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Running head: *Centre-Surround inhibition: modification*

Centre-Surround inhibition is a general aspect of famous person recognition: evidence from negative semantic priming from clearly visible primes.

Keywords: negative semantic priming, person recognition, Centre-Surround, inhibition, modification

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Abstract

A Centre-Surround Attentional Mechanism was proposed by Carr and Dagenbach (1990) to account for their observations of negative semantic priming from hard-to-perceive primes. The mechanism cannot account for the observation of negative semantic priming when primes are clearly visible. Three experiments (n = 30, 46, and 30) used a familiarity decision to names of famous people preceded by prime names of the same or different occupation. Negative semantic priming was observed at 150 or 200ms SOA with positive priming at shorter (50ms) and longer (1000ms) SOA. Experiment 3 verified that the primes were easily recognisable in the priming task at a SOA that yielded negative semantic priming, which cannot be predicted by the original Centre-Surround mechanism. A modified version is proposed that explains transiently negative semantic priming by proposing that Centre-Surround inhibition is a normal, automatically invoked aspect of the semantic processing of visually-presented famous names.

Introduction

The human ability to learn and to recall semantic information about a large number of known persons is essential to our social existence. This semantic information is commonly believed to be stored in a network structure such that a node representing an individual person is connected to nodes representing items of semantic information about that person. These items of semantic information are also connected to other known individuals who share the same semantics. So when a famous person is perceived activation can spread from the node representing the person to the node representing, for example, their occupation and then the nodes of other persons with the same occupation so that the recognition of these other famous persons is facilitated (e.g. Carson & Burton, 2001; Stone & Valentine, 2007).

Semantic priming occurs when the speed of response to a target is influenced by the prior presentation of a prime semantically related to the target. Semantic priming may arise between close associates (e.g. Brad Pitt and Angelina Jolie) or members of the same category (e.g. Brad Pitt and Johnny Depp have a common occupation). Categorical priming, typically using occupation as the shared category, has previously been reported in several investigations of famous person recognition (e.g. Bruce, 1983; Brennen & Bruce, 1991; Carson & Burton, 2001; Stone & Valentine, 2007).

Responses are usually faster to related targets than unrelated targets yielding positive semantic priming. However, under certain conditions, when primes have been presented for very brief, masked exposures, Stone and Valentine (2007) observed negative semantic priming for famous names primed by occupational category, i.e. responses were systematically slower to related targets than to unrelated targets. This finding fits with previous observations of negative semantic priming for words (e.g. Carr & Dagenbach, 1990; Dagenbach, Carr & Barnhardt, 1990; Dagenbach, Carr & Wilhelmsen, 1989; Frings, Bermeitinger, & Wentura, 2008; Stolz & Besner, 1997; Wentura & Frings, 2005), and for novel objects (Dagenbach & Carr, 1994). Negative semantic priming can be explained by Centre-Surround theory, a brief description of which follows.

Carr and Dagenbach (1990) proposed a Centre-Surround attentional mechanism to account for their observations of negative semantic priming. This attentional mechanism is invoked when a participant attempts to extract into consciousness the meaning of a prime, and when the meaning is hard to extract. Difficulty in achieving awareness of the prime's semantics could arise either because the prime is weakly activated, as with masked priming (Dagenbach et al, 1989; Frings et al, 2008; Stone & Valentine, 2007; Wentura & Frings, 2005) or because the meaning itself is weakly activated, as with newly learned vocabulary words (Dagenbach, Carr, & Barnhardt, 1990) or novel and arbitrary object categories (Dagenbach & Carr, 1994). The attentional mechanism boosts the degree of activation at the semantic code(s) representing the prime, the *Centre*, and suppresses the degree of activation at other codes receiving some spreading activation from the prime, the *Surround*. This helps to distinguish the semantic code(s) of the prime from surrounding codes and thus helps to extract the meaning of the prime into awareness. If the attempt is successful then the meaning of the prime crosses the threshold for conscious awareness, and spreading activation to related semantic codes ensures speeded responses to related items, i.e. positive priming. When the attempt fails, however, the suppression of activation at related codes leads to slowed responses to related items and hence to negative semantic priming. Carr and Dagenbach proposed that a necessary condition for the Centre-Surround attentional mechanism is that awareness of prime semantics must be severely restricted, for otherwise there is no need to invoke the attentional mechanism.

