Negative Priming of Novel Shapes in Younger and Older Adults: Effects of Time Lags, Stimulus Repetition, and Stimulus Luminosity

by

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Three experiments explored the effects of age, stimulus salience, stimulus luminosity, time lags, and stimulus repetition on negative priming (NP) using unfamiliar novel shapes. No differences in NP were observed between younger and older adults, which counters the view that there is a general decline in inhibitory processes as we age (Hasher & Zacks, 1988). Long-term NP with novel shapes did not occur at either a five-minute or a 24-hour time interval, which challenges reports of long-term NP with once-presented novel shapes (Treisman & DeSchepper, 1996). The finding that NP was more likely to occur with stimulus repetition supported contentions about the importance of stimulus repetition (Strayer & Grison, 1999). Other results demonstrated the sensitivity of the NP effect to minor variations in the experimental conditions. Manipulating the relative salience of target and distractor stimuli increased distractor interference, but did not affect NP. However, reducing the luminosity of prime and probe display stimuli eliminated NP and produced facilitation (positive priming) instead. This facilitation occurred despite the repetition of stimuli, which had proven to enhance NP under different conditions. The present study challenges a number of conclusions about the nature of NP, but also suggests ways of bringing a measure of cohesion to apparently contradictory findings.

1.0 Introduction

1.10. Selective Attention and the Negative Priming Paradigm

We frequently encounter multiple visual objects in the natural environment. Understanding selective attention involves discovering how we selectively respond to particular objects and events that are relevant to our immediate goals while ignoring irrelevant objects and events. A common explanation of selective attention is that it occurs by the amplification of the internal representations of target objects to ensure that the representation of a target stimulus is more prominent than that of distractor stimuli (Broadbent, 1958; Van der Heijden, 1981). Some consider selective attention to act like a spotlight, whereby objects within the spotlight beam receive processing beyond that of initial perceptual analysis (Broadbent, 1982; Posner, 1980). More recently, the inhibition of the internal representations of irrelevant objects and events has been proposed as a mechanism that complements the excitation of target sources of information in selective attention (Neill, 1977; Neill & Westberry, 1987; Tipper, 1985; Tipper & Cranston, 1985). On this view, inhibition of the internal representations of distracting objects takes place during the selection of a target stimulus. The role of excitatory processes in selective attention is widely accepted, however, the role of inhibitory processes in selective attention remains controversial.

The proposal of a role for inhibitory processes in selective attention has largely been due to the discovery of the negative priming (NP) effect. NP refers to the slowing of response times or the reduced accuracy of responses to a target stimulus that a participant had ignored on a prior occasion. This differs from repetition priming (a facilitatory

priming effect) where attending or passively perceiving a target stimulus on one trial typically facilitates responding to that stimulus or to a related stimulus when it reappears as a target on a later trial. In a typical NP task, each participant completes a large number of trial couplets. The first trial of each couplet is a 'prime trial' and the second trial in each couplet is a 'probe trial'. During a prime trial, a participant must selectively respond to some designated target stimulus or attribute of the prime target stimulus (e.g., a green shape) whilst ignoring a distractor stimulus (e.g., a red shape). During a probe trial, participants must respond to a target stimulus that is either related or unrelated to the prime distractor stimulus. Trials in which the prime distractor and the probe target are related serve as critical ignored repetition (IR) trials and trials in which the prime distractor and probe target are unrelated serve as control (C) trials. NP is present when there is impaired responding to related probe targets compared to unrelated probe targets. The NP effect may indicate the role of inhibitory processes in selective attention. If selection of a prime target stimulus involves inhibiting the internal representations of the prime distractor, and this inhibition persists from the prime to the probe trial, this could impair responding to a probe target that requires access to these inhibited representations (e.g., Neill, 1977; Tipper, Lortie, & Baylis, 1992).

The NP effect is not a new phenomenon. Using a sequential Stroop colour-naming task, Dalrymple-Alford and Budayr (1966) observed that if the ink colour to be named (e.g., red) on a current trial corresponded to the prior distractor word (RED), response times were slower than if the prior distractor word was a different colour word (e.g., green). Neill, (1977) replicated this finding with a discrete-trials version of the Stroop task (Neill, 1977). Tipper (1985) coined the term "negative priming" and

subsequently observed NP in identification tasks (Allport, Tipper, & Chimel, 1985; Tipper, 1985; Tipper & Cranston, 1985). For example, Tipper (1985, Experiment 3) found that participants were slower identifying a red target drawing of a common object overlapping a green non-target drawing of a common object when the red drawing had been the green drawing on the previous display compared to trials in which these drawings were unrelated. Since the mid-1980s, NP has been found in a variety of tasks such as: categorisation (Tipper & Baylis, 1987; Tipper & Driver, 1988), naming (Malley & Strayer, 1995; Tipper, 1985, Tipper & Cranston, 1985; Tipper & Driver, 1988), lexical decision (Neumann, McCloskey, & Felio, 1999; Yee, 1991); counting (Driver & Tipper, 1989) and matching (DeSchepper & Treisman, 1996; Neill, Lissner, & Beck, 1990). The NP effect has also been found using a range of stimuli such as words (Kane, Hasher, Stoltfus, Zacks, & Connelly, 1994; Neill, 1977), letters (Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Neumann & DeSchepper, 1992; Tipper & Cranston, 1985); common objects (Tipper, 1985), novel nonsense shapes (DeSchepper & Treisman, 1996; Treisman & DeSchepper, 1996), and human faces (Khurana, 2000). In addition, the NP effect occurs in tasks using a variety of response requirements such as a manual key-press, vocal naming, and reaching. Generally, NP tasks produce modest effects of less than 20ms (see Fox, 1995; May, Kane & Hasher, 1995, for reviews).

The NP effect also occurs in tasks involving the localisation of stimuli (Tipper, Brehaut, & Driver, 1990). In such tasks, responses are slower to a target symbol that appears in the same location as a distractor symbol appeared on a previous trial. There is evidence that the mediation of the NP effect found in localisation tasks involves different mechanisms than in identification tasks. Connelly and Hasher (1993) suggest that NP of

identity and location are mediated by two separate cortical visual pathways, the dorsal (occipitalparietal) pathway concerned with spatial location and the ventral (occipitotemporal) pathway, which may be specialised for processing the identity of objects. Two recent NP reviews have noted differences in these two types of task and suggest that different theoretical explanations underlie each (Fox, 1995; May et al., 1995). The current study will focus exclusively on identity NP.

The NP paradigm can provide insight into the nature of selective attention. In particular, NP may be informative about the issue of whether attentional selection occurs early or late in processing. According to early-selection theorists, unselected stimuli are filtered out of awareness at an early stage of processing before complete stimulus identification, therefore relevant stimuli are more likely to be identified than irrelevant stimuli. Conversely, late-selection theorists propose that all stimuli are identified regardless of their relevance to the task, but only a subset of these are selected for input to later processes. The late-selection view is supported by findings of interference effects in the NP paradigm and findings that NP occurs despite changes in the physical form of the critical stimulus from the prime to the probe trial (e.g., Dalrymple-Alford & Budayr, 1966; Driver & Baylis, 1993; Tipper & Driver, 1988). The NP effect may therefore provide evidence that selection occurs after identification and classification of both target and distractor items. Given that attention is vital for many other cognitive processes, understanding the mechanisms involved in NP may have important implications for cognition in general. In fact, the NP paradigm has been used to study an array of cognitive functions such as; working memory (Engle, Conway, Tuholski, & Shisler, 1995), long-term implicit memory (DeSchepper & Treisman, 1996), human-face

processing (Khurana, 2000), social cognition (Macrae, Milne, & Bodenhausen, 1995), mental representation and language processing in bilinguals (Neumann, McCloskey, & Felio, 1999), and psychopathology (e.g., Beech, Powell, McWilliam, & Claridge, 1989). As suggested by this body of literature, NP effects may be relevant to various facets of cognitive functioning.

With the profusion of NP studies, many empirical discrepancies in the NP literature with respect to various parameters and boundary conditions of NP have arisen. For example, some research indicates absent or reduced NP among populations with known cognitive deficits (e.g. Beech, Baylis, Smithson, & Claridge, 1989), but other research indicates that there are no such absences or reductions. Until these empirical inconsistencies are resolved, formulation of an adequate theory of NP will continue to be elusive. A sound theoretical understanding of NP is necessary in order to adequately understand and interpret potential individual differences in NP. Presently, a good understanding of NP does not exist, because, as will be seen, the various theories of NP appear to be inadequate.

1.20 Current theoretical explanations of Negative Priming

Despite the fact that there is currently no adequate theory of NP, numerous explanations of the NP effect do exist. Three of the most prominent theories of NP will be outlined in this section, whilst alternative theories of NP will receive consideration in the General Discussion section of this thesis.

Inhibition-Based Theories

An early account of NP proposed that the mental representations of distractor stimuli are deactivated by an inhibitory mechanism (Neill, 1977). On this view, positive and negative priming both reflect the degree of activation of a stimulus representation either above or below some baseline level. If the representation of a prime distractor becomes deactivated and this representation persists until the probe display then responding may be slower compared to a control condition. A subsequent inhibition-based theory proposed that the representations of distractor stimuli are initially activated but become blocked from access to response mechanisms (Tipper & Cranston, 1985). From this perspective, a protection mechanism operates which prevents incorrect information from eliciting a response through inhibiting the processes that translate stimulus representations into response codes.

More recently, Houghton and Tipper (1994) proposed a computational model of NP whereby both target and distractor representations receive activation by an excitatory system. According to this theory, target selection occurs when the representation of the target stimulus is sufficiently more activated than the representation of the distractor stimulus. A mechanism then operates to selectively inhibit the internal representation of the distractor. When target selection occurs and the external stimuli disappear, the excitatory influence on the internal representations of the target and distractor is removed. The persistence of inhibition on the internal representation of the distractor then pushes its representation below baseline. If the distractor stimulus appears as a target during this inhibitory rebound phase, then selection of the target will be impaired relative

to a control condition, as it will take longer for the target stimulus to gain threshold levels of activation.

Episodic Retrieval Theory (ER)

The Episodic Retrieval (ER) theory of NP (Neill & Valdes, 1992; Neill, 1997), denies the role of inhibitory mechanisms in NP, and instead proposes that retrieval processes play a crucial role (e.g., Neill & Valdes, 1992). The ER theory is based upon several notions contained in Logan's (1988) instance theory of automatization. Logan proposed that a learner will initially rely on a slow effortful algorithm to perform a task, but over time, this will shift to a reliance on the episodic retrieval of prior learning episodes. The reliance on memory-based performance is determined by a race between the retrieval process and the algorithm; whichever finishes first will determine performance. On this view, memory for an episode contains information about the response made to a stimulus and therefore allows a learner to select an appropriate response without using algorithmic processing. Each specific encounter with a stimulus is argued to be encoded, stored and retrieved as a separate instance. Therefore, practice results in more memory traces of an encounter with a particular stimulus (or instances). The more instances of a particular event a person has, the greater the probability that one will be retrieved quickly, making episodic retrieval more likely to win the race, thus leading to the automatisation of performance.

According to the ER theory, during ignored repetition trials in a NP task, the probe target item elicits prior episodes (especially the most recent one containing that stimulus) in which the current target stimulus had previously been a distractor. This

episode would thus include the identity of the item and an information tag about the response made to it, such as 'do not respond'. The automatic retrieval of these tags conflict with the current requirement to 'respond' to the target stimulus, delaying the response until this conflict has been resolved. Therefore, according to the ER theory, NP is explainable exclusively with respect to memory processes and therefore the ER theory denies the involvement of inhibition-based processes in NP.

Temporal-discrimination theory

A recent theory purporting to account for NP phenomena is the temporal-discrimination theory (Milliken, Joordens, Merikle, & Seiffert, 1998). According to this theory, on ignored repetition trials NP occurs due to a lengthened discrimination process required to decide which of two types of processing is appropriate. On the probe trial, participants respond to target stimuli quickly if stimuli can easily be categorised as new or old, whereas responding is slower if there is confusion as to whether stimuli are new or old. An orienting system is responsible for determining which stimuli are new or old. In the ignored repetition condition, a perceptual mechanism categorises the probe target as 'new' suggesting that attentional processing should occur. However, because the probe target and prime distractor are related, the probe target is also categorised as 'old' by a memory-based retrieval mechanism. Accordingly, NP is a result of poor discriminability between perceptual and memorial influences on behaviour, and reflects an attentional set that is biased towards the processing of temporally distinctive or novel stimuli over more familiar stimuli. In contrast with inhibition-based theories (which emphasise attention processes) and the ER theory (which emphasises memory processes), the temporal

discrimination theory proposes that both attentional and memory processes may interact to produce NP.

1.30 Some Determinants and Parameters of NP

This thesis contains an exploration of several determinants and parameters of NP. One such determinant will be perceptual aspects of the stimulus displays, such as the relative line thickness of target and distractor stimuli and the luminosity of the display stimuli. Other determinants and parameters under exploration will be the temporal duration of NP, the effects of stimulus novelty on NP, and the effects of age on NP. The investigation of these effects is important given that research on these determinants have revealed some empirical discrepancies. This section contains some of the conflicting research regarding these various determinants. In addition, this section will discuss research findings of the occurrence of positive priming in the ignored repetition conditions of NP tasks. Findings of positive priming instead of negative priming under certain experimental conditions are pertinent to a theoretical understanding of NP.

The Role of Perceptual Processing in NP

Although NP can be bound to specific features of an ignored stimulus, recent research suggests that the level at which NP operates may depend on the requirements of the task. Some NP tasks require attention to particular physical characteristics such as shape, whilst other tasks require abstract levels of representation, such as meaning (Fox, 1995). NP reflects more than just perceptual processes because in some NP experiments the prime distractor stimulus is physically different from the related probe target stimulus. Tipper and Driver (1988) found NP to generalise to semantic associates of

pictures and words. For example, when participants ignored a picture of a "dog" on the prime trial, this caused a slowing of responses to the probe display to the word "cat" on ignored repetition trials. However, perceptual similarity can also be important to negative priming. DeSchepper and Treisman (1996) found NP using once-presented novel shapes, as stimuli. NP must therefore have reflected perceptual shape characteristics, as the stimuli could not have had any preexisting representations. Given that perceptual processes can be important to NP, this thesis will pursue manipulations involving the perceptual characteristics of display stimuli to determine their effects on NP.

Prime Distractor Salience

A perceptual aspect of NP displays that has investigated is the salience of the prime distractor stimulus. There is evidence that NP is larger when prime distractors are highly salient (Houghton, Tipper, Weaver and Shore, 1996). DeSchepper and Treisman (1996) investigated NP in an experiment where the relevant target and irrelevant distractor shapes shared the same contour, so that the target shape was the figure and the distractor shape comprised the ground. NP occurred when the irrelevant ground became the relevant figure whilst non-significant PP occurred when the irrelevant and relevant stimuli were shown as physically separate figures. Khurana (2000) studied NP with unfamiliar human faces as stimuli. Target faces appeared as the second and the fourth faces in a row of five faces. NP occurred to faces that had appeared as distractors on a prime trial. In subsequent experiments, the distractor faces were either perceptually distorted by high frequency spatial noise or were contrast inverted. Under these circumstances, facilitatory response times occurred. This was not due to increased

selection difficulty, as the degradation actually made the distractor faces easier to distinguish from the target faces. These findings are compatible with the notion that the degraded distractors failed to provide sufficient competition to require their inhibition.

Loula, Kourtzi, Shiffrar (2000) employed a NP task where participants were required to match a target shape with a comparison shape. Target and distractor shapes overlapped each other and appeared either with or without surface segmentation cues. The comparison shape appeared to the side of the overlapping target and distractor shapes and always contained surface segmentation cues. NP occurred for outlined and transparent shapes that lacked surface segmentation cues, whilst PP occurred for shapes that were opaque or had transparent surfaces. The presence of selection cues may have enhanced selection ease, so that inhibitory mechanisms were unnecessary in this condition, resulting in positive priming instead. In general, a reduction in NP appears to occur in conditions that facilitate selection and may disappear completely when selection is especially easy. This is consistent with the idea that distractor stimuli do not receive inhibition if they do not vie vigorously enough with targets for the control of action. This is compatible with the proposal by Houghton et al. (1996, p.140), that "...inhibitory systems may be energised by what they inhibit...". On this view, inhibition is reactive to the increased disruption from distractors.

The ER theory might potentially account for the importance of distractor salience. When target selection is difficult such as with the absence of surface segmentation cues, items may receive more extensive encoding, leading to increased response conflict and therefore NP. In the Loula et al. (2000) study, the presence of surface segmentation cues may have allowed participants to easily perform the task without deeply processing the

distractor stimuli. If this were true, then response conflict during probe displays would be expected to decrease along with NP. However, in the above study, NP did not decrease but rather facilitation of participant response times occurred, therefore it is unclear how the ER theory would account for these findings.

Prime-Probe Similarity

It is possible that it is not the salience of stimulus items per se that determines NP, but the perceptual and contextual similarity of the prime and the probe display. Similarity of prime and probe displays may be an important determinant of NP. Using a letter-matching task Stolz and Neely (1993) varied the brightness of stimuli in both prime and probe displays and found that NP was greatest for dim probes following dim primes and for bright probes following bright primes. Fox and DeFockert (1998) manipulated stimulus strength by way of stimulus contrast between letter displays and their background in a flanker task, using either high contrast or low contrast displays. NP was greatest when the prime and probe displays shared the same intensity contrast. Low contrast stimuli on the prime followed by a high contrast probe trial resulted in positive priming. Whilst prime–probe display similarity was important in this study, high contrast stimuli did produce more NP overall compared to low contrast stimuli, suggesting an additional effect of stimulus brightness.

