf. Whittlesea & Leboe, 2000) than a probe display consisting of two stimuli that differ in their physical attributes. Furthermore, I propose that fluent stimulus processing represents another source of coherent processing that is easily confused with the coherence that people experience on same trials. Therefore, participants may attribute fluent stimulus processing caused by repetition as originating from sameness in the same way that they misattribute the source of fluent processing in a variety of other tasks. Such a misattribution could bias participants toward making a correct response on same trials and an incorrect response on
different trials. In actual performance, this bias would be expected to result in speeded performance on same-repeated trials and slowed performance on different-repeated trials.

Method

Participants. Fifteen undergraduate students enrolled in an introductory psychology course at McMaster University participated in this experiment for course credit. All participants had normal or corrected-to-normal visual acuity.

Stimuli and Apparatus. The stimuli consisted of four pairs of six-letter words: RANDOM-RANSOM, CARBON-CARTON, PORTAL-POSTAL, HAMPER-HARPER. The members of each pair of words differed by only one letter, in the third or fourth position. All stimuli were presented on a 15-inch Sony SVGA colour monitor that was connected to an IBM-compatible computer. Micro-Experimental Laboratory programming software (Schneider, 1988) was used to display the stimuli and to collect data.

Procedure. Each participant completed a session of 240 trials, divided into 30 blocks of 8 trials each. Participants pressed the ‘b’ key on the keyboard to initiate each block. Within each block, half of the trials required a same response and the other half required a different response. For both same and different trials, the proportion of repeated trials was .25. On different trials, three of the four word pairs used in the experiment were selected at random. One word from each pair was randomly assigned the role of prime word, left probe word, and right probe word, respectively. Thus, on trials in which a different response was required, the two probe words differed in their identity and were structurally dissimilar from each other. In other words, different trials
always consisted of structurally dissimilar words, such as RANDOM and CARTON, while structurally similar words, such as RANDOM and RANSOM, never appeared alongside one another on different trials. On same trials, two of the four word pairs used in the experiment were selected at random. One word from each pair was randomly chosen to serve as the prime word; one word from the other pair was chosen to be the identical left and right probe words.

On unrepeated trials, the assignment of words to the roles specified above was maintained, whereas on repeated trials, the prime word was reassigned to be identical to the left probe word. On repeated trials, then, the prime word matched both of the probe words that appeared on same trials and only the word that appeared to the left of the computer screen on different trials. On unrepeated trials, there was no relation between the prime word and either of the probe words.

Participants were seated approximately 60 cm from the computer monitor. At the beginning of each trial, a fixation marker was presented in the center of the computer screen. Participants initiated the trial by pressing the space bar on the computer keyboard, which led to the disappearance of the fixation marker and the appearance of the prime word for a duration of 600 milliseconds. On all trials, the prime word was presented in white and centered on the screen, about 1 cm above the location previously occupied by the fixation marker. After presentation of the prime display, the screen was blank for an interval of 514 milliseconds, followed by the onset of the probe display. The probe display consisted of two white upper-case words, one presented 2 cm to the left and the other 2 cm to the right of the location previously occupied by the fixation marker.
Prior to the experiment, participants were instructed not to respond to the prime word and to treat it simply as a warning signal for the onset of the probe display. Participants were told that their task was to indicate whether the two words that followed the prime word were the same or different. The probe display remained on the screen until the participant responded. Response time was measured as the latency between the onset of the probe display and the button-press (either “x” or “m” on the keyboard) indicating either a same or a different decision. The sequence of events occurring on repeated trials in Experiment 1 is displayed in Figure 1.
Figure 1: Trial procedure on repeated trials in Experiment 1.

NOTE: The prime word matched neither of the probe words on unrepeated trials.
Results and Discussion

Mean latencies for accurate responses and error rates for each Response (Same/Different) and Repetition condition (Repeated/Unrepeated) are reported in Table 1.3

Table 1: Mean Same/Different response times in milliseconds (RT) and error proportions (ERR) observed in Experiment 1 as a function of Response (Same/Different) and Repetition (Repeated/Unrepeated).

<table>
<thead>
<tr>
<th>Repetition</th>
<th>Same RT</th>
<th>Same ERR</th>
<th>Different RT</th>
<th>Different ERR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrepeated</td>
<td>740</td>
<td>.025</td>
<td>832</td>
<td>.018</td>
</tr>
<tr>
<td>Repeated</td>
<td>689</td>
<td>.019</td>
<td>852</td>
<td>.019</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difference</th>
<th>Same</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>+51</td>
<td>+.006</td>
<td>-.20</td>
</tr>
<tr>
<td>SE</td>
<td>(13.4)</td>
<td>(10.4)</td>
</tr>
</tbody>
</table>

A 2 x 2 repeated-measures Analysis of Variance (ANOVA) was conducted on mean response latencies and error rates, treating Response and Repetition as within-subject factors (see the Appendix for a more detailed discussion of the characteristics of this method for testing the reliability of differences between conditions). No reliable differences were observed in the error rate data. However, the analysis of Response Times (RTs) revealed a main effect of Response, \( F(1,14) = 10.79, \text{MSe} = 24627.21, p < .01 \), in that participants responded faster on same trials than on different trials. Also, the main effect of Repetition approached statistical reliability, \( F(1,14) = 3.05, \text{MSe} = 2356.14, p = .10 \) in that participants tended to respond faster on repeated than on
unrepeated trials. However, the most important result was a significant interaction between Repetition and Response, $F(1,14) = 18.98$, $\text{MSe} = 1984.49$, $p < .001$.

Subsequent tests of the Repetition effects for each Response revealed that the facilitation effect for repeated trials was significant only for same responses. On same trials, participants were 51 milliseconds faster on repeated than on unrepeated trials, $F(1,14) = 14.34$, $\text{MSe} = 2709.76$, $p < .01$. In contrast, the data suggested that repetition actually interfered with performance on different trials. On those trials, participants were 20 milliseconds slower on repeated compared to unrepeated trials, $F(1,14) = 3.67$, $\text{MSe} = 1630.87$, $p < .08$.

Based on this result, it might be tempting to argue that repetition facilitates perception more on same trials than on different trials. In other words, this pattern of results might be readily accommodated by Posner and Snyder’s (1975) view that prior activation occurring at the time of the prime event facilitated perception of the same stimulus when it appeared in the probe display. The influence of the prime event might benefit participants more on same trials because, on those trials, the prime matched both stimuli appearing in the probe display. On different trials, participants may not benefit from stimulus repetition to the same degree because the prime stimulus would only match one of the stimuli appearing in the probe display. By this view, repetition effects in the current experiment directly reflect prior activation of representations in memory. Nevertheless, this explanation of the present results would have difficulty accounting for evidence suggesting that repetition was costly for performance on different trials. There
is no way to explain this type of result if one assumes that all repetition effects are the consequence of previously activated representations speeding current perception.

As an alternative, I propose that the dependence of repetition effects on response reflects the contribution of an inferential process. Specifically, it is possible that people are influenced, in part, by reliance on a fluency heuristic in their efforts to generate same/different responses. If participants initially attribute fluent stimulus processing that actually derives from repetition as originating from "sameness", participants would be biased toward making a correct response on same trials and an incorrect response on different trials.

The purpose of Experiment 2 was to distinguish between these two theoretical accounts. In particular, I designed Experiment 2 to obtain convergent evidence that the tendency to attribute fluent perceptual processing to "sameness" was responsible for the differential effect of repetition on same relative to different trials.
Experiment 2: Forestalling the Fluency Attribution Process

I proposed that the results of Experiment 1 were consistent with the view that fluency attribution contributed to performance in the same/different judgment task. In particular, participants may have interpreted fluent processing caused by repetition as evidence that the two probe stimuli were the same. This bias to make a same response on repeated trials could then speed responses on repeated-same trials and slow responses on repeated-different trials. If this characterization of the results of Experiment 1 is accurate, then it ought to be possible to change this pattern of results by discouraging use of this fluency heuristic. In Experiment 2, I tested this hypothesis by making especially fluent processing non-diagnostic of the correct response. This was achieved by making the two probe words on trials that required a different response highly similar to each other. Indeed, they differed by only one letter. In Experiment 1, the assumption was that same/different decision-making was influenced, in part, by an evaluation of the “coherence” of processing. The expectation was that, in Experiment 2, reliance on this same basis would be discouraged given that participants would experience a high degree of “coherence” even on different trials due to the structural similarity of the words appearing on those trials. Under these circumstances, the prediction was that participants would not treat processing fluency arising from repetition as evidence of sameness, and that therefore the pattern of repetition effects observed in Experiment 1 would not be observed in Experiment 2.
Method

Participants. Seventeen undergraduate students enrolled in an introductory psychology course at McMaster University participated in this experiment for course credit. All participants had normal or corrected-to-normal visual acuity.

Stimuli and Apparatus. The same stimuli and apparatus used in Experiment 1 were used in Experiment 2. The only difference between the two experiments was that words presented in the probe display on different trials differed only by one letter. For example, in Experiment 1 the two probe words on a different trial might be RANDOM and CARTON, whereas in Experiment 2 the two probe words on a different trial might be RANDOM and RANSOM.

Procedure. The procedure on each trial was identical to that of Experiment 1. The sequence of events occurring on repeated trials is displayed in Figure 2.
Figure 2: Trial procedure on repeated trials in Experiment 2.

NOTE: The prime word matched neither of the probe words on unrepeated trials.
Results and Discussion

Mean latencies for accurate responses and error rates for each Response (Same/Different) and Repetition condition (Repeated/Unrepeated) are reported in Table 2.

Table 2
Mean Same/Different response times in milliseconds (RT) and error proportions (ERR) observed in Experiment 2 as a function of Response (Same/Different) and Repetition (Repeated/Unrepeated).

<table>
<thead>
<tr>
<th>Response Type</th>
<th>Same</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition</td>
<td>RT</td>
<td>ERR</td>
</tr>
<tr>
<td>Unrepeated</td>
<td>1448</td>
<td>.027</td>
</tr>
<tr>
<td>Repeated</td>
<td>1445</td>
<td>.014</td>
</tr>
<tr>
<td>Difference</td>
<td>+3</td>
<td>+.013</td>
</tr>
<tr>
<td>SE</td>
<td>(20.2)</td>
<td>(.009)</td>
</tr>
</tbody>
</table>

A 2 x 2 ANOVA was conducted on mean response latencies and error rates, treating Response and Repetition as within-subject factors. No reliable effects were observed in analysis of the error rates. However, analysis of RTs revealed a significant main effect of Response, \( F(1,16) = 5.07, \text{MSe} = 27723.01, p < .05 \), in that participants were slower to respond on same trials than on different trials. Most importantly, though, the interaction between Response Type and Repetition observed in Experiment 1 was not observed in Experiment 2. Indeed, the pattern of repetition effects for same and different responses was opposite to that observed in Experiment 1, although the interaction between Response and Repetition was not statistically reliable, \( F(1,16) = 1.64, \text{MSe} = \)
$8878.57, p = .22$. Unlike the results of Experiment 1, when a same response was required, participants were about as fast at responding on repeated trials as on unrepeated trials, whereas when a different response was required, participants were 45 milliseconds faster on repeated compared to unrepeated trials.