An important point is that Centre-Surround theory assumes a mechanism which is clearly hypothesised to be invoked to deal with a word whose meaning is hard to extract into awareness. In this regard it was an intriguing funding that negative semantic priming was observed from clearly visible primes (unpublished data). Thirty-one participants made a speeded familiarity decision to the name of a famous or non-famous person, preceded by the name of a famous person with the same or different occupation to a famous target. Primes were exposed for 150ms without masking so they were likely to have been clearly visible. The surprising result was that negative categorical priming was observed at 150ms SOA, contrasting with non-significantly positive priming at 1000ms SOA. This observation of negative semantic priming from clearly visible primes cannot be accommodated within the original Centre-Surround hypothesis, so if this result proves to be replicable then either a modification to the Centre-Surround mechanism or a new theory of negative semantic priming will be required.

The structure of the remainder of the paper is as follows. Experiment 1 examined a range of prime-target stimulus onset asynchrony (SOA) to investigate the relationship between SOA or prime visibility and direction of priming. Experiment 2 was designed to remove a potential confound in the design of Experiment 1 by controlling the stimulus energy at all levels of SOA. Experiment 3 was designed to offer verification that the primes were indeed clearly recognisable at the SOA that produces negative priming. The general discussion will consider how the Centre-Surround hypothesis might be modified to accommodate the results of these experiments and whether other accounts of semantic priming could offer an alternative explanation.

Experiment 1 investigated categorical priming from unmasked primes at stimulus onset asynchrony of 50ms, 200ms and 1000ms. At 50ms SOA the prediction was for positive categorical priming, as had been observed by Stone and Valentine (2007). Although that previous paper used masking whereas the present experiment did not, the effect of masking in the previous paper should have been to reduce the magnitude of priming, and so positive priming could be predicted under the more favourable unmasked conditions of the present study. Negative priming was predicted at 200ms SOA, following the unpublished pilot study in which this effect was observed. Positive priming was predicted at 1000ms because this was sufficiently long SOA to permit the operation of strategic processes, including expectancy, which are a key component of semantic priming (e.g. Neely, 1977). Participants had ample opportunity to observe that pairs of stimuli were sometimes related by virtue of sharing an occupation and Stone (2008) demonstrated that this is sufficient to produce positive priming at 1000ms SOA. According to the review by McNamara (2005; p155) strategic processes have relatively strong effect under conditions of long SOA, a lexical decision (or analogous name familiarity) task, and in category priming compared to associative priming, so positive semantic priming was predicted in the 1000ms condition of Experiment 1.

Experiment 1

Method

Participants

There were 30 participants, 24 female and six male, with ages ranging from 23 to 53, mean 37.2 years (SD 7.7). All were undergraduate or post-graduate students of the Open University.

Design

The task was a familiarity decision to the name of a famous or non-famous person. The prime was always the name of a famous person, so that prime fame had no predictive validity for target response. A famous target was either of the same occupational category (related condition) or different occupation (unrelated) to the prime. The unfamiliar targets were included only to generate the task demand. The primes were a separate set of names to the targets, i.e. no prime name was repeated as a target.

Centre-Surround inhibition: modification

There were two within-participant factors. Target condition was one of related, unrelated, or unfamiliar targets. There were three levels of prime-target SOA: 50ms prime exposure followed immediately by the target; 150ms prime exposure with a 50ms blank screen giving 200ms SOA; and 150ms prime exposure with 850ms blank screen giving 1000ms SOA. According to the review by McNamara (2005, p66) the SOA of 200ms should have been sufficiently brief to preclude substantial strategic processing.

The prime was followed by a blank screen (in the 200ms and 1000ms SOA conditions) rather than a mask. The mask could result in restricted awareness of the prime and if so, this would constitute a test of the original Centre-Surround hypothesis, i.e. that an attentional mechanism is invoked to deal with hard-to-perceive primes. The purpose of the present series of experiments was to investigate whether Centre-Surround inhibition arises even with easy-to-perceive primes, so no mask was used.