The ER theory might explain greater NP with greater prime-probe similarity by proposing that greater similarity between prime and probe displays results in improved retrieval of prime display information. The Houghton and Tipper (1996) model could also account for increased NP with increased similarity between prime distractors and

probe targets based on the assumption that the various attributes of a distractor stimulus are separately inhibited. If this assumption were true, then a probe target that shares a larger number of characteristics with a prime distractor would produce stronger NP.

Whilst some studies have found prime-probe similarity to be important, the proposal that similarity of prime and probe display episodes is a determinant of NP may be troublesome. Moore (1994, Experiment 5) varied the presence or absence of distractor stimuli on a probe display following a normal two-item prime display. When conflict and non-conflict probe displays were randomly intermixed, NP occurred towards a probe display containing only a target stimulus (non-conflict) following a typical two-item prime display. Clearly, in this situation there is little prime-probe similarity, yet NP still occurred. Furthermore, Tipper and Driver (1988) found NP when participants ignored pictures of objects on a prime display and then categorised semantically related words on a probe display. Semantic NP has also been found by Schooler, Neumann, Caplan, and Roberts (1997). These findings are problematic for the ER theory's adaptation of Logan's (1990) proposal that automatic retrieval of prior episodes is limited to identical or closely similar stimuli. Since NP is purportedly caused by the retrieval of episodes with the retrieval itself being triggered by the onset of an item consisting of the earlier ignored prime display stimulus, one would need to assume that the probe target retrieves conceptually similar as well as identical representations.

Lag Effects and Long-Term NP

Besides perceptual aspects of stimulus displays, a parameter of NP that is of theoretical importance is the duration of NP effects. NP occurs even after many trials

have intervened between prime displays and probe displays. Treisman and DeSchepper (1996) and DeSchepper and Treisman (1996) reported significant NP effects for unfamiliar novel shapes persisting over 200 intervening trials between prime and probe displays. Interestingly, when stimuli were familiar words, NP occurred in an immediate condition but long-term NP (NP after a large number of intervening trials between prime and probe displays) did not occur for these stimuli. The ER theory can explain the occurrence of NP after various lags, as the theory does not require active processing of a stimulus during a retention interval. In principle, according to this theory, NP could survive despite the occurrence of intervening events. This is because a target stimulus should automatically elicit the most recent encounter with that stimulus. Thus, if the most recent encounter with a given stimulus was one in which it was a distractor, the stimulus should have a "do not respond" tag attached to it, regardless of the number of intervening unrelated trials. In addition, because of the conflict this would cause with the current requirement to "respond", a delay in response should ensue. Interestingly, Tipper, Weaver, Cameron, Brehaut, and Bastedo (1991) found that NP attenuated if the previously ignored stimulus appeared as a target in an intervening trial, or if the intervening trial included a relatively unexpected stimulus. The ER theory can explain the first finding by suggesting that the intervening trial would create a more recent episode containing the correct response information, although it is not clear why the more recent "respond" tag (and persisting activation) would not cause positive priming. The second finding, that an unrelated but surprising event can reduce NP, is also difficult for the ER theory to explain. It is possible that such an event changes the retrieval context, therefore reducing the probability of retrieving information about the previous prime display.

Findings of long-term NP are difficult for a simple inhibition-based theory to explain, as participants must actively process and respond to the intervening trials between the prime and related probe displays. The ability to maintain an active inhibition despite other processing demands would imply a mechanism of unlimited processing capacity, which is inconsistent with findings of decreased NP with an increase in the number of distractors presented with the target stimulus (Neumann & DeSchepper, 1992). However, findings of long-term NP are not inherently damaging to inhibition-based theories. Tipper (1991) suggests that in situations where stimuli remain consistently relevant or consistently irrelevant for action, long-term inhibition of irrelevant stimuli may serve a useful behavioral function. In specific contexts, an individual may consistently select one stimulus for action, whilst another stimulus may consistently not be selected. More importantly, if indeed retrieval processes do operate in NP tasks, this does not preclude the involvement of an inhibition-based mechanism that may function to resolve the conflict between target and distractor stimuli during the encoding of prime display stimuli.

Repetition effects

Malley and Strayer (1995) in a series of experiments found that identity NP only occurred on ignored repetition trials when the critical distractor stimulus had been repeatedly presented throughout the experiment as a target stimulus. Furthermore, the magnitude of NP increased with the number of times that the critical distractor stimulus had appeared in the role of a target stimulus. When distractor stimuli were used that were experimentally novel, PP rather than NP occurred. Strayer and Grison (1999) also found

that repeating a stimulus many times in the role of a target before switching its role to a distractor was more effective in producing NP compared to when the stimulus had been repeated as a distractor before the critical probe trial. They also showed the generality of repetition effects using different stimulus materials, response requirements and tasks. Similarly, Dark and Schmidt (2000) found PP to occur in the ignored repetition condition when probe target stimuli were novel words that were semantically related to prime distractor stimuli. However, NP occurred when the stimuli were repeated throughout the experiment as targets, before they became prime distractors.

Malley and Strayer (1995) proposed an activation-inhibition model to explain the importance of stimulus repetition. According to this model, repetition increases the activation of a target stimulus to a level where the stimulus begins to compete for responding when the stimulus becomes a distractor. Whilst this model can predict that repetition of the target stimulus is crucial, the ER model cannot explain the importance of target stimulus repetition. According to the ER theory, repetition of the distractor stimulus would increase the number of memory traces available (the number of times the stimulus is paired with a "do not respond tag". This means that such an instance is more likely to be retrieved, which, in turn, should lead to the increased likelihood of NP. The ER theory therefore would predict that it is repetition of the distractor stimulus is crucial because it is the distractor stimulus that the "do not respond" tags become associated. It is unclear how the ER theory can account for the finding of initial PP effects, given that any experience with the distractor should lead the stimulus item to be labeled with a "do not respond" tag. The ER theory fails to explain why repetition of the target stimulus is important to NP.

Despite the above findings on the importance of stimulus repetition (Malley & Strayer, 1995; Strayer & Grison, 1999), DeSchepper and Treisman (1996) found NP after a single presentation of an irrelevant distractor stimulus. Furthermore, when compared to a pool of shapes presented repeatedly (old shapes) they actually found larger NP with experimentally novel shapes. They also found a build up of facilitation of participant response times when the same shape was repeatedly presented as a distractor stimulus. This finding suggests that with repetition, distractor stimuli become increasingly easier to ignore, although this repetition does not affect the magnitude of NP.

The above findings could be accounted for based on the notion that trace discrimination is important to retrieval processes. The ER theory might predict that when stimulus items are repeatedly presented as both targets and distractors, the probability of retrieving any specific tag is reduced, thus reducing NP. However, if an item has appeared only once in the role of a distractor before it becomes a target then it should have a high probability of retrieval of the "do not respond" tag and thus substantial NP. Neill and Mathis (1998) argue that familiar stimuli may be more effectively encoded in the processing episode or familiar targets may serve as a more effective retrieval cue for past episodes. In contrast, according to the temporal-discrimination theory, repeating a stimulus should reduce the novelty of that stimulus. A less novel stimulus will be less able to be discriminated temporally as a past verses a present source of influence on behaviour, therefore NP will diminish. Given the discrepant findings regarding stimulus repetition on NP, this thesis will examine the effects of stimulus repetition.

Individual Differences in Negative Priming

In addition, to the empirical discrepancies regarding various determinants and parameters of NP, a variety of studies report individual differences in the NP effect in some populations. For example, reduced and reversed NP effects have been reported in individuals with schizophrenia and schizotypal illness compared to normal control subjects (Beech, Baylis, Smithson, & Claridge, 1989; Beech & Claridge, 1987). Metzler and Parkin (2000) found reliable PP in patients with unilateral or bilateral damage to the frontal lobe in the ignored repetition condition of a NP task, whilst control participants showed NP. An inhibition-based theory can explain the absence of NP in brain lesioned patients as due to these individuals having deficient inhibitory mechanisms, given that there is evidence that the frontal lobes are involved in inhibition. Positive priming may have resulted from persisting activation of the representation of the prime distractor stimulus from the prime to the probe display. The ER theory cannot explain the finding of PP in lesioned patients unless it is claimed that the frontal lobes are important to memory retrieval. However, in this study patients with brain lesions were not deficient at memory retrieval but instead responded faster in the critical ignored repetition condition compared to the control condition. From the viewpoint of the temporal-discrimination account, it is possible that lesioned patients could have a damaged orienting system. However, if the orienting mechanism in the brains of these patients was malfunctioning, then only retrieval processes would have contributed to reaction time, so this theory also cannot explain findings of PP in patients with frontal lobe lesions.

There have been reports of age differences in the NP effect. Diminished NP has been reported in young children (Tipper, Bourque, Anderson, & Brehaut, 1989) and a

number of studies have failed to find identity NP in older adults despite studies finding intact location NP in older adults (Connelly & Hasher, 1993; Hasher, Stoltzfus, Zacks, & Rympa, 1991; McDowd & Oseas-Kreger, 1991; Tipper, 1991). Stoltzfus, Hasher, Zacks Ulivi, and Goldstein (1993) showed that age differences in NP were not due to the time-course of suppression by varying the response-to-stimulus interval (RSI). Similarly, Kane, Hasher, Stoltzfus, Zacks, and Connelly (1994) failed to find NP in older adults when the exposure duration to the target and distractor items was increased to allow participants more extensive processing of items. Hasher and Zack (1988) proposed that decrements in cognition as people age are due to a greater vulnerability to distraction and interference. This comes from a decreased ability to inhibit information irrelevant to the task goal from intruding into working memory, and this deficit may be the general underlying cause for cognitive decline in healthy older adults. Support for this idea comes from studies that show that older adults are more susceptible to the Stroop effect (Cohn, Dustman, & Bradford, 1984; Comalli, Wapner, & Werner, 1962) and slower in a speeded categorisation task when target words in one category were flanked by distractors from the competing category (Shaw, 1991). In studies of directed forgetting, older adults are less able to suppress the processing of items that they are instructed to forget compared to younger adults (Zacks, Radvansky, & Hasher, 1996). However, under certain circumstances older adults do show identity NP. The reason for these contradictory findings on aging and NP have yet to be adequately explained and therefore will be explored in this thesis.

Positive Priming in the Ignored Repetition Condition

A number of recent studies have revealed that under certain experimental conditions, negative priming either disappears or reverses to positive priming. For example, participants who are aware of the NP manipulation do not show NP but rather show PP (Driver & Baylis, 1993, but see Neill & Valdes, 1992). In a picture-naming NP task, Allport, Tipper, and Chimiel (1985, Experiments 4 and 5) exposed participants to a prime display consisting of a target stimulus and a distractor stimulus, followed by a pattern mask. When a pattern mask followed the prime by a long stimulus-onset asynchrony (SOA) so that participants could easily identify the prime target, NP occurred in the ignored repetition condition. However, when the pattern mask followed at a stimulus-onset asynchrony so briefly that the prime target was not identifiable, response times showed positive priming in the ignored repetition condition.

Neill and Westberry (1987) found that positive priming occurred in the ignored repetition condition, when participants were encouraged to sacrifice greater accuracy for speed. This may relate to the time-course of NP. If a distractor stimulus is initially activated and speed is emphasised then participants may respond before the representation of the stimulus has been fully suppressed. If the representation of the distractor stimulus is more activated than the baseline of control condition stimuli, then positive priming will occur. Under strict accuracy instructions, participants may suppress distractor information to a deeper level before responding, yielding NP. According to the ER theory subjects may be more likely to encode non-response information in episodic memory if more processing time is allowed for task performance (Neill, Valdes, Terry, &

Gorfein, 1992). If ignored information were less likely to be encoded and therefore retrieved, this would reduce NP. However, this explanation is problematic given that NP does not generally disappear with instructions for speeded responses but rather becomes positive (Neill, 1977, Experiment 2; Neumann & DeSchepper, 1992, Experiment 2), suggesting that the distractor stimulus had in fact been encoded.

Positive priming occurs in the ignored repetition condition of NP tasks for probe targets that appear without distractors (Lowe, 1979, Experiment 4; Tipper & Cranston, 1985, Experiment 3). Neill, Kahan, and Verwys (1996) also showed no NP for non-conflict probes. However, Moore (1994) showed that whilst NP is sensitive to probe trial conflict, this sensitivity depends on contextual characteristics of the experiment in which the conflict and non-conflict trials occur. NP occurred when high probe conflict was present in a letter identification task but did not occur when there was an absence of conflicting information on the probe trial (low-conflict probes). NP did occur however for low-conflict probes if they were randomly intermixed with high-conflict probe trials. These findings suggest that there is a release from NP when the participant does not expect interference, or if the probe trial can clearly be discriminated from trials where interference would occur. This supports an earlier finding by Lowe (1979), who reached the same conclusions using various combinations of conflict and non-conflict Stroop stimuli.

A simple inhibitory account of NP cannot explain the importance of probe trial conflict. On ignored repetition trials, slowed responding should occur to a probe target regardless of whether or not there is a probe trial distractor. It appears that facilitation and inhibition occur at different levels of processing and each may be brought about by

differing contextual factors. Tipper and Cranston (1985) proposed that inhibition functions to protect against erroneous responding to a distractor stimulus and will operate as long as a participant adopts a 'selection state'. If protection is not necessary, such as when interference is unlikely, then participants will relinquish the selection state and inhibition will not occur. Positive priming with non-conflict probes can be explained by Tipper and Cranston (1985) as the relinquishing of a selection state if the participant expects no interference on the probe trial or if a non-conflict probe can easily be discriminated from conflict probes. In such cases, positive priming may occur from the persisting activation of the distractor representation.

According to the Houghton and Tipper model (1994), if there was no competing code activated on a non-conflict probe trial, then the activation level of the target stimulus might immediately be greater than any other representation, and therefore target selection would occur quickly and no NP would occur. The presence of positive priming with non-conflict probe items could be explained on the assumption that only goal-related properties of distractors are inhibited so that representations associated with other properties of distractors could support facilitation. This model can account for positive priming effects with non-conflicting probes but cannot account for findings of NP when conflicting and non-conflicting probes are randomly intermixed. On these non-conflict trials, there is no competition so NP should have failed to occur. What appears to be important is not response competition per se but rather impending response competition.

According to the temporal-discrimination theory (Milliken et al., 1998), responding will be fastest when one can easily distinguish past influences on behaviour (memory-based) from present (perceptual-based) influences on behaviour. Novel or

unrepeated probe stimuli are thought to be more easily ruled out as a past source of influence on behavior than repeated stimuli. Therefore, if a distractor stimulus does not accompany the probe target, processing may benefit from repetition of an ignored prime, so positive priming might occur. The above findings of positive priming in the ignored repetition condition are pertinent to a theoretical understanding of NP. Additionally, findings in many NP experiments that up to one third of participants show facilitation rather than inhibition, suggest that NP may involve two separable components, one capable of producing a facilitatory effect and one capable of producing an inhibitory effect. On some level, facilitation appears to persist but under certain circumstances appears to be overridden by inhibitory processes.

1.40 Summary of theories

Inhibition-based theories assume that NP acts in a forward manner, from the prime to the probe display. Although a simple inhibition-based theory is inadequate, recent inhibition-based theories can explain a large portion of the NP literature. Evidence that NP survives intervening events and persists over time suggests that if inhibitory processes are involved in NP, then they function not only to aid concurrent selection but also after selection to prevent information classified as irrelevant from quickly becoming reactivated.

Findings of long-term NP and prime-probe similarity effects have been used to support memory-based theories of NP. However, the assumption of the importance of prime-probe similarity is problematic. Although this factor may contribute to NP, NP occurs in tasks using very different prime-probe displays, and an absence of NP

sometimes occurs in tasks with contextually similar prime-probe displays (both displays containing the same type of stimuli and the same number of items). Findings relating to the importance of probe-trial conflict support retrieval models, but are not necessarily problematic for inhibitory theories to account for.

A major problem with the ER theory is that it is under-specified. The theory does not explain how response tags become associated with the internal representations of the various stimuli. Tipper, Meegan, and Howard, (in preparation) have proposed that this process may in fact be one of inhibition associated with the internal representations of distracting stimuli during target selection; such inhibitory processes could have long-term effects. In addition, the informal verbal descriptions included in the model are flexible enough to cope with a range of new observations by including new assumptions. The ER theory cannot explain why NP sometimes reverses to positive priming in many experimental situations and in some abnormal populations.

More fundamentally, the basis of ER, Logan's (1988) theory of automatisation, is problematic as applied to NP. Logan (1988) suggested that in a varied-mapping task where individual stimulus items can be targets or distractors on different trials, retrieval of individual traces should provide little useful information. In discussing varied mapping designs, Logan (1988, p.509) states that, "all separate traces retrieved would yield inconsistent or incoherent information about how the current stimulus should be interpreted. Therefore, the participant should ignore them and respond based on algorithmic processing". Neill (1997) makes the additional assumption that the most recent episode is the one most likely to be retrieved. Furthermore, Logan (1988) proposed that information that is included in instances is that which is subject to attention. Ignored

stimuli in many NP studies cannot be immediately recalled or recognised after presentation and do not appear to enter awareness. It is unclear whether the episodes of the sort proposed by Logan (1988) can be created for unattended stimuli, and thus whether NP can be accounted for by retrieval of such episodes.