To test whether the pattern of repetition effects for same and different responses was reliably different in Experiments 1 and 2, RTs for both experiments were submitted to a $2 \times (2 \times 2)$ Mixed ANOVA, treating Experiment as a between-subjects variable and Response Type and Repetition as within-subject variables. This analysis yielded a reliable 3-way interaction between Experiment, Response Type, and Repetition, $F(1,30) = 8.86, MSe = 5661.3$, $p < .01$. This 3-way interaction confirms that, whereas repetition effects were more positive for same responses than for different responses in Experiment 1, this pattern of repetition effects was not observed for same and different responses in Experiment 2.

The purpose of Experiments 1 and 2 was to demonstrate that inferential processing contributes to performance in the same/different task. Specifically, in interpreting the results of Experiment 1, I argued that an inferential process caused participants to experience a “feeling of sameness” when repetition enhanced the perceptual fluency of probe stimuli. The observation of different effects of repetition on same and different trials is consistent with this idea. Consistent with an Activation approach, repetition led to faster responding on same trials. However, there was also suggestive evidence that repetition actually slowed responses on different trials. This type of result is difficult to explain if one assumes that all repetition effects are the
consequence of previously activated representations speeding current perception. Instead, I interpret this finding as supporting the contribution of a fluency attribution process to the generation of same/different responses.

In Experiment 2, given the presentation of structurally similar words on every trial in which a different response was required, participants could expect a “feeling of sameness” for the probe words to very often lead them astray. This feature of the current experiment was expected to discourage people from using a fluency heuristic in generating their same/different responses. Consistent with this idea, the results of Experiment 2 provided no evidence that repetition produced a larger benefit to performance on same trials than on different trials. If anything, the results of Experiment 2 produced the opposite pattern of results, with more positive repetition effects for different responses than for same responses.

Thus, the combined results of Experiments 1 and 2 demonstrate the difficulty in treating repetition effects as the inevitable outcome of prior activation of abstract knowledge structures. Instead, the results of these experiments reveal flexibility in the effect of repetition on performance on perceptual tasks, capable of producing either speeded or slowed performance across different circumstances. I propose that much of this flexibility can be explained as the outcome of inferences people make about speeded perceptual processing.
Chapter 3: The Inferential Basis of Stroop Colour Naming

As mentioned earlier, a vast number of studies demonstrate that exposure to an identical or related prior event is beneficial for performance on perceptual tasks. One goal of the preceding experiments was to offer evidence that the same influence that facilitates performance under one set of circumstances interferes with performance under other circumstances. Furthermore, the argument presented above was that whether a prime event is beneficial or costly to performance depends on the way that people interpret enhanced perceptual fluency that derives from that prime event. Henceforth, I use the term “negative transfer” to refer generally to any situation in which repetition (or relatedness) interferes with performance. As such, the results of Experiments 1 and 2 illustrate that inferences that derive from fluency attribution provide one possible basis for explaining a negative transfer effect. This chapter focuses on whether this same type of influence contributes to a particular type of negative transfer effect, known as “negative priming,” that has received considerable study.

The phenomenon of negative priming is typically studied using a selective attention procedure, such as the Stroop task (Dalrymple-Alford & Budayr, 1966; Lowe, 1979; Neill, 1977). For example, the word RED may appear in green as a prime stimulus, and participants respond by identifying the colour in which the word is displayed. In a following probe display, the word BLUE may appear in red. In this ignored-related condition, the target colour red matches the distracting word dimension of the preceding prime. The negative priming effect (Tipper, 1985; Tipper & Cranston,
1985) is defined by slower response times for these ignored-related trials than for trials in which the prime and probe are unrelated (see Fox, 1995; May, Kane, & Hasher, 1995; and Tipper, 2001, for reviews).

A common inference made by researchers following early demonstrations of negative priming (Dalrymple-Alford & Budayr, 1966; Neill, 1977; Tipper, 1985) was that the slowing for ignored-related trials occurs as a result of inhibitory attentional processing. This inference is based on the notion that performance in perceptual tasks directly reflects the activity level of abstract representations in memory. That is, ignoring the word RED in a Stroop task may be achieved by inhibiting an abstract memory representation of the concept "red". Consequently, a subsequent task that requires access to this memory representation (e.g., the word BLUE in red) may be slowed.

One problem with this class of explanations, however, is that negative priming may be observed even in the absence of any requirement to select between a prime target and a distracter (Milliken & Joordens, 1996; Milliken, Joordens, Merkle, & Seiffert, 1998; Milliken, Lupianez, Debner, & Abello, 1999; Neill & Kahan, 1999; Ortells & Tudela, 1996; Park & Kanwisher, 1994; Wood & Milliken, 1998). For example, Milliken et al. (1998), demonstrated that participants were slower at identifying the font colour of the word RED printed in green after mere exposure to the word GREEN printed in a neutral white. Such evidence challenges the assumption that slowed responding to the probe stimulus is caused by an inhibitory process dedicated to eliminating distraction in selective attention contexts. At the same time, these types of demonstrations have not proved fatal to the view that negative priming reflects the inhibition of abstract memory.
representations. Proponents of this theoretical view have argued that actively ignoring a prime stimulus that has no selective attention requirement also involves an inhibition process. Thus, when they are not required to generate a response to a prime, and when information provided by a prime holds little relevance for the following probe, participants may inhibit processing of the prime (Tipper, 2001). This idea is consistent with findings that negative priming is most robust when there is a low probability of trials in which a relation exists between the prime and the subsequent probe (e.g., Milliken et al., 1999; Milliken & Rock, 1997). That is, negative priming appears to occur primarily when there is no motivation for participants to attend to the prime in preparation for the onset of the probe display.

**Processing Mismatch Accounts of Negative Priming**

A second problem with the Inhibition account of negative priming effects is much more central to the issues of interest in this thesis. As mentioned above, there is substantial evidence that interactions between the present and past contribute to both memory and categorization performance. Such findings represent one of the major challenges to the idea that performance on these tasks is governed solely by the nature of underlying memory representations. An analogous challenge to the Inhibition account has also been proposed in the negative priming literature. In particular, a number of researchers have demonstrated that negative priming can depend on the contextual similarity of prime and probe episodes (Fox & DeFockert, 1998; Neill, 1997; Neill, Valdes, Terry, & Gorfein, 1992). Such evidence suggests that, rather than occurring as a
consequence of prior inhibition of ignored information, negative priming might occur when retrieval of the prime episode conflicts with current efforts to generate a response.

Neill and colleagues (Neill & Valdes, 1992; Neill et al., 1992, Neill, 1997) suggested that slowed performance in the ignored-related condition could occur because of a retrieval process occurring upon onset of the probe display. According to this “episodic retrieval” account, negative priming occurs in the Stroop task because the retrieval of an episode of having ignored the prime word interferes with the subsequent requirement to attend to the probe colour. Similarly, others have argued that perceptual mismatches are also present in the conventional negative priming procedure that could slow performance on ignored-related trials (McDonald & Joordens, 2000; McDonald, Joordens, & Seergobin, 1999; Park & Kanwisher, 1994). For example, in the Stroop task, the probe colour appears as the prime word in the preceding display on ignored-related trials. Therefore, slower responding on these trials might occur not as a consequence of having recently ignored the prime word but because identifying the colour of the probe suffers interference from having recently encoded that same colour as a word.

These Processing Mismatch accounts of negative priming suggest that recruitment of a related prior experience interferes directly with current perception. While acknowledging that processing mismatches represent one cause of negative transfer effects, a primary objective of this thesis is to argue that repetition effects also occur as a result of inferential processing. From this perspective, whether repetition leads to faster or slower performance on a perceptual task depends on inferences people make about the source of speeded processing. Therefore, in the absence of any source of processing
conflict from a related prior event, negative transfer effects may still paradoxically occur even when that event has a facilitatory effect on current perception.

An Inferential Basis of Negative Priming

In Experiments 1 and 2, the dependence of repetition effects on response type (same versus different) was explained with reference to a fluency attribution process. The central idea was that processing fluency actually caused by stimulus repetition can be misattributed to "sameness", resulting in a bias favouring "same" responses on repeated trials. What is noteworthy is that the way participants interpreted fluent processing was assumed to be intimately tied to the nature of the task that they performed.

The task that participants performed in Experiments 3-6 involved naming the font colour in which colour words were presented (Stroop, 1935; see MacLeod, 1991, for a review). Although, nominally, this task is quite different from the same/different task used in Experiments 1 and 2, an attribution process could influence response selection in the Stroop task as well. Specifically, when naming the font colour of a colour word, participants may evaluate whether word identity information will lead the response selection process astray, and then select a response accordingly. For example, in the case of an incongruent Stroop stimulus (word different from font colour), it would be to the participants' advantage to detect the incongruent status of the stimulus quickly, so that appropriate attentional processes can be engaged to filter out processing of the distracting word. In contrast, in the case of a congruent stimulus (word same as font colour), detecting the congruent status of the stimulus would allow participants not to engage in
selective filtering of the word, perhaps allowing processing of either word or colour to
determine response selection.

Thus, the decision not to engage in selective processing of the colour dimension
of a Stroop item could be a reasonable one under some circumstances. On congruent
trials, this inference would allow word reading to assist in the generation of an accurate
response. Nevertheless, it is unlikely that participants are directly in touch with whether
selective processing is necessary from one trial to the next. Instead, the decision about
whether to engage in selective processing in the Stroop task could be guided by a fluency
attribution process.  

In many instances, experiencing fluent processing might be useful for judging the
need to engage in selective processing. For example, processing fluency might indicate a
match between word and font colour, revealing that either dimension will lead to the
correct response. However, processing fluency could also occur for reasons other than
congruency between word and font colour. Specifically, enhanced processing could
occur because of a match between the prime word and the colour of the probe. I propose
that participants will interpret fluent processing caused by repetition in the same way that
they interpret fluent processing caused by congruency. That is, in both cases, participants
will infer that the correct response is readily available. Such an inference should curtail
further selective processing, which could, in turn, lead to an increase in the contribution
of word reading to response selection. In summary, then, I propose that the interpretation
of facilitated processing due to repetition as deriving from congruency could actually
increase the contribution of word processing on incongruent trials. As described below,
this idea provides a basis for explaining negative priming by reference to inferential processes.
Experiment 3: Task-Specific Effects on Priming

One hint that inferential processing might contribute to negative priming is provided by studies that have illustrated a dependence of negative priming on attentional demands of the probe task; that is, the task performed on the second of two consecutive displays in a “priming” procedure. In particular, it has often been found that negative priming occurs only when the probe task requires an act of selective attention (e.g., Bleile, 2000; Lowe, 1979; Milliken et al., 1998; Milliken et al., 1999; Neill & Kahan, 1999). For example, Bleile (2000) observed negative priming following presentation of a single unattended word only when the probe task required selective attention to a target in the presence of a distracter. When no distracter appeared in the probe display, the same prime event produced positive priming. A critical aspect of Bleile’s (2000) procedure was that presence or absence of the probe distracter varied randomly across the experimental session. As a result, the difference in priming effects for “distracter-present” versus “distracter-absent” trials could not be due to a difference in the way that participants treated the prime event. Participants had no way of knowing beforehand whether a distracter would appear in the probe display.