Stimuli

There were 120 target names altogether: 60 famous and 60 unfamiliar. There was a separate set of 120 prime names, all of them famous so that prime fame had no predictive value for the target response. None of the prime names were repeated as a target name. The 60 famous target names were all paired with a prime name of the same occupational category and divided into six sets of 10 pairs so that (as far as possible) each set had an equal number of pairs from the different occupational categories. The six sets were rotated round the six experimental combinations of SOA (50 or 200 or 1000) with relation (related or unrelated) so that each participant saw all of the six sets, and each set was used in each experimental condition an approximately equal number of times. An unrelated set was formed by re-pairing the related pairs in the set. See appendix A. Thus, the primes and targets were counterbalanced in related and unrelated conditions, and each item occurred in each experimental condition across participants but only once for each participant. As a further precaution, counterbalance was used as a grouping variable in analyses to make sure there were no unintended effects.

The choice of target names was made in order to maximise the likelihood of recognition by the experimental participants. This indicated a large number of popular film actors (24), followed by pop musicians (12), then comedians (6), TV presenters (6) and members of the UK royal family past and present (6), and a smaller number of politicians (3) and film directors (3).

Procedure

Participants performed the task alone in a quiet cubicle. The experimental trials were preceded by eight practice trials to ensure that the participant was familiar with the task. The prime was displayed in the centre of the screen, followed after the SOA by the target in the same screen position. Participants were asked to pay attention to the screen and read the prime name but not to respond to it. They pressed one of two keys on the keyboard to indicate whether the target name was famous or not. The inter-trial interval was one second. Participants were not informed of any relationship between prime and target names.

Verification of Prime Visibility

The same stimuli were presented exactly as in the main experimental task to a separate group of pilot participants, who were asked to name the prime on each trial instead of responding to the target. The response was recorded by the experimenter and subsequently checked for accuracy. The first three pilot participants (all male, aged 20, 24 and 31 years) achieved very high scores so no further data were collected. The number of primes missed at 50ms SOA by the three participants was 6, 12 and 1, an average of 15.8%; the number of primes missed at 200ms SOA was 3, 0 and 0, an average of 2.5%; and no participant missed any primes at 1000ms SOA. This confirms that the primes were readily visible in general and especially at the key SOA of 200ms at which negative priming was predicted.

Results

The mean response time was calculated per participant for each combination of prime-target relation and SOA. Analysis of variance (ANOVA) was performed on the mean response times with stimulus counterbalance as a between-participants variable. The Greenhouse-Geisser correction was used for violation of the assumption of sphericity. Significant interactions were investigated with paired-samples t-tests.

Responses were excluded if the response was incorrect (5.3 % of responses) or slower than 2.5 standard deviations above the participant mean (2.9% of responses). No responses were faster than 400ms. The means are presented in Figure 1 and Table 1.

There was no main effect or interaction involving the factor of stimulus counterbalance, all $F < 1.9$, ns. There was a significant interaction between SOA and prime-target relation [$F(2,23) = 11.24$, $p < 0.001$]. Paired-samples t-tests revealed that categorical priming was positive at 50ms SOA [$t(29) = 2.84$, $p < 0.01$], negative at 200ms SOA [$t(29) = 2.30$, $p < 0.03$], and positive again at 1000ms SOA [$t(30) = 2.78$, $p < 0.01$].

ANOVA was also performed on the accuracy data with the same factors. No effects were statistically significant, all $p > 0.1$, offering no suggestion of a speed-accuracy trade-off. See Table 1.