Neither retrieval nor inhibition-based theories can explain all the research evidence on NP without substantial modifications. However, inhibition-based theories can explain much of the research evidence on NP and such theories are not undermined by findings of long-term NP. In my view, a satisfactory theory of NP will need to incorporate the role of inhibitory and retrieval processes in NP. In a NP task, by necessity, information contained in a prime trial is removed from the external environment. Any enduring repercussions from such information must therefore involve some form of memory. However, what is unknown is the nature of this form of memory. Additionally, an adequate theory of NP would need to explain the interaction of two different types of processes that appear to play a role in NP tasks; facilitatory and inhibitory processes and how they might interact to determine performance.

1.50 The Present Experiments

The present study contains three experiments designed to examine different aspects of NP. Each experiment investigated the effects of different lags between prime and probe displays on NP. In addition to exploring the temporal duration of NP, each experiment also explored the effects of stimulus repetition on NP. Furthermore, each experiment explored an additional parameter or potential determinant of NP. Experiment 1 investigated NP using complex three-dimensional unfamiliar stimuli. In Experiment 2,

differences in NP between younger and older adults were investigated using a same-different matching task with unfamiliar novel shapes. In a third experiment, the salience of distractor stimuli was manipulated by changing the line-thickness of the distractor stimuli relative to target stimuli, and the luminosity of all stimuli on prime and probe displays was reduced relative to Experiment 2.

Finding evidence of long-term negative priming would lend support to Treisman and DeSchepper's (1996) findings of NP lasting over extended time intervals. Findings related to stimulus repetition would be of empirical importance given that the effect of stimulus repetition on NP is under dispute. Finding NP with once presented shapes would support the findings of NP with novel shapes (Treisman & DeSchepper, 1996), whereas finding NP only with stimulus repetition would support the findings of Strayer and Grison (1999). The present study is the first to investigate the effects of age on short and long-term NP for unfamiliar novel shapes. Thus, the findings are relevant to the existing literature on age effects and NP. The effects of increased stimulus salience and reduced stimulus luminosity on NP are of relevance to prior studies that have manipulated perceptual aspects of the stimulus displays, and to theories of NP. It is anticipated that overall the present findings will help clarify some of the empirical discrepancies existing in the NP literature and contribute to theoretical enhancement in this area of research.

2.0 Implicit Memory for Possible and Impossible Shapes

Implicit memory refers to the non-conscious retrieval of past-experience that is demonstrated in performance on tasks that do not require intentional recall of those past experiences. Neumann (1999) used a negative priming paradigm to investigate implicit memory for overlapping structurally possible and impossible three-dimensional (3-D) shapes. Neumann found short-term NP when a small pool of possible and impossible shapes was used and long-term NP (approximately 5-minutes) when a large pool of such stimuli was used. This shows that both possible and impossible objects with no pre-stored semantic representations can be registered and stored implicitly without conscious attention. In contrast, Schacter, Cooper, Delany, Peterson, and Tharan (1991) obtained evidence of implicit memory for briefly presented 3-D possible shapes but not 3-D impossible shapes. They claimed that the impossible shapes contained surface or edge violations that precluded their existence in the 3-D world and thus participants would find it difficult or impossible to create mental representations of such impossible shapes after brief encounters. Finding long-term NP for once (and only once) ignored impossible shapes in the present study would challenge the notion that priming can only occur for possible shapes.

This experiment sought to replicate and extend the findings of Neumann (1999) using a similar task and procedure, and therefore gain converging evidence for long-term NP with once presented novel shapes. However, rather than investigating NP after a large number of intervening trials and a 5-minute delay, this study tested whether NP for possible and impossible shapes persists over a 24-hour duration between related prime

and probe displays. Finding NP after a 24-hour time lag between related prime and probe displays would lend support to the finding of NP lasting up to 1 month with novel shapes (Treisman & DeSchepper, 1996) and would help to establish the generality of such findings, by showing long-term NP effects different stimuli. Whilst Treisman and DeSchepper (1996) used outline drawings of simple 2-dimensional shapes, the present study used complex line drawings of 3-dimensional shapes. In an immediate condition, a small set of stimuli were used interchangeably as both targets and distractors. In a lag condition, on the other hand, shapes were presented only once on a prime trial and once on a probe trial in the ignored repetition condition (and only once, otherwise). Finding significant NP in the lag condition of the present experiment would question the findings of Malley and Strayer (1995) and Strayer and Grison (1999) that stimulus repetition is necessary in order for NP to occur. Finding long term NP at a 24-hr lag could potentially be explained by both memory-based and by inhibition-based theories, especially an inhibition-based theory that also acknowledges the role of memory-based processes in NP.

2.20 Method

Participants

Twenty-eight University of Canterbury students (21 females and 7 males) were paid $10.00 each for participation in this study. The average age was 21.89 years, (range 19-35) and the average number of post-high school years of education was 1.88 years. All participants had normal or corrected visual acuity and normal colour-vision. Each participant gave informed consent before testing. A standardized copy of a participant

consent form for this experiment is contained in Appendix A. Approval by the University of Canterbury Human Ethics Committee for this study is contained in Appendix E. Data for one participant was not included in the data analysis due to a failure of the participant to complete the second session.

Apparatus and Stimuli

Stimuli were line drawings of 3-dimensional possible and impossible objects similar to those used by Schachter, Cooper, and Delany (1990). Stimuli were comprised of three different sets of shapes, which comprised three different blocks in the experiment. Each set of shapes included equal numbers of possible and impossible shapes. Trials (prime-probe couplets) involving possible shapes included only possible shapes and trials involving impossible shapes included only impossible shapes. The trials were randomly intermixed throughout the experiment. In the immediate condition, a small pool of 16 possible and 16 impossible shapes was used, whilst in the lag condition, a large pool of 120 possible and 120 impossible shapes was used. Colour was the selection cue, with the target shape always indicated by the colour green and the distractor shape always indicated by the colour red. The target and distractor shapes were displayed overlapping each other in the centre of a Macintosh computer screen against a white background. A black comparison shape appeared randomly to the left or to the right of the overlapping stimuli on each trial. On each display, participants responded whether or not the green and black shape matched via a response box with two buttons, one labeled "same" and the other "different". An example of the stimuli used in this

experiment and an example of an ignored repetition prime-probe couplet is provided in Figure 2.20.

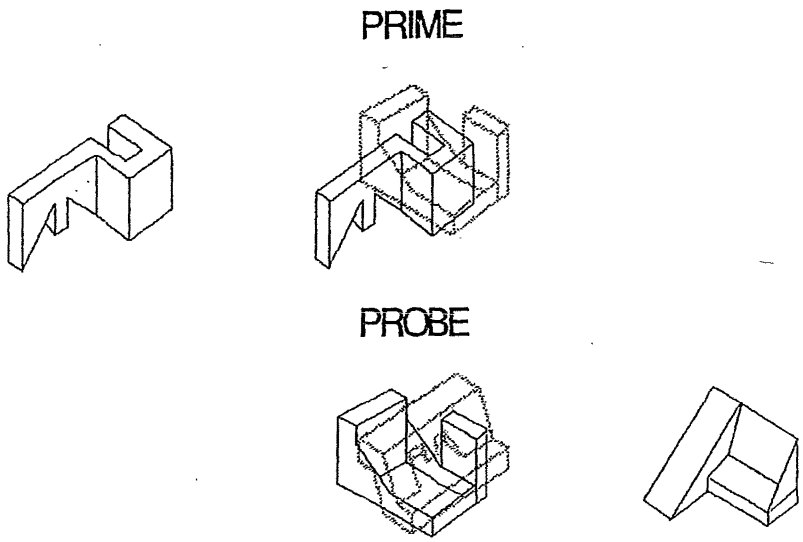

Figure 2.20. An example of a same-different negative priming pair with possible shapes.

Procedure

Participants received both written and oral instructions to decide as quickly and as accurately as possible whether the green target shape and black comparison shape were the same or different. A sample instruction sheet is contained in Appendix B. Each participant was required to attend two sessions of approximately 30 minutes each, separated by 24 hours. Before each session, participants completed a five-minute practice session. Following each practice session were 320 experimental trials. Experimental trials were divided into three experimental blocks which represented the three different sets of shapes. The presentation order of the three stimulus sets was fully counterbalanced across participants. The set of shapes used in the practice session for each participant was always the same as the shapes from the small pool of items that they encountered in the first block of experimental trials. Each block of experimental trials contained an equal number of possible and impossible shape trials, and an equal number of ignored repetition trials and control trials. For each set of shapes, each type of shape and each type of trial, there were four different response type combinations. These were same-same, same-different, different-different and different-same trials, which were presented in random order. Each participant underwent the experiment alone, in a dimly lit room.

Each trial began with a 2 sec fixation screen, with the word "READY" on it, followed by a blank screen appearing for 500 ms before the prime display. Each prime display consisted of the overlapping red and green shapes in the center of the screen with the black comparison shape appearing 50ms later. The black comparison shape appeared either randomly to the left or to the right of the red and green stimuli. A participant response terminated the prime display and a blank screen appeared for 500 ms before the

probe display. Thus, a response-to-stimulus interval (RSI) of 500 ms occurred between the response to the prime and the onset of the probe. The probe display was similar to the prime display except that all three shapes appeared simultaneously on the screen. After the response to the probe display, a blank screen appeared for 500 ms, followed by the next fixation screen. Figure 2.31 shows a pictorial representation of the sequence of events of a particular trial.

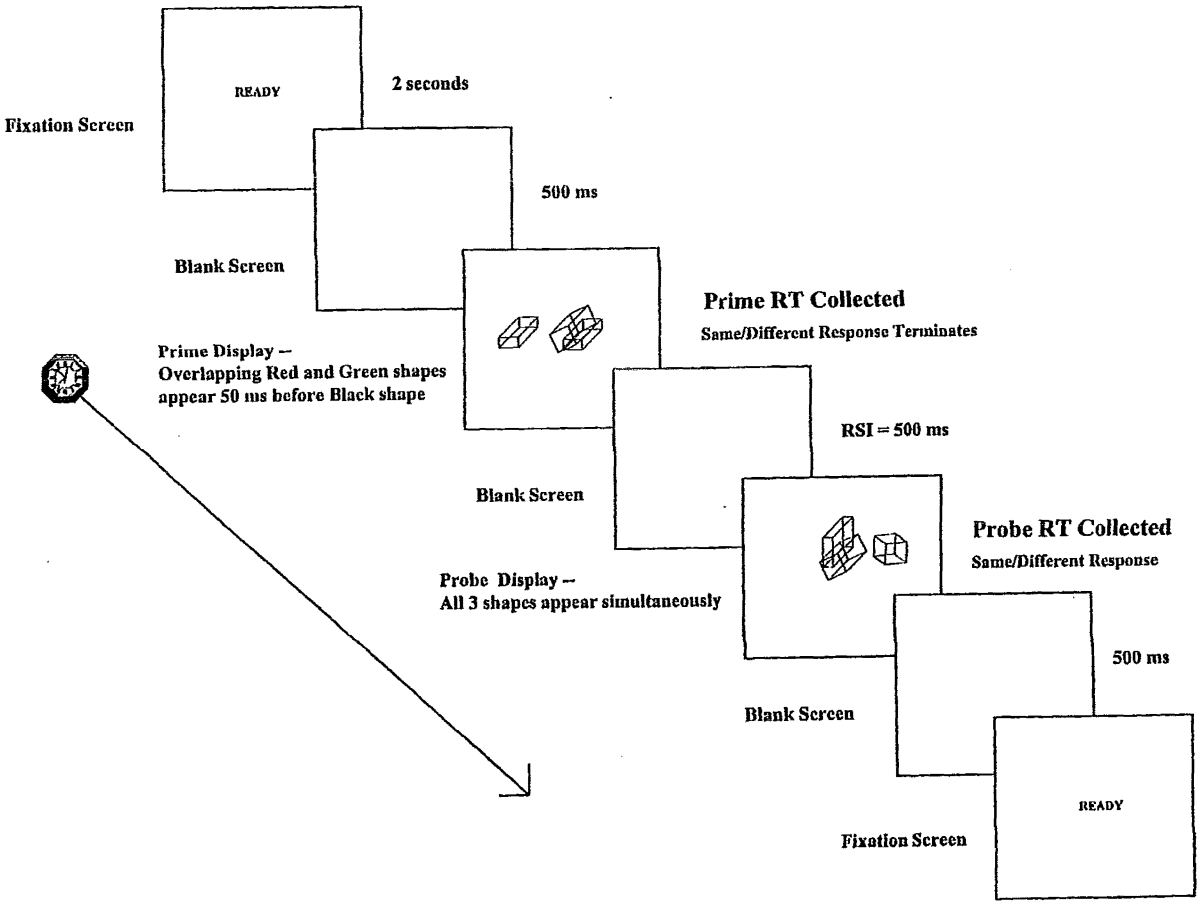

Figure 2.21. The sequence and timing of a typical trial's events

Participant reaction times and errors during the prime and probe display were recorded automatically via the computer software. A recognition catch trial followed the final experimental trial on the second experimental session to evaluate any explicit awareness of the red distractor stimulus. Catch trials consisted of either possible or impossible shapes which were regularly alternated between participants.

Design

A within-subjects design was employed. Within-subjects variables included, prime-probe trial type (ignored repetition versus control) with each trial type involving same-same (SS), different-different (DD), same-different (SD), and different-same (DS) response type combinations for the prime-probe couplets. Additional within-subject variables were shape type (possible versus impossible) and shape set (Schacter, Ratcliff A and Ratcliff B). The names of these different shape sets reflect the names of the different laboratories from which the shapes were sourced. A fourth within-subject variable was the time interval between prime and probe trials (immediate versus 24-hour lag). Stimuli in the experiment were fully counterbalanced across conditions and across participants.

2.30 Results

Reaction Time Data

Median reaction times on correct probe trials for each participant were calculated for the two experimental sessions (day 1 and day 2). Data analysis was conducted on the median probe reaction time data from day 1 and day 2. Mean probe reaction times for the

immediate condition were entered into a four-way within-subjects ANOVA. Within subject variables included; trial type (control versus ignored repetition), stimulus set (Ratcliff A versus Ratcliff B versus Schacter), stimulus type (possible versus impossible) and response type combination (same-same, same-different, different-different, different-same). The analysis revealed a significant effect of trial type, F (1,55)=5.57, p<.022. Subjects responded 13.17 ms slower in the ignored repetition condition than in the control condition, i.e. subjects showed NP. Figure 2.30 shows a comparison in responding between the immediate and the lag condition as a function of trial type. Subjects in the immediate condition produced NP whilst in the lag condition subjects produced a non-significant trend towards positive priming, F (1,27)=.16, p>.05.

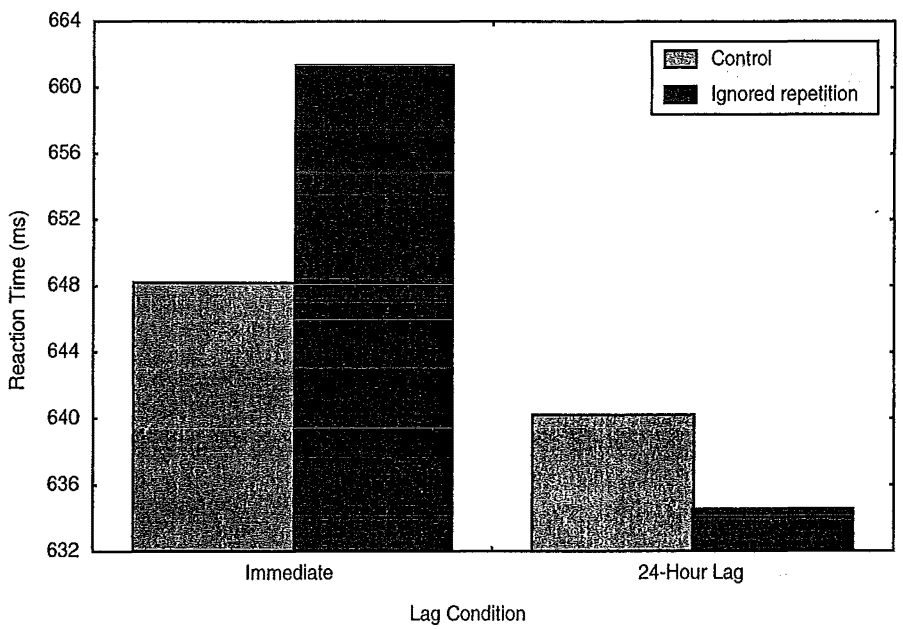

Figure 2.30. Mean reaction times for control trials and ignored repetition trials as a function of delay condition.

Table 2.30 shows means and standard deviations of participant reaction times in both the immediate and the 24-hour lag condition, for control and ignored repetition trials. The immediate data reflects probe trial data collected from day 1 and day 2 whereas the 24-hour lag data represents participant responding on day 2 probe trials that were each yoked to a prime trial from day 1.

Table 2.30

Means and Standard Deviations of Participant RTs for both Possible and Impossible Shapes as a Function of Trial Type and Delay Between Prime and Probe Displays.

	Possible Shapes		**Impossible Shapes**	
Conditions	Mean	SD	Mean	SD
Immediate				
Control	636.91	111.38	659.57	127.07
Ignored Repetition	648.90	122.50	673.92	130.40
Lag				
Control	636.07	139.3	644.31	156.06
Ignored Repetition	631.12	129.77	637.90	129.17

A subsequent within-subjects ANOVA was conducted on the immediate data only with day as a variable (day 1 versus day 2) along with four additional within-subject variables, trial type (control versus ignored repetition), stimulus type (possible versus

impossible), stimulus set (Ratcliff A versus Ratcliff B versus Schacter) and response type combinations (same-same, same-different, different-different, different-same). This showed a significant interaction effect between the trial type and day, F (1,27)=7.25, p< .012. Subjects showed larger negative priming on day 1 (24 ms) compared to day 2 (4 ms) with the small pool of shapes.