Naturally, it is difficult to account for this type of result by reference to an inhibitory process at the time of the prime event. One would expect that such an inhibitory mechanism would hinder perception of a stimulus regardless of the selective attention demands of the probe task. In the remainder of this chapter, I will develop the
idea that an inferential basis of negative priming arises out of the requirement to engage in selective attention during the probe task.

The purpose of Experiment 3 was simply to test whether the same prime event can have either negative or positive consequences for performance on the Stroop task, depending entirely on the type of stimulus that appears in the probe display. Although, Bleile (2000) observed this type of result in a word reading version of the negative priming procedure, it has been somewhat difficult to replicate in word reading (Neill & Kahan, 1999), and entirely elusive in the Stroop task (e.g., Milliken et al., 1999).

In Experiment 3, participants were required to name the colour of probe stimuli that consisted of either incongruent Stroop items (e.g., the word RED displayed in green), congruent Stroop items (e.g., the word GREEN displayed in green), or coloured rectangles. On every trial, the probe stimulus was preceded by the presentation of two identical colour words presented in white. For all probe types, the prime words corresponded to the colour of the probe on 25% of the trials (Repeated trials) and were unrelated to both the probe colour and the word on the remaining 75% of the trials (Unrepeated trials). The issue of interest in this experiment was whether repetition effects would vary as a function of the congruency of the Stroop probe. That is, Experiment 3 was meant to test whether it is possible to observe either speeded or slowed colour-naming performance for the same prime event depending entirely on the selective attention demands of the probe task.
Method

Participants. Fifteen undergraduate students from McMaster University participated in the experiment for course credit. All participants had normal colour vision and normal or corrected-to-normal visual acuity.

Apparatus and Stimuli. Stimuli were presented on a Sony SVGA colour monitor that was connected to an IBM-compatible 486 microcomputer. The experiment was run using Micro-Experimental Laboratory software (Schneider, 1988). Participants were seated approximately 60 cm from the monitor, and a small microphone was clipped to the front of their shirt or collar. The microphone was plugged into a voice-activated relay that was used to detect the time of onset of the vocal response of the participants.

On each trial, the first display contained a fixation marker, the second display contained two white prime words, and the third display contained the colour-word probe item. The fixation marker was a white plus symbol (‘+’) displayed in the middle of the screen against a dark background. The prime display contained two identical upper-case words presented in white and centered, occupying locations directly above and below the location occupied previously by the fixation marker. On all trials, both primes were the word RED, BLUE, GREEN, or YELLOW. The probe display consisted of either an incongruent Stroop item (a colour word displayed in a colour that did not correspond to its meaning), a coloured-rectangle, or a congruent Stroop item (a colour word displayed in the colour that corresponded to its meaning). The probe was centered on the location previously occupied by the fixation marker, and therefore appeared between the locations previously occupied by the prime words.
**Procedure.** On incongruent probe trials, three of the four colours used in the experiment (red, green, blue, and yellow) were selected at random. One of the colours was assigned the role of prime word, a second was assigned the role of probe distracter word, and the third was assigned the role of probe target colour. On congruent probe trials, two colours from the list of four were selected at random. One of those colours served as the prime words, the other served as both the probe word and the probe target colour. Finally, on trials in which a coloured-rectangle appeared as the probe target, two of the four colours used in the experiment were selected at random. One colour served as the prime word and the other colour served as the probe target colour. For all three types of probe targets, on unrepeated trials, the assignment of colours to the roles specified above was maintained, whereas on repeated trials, the probe target colour was reassigned the colour that corresponded to the prime words. Thus, on repeated trials, presentation of the word BLUE as the prime word would be followed by a probe stimulus displayed in blue, whereas on unrepeated trials, there was no relation between prime stimuli and the probe item.

Each participant completed a practice session of 20 trials and a test session of 400 trials. The test session was divided into 20 blocks of 20 trials each. Participants tapped the ‘b’ key on the keyboard in front of them to initiate each block. Within each block, on 40% of trials an incongruent Stroop item served as the probe stimulus and on 40% of trials a congruent Stroop item served as the probe stimulus. On the remaining 20% of trials in each block, a coloured-rectangle served as the probe stimulus. For each of these
probe types, the proportion of repeated trials within each block and, therefore, across the test session as a whole, was .25.

Participants initiated a trial by pressing the space bar on the computer keyboard. A blank interval of 500 ms followed the disappearance of the fixation display. The prime words were then displayed for 114 ms. Following the prime display, there was a 57 ms inter-stimulus interval (ISI) during which the screen was blank. This interval was then followed by the onset of the probe display. Participants were instructed to name the colour of the probe stimulus as quickly and accurately as possible. The probe display stayed on the screen until the participant responded. The experimenter then coded the trial as correct, incorrect, or a spoil. A trial was coded as a spoil when the voice key was triggered by something other than the response of the participant or when the response of the participant failed to trigger the voice key. A trial was coded as incorrect when a response made by the participant did not correspond to the target colour. RT was measured as the latency between the onset of the probe and the onset of the voice of the participant. An example of the sequence of events occurring on each trial is displayed in Figure 3.
Figure 3: Trial procedure on repeated trials in Experiment 3.

NOTE: On un repeted trials, the prime words matched neither the colour nor the word dimension of the probe stimulus.
Results and Discussion

For each condition, accurate colour naming latencies were subjected to an outlier elimination procedure. Van Selst and Jolicoeur's (1994) modified recursive outlier elimination procedure was used to ensure that different proportions of outliers were not systematically excluded from cells that contained different numbers of observations. This procedure led to the exclusion of less than 2% of the observations from further analysis. Mean correct RTs and error rates for each condition are displayed in Table 3.

Table 3: Mean colour naming response times in milliseconds (RT) and error proportions (ERR) observed in Experiment 3 as a function of Probe Type (Incongruent/Congruent/Rectangle) and Repetition (Repeated/Unrepeated).

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>Incongruent</th>
<th>Congruent</th>
<th>Rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>ERR</td>
<td>RT</td>
</tr>
<tr>
<td>Unrepeated</td>
<td>766</td>
<td>.082</td>
<td>630</td>
</tr>
<tr>
<td>Repeated</td>
<td>805</td>
<td>.123</td>
<td>604</td>
</tr>
<tr>
<td>Difference</td>
<td>-39</td>
<td>-.041</td>
<td>+26</td>
</tr>
<tr>
<td>SE</td>
<td>(10.8)</td>
<td>(.017)</td>
<td>(6.4)</td>
</tr>
</tbody>
</table>

The RT data were submitted to a repeated-measures ANOVA with Repetition (Repeated/Unrepeated) and Probe Type (Incongruent/Congruent/Coloured-Rectangle) as the independent variables. This analysis yielded a significant main effect for Probe Type in that participants were much slower to name the colour of incongruent probes (786 ms) than to name the colour of both congruent probes (617 ms) and coloured-rectangles (621 ms), \(F(1,14) = 55.87, MSe = 2120.04, p < .001\). More important, this analysis produced
a reliable Repetition x Probe Type interaction, $F(1,14) = 23.94$, $MSe = 329.65$, $p < .001$. The main effect of Repetition was not reliable, $F < 1$. To explore this interaction further, the simple effects of Repetition were tested for each of the three probe types.

On incongruent probe trials, participants were 39 ms slower on repeated than on unrepeated trials, $F(1,14) = 16.35$, $MSe = 671.53$, $p < .01$. In contrast, on congruent probe trials, participants were 26 ms faster at responding on repeated relative to unrepeated trials, $F(1,14) = 17.47$, $MSe = 302.20$, $p < .001$. Participants’ speed at responding to coloured-rectangles was about the same on repeated and unrepeated trials, $F < 1$.

An ANOVA was also conducted for the error rate data, treating Repetition (Repeted/Unrepeated) and Probe Type (Incongruent/Congruent/Coloured-Rectangle) as within-subject variables. Overall, this analysis revealed a significant main effect for Repetition in that participants made errors on 4.5% of repeated trials, whereas they made errors on only 3.2% of unrepeated trials, $F(1,14) = 6.65$, $MSe = 5.37$, $p < .05$. There was also a main effect of Probe Type, $F(1,28) = 31.72$, $MSe = 29.22$, $p < .001$, in that participants made a colour naming error on about 10.3% of incongruent trials, but on only 0.5% and 0.9% of congruent and coloured-rectangle trials respectively. There was also an overall Probe Type x Repetition interaction, $F(1,14) = 5.21$, $MSe = 8.75$, $p < .05$. The source of this interaction was investigated further by conducting separate analyses for each of the probe types, treating Repetition as a within-subject variable. For incongruent probes, participants’ error rates were higher for repeated trials than for unrepeated trials, $F(1,14) = 6.14$, $MSe = 20.20$, $p < .05$. In contrast, for both congruent and incongruent
probes, participants' error rates were no different for repeated and unrepeated trials, \( F < 1 \) for congruent probes and \( p > .15 \) for coloured rectangle probes.

The critical result obtained in this experiment was that reliable negative priming effects occurred only when colour naming was opposed by the presence of a distracting colour word. In contrast, when the probe stimulus was a congruent Stroop item, colour naming performance was actually faster for repeated than for unrepeated trials. This result is important because it is difficult to accommodate based on the idea that priming effects are solely determined by the effect of the prime event in activating or inhibiting abstract representations of acquired knowledge. If an inhibitory process is responsible for slowed responding on repeated trials when an incongruent probe item is presented, that same process ought to produce slowed responding when a congruent probe item is presented. The observation of qualitatively different priming effects depending on the nature of the probe stimulus in this experiment provides additional motivation to explain priming effects with reference to processes occurring during efforts to respond to the probe task.

Thus far, I have identified two bases by which processes occurring in the present could modulate the effects of a related prior event on perceptual performance. First, the nature of the overlap between present conditions and a prior event can determine the impact of that prior event on current performance. A number of researchers have demonstrated the contribution of this first influence on repetition effects in giving rise to negative priming effects. In particular, many studies have revealed that processing mismatches between the prime and probe events can produce negative priming
(MacDonald & Joordens, 2000; MacDonald et al., 1999; Milliken et al., 1994; Neill & Mathis, 1998; Park & Kanwisher, 1994). Second, I proposed that inferential processes at the time of the probe event may also contribute to perceptual performance, producing different consequences of stimulus repetition in different task contexts. The purpose of the following two experiments was to examine whether a "processing mismatch" might explain the dependence of repetition effects on the congruency of Stroop probes, as observed in Experiment 3. To the extent that processing mismatches fail to account for this dependence, some other process, triggered at probe onset, must be responsible for different repetition effects for congruent and incongruent probes. My proposal is that this process is inferential in nature.