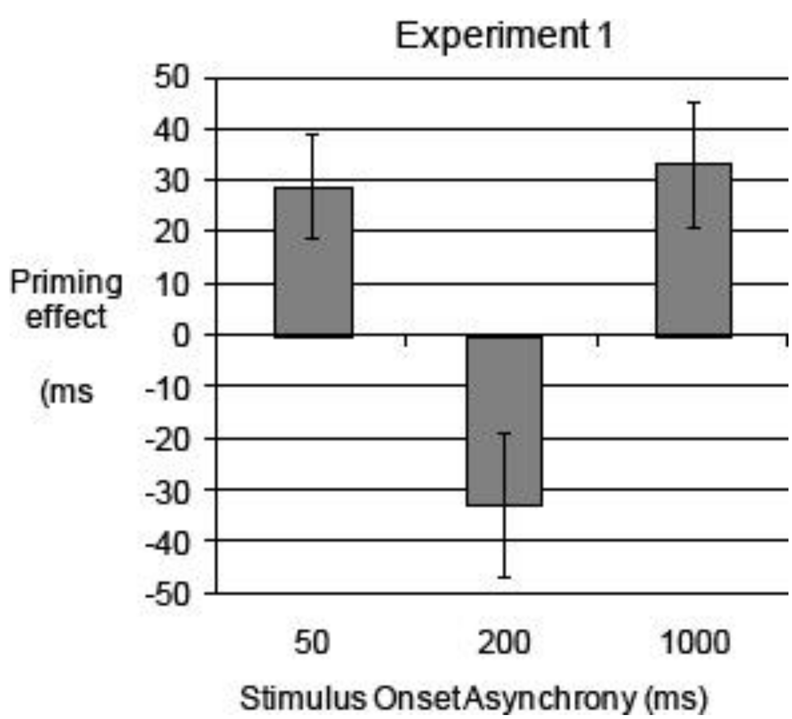

Figure 1: Mean priming effect in Experiment 1 calculated as the difference between response time in the unrelated and related conditions. Bars represent the standard error of the mean difference.

Table 1: Mean response times and errors in Experiment 1, 2 and 3.

	Response Time			Errors		
	Expt 1	Expt 2	Expt 3	Expt 1	Expt 2	Expt 3
50ms SOA						
Same category mean	844	910	1237	0.06	0.21	0.14
(SD)	(99)	(163)	(246)	(0.09)	(0.18)	(0.11)
Different categ mean	872	936	1285	0.09	0.19	0.16
(SD)	(107)	(179)	(251)	(0.09)	(0.15)	(0.13)
200/150ms SOA						
Same category mean	886	918	1233	0.06	0.21	0.11
(SD)	(107)	(174)	(235)	(0.08)	(0.19)	(0.12)
Different categ mean	853	868	1178	0.06	0.24	0.14
(SD)	(112)	(136)	(253)	(0.07)	(0.18)	(0.11)
1000ms SOA						
Same category mean	803	856	1047	0.07	0.23	0.16
(SD)	(120)	(173)	(187)	(0.08)	(0.18)	(0.14)
Different categ mean	836	884	1089	0.07	0.23	0.13
(SD)	(122)	(158)	(242)	(0.10)	(0.18)	(0.11)

Table 1: Mean (and SD) of response times measured in milliseconds and proportion of errors in the different SOA conditions of Experiment 1, 2, and 3.

Discussion

The pattern of results suggests that negative semantic priming of famous person recognition at an SOA of 200ms can arise when the meanings of primes are easy to extract into awareness. This contradicts a key assumption of the original Centre-Surround hypothesis of Carr and Dagenbach (1990).

There is, however, a limitation of the design of Experiment 1; the SOA conditions were not equated in terms of the stimulus energy of the prime. The 200ms and 1,000ms SOA conditions presented primes for 150ms whereas the

50ms condition only did so for 50ms. It could be argued that the change from positive priming at 50ms SOA to negative priming at 200ms SOA was due to the change in prime exposure, and the switch back to positive priming at 1000ms SOA was due to the increase in SOA. Experiment 2 was designed to overcome this limitation.

Experiment 2

This was similar to Experiment 1 with primes presented for the same 25ms in all conditions with a blank screen between the prime and the target. The duration of the blank screen was varied to achieve the experimental manipulation of SOA.

Method

Participants

There were 46 participants, 37 female and nine male, with ages ranging from 18 to 52, mean 25.3 years (SD 8.8). None had taken part in a previous experiment. All were undergraduate or post-graduate students of the Open University or the University of East London.

Design, materials and procedure

Everything was the same as in Experiment 1 except that all primes were exposed for 25ms and followed by a blank screen for 25ms, 125ms, or 975ms to make a total SOA of 50ms, 150ms or 1000ms.

Results

The mean response time was calculated per participant for each combination of prime-target relation (related vs. unrelated) and SOA (50ms, 150ms or 1000ms). Analysis of variance (ANOVA) was performed on the mean response times with these two within-participant factors and stimulus counterbalance as a between-participants factor using the Greenhouse-Geisser correction for violation of the assumption of sphericity. Significant interactions were investigated with paired-samples t-tests.

Responses were excluded if the response was incorrect (15.8% of responses) or slower than 2.5 standard deviations above the participant mean (2.8% of responses) or faster than 400ms (less than 1% of responses). The means are presented in Figure 2 and Table 1.