A four-way within–subjects ANOVA (trial type, stimulus set, stimulus type, response type combination) conducted on the immediate data for day 1 revealed a significant effect of trial type with subjects responding 24 ms slower in the ignored repetition condition than in the control condition, F (1,27)=7.64, p<.010. The same analysis for day 2 failed to show any evidence for NP (F <1).

Shape type and Set

There were no significant differences as a function of trial type between possible and impossible shapes and between the three different stimulus sets used (Schacter, Ratcliff A and Ratcliff B). There was a significant main effect of response type combination (same-same, same-different, different-same, different-different), indicating generally faster response times to 'same' probes. However, as this variable holds no theoretical interest for the present study, this variable will not be discussed any further, in this, and subsequent experiments.

Error Data

Probe trial error rates for each participant as a proportion of total trials for each condition were calculated. A four-way ANOVA (stimulus set, trial type, stimulus type,

response type combination) of the error data for the immediate condition showed no significant or marginally significant effects when the data for the two sessions were analysed separately. An analysis of lag data using a four-way ANOVA, (stimulus set, trial type, stimulus type, response type combination) also failed to find any significant effects.

Explicit Memory

A forced-choice catch trial presented at the end of the experiment revealed that participants selected the unattended shape on 14.29 % of trials. Because there were five different shapes to choose from, chance performance would be indicated by 20 % correct. Thus, if anything, participants were below chance at selecting the correct unattended shape.

2.40 Discussion

This experiment investigated NP for possible and impossible shapes in both a 24-hour lag and an immediate condition using a same-different shape-matching task. As expected, reliable NP occurred in the immediate condition. This was qualified, however, by a significant interaction between trial type and session day. Participants on day 1 showed significant NP whilst on day 2 NP was no longer reliable. Contrary to prediction, NP at a 24-hour time lag did not occur. Instead, there was a non-significant positive priming trend. These findings held true for both possible and impossible shapes and for each of the sets of shapes used. With regard to the findings of Schacter et al. (1991) of no implicit memory for briefly presented impossible shapes, the present findings are

inconclusive. This is because, in the lag condition of the present study, possible and impossible shapes were presented once on a prime trial and once on a probe trial in the ignored repetition condition and no implicit memory was detected for either possible or impossible shapes.

The finding that NP for complex unfamiliar shapes did not occur at a 24-hour lag challenges the generalisability of the findings of Treisman and DeSchepper (1996) who found NP with once-presented novel shapes that lasted up to a month. Neumann (1999), however, found that NP lasts up to 5-minutes, using identical stimuli and the same task as in the present study. This suggests that NP for complex novel 3-D shapes may survive over a 5-minute interval but does not appear to last for extended temporal durations.

There is an important difference between the lag and immediate conditions in the present study. In the immediate condition, a small set of shapes were repeatedly presented, whilst in the lag condition, shapes were presented only once as a prime distractor and once as a probe target on ignored repetition trials. It is possible that the absence of NP in the lag condition was because shapes were not sufficiently activated to require inhibition. This explanation is somewhat compatible with the findings of Strayer and Grison (1999) who reported positive priming to occur with experimentally novel stimuli. They proposed that stimuli had to reach a heightened threshold of activation before inhibition is required to suppress the representations of these stimuli. Stimuli that are repeatedly presented are thought to have higher levels of activation.

If this explanation for the absence of NP in the lag condition of the present experiment were correct, however, then larger NP effects should have occurred in the immediate condition of day 2 compared to day 1. Notably, participants would have had

more exposure to each of the stimuli in the small pool by day 2, which ostensibly should have resulted in increased activation levels. Conversely, significantly less NP occurred on day 2 compared to day 1. This finding does not appear to be congruent with the activation-inhibition hypothesis. However, it is possible that Strayer and Grison (1999) did not expect activation to persist over long temporal durations. In fact, it seems unreasonable to assume that the activation of shapes in the immediate condition would have persisted over the 24-hour lag. Nonetheless, since the same small pool of stimuli were was used in the immediate condition of day 1 as day 2, these items should have been at least as activated during day 2 as they were on day 1. Therefore, it is unclear why no significant NP was evident on day 2. The inability of the proposal by Strayer and Grison (1999) to fully account for the present findings places a constraint on their stimulus repetition hypothesis. However, the reduced magnitude of NP on day 2 indicates that something about participant's exposure to the task during day 1 did affect their performance on day 2.

Because the present experiment failed to find NP at a 24-hour time interval, the next experiment pursued the issue of long-term NP using a different set of stimuli. In the next experiment, a shorter temporal interval took place (approximately five-minutes) between related prime and probe displays and a large number of trials intervened between related prime and probe displays. In addition, the next experiment compared NP in a group of younger adults and a group of older adults.

3.0 A Between-Group Comparison of NP as a Function of Age, Prime-Probe Lag and Stimulus Set Size

This experiment compared NP in a group of younger and older participants using a different set of stimuli and procedures than the previous experiment. This comparison is of empirical interest as several researchers have reported a lack of NP, or reduced NP, in older adults compared to younger adults (e.g., Hasher, Stoltzfus, Zacks, & Rypma, 1991). However, there is evidence that under some circumstances older adults do show identity NP effects (Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Earles, Conner, Freiske, Park, Smith, & Zwah, 1997; Sullivan & Faust, 1993; Sullivan, Faust, & Balota, 1995). May et al. (1995) suggest that under certain circumstances in NP tasks (such as degraded viewing conditions, or tasks including attended repetition conditions) it may be beneficial for participants to retrieve prior-processing episodes in order to help identify the current target. It is under these circumstances that May et al. propose memory processes may operate in NP tasks. According to May et al., finding intact NP in older adults may be limited to tasks that encourage episodic retrieval. Under normal viewing conditions where inhibitory processes may underlie NP for younger adults, older adults should fail to show NP.

The Sullivan and Faust (1993) and Kramer et al. (1994) studies both included an attended repetition condition in which prime target stimuli were repeated as probe target stimuli. This may explain why older adults showed NP in these studies. Kane, May, Hasher, Rahhal, and Stoltzfus, (1997) conducted a study contrasting a condition in which probe stimuli were presented with or without visual degradation and in another experiment contrasted conditions in which there was either the presence or absence of a

large proportion of repeated trials. These manipulations were intended to induce retrieval of the prime episode because doing so could aid responding to the probe target in such trials. In their view, inducing episodic retrieval on such trials leads to episodic retrieval more generally on other trials as well. They found that while younger adults showed NP under retrieval and non-retrieval inducement conditions, older adults showed NP only under conditions thought to induce retrieval. These findings are consistent with the view of deficient inhibitory mechanisms in older adults.

Contrary to the above findings, Kieley and Hartley (1997) and Earles et al. (1997) found identity NP in older adults, despite conditions thought to reduce the likelihood of ER. Pesta and Sanders (2000) compared NP in younger and older adults using one task that included a repeated-target condition thought to induce episodic retrieval, and a second task that complied with May et al.'s (1995) criteria for measuring only inhibition, which involved a depth of processing manipulation. It was predicted that older adults would only show NP in the repeated target task, or at least more NP in this task, compared to the depth of processing task. Conversely, older adults produced equivalent NP to younger adults in the deemed pure inhibition task but no NP in the repeated target task.

Schooler, Neumann, Caplan, and Roberts (1997, Experiment 2) found that older participants actually showed more conceptual NP than did younger adults. Participants were required to make a categorisation response to overlapping pictures in the prime display and the same response to overlapping words in the probe display. Given the perceptually and physically dissimilar words in the probe display, one would not expect automatic retrieval of prime display items to have occurred. In addition, there were no

attended repetition trials to encourage retrieval. Despite these manipulations designed to decrease the likelihood of episodic retrieval, older adults showed NP in this study. Collectively, these findings question May et al.'s (1995) criteria for separating out inhibition and memory in accounting for age differences in NP tasks and question a general inhibitory deficit hypothesis of aging.

A recent meta-analysis conducted on NP and aging effects concluded that both younger and older adults both show identity NP (Verhaeghen & Meersman, 1998). However, the size of the NP effect was found to be smaller in older adults compared to younger adults. Given that an accurate meta-analysis is only as good as the quality of the studies it contains, factors not controlled for in these studies may account for the finding of age differences in NP. One factor may be the time of day that participants are tested. Intons-Peterson, Rocchi, West, McLellan, and Hackney (1998) observed NP in older subjects when they were tested at a time of day congruent with their preferred time of day for carrying out mental and physical activities, but did not find NP when they were tested at incongruent times. The majority of older adults in this study preferred the morning for performing physical and mental activities whilst the younger adults preferred the afternoon and evening. Older adults showed larger NP effects in the morning and younger adults showed larger NP effects in the afternoon. Intons-Peterson et al. (1998) proposed that age-related differences in time of day preferences reflect variations in circadian rhythms that may affect cognitive performance and physiological functioning. Other findings have also shown substantial differences across the day in the efficiency of inhibitory control processes. May and Hasher (1998) investigated synchrony effects between peak circadian arousal and time of testing influences in younger and older adults

on a variety of tasks thought to measure inhibitory control, such as a Stroop-task and a response inhibition task. Both younger and older adults demonstrated greater inhibitory efficiency at peak times relative to off peak times. When younger adults were at their peak but older adults were not, age differences in NP occurred. When testing of older adults occurred at times synchronous with their peak time, age differences in NP were wither reduced or eliminated. This suggests that discrepant findings regarding age differences in NP could be due to a lack of attention to circadian arousal effects, especially if time of testing is allowed to vary in such a way as to differentially disadvantage older adults.

In part, the present experiment is designed to test the inhibitory deficit model of aging. According to Hasher and Zacks (1988), older adults have a deficit in the inhibitory mechanism that restricts entrance of task relevant information to working memory and suppresses task-irrelevant information. If older adults in the present study do not show NP, this could also be due to deficient memory processes. Older adults in general show less competent memory on a variety of memory tasks such as primary, working and episodic memory tests. If older adults in the present study fail to show NP, then this may be due to a failure to effectively encode the information in the stimulus displays, to successfully retrieve previously learned episodic information, or to both. This interpretation may be problematic, however. If indeed memory mechanisms are involved in NP, then they involve implicit memory processes, given that participants are not explicitly aware of distractor stimuli in most NP tasks, as evidenced by catch trial performance. An abundance of research has shown that whilst explicit memory may decline with age, implicit memory does not. Findings of such age dissociations between

explicit and implicit memory tasks in older adults are evident using the process-dissociation procedure (Jacoby, 1991; Jennings & Jacoby, 1993; Schmitter-Edgecombe, 1999). Similarly, Schacter, Cooper, & Valdiserri (1992) compared implicit and explicit memory for novel visual objects in a yes/no recognition task. Compared with younger adults, older adults were impaired on the explicit recognition task, but not impaired on the implicit priming for possible objects task. Therefore, if older and younger adults showed equivalent NP effects in the present study, this would be best explained as reflecting intact inhibitory processes.

To date, investigations of NP in older adults have used only semantically familiar stimuli such as letters (Stolztfus, Hasher, Zacks, Ulivi & Goldstein, 1993), pictures (Tipper, 1991) or words (Kane, Hasher, Stoltzfus, Zacks & Connelly, 1994). To extend this line of research, the present experiment used unfamiliar stimuli. More specifically, this experiment compared NP in older and younger adults using Japanese Kanji figures (unfamiliar to the participants) as stimuli. Although the variable of time of day synchrony effects was not manipulated, data pertaining to this variable was collected and assessed in the present Experiment.

In testing a Japanese subject pool of young adults, Neumann, Iwahara, and Tajika (1999) found NP that survived a lag of 72 intervening trials (approximately 5 minutes) using a large pool of semantically familiar Kanji characters (a Japanese system of writing) that were presented once on a prime trial and once on the related probe trial. Neumann and Russell (2000) also found evidence of NP for familiar English words that were presented once on a prime trial and once on a probe trial, that survived a lag of 100 trials (approximately 10 minutes) in a word-naming task, but this was not the case with a

1-week lag. DeSchepper and Treisman (1996), however, obtained evidence of significant long-lasting NP of up to a month using a task in which participants responded to one of two overlapping novel nonsense shapes, that had been presented only once on a prime trial and once on a probe trial in the ignored repetition condition. This combination of findings on long-term NP suggests that long-term NP can occur with both unfamiliar and familiar stimuli presented once only on a prime display and once only on a probe display, however, this NP may be longer lasting for unfamiliar stimuli.

To further explore potential long-term NP, the present study varied the time interval between related prime and probe displays. Given that Experiment 1 did not produce NP at a 24-hour lag, this study reduced the lag interval between a prime and its probe to approximately five-minutes. The present study also included an immediate condition, which used a small set of stimuli, repeatedly presented interchangeably as targets or distractors. Half the trials in this condition were ignored repetition trials and the other half were control trials. In the lag condition, stimuli were drawn from a large pool of stimuli and a large number of trials intervened between each prime and probe couplet. In contrast to the immediate condition, each stimulus in the lag condition was presented only once, except to fulfill the constraints of the trial-type manipulation where a prime distractor becomes the target on a later probe trial. The lag condition also included an equal number of control trials and ignored repetition trials. It was expected that participants would show NP in the immediate and the lag condition, providing evidence of both short and long-term NP with unfamiliar novel shapes as reported by DeSchepper and Treisman (1996). A finding of long-term NP could be accounted for by the ER theory (Neill & Valdes, 1992), which could potentially allow for memory traces to be long-

lasting. On the other hand, finding long-term NP would not necessarily be damaging for inhibitory theories. Finding significant NP in the lag condition of the present experiment would however question Strayer and Grison's (1999) conclusions regarding the dependence of NP on stimulus repetition.

3.20 Method

Participants

Participants consisted of a group of 49 younger and a group of 44 older adults. The younger adults (19 males and 29 females) ranged in age from 18-39 years (*M*= 25.79 years). The older adults (28 females and 14 males) ranged in age from 56-86 years (*M*=69.48 years). The average number of years of post-high school education was 3.35 years for the younger group and 1.24 years for the older group. All participants had normal colour vision and normal or corrected-to normal visual acuity with no oriental language skills. Recruitment of participants was from the local community and all participants received $10.00 for their time and travel expenses. Written voluntary consent was gained from each participant (see Appendix C) and human ethics committee approval was obtained for the experiment and participants were naive the true purpose of the study. One subject from the younger groups data was not included in the data analysis due to exceptionally high error rates. Data from two older participants were not included in the final data analysis. One of these participants was unable to perform the task under suitable experimental conditions due to an anxiety disorder and the other participant was aware of the experimental manipulation.

Apparatus and Stimuli

Stimuli were displayed via a personal computer on a 15-inch General Colour Monitor. Participants responded via a response box containing two buttons (one labeled "same" and one "different") and were positioned 57 cm from the computer screen. Stimuli in the immediate condition included a small pool of 16 Kanji figures. In the lag condition, stimuli were drawn from a large pool of over 300 figures, and each appeared once only except to fulfill the ignored repetition constraint of a prime-probe couplet. On every trial, a distractor shape appeared in the colour red and occluded a green target shape wherever their lines intersected. The overlapping red and green figures appeared in the centre of the screen, and a white comparison Kanji figure appeared randomly to the left or right of the overlapping stimuli, against a black background. The line thickness of the distractor figure was twice that of the target and comparison figures (ratio 2:1:1). The computer software that generated stimulus presentation collected and tabulated reaction time and error data.

Procedure

Each participant individually completed the experiment in a dark, quiet room. Participants first read standardised written instructions (see Appendix D), followed by an oral review of the instructions by the experimenter. Participant instructions were to decide whether or not the green target and the white comparison figure matched whilst ignoring the red figure. If the shapes matched, participants were to press the "same" button on the response box and the "different" button if they did not match. Both speed and accuracy of responding were equally emphasised. Following five minutes of practice, each participant completed 256 experimental trials divided into two blocks. In contrast

with Experiment 1, block 1 contained both an immediate and a lag manipulation, as did block 2. In the immediate condition of both experimental blocks, the same small pool of stimulus items was used. In the lag condition, half of the large pool of items were used in block 1, and the other half in block 2.

The first trial began with the word "ready" appearing on the screen for 500ms before the prime display. Each prime display consisted of overlapping red and green shapes and a white comparison shape. A correct response terminated the prime display and replaced it with a blank screen for 500ms before the probe display. The probe display was equivalent in layout to the prime display and remained until a correct response was registered. Following the probe display, the screen was black for 500ms before the next trial began. Figure 3.20 shows pictorially the sequence of a typical trial's events.