One aspect of the procedure used in Experiment 3 that could produce interference through a processing mismatch is that the prime display always consisted of two colour words. Thus, on repeated trials, the relation between the prime and probe display involved a switch between encountering a colour in word form followed by the presentation of that same colour in colour form. Previous studies using Stroop items have revealed large costs to colour-naming performance when participants were required to respond to the word dimension on the preceding trial (e.g., Wylie & Allport, 2000). In Experiment 3, this switch from word to colour might have been problematic for participants because their task in responding to the probe stimulus involved identifying the colour and disregarding the word. Having just linked a colour label to the prime word might interfere with generating a response to a repeated probe because the response generated would be associated with both word (prime) and colour (probe).
Consistent with this idea, repetition led to faster responding on congruent trials. For congruent probes, participants are able to rely on word processing to generate a response, because word and colour are the same. As such, a recent experience of having read two words that correspond to the colour of the probe stimulus serves as a source of facilitation rather than interference. Experiment 4 was conducted as a test of this “processing mismatch” explanation of the negative priming effects observed in Experiment 3.
Experiment 4: Evidence for Perceptual Mismatching

As mentioned, the negative priming effect observed in Experiment 3 may have occurred because encountering a colour in word form conflicts with subsequent efforts to respond to that same colour when it appears in colour form. To test this idea, in Experiment 4 participants performed the same colour naming task as in Experiment 3, except that two coloured-rectangles were presented as the prime stimuli on every trial. On repeated trials, then, the colour of the probe was also presented as a colour in the preceding display. If the presentation of words in the prime display was a critical factor determining the occurrence of negative priming on incongruent trials in Experiment 3, then this change in procedure should eliminate the negative priming.

Method

Participants. Fifteen undergraduate students from McMaster University participated in the experiment for course credit. All participants had normal colour vision and normal or corrected-to-normal visual acuity.

Apparatus and Stimuli. The same apparatus used in Experiment 3 was also used in Experiment 4. The only difference in the stimuli presented in this experiment and the stimuli presented in Experiment 3 was the replacement of the two prime words with two coloured rectangles. These rectangle primes occupied locations directly above and below the location previously occupied by the fixation marker that appeared at the beginning of each trial. The four colours used in this experiment were assigned the role of prime
stimuli, probe distracter, and probe target for each of the Repetition and Probe Type conditions in the same way as in Experiment 3.

Procedure. The same trial procedure used in Experiment 3 was used in Experiment 4, except that two coloured-rectangles were presented as the prime stimuli on each trial. The sequence of events occurring on repeated trials in Experiment 4 is displayed in Figure 4.
Figure 4: Trial procedure on repeated trials in Experiment 4.

NOTE: The prime rectangles would appear in red font in this example. On unrepeated trials, the prime colour matched neither the colour of the probe stimulus nor the word dimension of the probe stimulus.
Results and Discussion

As in Experiment 3, accurate colour naming latencies from each condition were subjected to the modified recursive outlier elimination procedure developed by Van Selst and Jolicoeur (1994). This procedure led to the exclusion of less than 2% of the observations from further analysis. Mean correct RTs and error rates for each condition, averaged across participants, are displayed in Table 4.

Table 4: Mean colour naming response times in milliseconds (RT) and error proportions (ERR) observed in Experiment 4 as a function of Probe Type (Incongruent/Congruent/Rectangle) and Repetition (Repeated/Unrepeated).

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>Incongruent</th>
<th>Congruent</th>
<th>Rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>ERR</td>
<td>RT</td>
</tr>
<tr>
<td>Unrepeated</td>
<td>823</td>
<td>.054</td>
<td>696</td>
</tr>
<tr>
<td>Repeated</td>
<td>815</td>
<td>.081</td>
<td>629</td>
</tr>
<tr>
<td>Difference</td>
<td>+8</td>
<td>-.027</td>
<td>+67</td>
</tr>
<tr>
<td>SE</td>
<td>(11.1)</td>
<td>(.012)</td>
<td>(8.4)</td>
</tr>
</tbody>
</table>

Both mean RTs and error rates were submitted to a Repeated-Measures ANOVA that treated Repetition and Probe Type as within-subject variables. In the analysis of RTs, there was a reliable main effect for Probe Type, $F(2,28) = 74.70$, $MSe = 3883.99$, $p < .001$. Further investigation of the source of this main effect using Fisher’s Least Significant Difference procedure revealed that participants responded 181 ms faster on coloured-rectangle trials than on incongruent trials (638 ms vs. 819 ms respectively),
\( t(14) = 9.14, \text{SEM} = 76.92, p < .001, \) and 156 ms faster on congruent trials than on incongruent trials (663 ms vs. 819 ms respectively), \( t(14) = 8.88, \text{SEM} = 68.20, p < .001. \) The difference in response times between coloured-rectangle and congruent trials was also reliable in that participants were about 24 ms faster at naming the colour of rectangle probes compared to congruent word probes, \( t(14) = 2.94, \text{SEM} = 32.94, p < .05. \)

There was also a significant interaction between Repetition and Probe Type, \( F(2,28) = 23.92, \text{MSe} = 305.04, p < .001. \) To investigate this interaction further, separate analyses of the effect of Repetition were conducted for each of the three probe types. On coloured-rectangle trials, responses were 53 ms faster on repeated relative to unrepeated trials, \( F(1,14) = 38.25, \text{MSe} = 581.14, p < .001. \) Similarly, on congruent trials, responses were 67 ms faster on repeated compared to unrepeated trials, \( F(1,14) = 97.29, \text{MSe} = 346.75, p < .001. \) In contrast, on incongruent trials, response latencies were not reliably different on repeated and unrepeated trials, \( F < 1. \) It is this result that is most critical, given the purpose for conducting Experiment 4. When words were presented as primes in Experiment 3, negative priming was observed on incongruent trials. When the prime words were replaced with coloured-rectangles in this experiment, negative priming did not occur on incongruent trials. This result suggests that the occurrence of negative priming may indeed depend on the presence of a processing mismatch between the prime and probe displays.

With respect to the error rates, there was a main effect of Probe Type, \( F(1,14) = 9.39, \text{MSe} = 46.11, p < .001, \) in that participants made errors on about 6.75% of incongruent trials, whereas they made errors on only 1% of congruent trials and 3% of
coloured-rectangle trials. The interaction between Repetition and Probe Type also approached significance, $F(2,28) = 5.77$, $MSe = 18.44$, $p = .06$, owing to a higher proportion of errors on repeated trials than on unrepeated trials when participants were required to name the colour of an incongruent word, $F(1,14) = 3.78$, $MSe = 14.48$, $p = .07$. Thus, although presenting coloured-rectangles as the prime stimuli eliminated negative priming in the RT data, there was some evidence in the error rate data that performance was still impaired by a match between colour of the primes and the colour of the probe on incongruent trials. Participants were about as likely to make an error in colour naming on repeated and unrepeated trials for both congruent probes, $F < 1$, and coloured-rectangle probes, $F = 1.00$.

To analyze the effect of replacing the prime words used in Experiment 1 with coloured-rectangles in this experiment, I re-submitted the RT data from the current experiment and the data from the preceding experiment to a mixed ANOVA. In this analysis, Probe Type and Repetition were treated as within-subject variables; while Prime Type (Word/Coloured-Rectangle) was treated as a between-subjects variable. This analysis revealed a reliable interaction between Prime Type and Repetition, $F(1,28) = 24.91$, $MSe = 1016.65$, $p < .001$, in that repetition effects were more positive when the prime stimuli consisted of coloured-rectangles than when they consisted of two colour words.

Experiment 4 was conducted to test the idea that presentation of colour words as the prime stimuli was a critical factor in the observation of negative priming on incongruent trials in Experiment 3. In particular, I suggested that a recent experience of
having read a word that matches the colour of the probe might lead to confusion over
whether word or colour processing is driving response selection. At first glance, the
results of this experiment appear consistent with this account. Whereas negative priming
was observed in Experiment 3 using words as primes, no negative priming was observed
in Experiment 4 using coloured-rectangles as primes. Still, on closer inspection, the
processes responsible for negative priming in Experiment 3 appear not to have been
eliminated by the use of coloured rectangles in Experiment 4. In particular, there
remained a tendency for participants to make more errors on repeated-incongruent trials
than on unrepeated-incongruent trials. Also, although use of coloured rectangles
eliminated negative priming for incongruent probes in Experiment 4, it also resulted in
more positive effects for both coloured-rectangle and congruent trials than in Experiment
3. Indeed, the difference between repetition effects on congruent and incongruent trials
was highly similar across the two experiments.

In Experiment 3, the repetition effect for incongruent trials differed from the
repetition effect for congruent trials by 65 ms (-39 ms vs. +26 ms respectively), whereas
in Experiment 4 this difference was 59 ms (+8 ms vs. +67 ms respectively). To test this
change in repetition effects across Experiments 3 and 4, RTs for congruent and
incongruent trials were submitted to a mixed-factor ANOVA, treating Experiment as a
between-subjects factor and Probe Type and Repetition as within-subject factors. This
analysis revealed a reliable Experiment x Repetition interaction, $F(1,28)$, MSe = 20.34, p
< .001, that did not interact with Probe Type, $F < 1$. 
A reasonable interpretation of the results of these two experiments, then, is that whatever impaired participants' ability to name the colour of incongruent probes on repeated trials in Experiment 3 was also contributing to performance in Experiment 4. Replacing colour words with coloured rectangles might have simply introduced a general positive influence of repetition that masked an underlying negative priming effect on incongruent trials. By this interpretation, a perceptual mismatch between the prime and probe displays did not directly cause the negative priming effect observed in Experiment 3. If this interpretation is correct, it ought to be possible to observe slowed responding on repeated-incongruent trials even when coloured rectangles are presented in the prime display. This possibility was tested in Experiment 5.
Experiment 5: Evidence Against Perceptual Mismatching

The rationale for presenting coloured-rectangle primes in Experiment 4 was to examine whether the conflict between naming a colour and having processed that colour as a word in the preceding display was responsible for negative priming. However, this procedure may have had other consequences that affected whether negative priming would occur. In particular, given that both the prime and probe target dimensions were colours, the relation between the prime and probe on repeated trials may have led participants to integrate these two events. By treating the prime and probe displays as an integrated event, the combined evidence favouring a particular colour-naming response could have produced particularly fast responses on repeated trials. Moreover, this influence of perceptual integration ought to be present for all of the probe items rather than only for the incongruent probe items.

If this influence of perceptual integration on the repetition effects observed in Experiment 4 was independent of the influence of Probe Type, then different repetition effects for congruent and incongruent trials would persist from Experiment 3 to Experiment 4, despite an overall shift of repetition effects in a positive direction. As such, rather than indicating that negative priming was absent in Experiment 4, it is possible that the influence of a perceptual match introduced in this experiment merely made negative priming difficult to observe. If so, it ought to be possible to observe negative priming even under these circumstances when the positive effect of perceptual integration on performance is reduced.
Thus, Experiment 5 was conducted to determine whether the elimination of a perceptual mismatch on the one hand, or the positive influence of perceptual integration on the other hand, caused the failure to observed negative priming in the reaction time data of Experiment 4. However, before describing details of this experiment, it is worth reviewing where it fits within the larger theoretical argument forwarded in this thesis. In particular, I have argued that, in addition to the contribution of processing overlap between the prime and probe events, inferences about the source of current processing also contribute to repetition effects. By ruling out processing mismatches as a cause of the negative priming effect in the Stroop task, it becomes reasonable to consider how this effect might instead arise as a consequence of an inferential process.