The main effect of SOA was significant [$F(2,39) = 4.82$, $p < 0.05$] showing mean responses becoming faster as the SOA increased. This is probably due to the increasing utility of the prime as a cue for the onset of the target. There was no significant main effect or interaction involving the factor of stimulus counterbalance [all $F < 1.5$, $p > 0.2$]. As predicted, the two-way interaction of SOA and relation was significant [$F(2, 39) = 8.25$, $p<0.005$]. Paired-samples t-tests examined priming at each SOA. At 50ms SOA priming of +26ms was significant [$t(45) = 2.15$, $p < 0.05$], at 150ms SOA priming of -50ms was significant [$t(45) = 3.16$, $p < 0.005$], and at 1000ms SOA priming of 28ms was significant [$t(45) = 1.77$, $p < 0.05$, one-tailed].

ANOVA on the accuracy data with the three factors of SOA, prime-target relation and stimulus counterbalance revealed no statistically significant effects, all $p > 0.1$, offering no suggestion of a speed-accuracy trade-off.

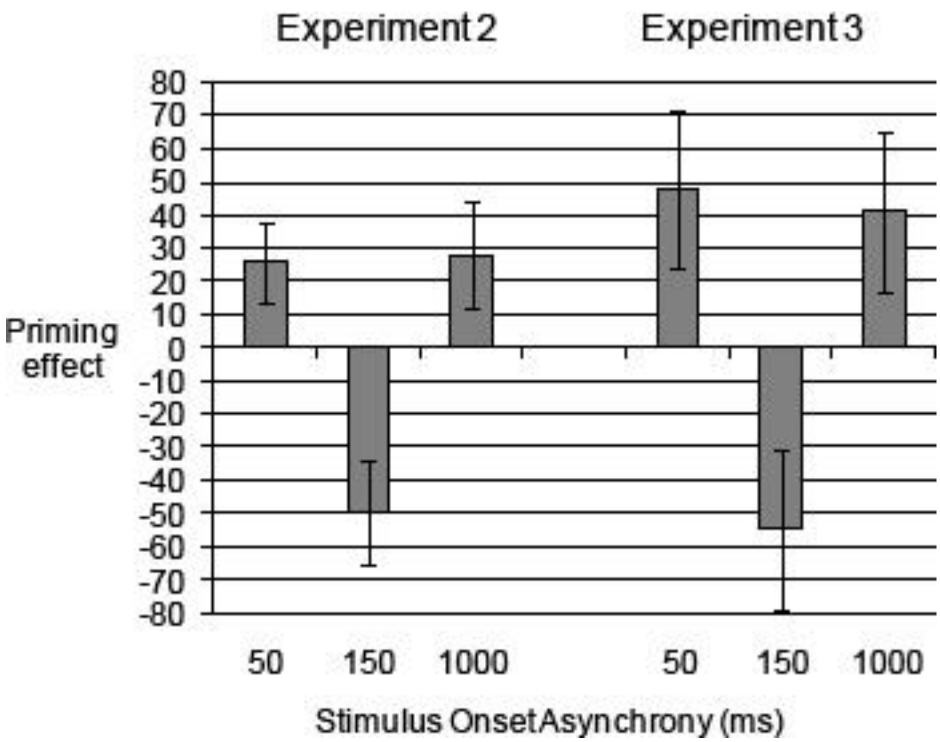

Figure 2: Mean priming effect in Experiment 2 and 3 calculated as the difference in response time between the unrelated and related conditions. Bars represent standard error of the mean difference.

Discussion

This experiment confirms the observation of transient negative semantic priming in a design in which the prime exposure duration, and thus stimulus energy, was equated across all SOA conditions, and in which the sequence of presentation of prime then blank screen then target was the same for all SOA. The results rule out the possibility that the change in direction of priming in Experiment 1 with increasing SOA could have been caused by the difference in stimulus energy.

However, another potential problem is that the prime visibility study of Experiment 1 was done with a different set of participants, and that when they tested the visibility of the prime they were not also required to respond to the target on the same trial. This would have made it easier to focus and concentrate on the prime and so the prime might have been more visible in the prime visibility task than it was in the actual priming task. If this is the case, then it could be argued that the negative categorical priming observed at 200ms SOA (Experiment 1) or 150ms SOA (Experiment 2) in the priming task might be a result of inability to perceive the prime that resulted from a lack of attention. Experiment 3 was designed to investigate this alternative explanation.