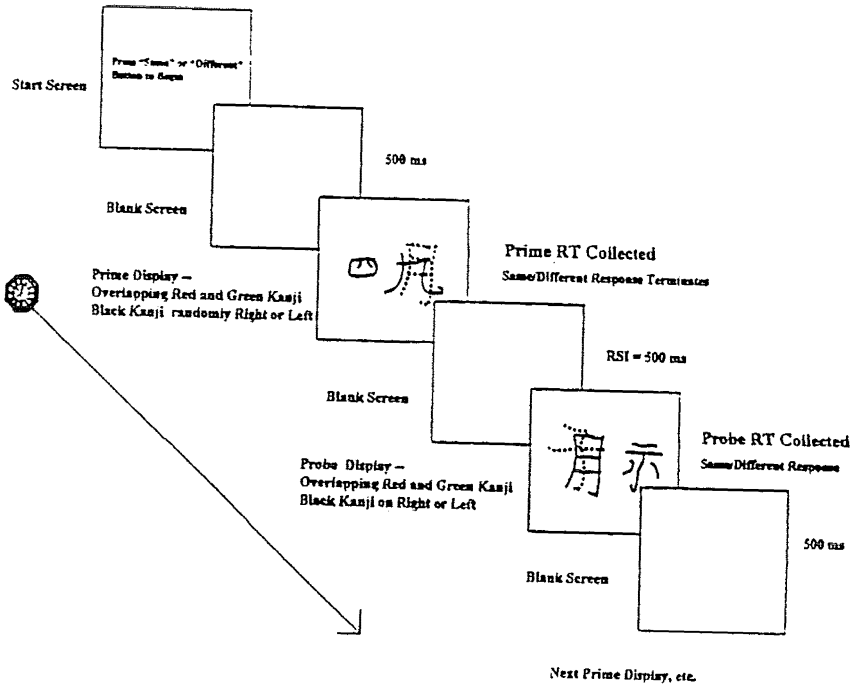

Figure 3.20. Shows a sequence of events for an ignored repetition prime-probe couplet.

On completion of the experimental trials, a catch trial was presented to test subject awareness and memory for the non-target item, followed by the target item. The catch trial involved subjects responding to a prime trial followed by an unexpected explicit recognition test wherein they had to select from five shapes the shape that was the red shape on the previous trial and then from another set of shapes the shape that was the green shape on the previous trial. Upon completion, the experimenter verbally also asked each participant whether at any time during the experiment they noticed that the red figure on one display became the green figure on a subsequent display. The entire experiment required approximately 30 minutes to complete.

Design

This experiment was a mixed between and within-subject design. Age was the between-subjects variable with two levels (young versus older adults). The main within-subject variable of interest was the trial type based on the particular prime-probe relationship. The two levels of this variable were 1) control where the probe target figure is different from the prime distractor, and 2) ignored repetition, where the probe target figure is the same as the prime distractor figure. Half the trials were control trials and half were ignored repetition trials. Each prime-probe couplet had four possible response type combinations: yoked same-same, different-different, same-different, and different-same. A second within-subject variable was the interval between a prime and probe couplet (immediate versus lag). In the immediate condition, the probe trial followed immediately after its prime trial whereas in the lag condition a probe trial corresponding to a given

prime did not appear until 72 trial couplets after that prime display. The order to which subjects were exposed to trials representing the different conditions in the experiment was randomised across participants, as were the stimuli used for each trial.

3.30 Results

Probe Reaction Time Data

Means of median correct probe reaction times in each condition for each participant were calculated. The mean and standard deviations of probe RT's and ER's for Experiment 2 can be seen in Table 3.30. The mean RTs were then submitted to a mixed ANOVA, with age (young versus older) as a between-subject variable and trial type (control versus ignored repetition), delay (immediate versus lag) and response type combinations (SS, SD, SD, DS) as within-subject variables. All significance tests were performed using a .05 significance level (two-tailed). Although older adults responded significantly slower and made more errors than younger adults, no significant differences as a function of trial type were found between younger and older adults, therefore the data were collapsed across all subjects. Median RTs were calculated separately for each experimental block.

Table 3.30

Mean and Standard Deviations of Reaction Times and Error Rates for Younger and Older Subjects on Ignored Repetition and Control Trials as a Function of Lag Condition and Block.

	Younger				Older			
condition	RT	SD	ER	SD	RT	SD	ER	SD
Immediate								
Block 1								
Control	871.89	211.15	0.05	0.09	1796.06	687.93	0.05	0.09
Ignored Repetition	885.57	235.86	0.04	0.08	1767.29	742.11	0.04	0.07
Block 2								
Control	813.95	171.96	0.04	0.08	1632.30	773.77	0.04	0.07
Ignored Repetition	838.39	209.35	0.04	0.08	1698.57	869.86	0.04	0.07
Lag								
Block 1								
Control	933.01	276.95	0.05	0.11	1832.96	850.48	0.04	0.10
Ignored Repetition	910.52	260.79	0.03	0.08	1843.60	789.36	0.04	0.11
Block 2								
Control	893.91	260.26	0.05	0.11	1874.59	1088.73	0.03	0.08
Ignored repetition	905.51	271.45	0.04	0.11	1797.05	922.63	0.04	0.11

A within-subjects three-way ANOVA involving trial type (control versus ignored repetition), delay (immediate versus lag), and response type combinations (SS, SD, DS, DD) revealed a significant interaction between delay and trial type F (1, 89)=4.50, $p<$ .037. Subjects showed NP in the immediate condition (18.91ms), but showed positive priming (23.48 ms) in the lag condition. Figure 3.31 shows this interaction graphically.

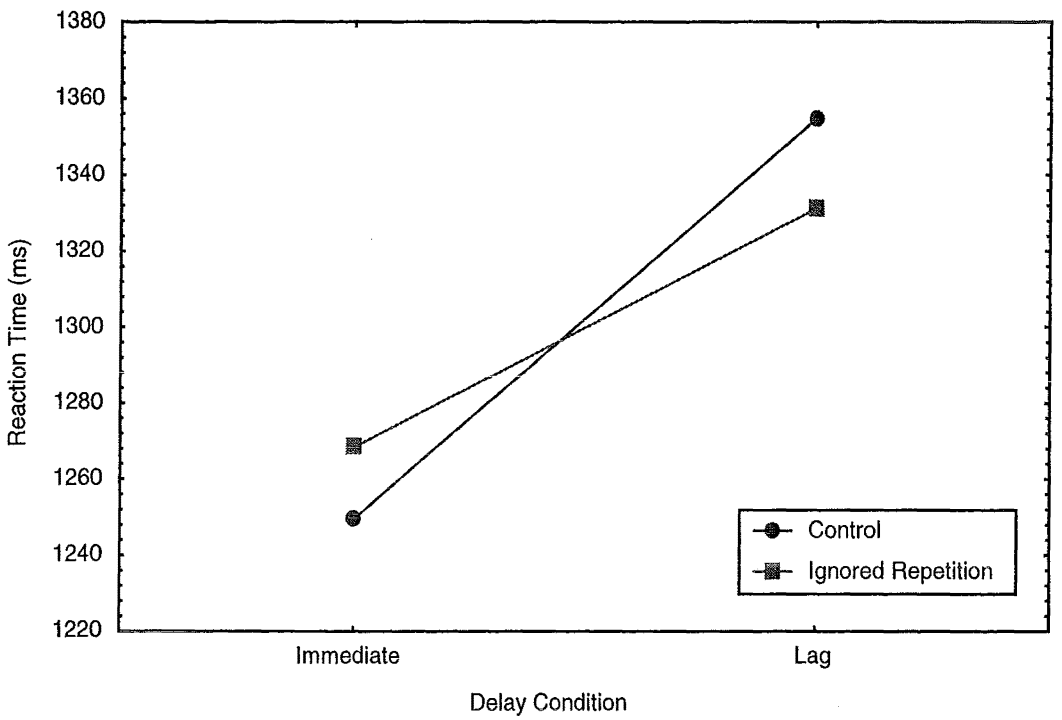

Figure 3.31. Mean participant RTs in an immediate condition and a lag condition as a function of trial type.

A further three-way within-subjects ANOVA was performed on the immediate data in order to assess the effects of stimulus repetition. This analysis included trial type (control versus ignored repetition), block (block 1 versus block 2), and response type combination (SS, SD, DD, DS). It revealed a significant interaction effect between trial

type and block, F (1,89)=7.56, p< .007. During block 1, subjects showed positive priming of (6.13 ms) which was not reliable but this reversed to NP (43.96 ms) in block 2. The NP in block 2 was significant, F (1,89)= 8.93, p< .004. Figure 3.32 shows this interaction.

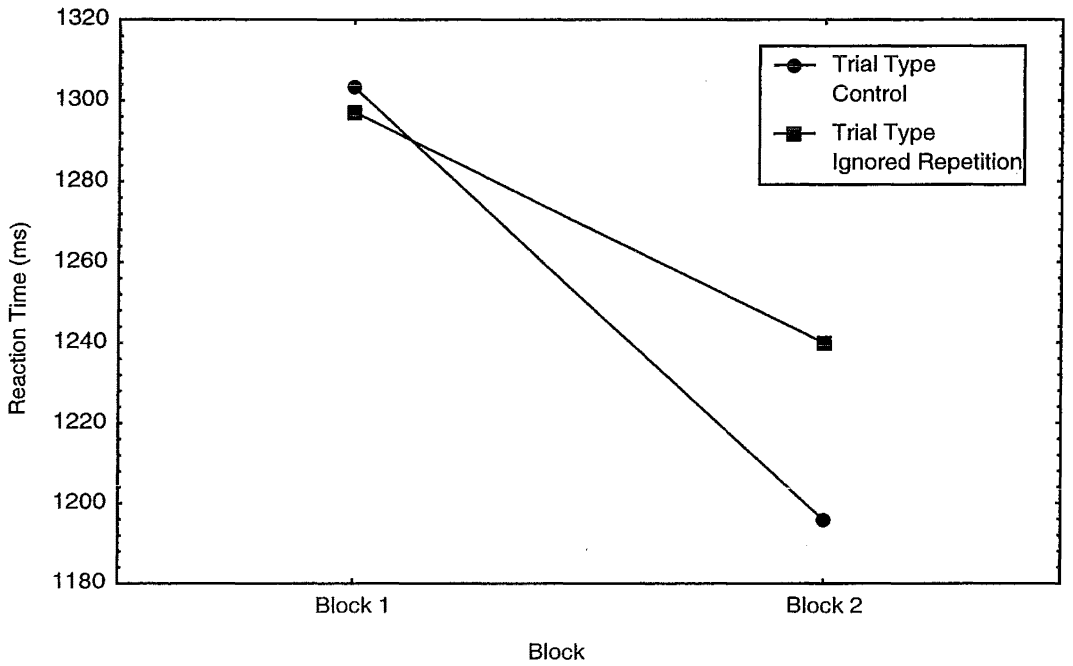

Figure 3.32. The interaction between block 1 and bock 2 and trial type for the immediate condition.

In the lag condition, reaction times on control trials tended to be longer than on ignored repetition trials. The difference between these two types of trials reflects a trend towards positive priming (24 ms) approaching significance, F (1,89)=2.65, p<.107. Delay also produced a significant main effect F(1,88)=33.16, p< .001. Subjects were responding

significantly faster to stimuli in the immediate condition than stimuli in the lag condition. Familiarity with stimuli in the immediate condition apparently facilitated responding to those stimuli. No other main effects or interactions of interest reached significance.

Probe Trial Errors

Probe errors rates were calculated as a proportion of trials for each condition. A within-subjects ANOVA conducted on error data showed that there were no significant or marginally significant main effects or interaction effects present in the error data.

Participant Awareness Data

An analysis of the catch trial data showed that subjects were only able to correctly identify the previous distractor shape 15.56% of the time, compared to 20.00% for correctly identifying the target shape. If subjects were simply guessing then one would expect subjects to correctly identify shapes on 20% (1 out of 5) of the trials. The green shape was selected at chance rates whilst the red shape was selected, if anything, at below chance levels. Apparently, after being quizzed for the non-target red shape, participants are not even explicitly remembering the target green shape. An analysis of participant answers to the question regarding their awareness of any prime-probe relationship revealed that only three subjects noticed that a distractor shape on one trial became a target shape on a subsequent trial. Two of these subjects only noticed this pattern on a few occasions, whilst the third subjects stated they noticed the pattern throughout the experimental session. This subject also correctly identified the red distractor stimulus on the recognition test. Data for this subject was not included in the data analysis.

Time of day data

At the end of the experimental session each participant was asked 'Do you consider yourself to be generally more mentally alert in the morning or in the afternoon?" The majority of older participants preferred the morning rather than the afternoon (77%) whereas the majority of younger subjects preferred the afternoon (52%). Each participant's preferred time of day was compared to the time they were tested, to determine whether the time of testing was congruent or incongruent with each subject's preferred time of day. An ANOVA conducted on the RT data of older and younger subject's with congruency as an additional between-subjects variable failed to reveal any significant interaction effects. Although not significant, there was a slight trend for congruent participants to show larger negative priming effects (25 ms) than for incongruent participants (15 ms). A supplementary analysis of older adults only in the immediate condition of block two revealed significant NP, $F(1, 40) = 4.5$, $p < .04$, with no hint of an interaction between trial type and congruency $F(1,40) < 1$.

3.40 Discussion

This experiment obtained significant NP for semantically unfamiliar shapes in an immediate condition using a small pool of shapes. Catch trial data showed that participants followed instructions to ignore the distractor stimulus and that the vast majority of participants were unaware of the trial type manipulation in this study. There were no significant differences in NP between older adults and younger adults. Rather than the finding NP in the lag condition, a weak trend towards positive priming was

found instead. The absence of NP in the lag condition challenges the generality of the finding of long-term NP with once-presented shapes reported by Treisman and DeSchepper (1996).

An absence of differences in NP between younger and older adults has important empirical and theoretical implications. As a first experiment evaluating NP in older adults with unfamiliar novel shapes, the present study helps extend the generality of stimuli to which older adults show intact NP, and in doing so questions those studies that report a lack of NP in older adults. These findings also question a general inhibitory deficit model of aging as well as suggestions that older adults may not show NP due to memory deficits. The data collected on time of day effects are not conclusive, although the data suggests that being tested at a time of the day incongruent with an individual's preferred time of day may reduce the magnitude of NP observed. However, NP still occurs, because a supplementary ANOVA on the immediate condition of block 2 for the older adults yielded a significant NP effect, with no additional contribution due to congruency. Therefore, this variable in itself is not sufficient to explain the discrepancies regarding age differences in NP found in the literature. This study replicates previous studies that have also found that older participants claim to be more mentally alert in the morning whilst younger people generally have peak mental alertness in the afternoon and evening (Intons-Peterson et al., 1998).

The tendency toward positive priming in the lag condition is consistent with failures to find long-term NP in Experiment 1. It is unclear why a tendency toward positive priming occurred in the lag condition instead of negative priming as reported by Treisman and DeSchepper (1996) with unfamiliar novel shapes. The present findings

suggest that in the lag condition once-ignored prime distractors did influence later performance when they eventually became a target, but that the influence, if anything, was facilitatory. It is possible that inhibition did not take place for these ignored shapes during the prime trial. This could be because the representations of once-presented stimuli in this condition were not sufficiently activated to create enough competition between target and distractor stimuli, thus making inhibition unnecessary.

The trend towards positive priming in the immediate condition of block 1 may have occurred for the same reasons. The stimuli in these blocks may not have been sufficiently activated. It is possible that only in block 2 when participants had encountered each stimulus numerous times in the role of a prime target that these stimuli were sufficiently activated to warrant inhibition when they became prime distractors, thus producing NP. This explanation of the current pattern of findings is consistent with the proposal that stimulus repetition is necessary for NP to occur and the finding that positive priming occurs with novel non repeated stimuli (Strayer & Grison, 1999).

The present findings are difficult to explain from the vantage of ER theory. If a stimulus is ignored on a prime trial, it should receive a "do not respond" tag, which should then be elicited when that stimulus subsequently becomes a probe target. The ensuing conflict with the requirement now to "respond" should lead to NP. Although not significant, the trend towards facilitation in the lag condition, suggests from an ER perspective that "respond " tags became associated with distractor stimuli. However, this explanation is inconsistent with the basic tenants of the ER theory. The ER theory provides no reason why a ''respond" tag would become linked with a distractor stimulus.

The next experiment utilised the same task and stimuli as the present study, but the luminosity and the salience of the display stimuli was manipulated. If it were the case that the degree of competitiveness between a target and its distractor influences the likelihood of obtaining NP effects, then manipulating the brightness of the stimuli might influence the immediate and lagged priming effects reported in this Experiment in an as yet, indeterminate manner. Rather than using a between-group design to compare a group of younger and older adults, the next Experiment compared three groups of younger adults. The classification of these younger adults was based on the salience of the stimuli to which they were exposed.

4.0 Manipulating Stimulus Salience

By focusing on inhibitory and memory-based hypotheses regarding the processes underlying NP, little attention has been directed at the information encountered in the stimulus displays themselves. This is problematic because NP experiments employ vastly different stimuli and experimental conditions. Findings from these diverse experiments are compared with one another as they are deemed to tap into the same cognitive processes. Given the many empirical discrepancies in the NP literature, it is important to know to what extent NP may depend on the specific nature of the stimulus information encountered by the observer. The present experiment manipulated the salience of the distractor stimulus and the luminosity of the entire stimulus display in order to determine their effects on NP.

The relative line thickness of the distractor to the target stimulus was manipulated between-subjects, with three different groups of participants. For the first group, the line thickness of the distractor, the target and the comparison figure was the same (ratio of distractor to target to comparison figure, was 2:2:2). For the second group, the line thickness of the distractor, the target and the comparison figure was different (the ratio of the distractor to the target to the comparison figure, was 2:1:1). A third group of participants received a mixture of both line thickness ratios across the two different blocks of the experiment. Based on past research (Kobari, 1998), it was anticipated that the group with the distractor to line thickness ratio of 2:2:2 would show a reduced magnitude of negative priming compared to the 2:1:1 ratio group, with the mixed group performing somewhere in between.

Both an ER model and an inhibition-based model could explain a finding of larger NP when the distractor to target line thickness ratio is 2:1:1. The ER theory might predict greater encoding of the distractor stimulus might occur when the distractor is thicker and thus more

salient, making subsequent retrieval more likely and therefore NP. However, in the 2:1:1 condition, there would also be a reduction in similarity between the prime and probe display as the prime distractor changes in both colour and salience when it becomes the probe target. Therefore, the ER theory does not make a clear prediction regarding the effect of increased distractor salience on NP. Inhibition-based theories such as the Houghton and Tipper model (1994; 1996) might predict that in the 2:1:1 condition because the distractor stimulus would be more salient, it might interfere more with responding and therefore would receive stronger inhibition, thus resulting in increased NP.