In both Experiments 3 and 4, the time separating the offset of the prime display and the onset of the probe item was very short (only 57 ms in both cases). When there was a perceptual match between the prime and probe, this very brief interval may have encouraged participants in Experiment 4 to treat the two displays as an integrated event. Prior research demonstrates that the facilitatory effect of a perceptual match between a prime and probe declines rapidly as a delay is introduced between these two events (Posner, Boies, Eichelman, & Taylor, 1969). Thus, if perceptual integration of the prime and probe displays masked an underlying negative priming effect on incongruent trials in Experiment 4, this effect might be revealed by increasing the inter-stimulus interval (ISI) between the prime and probe events. Experiment 5 was conducted to test this idea. The procedure of this experiment was virtually identical to the procedure that was used in Experiment 4, with the exception of one important modification. Varying at random
across trials, the prime-probe ISI was either 57 ms, as in Experiment 4, or a much longer 757 ms. For purposes of comparison, another group of participants was exposed to the same ISI manipulation across trials except that, as in Experiment 3, these participants encountered only colour words in the prime display.

Method

Participants. Thirty-two undergraduate students from McMaster University participated in the experiment for course credit (sixteen in each group). All participants had normal colour vision and normal or corrected-to-normal visual acuity.

Apparatus and Stimuli. For the participants in the Rectangle Primes group, the apparatus and the stimuli were identical to those used in Experiment 4. For the participants in the Word Primes group, the apparatus and the stimuli were identical to those used in Experiment 3.

Procedure. For the participants in the Rectangle Primes group, the sequence of displays on each trial was similar to that used in Experiment 4 with the exception of the manipulation of prime-probe ISI across trials. For the participants in the Word Primes group, this manipulation of ISI was also the sole difference between the sequence of events on each trial in this experiment and the trial procedure of Experiment 3. For both groups of participants, the interval between the offset of the prime and the onset of the probe display was either 57 or 757 milliseconds, varying at random from trial to trial.

Each participant in both groups completed a test session of 640 trials. The test session was divided into 20 blocks of 32 trials each. As in the previous experiments, for all participants, within each block of trials the probability of encountering a particular
probe stimulus and the probability of repeated trials were the same as across the test session as a whole. Coloured-rectangles were not presented as probe stimuli in this experiment. Within each set of incongruent and congruent probe trials, 4 were repeated and 12 were unrepeated. The two ISIs were assigned to these different sets of trials within blocks with the constraint that there were an equal number of trials at each ISI within the repeated and unrepeated conditions for both types of probe stimuli.

Results and Discussion

Correct RTs for each cell were submitted to the same outlier elimination procedure used in Experiments 3 and 4. This procedure led to the elimination of less than 3% of RTs from further analysis. Mean correct RTs and error rates for Experiment 5 are reported in Table 5.
Table 5: Experiment 5: Mean colour naming response times in milliseconds (RT) and error proportions (ERR) as a function of Inter-Stimulus Interval (Short/Long), Probe Type (Incongruent/Congruent), Prime Type (Rectangle/Word), and Repetition (Repeated/Unrepeated).

<table>
<thead>
<tr>
<th>Inter-Stimulus Interval</th>
<th>SHORT</th>
<th></th>
<th>LONG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incongruent</td>
<td>Congruent</td>
<td>Incongruent</td>
<td>Congruent</td>
</tr>
<tr>
<td>Probe Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>ERR</td>
<td>RT</td>
<td>ERR</td>
</tr>
<tr>
<td>Unrepeated</td>
<td>764</td>
<td>.017</td>
<td>648</td>
<td>.000</td>
</tr>
<tr>
<td>Repeated</td>
<td>792</td>
<td>.023</td>
<td>646</td>
<td>.000</td>
</tr>
<tr>
<td>Difference</td>
<td>-28</td>
<td>- .006</td>
<td>+2</td>
<td>- .000</td>
</tr>
<tr>
<td>SE</td>
<td>(8.5)</td>
<td>(.005)</td>
<td>(7.5)</td>
<td>(.000)</td>
</tr>
<tr>
<td>Rectangle Primes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>ERR</td>
<td>RT</td>
<td>ERR</td>
</tr>
<tr>
<td>Unrepeated</td>
<td>795</td>
<td>.010</td>
<td>684</td>
<td>.000</td>
</tr>
<tr>
<td>Repeated</td>
<td>787</td>
<td>.019</td>
<td>645</td>
<td>.000</td>
</tr>
<tr>
<td>Difference</td>
<td>+8</td>
<td>- .009</td>
<td>+39</td>
<td>- .000</td>
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<tr>
<td>SE</td>
<td>(15.6)</td>
<td>(.006)</td>
<td>(8.5)</td>
<td>(.000)</td>
</tr>
</tbody>
</table>

Mean correct RTs and error rates for each participant were first submitted to a mixed-factor ANOVA, treating Repetition, Probe Type, and ISI as within-subject variables and Prime Type as a between-subjects factor. In the analysis of the error rates, the only significant result observed was a main effect for Probe Type, $F(1,30) = 22.26$, $MSe = 151.75$, $p < .001$, in that participants made more errors on incongruent trials than on congruent trials. In the analysis of RTs, there was a significant main effect for ISI in that participants responded faster on trials with a long ISI than on trials with a short ISI, $F(1,30) = 25.74$, $MSe = 4937.75$, $p < .001$. There was also a main effect for Probe Type
in that participants were much slower at responding to incongruent probes (760 ms) than they were at responding to congruent probes (636 ms), $F(1,30) = 285.08$, $MSe = 3405.08$, $p < .001$. Moreover, similar to the results of Experiments 3 and 4, there was a reliable interaction between Probe Type and Repetition, $F(1,30) = 23.52$, $MSe = 400.91$, $p < .05$ in that repetition effects were more positive on congruent trials (+11 ms) than on incongruent trials (-52 ms). The analysis also revealed a significant interaction between ISI and Repetition, $F(1,30) = 4.49$, $MSe = 616.95$, $p < .05$, in that repetition effects were more positive in the short ISI condition (+47 ms) than in the long ISI condition (-30 ms). The main effect for Prime Type was not reliable, $F = 1.24$. However, for the purpose of the current experiment the most critical result was that there was a significant three-way interaction between Repetition, ISI, and Prime Type, $F(1,30) = 14.25$, $MSe = 616.95$, $p < .001$. This interaction was examined further by submitting the data for each Prime Type to separate ANOVAs, treating Repetition, Probe Type, and ISI as within-subject variables.

**Word Primes Condition.** For participants presented with words in the prime display, there was a reliable Repetition by Probe Type interaction that did not interact with ISI, $F(1,15) = 12.26$, $MSe = 336.73$, $p < .01$. To investigate this interaction further, I tested the simple main effects of Repetition for each Probe Type, collapsing across ISI. This analysis revealed that, for incongruent probes, participants were slower on repeated compared to unrepeated trials, $F(1,15) = 12.75$, $MSe = 428.18$, $p < .01$. In contrast, for congruent probes, repetition had no effect on response times, $F < 1$. Similar to the results of Experiment 3, then, presentation of colour word primes produced negative priming on
incongruent trials. Moreover, as in Experiment 3, negative priming did not occur on congruent trials.

**Rectangle Primes Condition.** For participants encountering coloured-rectangles in the prime display, reliable interactions were observed both between Repetition and Probe Type, $F(1,15) = 11.49$, $MSe = 465.08$, $p < .005$, and between Repetition and ISI, $F(1,15) = 14.09$, $MSe = 760.47$, $p < .005$. These interactions were investigated further by testing the effect of repetition separately for each Probe Type at both the long and the short ISI. Recall that the critical result of Experiment 4 was that presentation of coloured-rectangle primes eliminated the negative priming that was observed in Experiment 3. Consistent with this result, for the incongruent probes in Experiment 5, participants were about as fast to respond on repeated trials as they were on unrepeated trials at the short ISI, $F < 1$. However, the most critical result of this experiment was that a robust negative priming effect was observed when a much longer delay separated the prime and probe events. At the long ISI, responses were 23 ms slower on repeated trials than they were on unrepeated trials, $F(1,15) = 5.43$, $MSe = 796.77$, $p < .05$.

Manipulating the delay between prime and probe had a similar consequence for repetition effects on congruent trials. When the ISI was short, participants were 39 ms faster to respond on repeated than on unrepeated trials, $F(1,15) = 21.47$, $MSe = 572.21$, $p < .001$, whereas at the long ISI participants were no faster at responding on repeated than on unrepeated trials, $F < 1$. This shift in the effect of repetition in a negative direction on both congruent and incongruent trials at the longer ISI is consistent with the idea that perceptual integration of prime and probe contributed an overall positive influence for
colour-naming performance in Experiment 4. This role of perceptual integration on repeated trials would be expected to be at its maximum with a very short delay between the prime and probe displays, but to decline as that delay increases.

I proposed that negative priming may have been difficult to observe (rather than absent) in Experiment 4 because this influence of perceptual integration produced an effect opposite to that of the process that caused negative priming. If so, then measuring repetition effects using a longer temporal interval between prime and probe ought to reveal a negative priming effect if one exists. Indeed, on trials in which there was a relatively lengthy delay between the prime and probe events, a reliable negative priming effect was observed in spite of coloured-rectangles being presented in the prime display.

This finding poses a serious challenge to a processing mismatch explanation for the negative priming observed on incongruent trials in Experiment 3 and in the Word Primes condition of the current experiment. From that perspective, slower responding on repeated trials occurred because of interference between the way that participants initially encoded a colour concept and the form in which they encountered that same concept during the probe event. This notion cannot account for the demonstration here that negative priming can be observed even when there is a match in the conceptual and the perceptual properties of the prime and probe stimuli. Instead, the results of Experiment 5 offer the possibility that some other process is responsible for negative priming on incongruent trials. Specifically, the current results provide a justification for considering how an inferential process might lead to negative priming effects in the Stroop task. That is, it may be useful to consider how the way participants interpret the source of facilitated
processing caused by repetition can contribute to their colour-naming performance. As discussed above, colour-naming on incongruent trials may be slowed on repeated trials because participants interpret facilitated processing as evidence that selective attention to colour is unnecessary. Such an inference could result in an increase in the contribution of word reading to response selection.
Experiment 6: A Role for Fluency Misattribution

In the introduction to this chapter, I offered a specific example of how inferential processes might contribute to performance in the Stroop task. Specifically, experiencing fluent processing might provide a useful basis for judging the need to engage in selective processing. Processing fluency might be diagnostic of a match between word and font colour, indicating that either dimension will lead to the correct response. On the other hand, processing fluency may also occur for reasons other than congruency between word and font colour. In the Stroop version of negative priming, for example, enhanced processing could occur because of a match between the prime word and the colour of the probe. I propose that participants will interpret fluent processing caused by repetition in the same way that they interpret fluent processing caused by congruency. That is, negative priming could occur because fluent processing due to repetition can lead to the inference that the correct response is available without further selective processing. In turn, failing to selectively attend to colour could increase the contribution of word reading to response selection. For this reason, repetition may cause participants to experience more conflict between word and colour processing on incongruent trials.