Experiment 3

The purpose of Experiment 3 was to (a) check whether the same pattern of positive priming at 50ms SOA, negative priming at 150ms SOA, and positive priming at 1000ms SOA, would be observed when participants were forced to attend to the prime, and (b) to offer evidence that the prime was clearly visible and its relevant semantics were readily retrieved within the priming task itself and with the same group of participants.

Experiment 3 used a dual-task paradigm, in which participants were asked to respond to either the prime or a target on each trial, and the type of response required was pseudo-randomly varied between trials. In this way the two tasks of prime visibility and target response were tested under the same conditions and by the same participants. At the start of each trial, and while the prime was presented, participants did not know to which stimulus they would be asked to respond, and so they were compelled to pay attention to the prime. If the prime is found to be clearly visible and its relevant semantics are readily activated under these conditions, and if negative semantic priming is observed at the intermediate level of SOA, this would confirm that transient negative semantic priming can be observed from clearly visible primes.

Method

Participants

There were 30 participants, 22 female and 8 male, with ages ranging from 23 to 47, mean 34.3 years (SD 6.7). None had taken part in a previous experiment. All were undergraduate or post-graduate students of the Open University or the University of East London.

Design, materials and procedure.

All aspects are the same as in Experiment 2 except for the following details.

The main difference was that participants were asked to respond to either the prime or to the target on each trial, pseudo-randomly organised so that there were equal numbers of responses to the prime and to the target. After the prime was presented either the target or an instruction to respond to the prime would appear. Thus, only when the second stimulus was presented did participants discover whether they should respond to the prime or to the target. To facilitate this design the response to the prime was to specify whether the person was an actor or not (as similar method was used by Huber, Clarke, Curran and Winkielman, 2008) so that the response to the prime was a simple binary Yes or No, as was the response to the target. The response to the prime required the recognition of the famous name and the retrieval of the item of semantic information representing the person's occupation; this was the aspect of semantics implemented in the design of related and unrelated conditions.

All primes were exposed for 25ms, followed by a blank screen for the remainder of the SOA (25ms, 125ms, or 975ms), as in Experiment 2, and then followed by the second stimulus. There were two conditions: if the second stimulus was the target it was presented slightly higher on the screen and in green ink and participants made a fame decision, as before. If the second stimulus was the prompt 'actor?' presented in the same screen location as the prime then participants responded to the prime with a binary Yes or No decision. Thus, the same response keys were used to respond to the prime or to the target. Each prime was presented twice, once for a prime visibility test, and one for a target response.

Results

Responses to primes. Responses to the prime were 87.9% accurate, which compares very closely with 87.5% accuracy for responses to the target, and is slightly better than accuracy in Experiment 2. This suggests that the primes were at least as readily visible as the targets and, given that the targets were presented on the screen until the participant responded, this suggests that the primes were readily visible. Any shortfall in correct responses to the primes seems likely to have been due to a genuine lack of familiarity with the famous persons or to random error. It is also relevant to note that the task on the prime was a decision about the corresponding occupation and so this demonstrates that the relevant semantics were readily retrieved from memory.

Responses to the primes were of equivalent accuracy at each SOA so there is no evidence that primes were especially difficult to perceive at the intermediate 150ms SOA at which negative semantic priming was predicted. Mean accuracy of responses to the prime was 86.5% (SD 7.1) at 50ms SOA, 88.0% (SD 7.3) at 150ms SOA, and 89.3% (SD 7.6) at 1000ms SOA. ANOVA with repeated measures on SOA showed no significant differences in the accuracy of prime responses [$F(2,28) = 1.42$, ns].

Responses to targets. The mean target response time was calculated per participant for each combination of prime-target relation and SOA (on only those trials on which a response was made to the target). Responses were excluded if the response to the target was incorrect (12.5% of responses) or slower than 2.5 standard deviations above the participant mean (1.5% of responses) or faster than 400ms (none). The means are presented in Figure 2 and Table 1.