A second variable of interest was the decreased luminosity of all stimuli in both the prime and probe displays, relative to that used in Experiment 2. In accordance with an inhibition-activation account of NP, dull stimuli might reduce the activation level of stimuli and therefore the amount of competition between target and distractor stimuli. With little competition, there might be a reduced likelihood for the distractor stimulus to require as much inhibition. It is predicted that the reduced luminosity of the stimuli should result in a reduction in the magnitude of negative priming in this experiment compared to Experiment 2 in which the luminosity of all stimuli on prime and probe displays was brighter.

It is unclear what the ER theory would predict regarding the effects of stimulus luminosity on NP. The ER theory might predict that more luminous stimuli are likely to be encoded more extensively than less luminous stimuli, and therefore would be more likely to be retrieved, leading to greater NP. In any event, finding an effect of stimulus luminosity would be empirically important given that in the NP literature there are many inconsistent findings that could simply reflect the use of varying luminosity levels of the stimuli used in various studies.

Like Experiment 2, the present experiment included an immediate and a lag condition, with stimuli in the immediate condition drawn from a small pool of shapes and stimuli in a lag condition drawn from a large pool of shapes. Stimuli were the same as those used in Experiment 2. The present study examined the effect of stimulus repetition on NP as well as the effects of lag on NP with non-repeating stimuli. If the present experiment found similar stimulus repetition effects on NP and lag effects (a trend toward, or positive priming in the lag condition with once presented novel shapes) it would help to strengthen the reliability of the findings in Experiment 2. On the other hand, if salience and/or luminosity influence the magnitude or possibly the direction of the priming effects, this would cast some light on potential underlying mechanisms of NP.

4.10 Method

Participants

In total 54 participants were included in this study (27 females, 27 males), average age = 22.88, range (17-35 years). Participants were randomly assigned to three different groups, with 18 participants in each. Each subject received entry into a $50.00 cash prize draw in return for participation. All participants had normal or corrected vision, normal colour vision, and had no knowledge of oriental languages. Participants gave their informed consent to participate in the study.

Apparatus and Stimuli

The apparatus and stimuli used in this experiment were identical to the Experiment 2 except for the following changes. For one group the distractor to target line thickness ratio was 2:1:1 (where the red item was twice as thick as the green target) whilst another group the ratio was

2:2:2 (where the two items were of equal thickness). For a third group, the line distractor ratio varied between blocks in the experiment. For this third group, half the subjects received ratio 2:2:2 in block 1 and 2:1:1 in block 2 whilst the opposite occurred for the other half of subjects. Stimuli with a line thickness of two were 2 mm thick and stimuli with a line thickness of one were 1 mm thick.

A final manipulation was that the luminosity level of all display stimuli in both prime and probe displays was reduced compared to Experiment 2. Unfortunately, the sophisticated apparatus needed to measure this reduced luminosity was unobtainable. However, in Experiment 2 the brightness and contrast knobs on the computer monitor were turned 45 degrees anticlockwise from the maximum contrast and brightness position. In the present experiment, luminosity was reduced by turning the brightness knob anti-clockwise by a further 75 degrees and the contrast knob a further 15 degrees, from their position in Experiment 2.

Procedure

Apart from the random assignment of subjects to three different experimental groups, the experimental procedure was identical to that of Experiment 2.

Design

This experiment employed a mixed between and within-subject design. The between-subjects variable was the distractor to target line thickness ratio with three levels. For one group, the stimulus line thickness ratio of distractor to target was 2:1:1 whilst for a second group the ratio was 2:2:2. For a third group, the distractor to target line thickness ratio was manipulated within-subjects. In this group, half of the subjects encountered 2:1:1 line thickness for block one and 2:2:2 for block 2 whereas the other half of the subjects were exposed to the opposite order. For each group the line thickness of the comparison shape was

identical to that of the target shape. The major within-subject variable was the prime-probe trial type. As in Experiment 2, the two levels of this variable were; 1) control where the probe target figure is different from the prime distractor figure and 2) ignored repetition where the probe target figure is the same as the prime distractor figure. Half the trials were control trials and half were ignored repetition trials. Within each prime-probe couplet were four possible response type combinations; yoked same-same, different-different, same-different, and different-same.

Another within-subject variable was the interval between a prime and probe display. In the immediate condition, the probe trial followed immediately from a prime trial whereas in the lag condition a probe trial corresponding to a given prime did not appear until 64 trial couplets after that prime display (approximately 5 minutes). Stimuli and experimental trials representing the various conditions of the experiment were presented randomly for each participant.

4.20 Results

Median reaction time and error data were calculated exactly the same way as in Experiment 2.

Prime Reaction Time Data

In order to assess any effects based on the stimuli ratios, an initial analysis was conducted on prime trial data (i.e., before any other manipulations occurred). Analysis of the prime reaction time data revealed differences between the three groups. During the prime trial, subjects in the 2:2:2 group were responding fastest followed by the mixed ratio group, with the 2:1:1 group showing the slowest response times. This difference was significant, $F(2,51)=3.96$, $p< .025$.

Probe Reaction Time Data

An analysis of overall RT's on probe displays showed the same pattern of responding, again this difference in RT's between the three groups was significant F (2,51)=4.45, p<.017. However, although there was a significant main effect as a function of distractor salience, there were no significant differences between the three groups as a function of trial type. All three groups showed the same pattern of responding. Therefore, subsequent data analyses were conducted on data pooled across the three subject groups. The mean RTs and error rates can be seen in Table 4.30.

A four-way within–subject ANOVA, with delay (immediate versus lag), trial type (control versus ignored repetition), block (block 1 versus block 2), and response type combinations (same-same, different-different, same-different, and different-same) revealed overall positive priming of 12.11 ms, which was significant, F (1,53)=4.72, p<.034. Figure 4.21 shows response times in the ignored repetition trials compared to control trials for both the immediate and the lag condition. Delay also produced a significant effect, with faster reaction times in the immediate than in the lag condition, F (1, 53) =4.33, p<0.43. Again, familiarity with the stimuli apparently facilitated responding. No other main effects or interactions of interest reached significance.

Table 4.30.

Means and Standard Deviations of Participant Reaction Times and Error Rates for Immediate and Lag Data Separated into Blocks as a Function of Trial Type.

	Reaction Time		Error rate	
Condition	M	SD	M	SD
Immediate				
Block 1				
Control	796.91	230.53	0.0452	0.077
Ignored Repetition	772.68	206.20	0.0518	0.084
Block 2				
Control	760.13	200.03	0.052	0.082
Ignored Repetition	766.68	191.00	0.046	0.083
Lag				
Block 1				
Control	800.04	245.25	0.0555	0.108
Ignored Repetition	776.67	241.55	0.0486	0.108
Block 2				
Control	794.66	247.40	0.0463	0.117
Ignored Repetition	787.74	243.91	0.0521	0.113

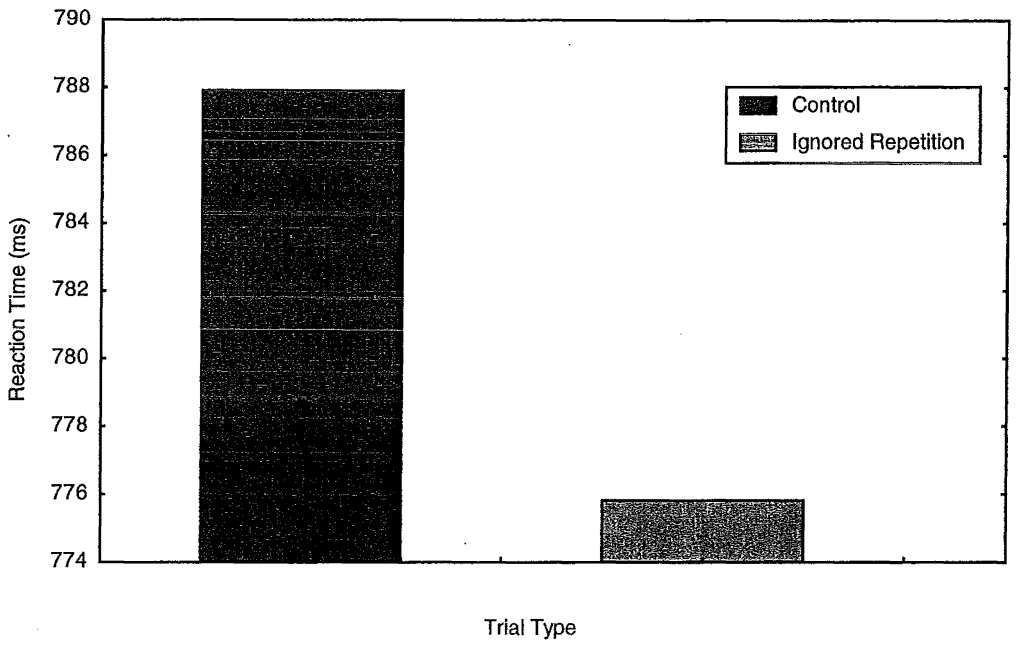

Figure 4.21. Mean participant reaction times on ignored repetition trials compared to control trials.

ANOVAS were also conducted separately for immediate and lag conditions. Most importantly, a three-way within subjects ANOVA (trial type, block, response type combinations) on the immediate data revealed a significant interaction between trial type and block, F (1,53) =6.68, p<.013. Subjects showed positive priming (24 ms) in block 1 and a slight trend toward NP (5 ms) in block 2. This positive priming in block 1, was significant, F (1,53) = 7.32, p< .01.

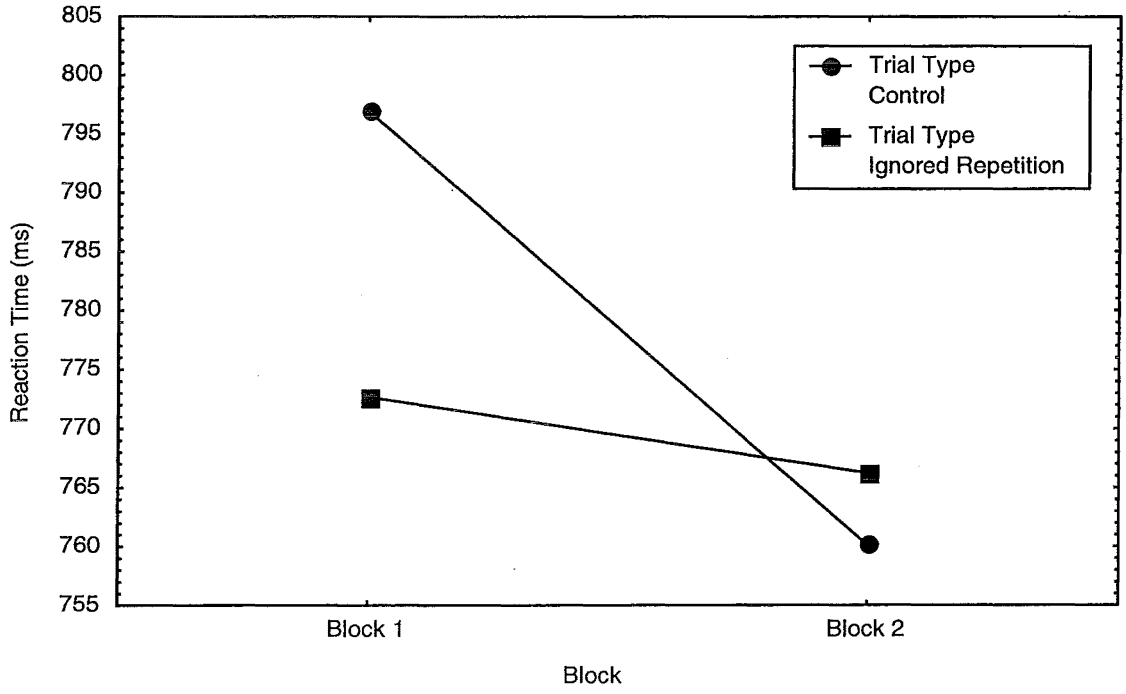

Figure 4.22. The interaction between participant RTs in the immediate condition of block 1 and block 2 as a function of trial type.

The main effect of trial type in the lag condition indicated a marginally significant trend towards positive priming (15.5 ms) which approached significance, F (1, 53)=3.56, p<. 065.

Probe error data

An analysis of error data revealed no significant effects or marginally significant effects of trial type. Thus, the evidence of positive priming in the RT data cannot be attributed to a speed/accuracy trade-off.

Catch Trial Data

An analysis of the catch trial for recognition of the attended and unattended shapes revealed that on 26% of the trials subjects correctly selected the red distractor stimulus and on 35% of trials subjects correctly selected the green target stimulus. If subjects had been guessing randomly, one would expect correct selection of the shapes on 20% of the trials. Therefore, subjects appear to be at about chance at selecting the distractor stimulus from the previous trial, and above chance at recognising the green target shape. An analysis comparing the performance of the subjects who did with those who did not correctly select the distractor shape failed to show any differences in the pattern of performance. Participant answers to the question of whether they noticed a pattern of the distractor on one trial becoming a target shape on a subsequent trial, revealed that no participants noticed the distractor repetition pattern.

Between-experiment analysis

A between-experiment comparison of the younger adults from Experiment 2 with the subjects from the present experiment was carried out. Given that the distractor salience manipulation did not affect NP, the main difference between the two groups was that younger subjects from the Experiment 2 encountered the stimuli with a higher luminosity rating than in the present experiment.

A mixed-design ANOVA with experiment as a between-subjects variable and three within-subject variables; trial type (control versus ignored repetition), delay (immediate versus lag) and response type combination (same-same, same-different, different-different, different-same), revealed a significant interaction between experiment and trial type, F (1,100)=5.65, p<.019. Subjects in Experiment 2 showed a predominance of NP whilst subjects in the present experiment showed a predominance of positive priming.

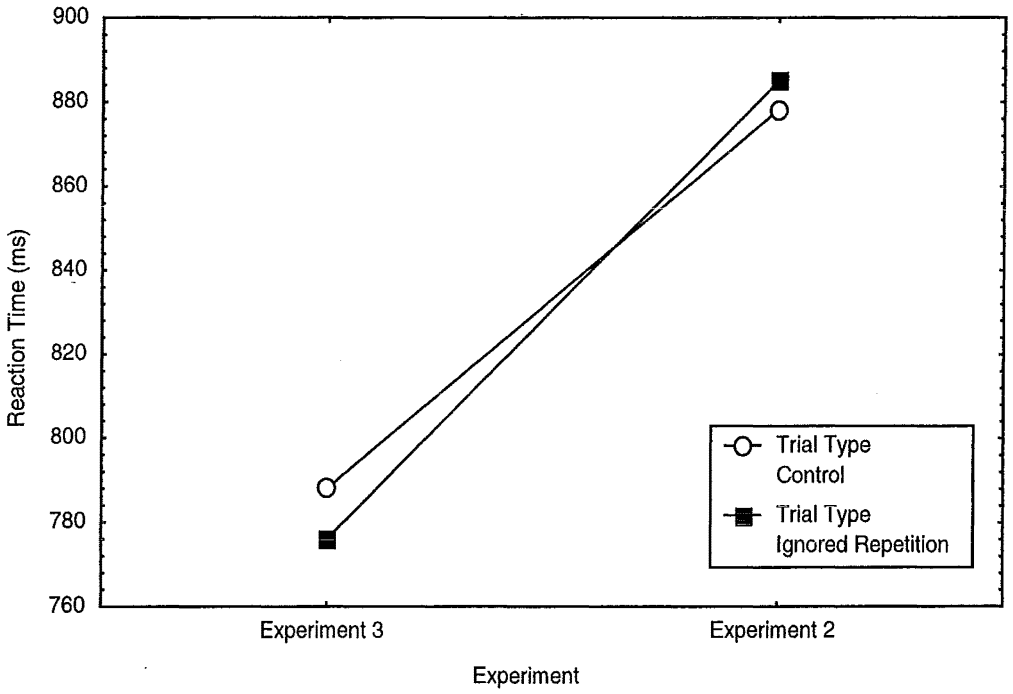

Figure 4.23. The interaction between trial-type and experiment. Experiment 2 represents the younger adults from the previous experiment and Experiment 3 represents all participants (younger adults) from the present experiment.

A comparison of prime and probe RTs in the control condition for Experiment 2 and Experiment 3 revealed significant differences in overall RT times. For probe control trials, participants in Experiment 2 were responding slower (M=878.19 ms) compared to subjects in Experiment 3 (M=787.93 ms). This difference in mean reaction times was reliable F (1, 100)=6.20, $p<.015$. This effect was duplicated when analysing overall prime RT data. In the present experiment participants were responding on average in 822.44 ms whereas participants in the previous experiment were responding on average in 931.96 ms. This difference was found to be significant, F (1,99)= 8.32, $p<.005$. No significant differences in error rates occurred between Experiment 2 and 3.

4.30 Discussion

Contrary to prediction, there were no significant differences in responding between the three experimental groups as a function of trial type. Therefore, selection difficulty (as indicated by the line thickness of the distractor relative to the target stimulus) did not modulate NP. There were differences however, with respect to overall reaction times between the three groups, suggesting that the manipulation of line thickness ratio had an effect on distractor interference. This is compatible with other studies that have shown dissociations between NP and distractor interference effects. Manipulating the line thickness ratio of distractor to target stimuli may well influence the level of the NP effect, as found by Kobari (1998). However, something about the conditions of the present experiment prevented negative priming from emerging at all. Rather, positive priming occurred in all three experimental groups.