At first blush, the notion that an inferential process occurs immediately upon onset of the probe display might seem implausible. This idea hinges on the assumption that participants can rapidly engage in decision-like processing that determines how the response selection process should proceed. Nevertheless, other research has established
that rapid control over response selection can contribute to performance in the Stroop task.

A number of studies have demonstrated that the inclusion of congruent trials is a particularly effective way of increasing the degree of interference from word reading on incongruent trials (e.g., Lowe & Mitterer, 1982). Presumably, presentation of a number of trials in which both word reading and colour processing lead to a correct response causes participants to allow word reading to contribute to the response selection process. One might interpret this result as deriving from a deliberate strategy that people apply consistently across an experimental session. However, other research reveals that the biasing effect of exposure to congruent trials can occur much more flexibly. Jacoby, McElree, and Trainham (1999) manipulated the likelihood that particular colour words appeared in a congruent colour. For example, the words GREEN and YELLOW might appear in a congruent colour on 80% of trials in which they appeared, whereas the words BLUE and RED might appear in a congruent colour on only 20% of trials in which they appeared. The outcome was that naming the colour of incongruent Stroop items was especially slow for colour words that were highly likely to appear in a congruent colour on other trials. In contrast, the amount of interference observed on incongruent trials was much less for colour words that were relatively unlikely to appear in a congruent colour. The authors referred to this result as a “stimulus-specific Stroop effect”.

What is important to note is that the participants in the Jacoby et al. (1999) study did not know which colour word would appear from one trial to the next. Therefore, different amounts of Stroop interference for specific colour words could not be the result
of a deliberate strategy across trials about whether to allow word reading to contribute to response selection. Instead, this stimulus-specific Stroop effect must result from a rapid decision, when the probe stimulus appears, as to whether word processing is a useful source of information. The purpose of Experiment 6 was to obtain evidence that a similarly rapid decision process is also responsible for the negative priming effect observed on incongruent trials in Experiments 3 through 5.

The idea that Stroop negative priming occurs because of a fluency attribution process that occurs immediately upon onset of the probe stimulus closely parallels the putative cause of the “stimulus-specific Stroop effect”. That effect is also thought to occur because of a decision process that determines the degree to which word reading contributes to performance, and it is also assumed to occur rapidly upon onset of the probe stimulus. If both of these effects tap into the same type of processing heuristic, then they ought to interact with one another (Sternberg, 1969).

To illustrate with a concrete example, consider presentation of the word BLUE in red, and assume that when the word BLUE appeared on previous trials it usually appeared in the colour blue. The “stimulus-specific Stroop effect” illustrates that participants rapidly take advantage of this predictability, after the stimulus itself has been presented. As a consequence, participants ought to be biased to treat processing of the word BLUE as a useful basis of responding, biasing them to the incorrect response of “blue”. Now consider what would happen when the word BLUE in red was immediately preceded by presentation of the word RED. This relation between the prime word and the probe colour ought to facilitate processing of that colour. If people infer that fluent
processing provides an indication of the availability of a correct response, this inference could corroborate the general expectation that the word BLUE will appear in a congruent colour. Consequently, in this example, participants will be at even greater risk on repeated trials for wrongly deciding that selective processing of the colour red is not necessary, leaving them most vulnerable for processing of the word BLUE to contribute to response selection.

In comparison, consider presentation of the word YELLOW in green, and assume that when the word YELLOW appeared on previous trials it rarely appeared in the colour yellow. In this case, the “stimulus-specific Stroop effect” indicates that participants will exhibit a rapid bias not to allow processing of the word YELLOW to contribute to responding. Instead, people ought to be more biased to engage in selective processing of the colour green when the probe stimulus appears. Now consider the consequence of presentation of the word GREEN immediately prior to onset of the word YELLOW in green. As in the previous example, this relation between the prime word and the probe colour ought to facilitate processing of that colour. However, under these conditions, the inference that fluent processing derives from congruency must overcome the general expectation that the word YELLOW will not appear in a congruent colour. As a result, the correct decision that response selection should proceed from selective processing of the colour green may be more likely to occur despite enhanced processing fluency. Therefore, there should be a lesser likelihood that processing of the word YELLOW will interfere with response selection.
I tested these ideas in Experiment 6 by manipulating both repetition and the likelihood that particular colour words appeared in a congruent colour. Half of the colour words (e.g., the words GREEN and RED) appeared in a congruent colour 80% of the time, whereas the other half (e.g., the words YELLOW and BLUE) appeared in a congruent colour only 20% of the time. Crossed with this probability-congruent manipulation, the colour of the probe stimulus either matched or did not match the preceding prime word on 25% of trials. The expectation was that the combined influence of a fluency attribution process on repeated trials and “the stimulus-specific Stroop effect” would be especially problematic, resulting in particularly slow and less accurate colour naming responses on repeated trials for colour words that are highly likely to appear in a congruent colour.

Method

Participants. Twenty undergraduate students from McMaster University participated in the experiment for course credit. All participants had normal colour vision and normal or corrected-to-normal visual acuity.

Apparatus and Stimuli. The same apparatus and stimuli used in Experiments 3 through 5 were also used in Experiment 6.

Procedure. The procedure on each trial was identical to that of Experiment 3, except that there were no trials in which a coloured-rectangle appeared as the probe stimulus. The critical difference between the two experiments was that particular colour words differed in their likelihood of appearing in a congruent colour. Prior to the experimental session, two colour words (e.g., RED and GREEN) were allocated to appear
in a congruent colour on 80% of trials, whereas the remaining two colour words (e.g., BLUE and YELLOW) appeared in a congruent colour on only 20% of trials. The pair of colour words that was assigned to the high- and low-probability congruent conditions was counterbalanced across participants.

To ensure that the probability congruent manipulation was consistent within each block, the number of trials per block was increased to 40. For half of these trials, one member of the pair of colour words assigned to the high-probability congruent condition served as the probe target, appearing in a congruent colour on 16 trials. On the remaining 4 trials, the probe target was presented in one of the other three colours, chosen at random. For the other half of the trials within each block, one member of the pair of colour words assigned to the low-probability congruent condition served as probe target, appearing in a congruent colour on only 4 trials. On the other 16 trials, one of the other three colours was randomly chosen as the target colour. Within each of these trial types (Congruent/Incongruent and High/Low Probability Congruent), the proportion of repeated trials was .25.

Results and Discussion

As in Experiments 3-5, accurate colour-naming latencies for each condition were subjected to the modified recursive outlier elimination procedure developed by Van Selst and Jolicoeur (1994). This procedure led to the exclusion of less than 2% of the observations from further analysis. Mean correct RTs and error rates for each condition are displayed in Table 6.
Table 6: Experiment 6: Mean colour naming response times in milliseconds (RT) and error proportions (ERR) as a function of Probability Congruent (High/Low), Probe Type (Incongruent/Congruent), and Repetition (Repeated/Unrepeated).

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>HIGH</th>
<th>Incongruent</th>
<th>Congruent</th>
<th>LOW</th>
<th>Incongruent</th>
<th>Congruent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>ERR</td>
<td>RT</td>
<td>ERR</td>
<td>RT</td>
<td>ERR</td>
</tr>
<tr>
<td>Unrepeated</td>
<td>783</td>
<td>.043</td>
<td>653</td>
<td>.001</td>
<td>723</td>
<td>.032</td>
</tr>
<tr>
<td>Repeated</td>
<td>816</td>
<td>.075</td>
<td>640</td>
<td>.000</td>
<td>741</td>
<td>.029</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>-33</td>
<td>+13</td>
<td>-18</td>
<td>+0.003</td>
<td>+25</td>
</tr>
<tr>
<td>SE</td>
<td>(11.5)</td>
<td>(.014)</td>
<td>(2.9)</td>
<td>(.001)</td>
<td>(5.4)</td>
<td>(.007)</td>
</tr>
</tbody>
</table>

Stroop Effects. The RT and the error rate data were each submitted to a 2 x 2 x 2 Repeated-Measures ANOVA, treating Repetition (Repeated/Unrepeated), Probe Type (Incongruent/Congruent), and Probability Congruent (High/Low) as the independent variables. These analyses resulted in reliable Probe Type x Probability Congruent interactions both for RTs, $F(1,19) = 36.74, MSE = 587.22, p < .001$, and for error rates, $F(1,19) = 15.85, MSE = .0004, p < .001$, indicating that the contribution of word reading to performance was most pronounced in the high-probability congruent condition. In that condition, participants were 153 ms slower to name the colour of incongruent items relative to congruent items (800 ms vs. 647 ms, respectively). In contrast, they were only 87 ms slower to name the colour of incongruent items relative to congruent items in the low probability congruent condition (732 ms vs. 645 ms, respectively). Likewise, participants were particularly likely to make an error on incongruent trials in the high-probability congruent condition. Although colour-naming errors were extremely rare on
congruent trials, participants were nearly 3% more likely to make an error on incongruent trials in the high-probability congruent condition than in the low-probability congruent condition. Thus, both the RT and the error rate data provide evidence of the "stimulus-specific Stroop effect" originally observed by Jacoby et al. (1999).

Repetition Effects. Most critical for the purpose of the current experiment was the prediction that the combined influences of the "stimulus-specific Stroop effect" and the fluency attribution process would lead to a more pronounced negative priming effect. To evaluate this prediction, RTs and error rates for both congruent and incongruent trials were submitted to separate 2 x 2 ANOVAs, treating Repetition and Probability Congruent as within-subject factors. On incongruent trials, the predicted interaction between Repetition and Probability Congruent was not confirmed in this analysis, $F(1,19) = 1.46$, $MSe = 759.45$, $p = .24$, although participants were about 26 ms slower overall on repeated relative to unrepeated trials (753 ms vs. 779 ms, respectively), $F(1,19) = 15.94$, $MSe = 851.29$, $p < .001$. The analysis of error rates on incongruent trials, however, revealed that repetition was especially problematic for colour-naming performance in the high-probability congruent condition. Participants were about 3% more likely to make an error on repeated relative to unrepeated trials in that condition, whereas they were no more likely to make an error on repeated relative to unrepeated trials in the low-probability congruent condition. In this case, the Repetition x Probability Congruent interaction was significant, $F(1,19) = 4.67$, $MSe = .001$, $p < .05$. This finding provides some support for the prediction that the simultaneous occurrence of fluent processing due to repetition and the "stimulus-specific Stroop effect" would be particularly costly to
performance on incongruent trials. In combination, these influences may have increased participants' likelihood of making colour-naming errors by bringing about a greater contribution of word reading to response selection.