Analysis of variance (ANOVA) was performed with two factors of SOA (50ms, 150ms, 1000ms) and relation (related or unrelated) on the mean response times, with stimulus counterbalance as a third, between-participants factor. Significant interactions were investigated with paired-samples t-tests. The Greenhouse-Geisser correction was used for violation of the assumption of sphericity.

The main effect of SOA was significant [$F(2, 23) = 33.43$, $p < 0.001$] showing mean responses becoming faster as the SOA increased. This is likely due to the increasing utility of the prime as a cue for the onset of the target. There was no significant effect involving the factor of stimulus counterbalance, all $F < 2$, $p > 1.2$. As predicted, the interaction of SOA and relation was significant [$F(2, 38) = 6.50$, $p < 0.01$] and paired-samples t-tests examined priming at each SOA. At 50ms SOA priming of +48ms was significant in a one-tailed test [$t(29) = 1.98$, $p < 0.05$], at 150ms SOA priming of -55ms was significant [$t(29) = 2.32$, $p < 0.05$], and at 1000ms SOA priming of 41ms was significant in a one-tailed test [$t(29) = 1.72$, $p < 0.05$].

ANOVA was performed on the accuracy data with the same three factors of SOA, prime-target relation and stimulus counterbalance. No effects were significant, all $p > 0.1$, offering no suggestion of a speed-accuracy trade-off.

Discussion

Responses to the primes were as accurate as responses to the targets. Since the former required retrieval of the prime's occupation there is no evidence that participants were unable to retrieve the relevant semantics of the primes. The design ensured that participants paid equivalent attention to the primes on all trials. So it can be safely concluded that the primes were attended and their semantics were readily retrieved on trials where participants responded to the target. This confirms the observation of transient negative semantic priming from clearly visible primes, which contradicts a key assumption of the Centre-Surround attentional mechanism theory.

General Discussion

Negative categorical priming was observed at 200ms stimulus onset asynchrony (SOA) in Experiment 1 and at 150ms SOA in Experiment 2 and 3; responses were slower when the target person had the same occupation as the prime compared to a different occupation. This contrasts with positive categorical priming at the longer SOA of 1000ms and at the shorter SOA of 50ms. An additional check in Experiment 3 confirmed that primes were clearly visible at all SOA and their relevant semantics were readily retrieved. Experiment 2 ruled out a possible explanation based on differing stimulus energy to focus on SOA as the primary influence on the direction of categorical semantic priming.

Several theories of semantic priming can only account for positive priming and so these are not candidates for the present set of results: the spreading activation models proposed by Quillian (1967) and by Collins and Loftus (1975); Becker’s (1980) Verification Model; Compound-cue Models (Ratcliff & McKoon, 1988); and Distributed Network Models (e.g. McClelland & Rumelhart, 1985). In addition, the paradigm of negative priming from ignored distractors (e.g. Milliken, Joordens, Merikle, & Seiffert, 1998) cannot account for negative semantic priming under the conditions of the present experiments, with only one prime and one target on each trial and no prime repeated as a target.

Other theories that could, potentially, explain the present observations of negative semantic priming will be examined.

Negative Compatibility Effect

In the studies by Eimer and Schlaghecken (2006) the prime and target stimuli were arrows pointing either right or left and the required response was a key press with the corresponding hand. At longer SOA the responses were faster when the prime and target were incompatible than when they were compatible, termed the Negative Compatibility Effect, in contrast to a positive compatibility effect at very short SOA. The explanation is based on the inhibition of a response to the prime that takes some short time to develop. The NCE does not appear to apply to the present studies, as its application is limited to experimental designs in which the target response is primed whereas in the present series of experiments the target response was a fame decision but all the primes were famous names and priming arose from the semantics of the prime.

False Fame Illusion

In the “false fame” illusion of Jacoby, Kelley, Brown and Jasechko (1989) a person’s name is read without attention so that on a later occasion it cannot be consciously recalled. However, if the name is perceived later it may be falsely identified as a famous name because it engenders a feeling of familiarity in the absence of conscious recollection of a prior perceptual episode. If this idea is applied to the present experiments, a briefly-presented 50ms prime may invoke some activation of the occupational category, but without conscious awareness, and if the target has the same category the misattribution of the category from prime to target may facilitate a familiarity response to the target. Conscious awareness of the prime name at 150ms SOA could potentially explain the disappearance of positive priming at this SOA. However, there is no apparent mechanism whereby this could produce a negative semantic priming effect at 150 ms SOA, or a return to positive semantic priming at 1000ms SOA.