The present findings are relevant to the debate over the effects of stimulus repetition on NP. In the immediate condition, trial type interacted significantly with block. Large positive priming occurred in block 1, which reverted to a small trend towards positive priming in block

2. The pattern of priming across blocks might be compatible with Experiment 2 in the following sense; in Experiment 2, small trends towards positive priming occurred in block 1 with rather large NP emerging in block 2. In both experiments, inhibition appears more likely to occur with stimulus repetition over time. This is consistent with the demonstration of the importance of stimulus repetition on NP (Strayer & Grison, 1999).

The absence of NP in the lag condition of the present experiment also supports the stimulus repetition hypothesis because the critical stimuli were not repeated throughout the experiment. Apparently, NP only occurs when a sufficient degree of inhibition is applied to a distractor stimulus, whether this is in the short-term, or, in principle, even in the long-term. Finding an absence of long-term NP also challenges memory–based models that use evidence of the long-term nature of NP in support of their arguments. Additionally, the present findings challenge the generality of findings of long-term NP with novel shapes.

Participants in this experiment showed significant positive priming whilst those of the Experiment 2 showed negative priming. The difference in the luminosity of stimuli between the experiments may have resulted in this difference. A memory-based model might explain the effects of stimulus luminosity on NP by claiming that a reduction in brightness of stimuli might lead to poorer encoding and retrieval compared to when the stimuli are brighter, thus reducing or eliminating NP. However, such an explanation could not account for the positive priming found under these conditions. It is possible that the observed positive priming was due to persisting activation, but a persisting activation account would have difficulties explaining the occurrence of positive priming in the lag condition. It is unlikely that persisting activation would last over this duration.

An inhibition-activation model might be able to explain findings of stimulus luminosity. Preliminary results investigating brain activity using fMRI in response to

increasing image contrast have shown an increase in brain activity in the primary visual cortex. Neurons in the primary visual cortex fire more as the brightness contrast between the stimulus and its background increases (Menon, 2000). In the present study, the low luminance of the stimuli may have reduced the activation level and therefore the competitiveness of the distractor stimulus. This would be expected to make the task easier to perform. Support for this conjecture comes from a comparison of overall reaction times from this experiment with the younger participants from Experiment 2. Participants in the present experiment responded significantly faster than in Experiment 2, suggesting that the distractor items were not as competitive (and thus not as interfering) with target items.

The above explanation might also explain why the magnitude of positive priming in block 1 of this experiment was greater than in block 1 of Experiment 2, and why NP never fully emerged in block 2 in this experiment (in contrast with Experiment 2). A slower buildup in the engagement of inhibition appeared to have occurred in this experiment compared with Experiment 2. Although repeating these low activated stimuli did appear to increase the involvement of inhibitory mechanisms over time (as evidenced by a marked reduction in positive priming in block 2 compared to block 1), stimulus repetition in itself was not sufficient to result in NP with the low luminosity display. Whilst under some experimental conditions stimulus repetition might be necessary for NP to occur, other variables besides stimulus repetition might affect the competitiveness of target and distractor stimuli. One such variable may be the brightness of the stimuli that might affect their initial activation levels. When the initial competitiveness of stimuli is high, such as with very bright stimuli, it is possible that NP could occur even with a once presented novel shape.

5.0 General Discussion

Three experiments investigated identity NP with initially unfamiliar novel shapes. The luminosity of the stimuli, the time interval between related prime and probe displays and the repetition of the stimuli appeared to influence the presence of NP. These findings shed light on the determinants of NP and are relevant to theories of NP. The activation-inhibition account of NP is most compatible with the present findings. However, the present findings suggest that the activation-inhibition account may be too restrictive and needs broadening to incorporate other factors that could affect the activation level of stimuli. The activation-inhibition account also needs to acknowledge the role that retrieval processes appear to play in NP. A consideration of these findings with respect to the existing literature and various theories of NP will now follow.

5.10 Research Findings

Stimulus Luminosity Effects

In Experiment 3, stimulus luminosity was reduced compared to Experiment 2 and the task and procedure was held constant. This reduction in luminosity resulted in NP reversing to positive priming in the immediate condition of Experiment 3. This effect of stimulus luminosity is pertinent to theories of NP. An inhibition-based theory can explain these findings as due to stimulus luminosity affecting the activation level of stimuli. In support of this, Goodyear and Menon (1998) showed that in the human visual cortex there is an increase in the activity of cells in the V1 area with increasing luminance contrast. In Experiment 3, the lower luminosity levels of the stimuli might have resulted in the stimuli having lower levels of activation. This lowered activation might have reduced the level of competition between distractor and target stimuli.

When distractor stimuli were not highly competitive with target stimuli, inhibition may not have been emitted or may have been emitted but to a lesser degree. This could explain why there was so little NP in Experiment 3.

The ER theory might explain the effect of stimulus luminosity on NP by claiming that the reduced luminosity of stimuli in Experiment 3 might have impaired the encoding and/or the retrieval of the stimuli, thus reducing NP. If this explanation were correct, however, then null effects might have been the expected outcome rather than overall significant positive priming. From an ER viewpoint, the occurrence of positive priming suggests that "respond" tags were attached to distractor stimuli. However, the ER theory does not provide any reason why a "respond" tag would be linked to a distractor stimulus. It could be that the obtained positive priming effects were due to persisting activation, which Neill et al. (1992) do propose as a potential secondary source of facilitation. However, Neill et al. also suggest that this facilitation should only occur under circumstances in which a probe target stimulus or a probe display is sufficiently different from the prime stimulus or prime display so as not to elicit retrieval of the prior prime episode. Moreover, given that trends towards positive priming occurred in the lag condition in Experiment 2 and 3, it is unlikely that persisting activation would last over this extended time interval to explain the presence of positive priming.

The finding that the luminosity of stimuli affects NP is empirically important. Firstly, the occurrence of positive priming when the luminosity of stimuli was low, supports other studies that have found positive priming to occur under certain experimental conditions instead of negative priming in the ignored repetition condition. Secondly, the present findings lend partial support to those of Fox and De Fockert (1996). Whilst Fox and De Fockert reported that low luminosity stimuli do

produce NP as long as prime and probe displays shared the same luminosity (unlike the present findings), they did find greater levels of NP to occur with brighter stimuli which is consistent with the present findings.

A third reason why an effect of luminosity is empirically important is that findings of null and positive priming effects along with the many empirical discrepancies in the NP literature could be due to a lack of attention to the information provided in stimulus displays. NP experiments vary enormously in the type of stimuli used, the type of spatial arrangements, colours, luminosity, and stimulus presentation times. Given that stimulus-driven properties such as stimulus luminosity appear to influence NP, some of the empirical discrepancies in the NP literature could be due to differences in the stimuli used across NP studies, especially with respect to the competition they are likely to induce. Thus, an especially important consideration for researchers in this area would be to develop an objective method for determining whether the parameters of the stimuli used in a particular task are such that they are sufficient to elicit the inhibition of distractors. Only after such minimal requirements have been established would it be possible to test hypotheses such as inhibitory deficiencies in older adult populations, for example.

Repetition Effects

Experiment 2 and 3 each contained two experimental blocks presented in sequential order. In the immediate condition, the same small pool of stimuli was used repeatedly in blocks 1 and 2 whereas in the lag condition, block 1 included half of a large pool of stimuli with the remaining half being presented in block 2. The immediate condition of Experiment 2 and Experiment 3 thus allowed an evaluation of stimulus repetition effects on NP. In Experiment 2, NP only occurred in block 2, not

in block 1, suggesting the importance of stimulus repetition in producing NP. In Experiment 3, positive priming occurred in block 1 which was no longer significant in block 2 (rather a trend towards NP). Thus, in both experiments, positive priming decreased over time and tended to reverse to NP (significantly so in Experiment 2). These findings suggest that inhibition is more likely to play a role, or to become stronger, after repeated encounters with stimulus items over time.

The activation-inhibition account of NP could explain the effects of stimulus repetition on NP by claiming that stimuli must reach a threshold level of activation for NP to occur. On this view, when stimuli are encountered as targets they receive boosts in activation as a function of repeated exposures, so that they eventually become more competitive when they appear as prime distractors. Such highly competitive distractors are more likely to undergo inhibition and NP thus results when they become probe targets. Distractor stimuli that are not highly activated may produce facilitation from residual activation due to the absence of this enhanced degree of inhibition.

Although the activation-inhibition account can handle the findings from Experiment 2 and 3, participant responding in the immediate condition of Experiment 1 places a limitation on the activation-inhibition account. In Experiment 1, participants showed significantly larger NP effects on day 1 compared to day 2 in the immediate condition. Strayer and Grison's (1999) repetition hypothesis and the activation-inhibition account of NP, would predict that participants would show more NP on day 2 compared to day 1. This is because on day 2 participants would have encountered each stimulus in the small pool of stimuli more times than on day 1 (because the same small pool continues to be used on day 2). It is possible that the activation of the representations of the shapes did not survive over the 24-hour time

lag, so that increased NP on day 2 did not occur. However, even if this were the case, participants on day 2 should have showed at least as much NP as on day 1. Findings from Experiment 1 therefore question the generality of Strayer and Grison's (1999) repetition hypothesis.

The ER theory cannot explain why NP showed a tendency to increase over time in the immediate condition of Experiment 2 and 3. It is possible that the number of memory tags attached to each stimulus increases over time, resulting in a higher probability of retrieval and therefore greater NP. The composition of the present tasks dictates against this, however. The small pool of items used in the immediate condition fulfill the role of both target and distractor stimuli randomly throughout the immediate condition, except to fulfill the constraints of an equal number of control and ignored repetition trials. Thus, on average, each item serves as both a target and distractor an equal number of times. Importantly, however, the most recent status of a probe target item in an ignored repetition trial would be as the prior prime distractor, and, as such, should have a " do not respond" tag attached to it. Although, there might be a higher chance over time of null effects due to these two types of tags canceling each other out, the ER theory would not predict an increase in the NP effect due to stimulus repetition.

In contrast to the present findings and those of Strayer and Grison (1999), DeSchepper and Treisman (1996) found NP to occur with once-presented novel shapes. The reason for this discrepancy is unclear. Strayer and Grison (1999, Experiment 5A & 5B) attempted to replicate Treisman and Deschepper (1996, Experiment 2) and found non-significant positive priming, using 16 trial-couplets (comprised of 8 ignored repetition trials and 8 control trials), which took participants 5 minutes to complete. By comparison, DeSchepper and Treisman found significant

NP for novel shapes that were presented only once on a prime trial and once on a probe trial using 40 trial-couplets. Given the difference in the number of trials between the two studies, the discrepant findings might be due to the limited number of data points collected and the brevity of the experimental session in the Strayer and Grison study.

If under some experimental situations, NP can occur with once presented novel shapes, it is possible that it could take some time to emerge. One reason for this might be that focused concentration may need time to develop or to become heightened in NP experiments. Therefore, although in some experimental situations NP may occur for once presented novel stimuli, participants may still require a certain period of responding in order for NP to occur. In this vein, there is evidence that participant expectancies of probe trial conflict can affect NP, as has been discussed earlier. The present findings further suggest that the degree of conflict encountered in primes, as well as probes, can affect NP. Appropriate expectancies regarding the degree of anticipated conflict encountered over trials appears to require time to develop.

Another potential explanation for the above discrepant findings hinges on the same explanation given for the present findings. That is, differences in the luminosity levels of the stimuli used in the two above studies might have affected the activation level and thus the competitiveness of distractor stimuli with their targets. Unfortunately, the luminosity levels of the stimuli in the above two studies is unknown. A plausible reconciliation, given my explanation above, is that both laboratories are correct. NP may occur for once presented ignored novel shapes that are sufficiently activated on their first encounter. As has been proposed, the activation level of representations of stimulus items might be influenced by the luminosity of the

stimuli. Hence, distractor representations with low activation levels that do not require inhibition may produce positive priming instead. For these stimuli, repetition may be required in order to increase their activation levels, thus leading to their inhibition and NP.

Age Effects

In the immediate condition of Experiment 2, older adults showed NP equivalent to that shown by younger adults with unfamiliar novel shapes. This finding complements a number of studies that have found intact identity NP in older adults using familiar words and pictures, and extends findings of intact NP in older adults using unfamiliar novel shapes. Given the proposal that inhibitory processes at least partly underlie NP, the older adults in the present sample do not appear to have impaired inhibitory processes. Conversely, if retrieval processes underlie NP (exclusive of inhibitory processes) then older adults do not appear to have deficient retrieval processes either. With respect to the variable of time-congruency, this factor did not significantly contribute to the magnitude of NP. This contrasts with findings emphasising the importance of time of day effects (Intons-Peterson et al., 1998).

Lag Effects

Contrary to predictions, NP after varying lags between related prime and probe displays did not occur in the present experiments. Experiment 1 failed to find NP at a 24-hour time lag between related prime and probe displays. Two additional experiments examining NP at a shorter 5 minute time lag also failed to find evidence of long-term NP and conversely, found trends towards positive priming (approaching significance in Experiment 3). It appears that NP for the stimulus sets and conditions of the present experiments using unfamiliar novel shapes is not of a long lasting nature. However, whilst the processes underlying NP may not be long lasting, the

weak facilitatory trend found in the lag condition of Experiment 2 and the strong facilitatory trend found in the lag condition of Experiment 3 suggest that participants remembered something about the prime display that influenced their responding on the related probe display. This suggests that participants created a unique memory trace for each stimulus that facilitated subsequent responding to that stimulus on its next appearance.

Failure to find long-term NP with once presented novel shapes is inconsistent with findings of long-term NP with once-presented novel shapes (Treisman & DeSchepper, 1996). The present findings are also inconsistent with findings of long-term NP for familiar English words (Neumann & Russell, 2000), and long-term NP using Kanji figures with native Japanese speaking participants (Neumann, Iwahara, & Tajika, 1999). The present findings therefore question the generality of long-term NP effects.

The absence of NP with unfamiliar shapes is theoretically important because findings of long-term NP have been used a basis for supporting the ER theory. However, the failure to observe long-term NP in this study does not mean that retrieval processes are not involved in a NP task. In the present experiments, insufficient competitive activation of stimuli may have prevented inhibition-based processes from operating. Therefore, implicit memory of the prime distractors could have affected responding but without any associated inhibition, thus precluding finding long-term NP. This form of implicit memory for the distractor that can instead produce facilitation remains to be determined.

Research Findings and Alternative Theories of NP

The present findings are relevant to alternative theories of NP. The temporal-discrimination theory (Milliken, Joordens, Merikle, & Seiffert, 1998) focuses on processes that purportedly occur on the probe display rather than on the prime display. This theory can explain the effects of repetition on NP, because the theory would expect that NP would be most robust when small stimulus sets are used. This is because the proposed discrimination process takes on increased importance with small stimulus sets. However, like the ER theory that also includes memory processes, these theories consider retrieval to be an automatic phenomenon elicited by the probe target. If this is the case, then it is unclear why NP is influenced by the luminosity of stimuli in a display.

The transfer inappropriate processing-transfer appropriate processing (TIP-TAP) theory was recently developed by Neill and Mathis (1998). It was developed as a general theory of cognitive processing in the fields of selective attention and memory. The theory lays down conditions that give rise to transfer-inappropriate processing (TIP) and facilitation of performance or transfer-appropriate processing (TAP). According to TIP-TAP, NP results from the retrieval of processing information that is incompatible with the current probe trial processing requirements, whereas positive priming may result from the retrieval of processing information that is compatible with current processing requirements. Whether retrieval processes determine performance depends on the speed of retrieval relative to the speed of algorithmic processing. Although retrieval of discrepant features as well as conflicting response information could cause NP, the theory stresses task-relevant processing mismatches.

In the present series, the direction of priming effects was influenced by stimulus repetition and the luminosity of stimuli. Explaining the direction of priming effects in the present experiments by reference to whether transfer-appropriate or transfer-inappropriate processing occurred is therefore troublesome. Neither the luminosity of stimuli or the repetition of stimuli relate to task-relevant processing. The task requirements between the various conditions in each experiment and between Experiment 2 and Experiment 3 were the same.

5.20 Limitations of the Present Research

A potential criticism of Experiments 2 and 3 is that the Japanese Kanji figures used as stimuli were inherently more complex than those used by DeSchepper and Treisman (1996). This may account for the different outcomes between the two experiments. Perhaps the added complexity of the stimuli affected access to the appropriate response-tagged tokens upon presentation of the probe target. This may explain why NP failed to occur in the lag conditions of these experiments. However, the strong trend toward positive priming with once-presented novel shapes in Experiment 3 suggests that participants created a unique memory representation for each stimulus that influenced subsequent behaviour towards that particular stimulus on its next appearance.

Another potential criticism is that the older participants in Experiment 2 might not be representative of older adults in the general population, in that they may be more highly educated or be more highly functioning. However, the younger participants had far higher levels of education than the older adults did. In fact, the older adults in Experiment 2 were overall not highly educated, with the majority reporting no tertiary education. Although older adults in Experiment 2 showed NP, it

is unclear whether this NP reflects intact inhibition-based mechanisms, memory processes, or both. It is possible that the obtained NP indicates that both processes are intact. If so, the finding of intact NP in older adults contradicts a general inhibitory deficit theory of aging (Hasher & Zacks, 1988). Unfortunately, the time congruency variable in Experiment 2 was not directly manipulated, ruling out any definitive conclusions regarding time of day congruency effects in explaining age differences in NP, when they occur. Future researchers need to carefully consider this variable and the effect it may have on NP.