The data on congruent trials yielded a significant main effect for Repetition in that participants were about 19 ms faster at naming the colour of congruent items on repeated relative to unrepeated trials (636 ms vs. 655 ms, respectively), \( F(1,19) = 17.72, \text{MSe} = 393.56, p < .001 \). The Repetition x Probability Congruent interaction approached significance, \( F(1,19) = 2.96, \text{MSe} = 292.17, p = .10 \), suggesting that this source of facilitation was more pronounced in the low-probability congruent condition.\(^7\)

In the introduction to this chapter, I suggested that a rapid inferential process occurring upon onset of the probe stimulus is responsible for negative priming in the Stroop task. Specifically, fluent processing of the probe colour due to repetition leads to an inference that the correct colour-naming response is readily available. As a consequence, participants seek to generate a colour-naming response without ensuring that the response derives from selective processing of colour. This failure to selectively attend to colour, in turn, allows for a greater contribution of word reading to response selection on repeated trials.

The results of Experiment 6 are consistent with this proposal that an inferential process occurring immediately upon onset of the probe stimulus is responsible for the negative priming effect. As discussed above, a similarly rapid decision process is the likely cause of the "stimulus-specific Stroop effect" observed here and previously by other investigators (Jacoby et al., 1999). That is, presentation of colour words that
usually appear in a congruent colour leads to the rapid decision to allow a greater
contribution of word reading to performance. Because both of these decision processes
are presumed to be invoked simultaneously when the probe stimulus appears, the
expectation is that their combined influence would interact to produce a particularly high
contribution of word reading to response selection. If not in the RTs, the error rate data
obtained in Experiment 6 support this prediction. When both repetition and the
probability that specific colour words would appear in a congruent colour were
manipulated in the same experiment, the combination of these two influences placed
participants at particular risk for making colour-naming errors.
Chapter 4: General Discussion

A common approach to cognitive research is to assume that cognitive judgments are controlled directly by relevant representations of knowledge. In the memory domain, performance on remembering tasks was thought to directly depend on the "accessibility" of a representation of that experience (e.g., Craik & Lockhart, 1972; Tulving & Thompson, 1973). In the domain of categorization research, a number of theorists have assumed that the ability to treat a stimulus as a member of a class is governed by abstract knowledge of categorical structure (e.g., Reber, 1993; Rosch, 1978). Alternatively, other theorists assume that categorization proceeds from knowledge of features possessed by category members provided by representations of stored "instances" (e.g., Brooks, 1978; Medin & Schaffer, 1978; Hintzman, 1986). The fundamental flaw in these approaches is that, rather than being determined solely by stable properties of acquired knowledge, processes peculiar to present circumstances also contribute to decision-making in memory and classification tasks. The thoughts people have about the past or about stimuli that are physically present are not an inevitable consequence of prior learning. Instead, such thoughts arise out of the interaction between processes occurring in the present and stored representations in memory (cf. Whittlesea, 1997).

More recent research provides two reasons to believe that situational factors are critical for guiding remembering and categorization judgments. First, a number of investigators have found that performance in both of these situations obeys the principle of transfer-appropriate processing (e.g., Morris et al., 1977; Whittlesea & Dorken, 1993).
Second, other research demonstrates that remembering and categorization decisions can also depend on inferences people make about the origin of current processing (e.g., Begg, Maxwell, Mitterer, & Harris, 1986; Jacoby et al., 1989; Leboe & Whittlesea, 2002; Whittlesea & Leboe, 2000).

The same “fundamental attribution error” influential in guiding memory and categorization research has also provided a key foundation for perception research. Specifically, many models of perception propose that perceptual decision-making is determined by levels of activity in abstract mental representations (see Bowers, 2000, for a review). The essence of this view is that such representations serve as a passive receiver for specific types of sensory input, detecting their presence and initiating appropriate responses. Other theorists have challenged this notion, arguing that perceptual performance is often a consequence of the way that a stimulus is processed under present circumstances in interaction with representations of specific prior experiences (e.g., MacLeod & Masson, 2000). This notion derives support from evidence that perceptual performance depends on whether cognitive operations engaged in during a single prior event are appropriate for meeting current task demands (e.g., Blaxton, 1989; Jacoby, 1983; Kolers & Roediger, 1980; Whittlesea & Jacoby, 1990; Whittlesea & Brooks, 1988).

As a complement to this research, the current experiments sought to demonstrate the contribution of inferential processing to performance on perceptual tasks. Specifically, the goal was to determine whether the same fluency attribution process known to influence remembering (Jacoby et al., 1989; Whittlesea & Williams, 2001a,
2001b) and classification judgments (Whittlesea & Leboe, 2000) also plays a role in guiding performance in tasks that require more primitive perceptual judgments.

The Inferential Basis of Perceptual Performance: Repetition Benefits

According to the "Activation" approach to repetition effects, faster responding owing to a related prior experience derives from a temporary increase in the activation level of underlying abstract representations. Experiments 1 and 2 were conducted, in part, to reveal the problem with relying on this approach to repetition effects. Using a modified version of the Same/Different task employed by Posner and Snyder (1975), the results of Experiment 1 demonstrated that repetition effects cannot be fully explained with reference to the activation level of mental representations. Instead, repetition effects in that experiment were found to be largely dependent on the nature of the response participants were required to make. Specifically, repetition was much more beneficial to performance on same trials than on different trials. I argued that this different pattern of repetition effects occurred because participants attributed fluent processing caused by repetition to sameness, thereby speeding responses on same trials and slowing responses on different trials.

This interpretation of the results of Experiment 1 was confirmed by the results of Experiment 2. In that experiment, participants were discouraged from relying on a fluency attribution process because of the high degree of similarity between words that appeared on different trials. The outcome was that same responses no longer benefited more from repetition than different trials. In combination, the results of Experiments 1
and 2 demonstrate the role of an inferential process in guiding decision-making in a simple perceptual task.

The Inferential Basis of Perceptual Performance: Repetition Costs

Negative priming represents one of the most problematic phenomena for a simple “Activation” approach to repetition effects to explain. By that view, such effects can only be explained by assuming that exposure to a stimulus can have inhibitory, as well as facilitatory, effects. To accommodate negative priming into this framework, then, explanations typically center on the role of ignoring in temporarily inhibiting an abstract representation of a stimulus (e.g., Tipper, 2001). Nevertheless, it is difficult to explain many of the “repetition costs” reported in this thesis with reference to an inhibitory process occurring at the time of the prime event. In Experiment 1, evidence was suggestive that participants were selectively slower on repeated trials when required to make a different response. In contrast, the same prime event led to faster responding on same-repeated trials. This result cannot be explained with reference to prior inhibition because whether a same or a different response was required was not determined until onset of the probe display. Instead, as mentioned above, this repetition cost to performance on different trials would be expected to occur if participants’ tended to attribute fluent stimulus processing to sameness. In this case, then, allowing for the possibility that inferential processing can contribute to performance in perceptual tasks provides a more reasonable basis than the construct of “inhibition” for explaining a negative priming effect.
A similar conclusion can be drawn from the results of Experiments 3, 5, and 6. In those experiments, negative priming was observed consistently when participants were required to name the colour of an incongruent Stroop item that matched a colour word that appeared in the preceding display. If this negative priming effect was the result of an inhibitory effect that occurred at the time of the prime event, colour-naming performance ought to be impaired regardless of the nature of the stimulus that appears in the probe display. Contrary to this prediction, in most of the experiments reported here, repetition speeded responding when participants named the colour of congruent Stroop items. On this basis, I rejected the “Inhibition” approach as capable of explaining the negative priming effect that was observed on incongruent trials.

In interpreting the contribution of inferential processing to performance in the Same/Different task, the assumption was that the fluency attribution process influenced the way that participants subjectively experienced the probe stimuli. In contrast, when the Stroop colour-naming task was employed in Experiments 3-6, the assumption was that a fluency attribution process would contribute to the way that participants experienced the requirements of the current task. Specifically, I suggested that an evaluation of the fluency of colour processing upon onset of the probe stimulus could influence whether participants decide to generate their response based on selective processing of the colour dimension. On repeated trials, then, enhanced processing of colour could bias participants to decide that selective processing is unnecessary, thereby allowing a greater contribution of word reading to the response selection process. The results of Experiment 6 were compatible with the suggestion that a rapid inferential
process causes negative priming in the Stroop task. In that experiment, the highest error rates occurred in the condition in which the combination of a fluency attribution process and the “stimulus-specific Stroop effect” were expected to cause people particular difficulty in naming the colour of incongruent items.

Distinguishing Inferential Effects from Transfer Effects

Taken as a whole, then, the data reported here reveal that performance on perceptual tasks can be determined by inferences participants make about the basis for current processing. As such, the current research can be seen as complementary to demonstrations that the principle of transfer-appropriate processing applies to perceptual performance in the same way that it applies to performance on other cognitive tasks. Demonstrations of an inferential basis of perception provide an additional rationale for considering “Activation” and “Inhibition” approaches to repetition effects examples of the “fundamental attribution error”. Interpreted in this way, the current research simply reveals an alternative means by which processes occurring in the present can modulate the contribution of prior experience to performance on perceptual tasks. Contrary to this interpretation, however, I argue that the implications of identifying a role for inferential processing in perception are much more fundamental.

Although both transfer effects and inferential processes can be seen as “situational” influences on the way people perform tasks, it is also obvious that these two influences differ in important ways. First, transfer-appropriate processing operates directly on how efficiently people gain meaning from stimuli. For example, it determines
how quickly people can generate the identity of a stimulus from sensory input (e.g., Jacoby, 1983; MacLeod & Masson, 2000). Inferential processing, on the other hand, differs in that one's success in gaining meaning from a stimulus is itself the object of scrutiny. If such processing unfolds particularly fluently, an attempt is made to arrive at a conclusion about the source of fluent processing (e.g., Jacoby, Kelley, & Dywan, 1989; Whittlesea, 1993; 1997). Second, the contribution of transfer-appropriate processing to perceptual performance constitutes a passive influence of the past in interaction with current processing demands. In contrast, the role of inferential processing reveals that perceptual decision-making is also determined by an active construction of experience. That is, people actively seek to infer the significance of particularly fluent processing, taking into account salient aspects of the current situation (cf. Whittlesea & Leboe, 2002; Whittlesea & Shimizu, 2002). In the Same/Different experiments reported here, the assumption was that people attributed fluent processing to a property of the stimulus display, inferring that the probe stimuli were the same. In the Stroop experiments, I argued that people attributed fluent processing to a property of the task itself, inferring that the correct response was readily available without the necessity of engaging in selective processing.

Thus, transfer-appropriate processing and inferential processing represent two very different means by which processes exclusive to the current situation can contribute to performance. As a result, it is necessary to be cautious in explaining repetition effects with reference to situational factors. The Stroop experiments described here provide an illustration of this need for caution. That is, it was only ruling out the possible role of
transfer effects that justified investigating an inferential basis of the negative priming effect in Experiment 6.