Unfortunately, software limitations prevented inclusion of a novel stimuli condition in the immediate condition of each experiment. The occurrence of NP in this condition, might have suggested that NP could occur for once-presented shapes, but that this is not particularly long lasting. On the other hand, if positive priming had occurred in this condition rather than NP, it would have strengthened the stimulus repetition hypothesis (Strayer & Grison, 1999).

A final limitation is that the luminosity of stimuli was manipulated between Experiments 2 and 3. A more powerful demonstration of this effect in the future would be to manipulate this variable using a within-subjects design. Regardless, experimenters should begin to describe luminosity levels of stimuli in their experiments, and the nature of the background/stimulus contrasts used in their experiments.

5.30 The Role for Inhibitory and Excitatory processes in Selective Attention

The present findings may be best accounted for with respect to the operation of inhibition-based processes. Neurophysiological evidence supports such a role for inhibitory processes in selective attention (e.g., DeLosh, Peterson, Cincotta, Merritt, Seger, & Reilly, 2000). For example, Moran and Desimone (1985) demonstrated that when one stimulus was ignored while attention was directed to another stimulus, the response of the cell in whose receptive field the ignored stimulus was located was suppressed. Furthermore, Arsten (1993) showed that the drug Naloxone improves selectivity in the frontal lobes by increasing the suppression of distractors rather than by changing the analysis of the attended targets.

Besides supporting the role of inhibition in NP in Experiments 1 and 2, Experiment 3 has also shown the presence of facilitatory effects in the same NP task using the same procedure and same type of stimuli. The presence of facilitatory effects supports the notion that both inhibitory and excitatory processes are involved in selective attention. This finding is consistent with Khurana (2000) who also found facilitatory and inhibitory effects to occur in the same task. Khurana noted that the involvement of both facilitatory and inhibitory processes in NP indicate that the inhibition measured in NP tasks may be an underestimate of the actual inhibition present because of the opposing facilitation.

Tipper and Milliken (1996) explain how the proposal for the role of inhibitory and excitatory processes in selective attention is essential, given that any amplifying or inhibiting mechanism must operate within finite limits. Therefore, the rate at which one signal can be amplified relative to another must have some upper limit. A dual-mechanism that can excite a target and inhibit a distractor signal would greatly increase the speed at which a target and distractor signal can be disentangled. Such

rapid selection would be biologically adaptive. Signals in a biological information-processing system must also have a limited dynamic range. Two very weak stimuli may be easy to separate out using only an excitatory mechanism. The lower degree of competition involved, under such conditions might be less likely to recruit inhibition, or at least not the same degree of inhibition as with two intense stimuli. Two intense stimuli may be more likely to evoke inhibitory mechanisms, as neural response to them would be close to threshold, making selection from only an excitatory system difficult. An inhibitory mechanism working in conjunction with an excitatory system would be able to separate out target and distractor signals more efficiently than an excitatory system operating alone. This would be especially adaptive in situations where target selection is difficult such as when target and distractor stimuli are highly competitive with one another, as in Experiment 2 where the luminosity of the target and distractor stimuli was high.

The Nature of Inhibition

Whilst inhibitory processes appear to play a role in selective attention, the precise nature of inhibitory processes is unclear. Rather than inhibition being a largely automatic process, there is evidence that inhibition may consume attentional resources (Neumann & DeSchepper, 1992). Conway and Engle (1994) showed that inhibition is resource demanding and that participants differ in the attentional resources available to them. In their study, participants with greater attentional resources showed a greater capacity for inhibiting information that was irrelevant to performing the task. Conway, Tuholski, Shisler, and Engle (1999) looked at effects of a verbal and non-verbal memory load on a letter-naming NP task and only found NP under conditions of a zero memory load. An investigation of NP in patients with hemispatial neglect

showed that NP only occurred when ignored stimuli were presented in the non-neglected field of participants, whereas stimuli presented into their neglected fields resulted in positive priming. Attention may therefore be necessary in order for NP to occur (Kim, 2000).

Although attention to a distractor stimulus may be necessary for NP to occur, there may be a difference between a distractor being ignored and being unattended. In most NP experiments, ignored distractor stimuli cannot explicitly be reported. However, there is evidence that substantial high-level processing of these ignored stimuli can occur. One possibility is that ignored stimuli are processed and entered into implicit memory without being encoded into explicit memory. Therefore, these stimuli receive the influence of some processing resources but do not leave any lasting overt impressions on the observer. Wolfe (1997a) points out that these stimuli may be seen, but are instantly forgotten. This leaves implicit but not explicit traces for the experimenter to measure.

The Role for Selective Attention Processes and Retrieval Processes in NP

Pesta and Sanders (2000) recently proposed that both inhibition-based and memory processes are involved in NP tasks. In particular, they proposed that the memory representation of all attended to prime items (both targets and distractors) are positively primed, proportional to the degree of attention they have received. This positive priming then facilitates subsequent responding to that item. Additionally, a 'respond' tag becomes linked to the semantic memory representation of the target stimulus. Although separate, the positive priming effect of this tag summates with positive priming due to attention, further facilitating responding to that stimulus on its next appearance as a target. For the distractor stimulus, an 'ignore me' tag becomes

associatively linked to its semantic memory representation and its retrieval results in slowed responding to the stimulus when it next appears as a target. However, this NP also summates with the positive priming resulting from attention. Whether the overall effect when the item next occurs is to facilitate or to impair responding depends on the relative strengths of the combination of these processes in that item's episodic history.

This model can explain findings of positive priming in the present series under certain experimental conditions without relying entirely on explanations based on persisting activation. This is important because it may be unreasonable to expect that persisting activation would last over long temporal durations. However, the Pesta and Sanders (2000) model does not include the important idea that inhibition may be reactive to the activation level of a stimulus. The findings from the present series of experiments reinforce the notion that inhibition of a distractor stimulus can take place to varying degrees based on its initial activation level.

5.40 New Theoretical Model of NP

Despite problems with the Pesta and Sanders (2000) model, it is the first model of NP to explicitly recognise that the NP paradigm measures both selective attention and memory processes. In a NP task, the prime display requires that participants selectively attend to the target stimulus and ignore the distractor stimulus. The probe display also involves selective attention and sequential responding, (responding to the probe target that had previously been encountered as a distractor on the prime display) in the ignored repetition condition. Given that information contained in the prime display is no longer present in the physical environment, any effects from this information on a probe display must involve memory retrieval. In

some circumstances, this retrieval of prime display information slows responding on ignored repetition trials compared to control trials.

Theories to date have focused on explaining selective attention processes that are most relevant on the prime trial or they focus on retrieval processes that are most relevant on the probe display. Some authors have acknowledged the contribution of both processes to NP (Kane, et al. 1997), however, rather than correctly acknowledging that these two processes operate in unison, they suggest that certain experimental conditions make either inhibition or memory processes more likely to occur at one time or another. The proposal for the involvement of both inhibitory and memory processes operating together in NP tasks may have too many degrees of freedom to be testable. However, this proposal may be necessary given that the NP paradigm clearly involves more than just selective attention, and more than just memory retrieval.

In accordance with Pesta and Sanders (2000), I also propose that all prime display stimuli receive activation proportional to the amount of processing they receive. After target selection, inhibitory mechanisms function to suppress the representation of the distractor stimulus if the distractor stimulus provides sufficient competition with the target stimulus. This inhibition functions to reduce the likelihood that distractor stimuli are erroneously selected for responding. The magnitude of this inhibition is reactive to the amount of activation the distractor stimulus initially receives. On the probe display, repercussions of this inhibition will cause a slowdown of responding if it outweighs the underlying activation of the stimulus due to prime trial processing. As others have suggested, inhibition may take the form of a tag labeling a stimulus as relevant or irrelevant for a response. This tag may be encoded

as part of the episodic memory representation of that distractor stimulus during the prime trial and might be retrieved during the probe trial to influence responding.

On this view, positive priming would be expected if the prime distractor was not inhibited on the prime trial due to being insufficiently competitive, or because the stimulus was inhibited but not of a sufficient magnitude to override the underlying initial excitatory process. This proposal can explain findings of facilitatory trends in the ignored repetition conditions of the current experiments. Without sufficient inhibition, positive priming may have resulted from the retrieval of a specific memory trace for a stimulus without any associated inhibition, thus facilitating subsequent responding to that stimulus. A secondary more time-limited source of facilitation, persisting activation, may also have contributed to this facilitation of response times, as for example, in block 1 of Experiment 3.

The fact that many individuals in the present series and in many NP experiments show positive priming rather than NP, suggests that there are differences in the selective attention processes that individuals employ. Some individuals appear to selectively respond based on excitatory mechanisms alone. Perhaps the level of stimulus competition needed for inhibitory mechanisms to operate may be higher in these individuals than in others.

Based on this proposed model, the occurrence of null effects in some NP studies may be because inhibitory and excitatory processes have cancelled each other out. When positive priming occurs, inhibition may be present but may not appear in participant reaction times because the inhibition may be too weak to override residual activation of the representation that persists from the prime to the probe trial. Thus, the magnitude of NP, and the direction of priming, may depend on the relative strengths of these two aspects of selective attention; namely, facilitatory and

inhibitory processes, and the subsequent retrieval of the outcome of the instantiation of these processes elicited by the probe display.

An assumption of this model is that selective attention is best conceptualised as a process that allows one to respond to task relevant stimuli whilst not responding to task irrelevant stimuli. Such an action-based view of selective attention is in accordance with Tipper and Cranston (1985) who proposed that the representations of distractor stimuli themselves are not inhibited, but rather the link between distractor representations and response mechanisms. Another assumption is that responding on a NP task involves a 'template for responding' based on an anticipated level of conflict in performing the task. Support for this assumption comes from evidence that NP fails to occur for non-conflict probes but occurs for non-conflict and conflict probes that are randomly intermixed (Moore, 1994). Whilst some have suggested that a template might contain mainly object-based information such as target features (Houghton & Tipper, 1996), the present proposal is more in line with an action-centered view of selective attention, whereby a participant's template includes the anticipation of a particular amount of competition occurring between target and distractor stimuli. This template would be analogous to Tipper and Cranston's (1985) notion of participants maintaining a 'selection state'.

5.50 Concluding Remarks

Future researchers need to carefully consider the nature of the stimuli used in NP displays and the likely competition they afford. It is possible that some of the empirical discrepancies in the NP literature might reflect subtle differences in stimulus displays. Stimulus repetition may be one of the determinants of NP, but only if stimuli are not already sufficiently competitive with one another based on their

initial activation levels. Stimuli with low activation levels due to low luminosity or any other factor that could reduce the competitiveness of target and distractor stimuli may produce a facilitation of response times despite repeated exposures of the same stimulus. This facilitation could occur due to persisting activation of the prime display and/or the episodic retrieval of the previous prime distractor on its next appearance, without any associated inhibition.

Despite challenges, NP is best understood with regard to inhibitory mechanisms in combination with probe trial retrieval processes. Clearly, the operation of these two processes together is not mutually antagonistic. Whilst NP does measure the influence of selective attention, it also measures the complex interplay of selective attention with sequential responding and memory processes. Considering NP as a pure measure of inhibitory processes in selective attention may therefore be troublesome. The other cognitive processes that are involved in a NP task may distort the interpretation of individual differences in NP as reflecting only inhibitory deficits, when no NP is obtained with special populations.

Both excitatory and inhibitory processes appear to be involved in selective attention. Whilst excitatory processes may operate automatically under conditions were there is little potential danger of responding to irrelevant stimuli, a complementary inhibitory mechanism may be crucial in real life and experimental situations where there is heightened potential for incorrect responding to irrelevant stimuli or events. When this mechanism does operate, the combination of both inhibitory processes directed towards the distractor stimulus and excitatory processes directed towards the target stimulus may result in more efficient selection than either process alone. Because the combination of these two processes determines both the presence and magnitude of NP, inhibition may often be present in NP tasks but may

go undetected. Whatever inhibition is found in a NP task may therefore be only the tip of the iceberg.

Finally, researchers in many areas of cognitive psychology are now beginning to rediscover the importance of inhibitory processes in cognitive functioning (e.g., see Anderson & Green, 2001). This has been slow coming as the importance of inhibitory processes has long since been recognised. Over 100 years ago, Wundt (1904) proposed the importance of inhibitory processes in cognitive activity as follows:

> " The basic phenomenon of all intellectual achievement is the so-called concentration of attention. It is understandable that in the appraisal of this phenomenon we attach importance first and therefore too exclusively to its positive side, to the grasping and clarification of certain presentations. But for the physiological appraisal it is clear that it is the negative side, the inhibition of the inflow of all other disturbing excitations...which is more important" (p.481).

6.0 References

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7.0 APPENDICES

APPENDIX A:

Consent to Participate in a research study: 3-D shape-matching experiment

I invite you to take part in a research study as part of my masters thesis in the Psychology department of the University of Canterbury. It is important that you read and understand some general principles that apply to all who volunteer to take part in this study (a) taking part in this study is entirely voluntary; (b) personal benefit may not results from taking part in this study, but knowledge gained that will benefit others; (c) if you wish to withdraw your participation, you may do so at any time. The nature of this study, the risks, inconveniences, and other pertinent information are discussed below. You urged to discuss any questions you have about this study with myself.

Purpose:

The purpose of this study is to investigate how different people attend to., perceive and remember information. You will be asked to complete a task which involves making timed response in the form of "same" vs "different" matching judgements to pairs of shapes on a computer screen.

Inconvenience, Risk and Confidentiality:

The length of the first session will be approximately 30 minutes with a similar length session following approximately 24 hours later. I expect that you will not find participation in this study unpleasant, and there is no foreseeable risk as a result of your participation. If however you wish to withdraw your participation you may do so at any time. Your data will be held in the strictest confidence and will be identified by an alphanumeric code. Only my supervisor and myself will have access to the names of participants and their data.

Adults Participants Consent

I have read the explanation about this study and have been given the opportunity to discuss it and ask any questions. I hereby consent to take part in this study.

Signature of Adult Participant & Date signed

Signature of Investigator & Date Signed

APPENDIX B:

Instructions for 3-D shape matching experiment

In this experiment you will see overlapping **red** and **green** shapes in the centre of the computer screen and a **black** shape that will appear either to the left or to the right of the overlapping **red** and **green** shapes.

Your task is to respond as quickly and as accurately as to whether the **green** and the **black** shapes are the same or different. The **red** shape is there to make the task more difficult so ignore the **red** shape as best you can. The better you ignore the **Red** shape the faster and more accurate you will be able to respond to the **green** and **black** target shapes.

Respond on each trial by pressing the "same" button if the **green** and **black** shapes are the same and the "different" button if the **green** and **black** shapes are different. Remember to respond as fast as you can without making any errors.

Use your left index finger to press the "same" button and your right index finger to press the "different" button.

There will be a brief practice session before the experimental trials. The experimental session will be divided into three blocks. The entire session will take about 30 minutes.

APPENDIX: C

Consent to Participate in a research study: Kanji Figures Shape-Matching Experiment

I invite you to take part in a research study as part of my masters thesis in the Psychology department of the University of Canterbury. It is important that you read and understand some general principles that apply to all who volunteer to take part in this study (a) taking part in this study is entirely voluntary; (b) personal benefit may not results from taking part in this study, but knowledge gained that will benefit others; (c) if you wish to withdraw your participation, you may do so at any time. The nature of this study, the risks, inconveniences, and other pertinent information are discussed below. You urged to discuss any questions you have about this study with myself.

Purpose:

The purpose of this study is to investigate how different people attend to., perceive and remember information. You will be asked to complete a task which involves making timed response in the form of "same" vs "different" matching judgements to pairs of unfamiliar shapes on a computer screen.

Inconvenience, Risk and Confidentiality:

The length of the first session will be approximately 30 minutes in length. I expect that you will not find participation in this study unpleasant, and there is no foreseeable risk as a result of your participation. If however you wish to withdraw your participation, you may do so at any time. Your data will be held in the strictest confidence and will be identified by an alphanumeric code. Only my supervisor and myself will have access to the names of participants and their data.

Adults Participants Consent

I have read the explanation about this study and have been given the opportunity to discuss it and ask any questions. I hereby consent to take part in this study.

Signature of Adult Participant & Date signed

Signature of Investigator & Date Signed

APPENDIX D:

Instructions for kanji-figures shape-matching task

In this experiment you will see overlapping **Green** and **Red** shapes in the centre of the computer screen and a **White** shape off to the side. Your task is to respond as quickly and accurately as possible as to whether the **Green** shape matches the **White** shape. The **Green** and **White** shapes can be thought of as target shapes. The **Red** shape is there to make the task more difficult so ignore the **Red** shape the best you can. The better you ignore the **Red** shape the faster and more accurate you will be able to respond to the **Green** and **White** shapes.

Of interest is how quickly and accurately you can respond, so try and respond as fast as you can without making errors.

Respond on each trial of the experiment by pressing the "same" button if the **Green** and **White** shapes match and the "different" button if the **Green** and **White** shapes do not match.

Hold the response box with both hands and use your thumbs to respond. Use your Right thumb to press the different button and your left thumb to press the "same button".

There will be 5 minutes of practice trials before the experimental trials begin. The entire session should take about 30 minutes. You may begin when you are ready by pressing either the "same" or the "different button on the response box.

APPENDIX E:

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1 October 2000

'iona R Hern
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Dear Fiona

The Human Ethics Committee advises that your research proposal **"Inhibitory mechanisms in selective attention and memory"** has been considered and approved.

Yours sincerely

Isobel S Phillips
Secretary