Several attempts have been made to account for negative priming effects based on an inappropriateness of prior processing for meeting the demands of the probe task (e.g., MacDonald & Joordens, 2000; Neill & Mathis, 1998; Park & Kanwisher, 1994). These approaches have been highly successful in demonstrating that negative priming can occur as the result of processing mismatches. Consequently, such demonstrations made it necessary to rule out inappropriate transfer as a potential cause of negative priming in the Stroop experiments presented here. In Experiment 3, a negative priming effect was observed on incongruent trials when the prime display consisted of two colour words, whereas a similar effect did not occur when the prime display consisted of two coloured-rectangles in Experiment 4. Thus, the negative priming effect observed in Experiment 3 could have occurred because forcing participants to encode a colour as a word mismatched with the requirement to process that colour when it appeared in the form of a colour. This account was abandoned based on the results of Experiment 5. In that experiment, when the tendency to treat the prime and probe display as an integrated event was discouraged by increasing the delay between the two events, a negative priming effect was observed even when coloured-rectangles appeared in the prime display.

There is little doubt that the principle of transfer-appropriate processing provides a powerful framework for explaining performance on a wide range of tasks. For example, a number of studies demonstrate that a similarity between prior processing and current processing demands provides a benefit to performance in tests of remembering
(Morris et al., 1977), classification (Whittlesea & Dorken, 1993), text processing (Kolers & Roediger, 1980), and tachistoscopic identification (Jacoby, 1983). However, it is possible that over-reliance on this principle could hinder a complete understanding of the processes that govern cognitive decision-making. The experiments reported here suggest that the positive effects of repetition could also arise from the contribution of inferential processing to perceptual performance. Moreover, a number of the results reported in this thesis reveal the inadequacy of a reliance on "Inhibition" accounts of impaired performance caused by stimulus repetition (or relatedness). Nevertheless, similar approaches remain a primary basis for explaining a host of these types of effects, including negative semantic priming (Dagenbach & Carr, 1994), repetition blindness (Kanwisher, 1987), the "inhibition" of a prior action (Mayr & Keele, 2000), and "inhibitory" attentional cueing effects (Taylor & Klein, 1998). One potential reason for the continued appeal of this approach to repetition effects is that there is often no obvious rationale for considering inappropriate transfer as the cause of such effects. Beyond the present research, however, few efforts have been made to test the idea that these negative priming effects might arise as a consequence of inferences people make about the source of current processing. One implication of the research described here is that such inferences could provide a more compelling alternative to efforts to explain these effects with reference to inhibitory mechanisms.

A further motivation to treat inferential processing as a complement to transfer-appropriate processing as a basis for explaining performance on perceptual tasks is the growing evidence that performance in a variety of other task domains rely on a
combination of these two influences. According to the SCAPE (Selective Construction and Preservation of Experience) account developed by Whittlesea and colleagues (Whittlesea, 1997; Whittlesea & Leboe, 2000; Whittlesea & Price, 2001), performance on any task is determined by the joint contribution of the two main functions of memory. These two functions, referred to as Production and Evaluation, directly correspond to the distinction between the appropriateness of prior learning for current processing and the contribution of inference about the source of current processing identified here. This framework has provided a useful basis for explaining performance in tests of remembering (e.g., Whittlesea & Williams, 2001a, 2001b) and classification (Whittlesea & Dorken, 1993; Whittlesea & Leboe, 2000; Leboe & Whittlesea, 2002), and in giving rise to a variety of subjective experiences, such as pleasantness (Whittlesea & Price, 2001), interest (Whittlesea & Shimizu, 2002), and one's own current state of alertness (Whittlesea & Shimizu, 2002). The current research represents an attempt to further apply this framework toward understanding the role of prior experience in guiding performance in tasks that require simpler perceptual judgments.
Footnotes

1. It is important to note that some models seek to account for priming effects with reference to both the concept of forward-acting activation and retrieval processes occurring at the time of the probe event (e.g., McKoon & Ratcliff, 1979; Neely, 1989).

2. I assumed that participants would have a tendency to make their comparison of the probe words from left-to-right. For this reason, on different trials, facilitated processing of one of the probe words was expected to have the greatest influence on decision-making if it was always presented on the left-hand side. Supposing that the left-hand word is processed first, repetition would facilitate processing of that word immediately upon onset of the probe display.

3. Many of the critical results of the experiments reported here are based on mean differences in response time and error rate between repeated and unrepeated trials. For this reason, these difference scores are reported at the bottom of each table along with the standard error of the difference scores (SE) across participants. By convention, one can be confident that a particular difference score is greater than would be expected by chance if it is about twice as large as the standard error.

4. Presentation of a congruent probe may not be the only reason why people might consider it unnecessary that their response be guided by selective processing of font
colour. After having responded to a number of trials, participants may have available to them a host of similar prior experiences that can be used to select a response (e.g., the word GREEN printed in red has been responded to a number of times before). Therefore, rather than computing a response by perceptually categorizing the current colour, participants may be able to retrieve from memory the response given to an identical stimulus on a prior occasion (Logan, 1988). The assumption made here is that the fluency attribution process helps to determine whether people engage in selective processing generally, rather than whether people categorize the probe as congruent.

5. The observation of faster responses on same trials in Experiment 1 is a typical result in other experiments using the same/different judgment task. The cause of this “fast-same effect” is a point of some controversy. However, one explanation that has a degree of empirical support is compatible with a fluency attribution account of the different repetition effects on same and different trials also observed in Experiment 1. According to the “noisy-operator model” developed by Krueger (1978), same/different decision-making begins with an initial evaluation of the degree of difference between the two probe stimuli. An important feature of this model is that participants will perceive some level of “difference” even on same trials because of noise in acquiring a mental representation of sensory input. As a result, a rapid decision to make a same response will occur if initial processing of the probe stimuli results in the perception of very little “difference”. In contrast, if people initially perceive a moderate degree of “difference”, re-checking will occur to confirm that the stimuli are not the same. Because a greater
perception of “difference” will more often occur at an early stage of processing on
different trials, re-checking occurs primarily on those trials and results in participants
making different responses relatively slowly.

Above, I proposed that same/different performance in Experiment 1 was, in part,
influenced by an evaluation of “coherence” of processing that can derive either from a
match between the probe stimuli or greater processing fluency on repeated trials. I
consider this evaluation of “coherence” to be similar to Krueger’s notion of the
perception of “difference”. In Krueger’s terminology, then, repetition had the effect of
reducing the amount of perceptual noise participants experience upon onset of the probe
display, reducing the perceived level of “difference”. As a result, repetition biased
participants to make a same response in Experiment 1, speeding responses on same trials
and slowing responses on different trials.

Using the same model, Krueger (1983) has argued that the “fast-same effect” may
disappear or even reverse under conditions that encourage analytic comparison of the
probe stimuli. Specifically, if a small number of features distinguish stimuli on different
trials, a global evaluation of “difference” would be less useful than the identification of a
specific feature that differs between the two stimuli. In this situation, participants would
be less prone to re-check on different trials and, instead, would make fast different
responses after locating a single distinguishing feature. Given that probe words differed
only by one letter in Experiment 2, the reversal of the “fast-same effect” is consistent
with this argument. Moreover, eliminating participants’ reliance on a global evaluation
of “difference” would have the additional consequence of eliminating the role of
processing fluency to the generation of same/different responses. Thus, my suggestion that the observation of different repetition effects in Experiments 1 and 2 represents a change in the role of inferential processing is consistent with Krueger's (1983) argument about the way participants perform same/different judgments under analytic versus holistic processing conditions.

6. Although the nature of participant errors was not recorded systematically, casual observation indicated that colour-naming errors on incongruent trials in this experiment were overwhelmingly the result of participants mistakenly reading the word. As a result, the error rate data can be treated as a valid measure of the extent that word processing contributed to response selection.

7. The combination of more negative priming on incongruent trials in the high-probability congruent condition and less positive priming on congruent trials in the low-probability congruent condition resulted in an overall Probability Congruent x Repetition interaction that approached statistical significance, $F(1,19) = 3.44, \text{MSe} = 571.76, p < .08$. In other words, repetition was less beneficial for performance overall, regardless of whether word reading provided an accurate basis of responding.

One way of interpreting this result is that the influence of word reading might counter-intuitively represent a source of response conflict even on congruent trials. By this view, fast responding on congruent trials derives primarily from participants accidentally reading the word. Naturally, such word reading errors would be coded as
fast correct responses, resulting in overall faster performance on congruent trials.

However, on other trials, people would actually be slowed by confusion about whether their response is being guided correctly by colour processing or being led astray by word processing (MacLeod & MacDonald, 2000). Thus, in Experiment 6, it is possible that a particularly large contribution of word reading due to the combined influence of repetition and the "stimulus-specific Stroop effect" could be problematic for performance on both congruent and incongruent trials.
References


Appendix

Analysis of Variance is a method of testing whether differences observed between conditions are greater than what would be expected by chance. This test is achieved by comparing variability in the dependent measure based on levels of the independent factor relative to variability within levels of the independent factor. To the extent that variability between the levels of an independent variable is significantly greater than variability within the levels, one can have greater confidence that the effect of the independent factor on the dependent measure cannot be attributed to chance alone. The measure of variability that is attributed to chance is conventionally referred to as error variability and is reported in this manuscript as the Mean-Squared Error (MSe). The ratio of the variability between levels of an independent factor relative to this measure of error variability is provided by the F-statistic. Thus, confidence in whether differences associated with the levels of an independent factor are not attributable to chance depends on the extent to which the value of the F-statistic is significantly greater than 1.00.

The F-statistic observed from a set of data is assumed to be merely an estimate of the true value of that statistic based on a sample taken from a much larger population. Thus, as the number of observations that contributes to the computation of an F-statistic increases, so does confidence in whether a particular value of the F-statistic indicates a true effect of an independent factor on the dependent measure. Based on the value of the F-statistic and the number of observations used to compute it, one can mathematically derive a measure of the reliability of an observed difference between the levels of an
independent factor. This measure is referred to as the p-value and indicates the probability that an observed difference in the levels of an independent factor could be due to chance alone. The conventional threshold for concluding that an observed difference cannot be attributed to chance in experimental psychology is \( p < .05 \).

In the between-subjects version of ANOVA, different participants contribute data for each level of the independent factors. As a result, variability within the levels of the independent factor is comprised of variability in the dependent measure due to systematic differences between subjects as well as variability due to chance. In the repeated-measures design, however, each participant contributes data for each level of the independent factors. The value of this design is that it permits computation of variability in the dependent measure caused by individual differences between subjects. In the repeated-measures version of ANOVA, this source of variance is treated as attributable to a separate factor in addition to the other independent variables of interest. As a result, an F-statistic can be computed with variability owing to differences between subjects removed from the MSe. This feature makes the repeated-measures design a much more powerful statistical test, given that the same amount of variability between the levels of an independent factor will result in a larger value of the F-statistic as the MSe decreases.

It is also important to note that by treating differences in the dependent measure owing to individual differences as a known source of variability, it is also appropriate to derive separate MSe’s for testing the effect of each independent factor in the design. In essence, the MSe used for testing the significance of each independent factor (or interaction of independent factors) is the sum of two components: (1) variability
unaccounted for by any known source, and (2) variability in the *effect* of the independent factor of interest across participants (for a more extensive discussion of this issue see Howell, 1997, pp. 485-490).