ROUSE theory

The Responding Optimally with Unknown Sources of Evidence (ROUSE) model was proposed by Huber, Shiffrin, Lyle and Ruys (2001) and applied to a neural habituation model by Huber (2008). In a task involving the perceptual identification of briefly-presented words, positive repetition priming was observed with prime exposure of up to 150ms and negative repetition priming at durations of 400ms or over. A key element of the theory is that the neural representations of the prime and its semantics will habituate after a certain processing duration. At short SOA the prime's semantics are still activated when a related target is presented providing facilitation to the processing of the target and positive priming. After a longer prime exposure the prime's semantics are habituated so that the processing of a related target is inhibited and there is negative semantic priming.

It is unclear whether the ROUSE theory with neural habituation can be applied to the present results. Huber (2008) attributed negative repetition priming to habituation of visual features of the primes after 400ms. Given that semantics would likely take longer to activate and longer to habituate than visual features (Huber, 2008, p328) it is not clear that ROUSE can explain negative semantic priming after 200ms SOA. Also, it is not clear that ROUSE could explain the third phase of positive semantic priming; such an explanation would rely on recovery from neural habituation and it is not clear that this could occur with 1000ms SOA.

Psychophysical account of contrast effects

This account was proposed by Klauer, Teige-Mocigemba, and Spruyt (2009) to account for contrast effects (conceptually similar to negative priming) in affective priming studies. According to this account, a 'counter' records the rise in activation at a particular concept representation e.g. there are counters for positive and negative valence. The ease of categorisation of a stimulus as positive or negative depends on the rise in value of the corresponding counter during a particular time window. If a prime and target are presented close together then the activation induced by the prime is included within the time window of the target, so boosting the apparent rise in the counter for a compatible target so that positive priming results. If there is a longer delay between prime and target then the activation induced by the prime is not included within the window for the target. The counter for a compatible target rises more slowly if it is already somewhat activated by the prime compared to a counter not already activated by the prime, so it is easier to detect a contrasting target and negative priming results.

This could be applied to the present series of experiments by replacing the idea of the counter for affective valence with a counter for occupation. However, there does not appear to be any way to explain the third phase of priming i.e. a return to positive priming with longer SOA.

Centre-Surround inhibition

Centre-Surround inhibition: modification

The Centre-Surround attentional mechanism of Carr and Dagenbach (1990) was described in the introduction. Carr and Dagenbach proposed that a necessary condition for the Centre-Surround attentional mechanism is that awareness of prime semantics must be severely restricted, for otherwise there is no need to invoke the attentional mechanism. Experiment 3 in the present series demonstrated that the primes were clearly perceptible and their relevant semantics were retrievable and so this condition was not met.

A modified Centre-Surround mechanism is proposed that is conceived as being invoked automatically rather than strategically, as a feature of the normal semantic processing of person names, so it is not necessary for primes to be hard to perceive or for their semantics to be hard to retrieve. Indeed, Barnhardt, Glisky, Polster & Elam (1996) and Wentura and Frings (2005) have already suggested that Centre-Surround inhibition is invoked automatically rather than strategically. The modified mechanism overcomes a second drawback of the Centre-Surround Attentional Mechanism, which is that it seems implausible for the visual processing system to decide that the meaning of a stimulus is hard to retrieve into awareness within the timings that have been observed to produce negative semantic priming (e.g. SOA of 217ms in Stone & Valentine, 2007; 260ms in Frings et al, 2008; and 280ms in Wentura & Frings, 2005).

Modified Centre-Surround Mechanism

The proposed mechanism of Centre-Surround inhibition works like this. When a person name is presented (time (a) in Figure 3) activation spreads to codes representing the names of related persons (time (b) in Figure 3) and positive priming may be observed. After a short delay, within-pool inhibition begins to be applied by the prime name to the names of related persons (time (c)) to ensure that the identification of a seen name inhibits the simultaneous identification of other names. The effect is that the names of categorically-related persons may be below their resting level of activation (between time (c) and (d)) and negative priming may be observed. If visual input is sustained, the activation at the prime name continues to rise, and the activation at related names rises again above resting level while still maintaining a differential below the prime name (time (d) onwards). In the later time window positive priming may be observed.

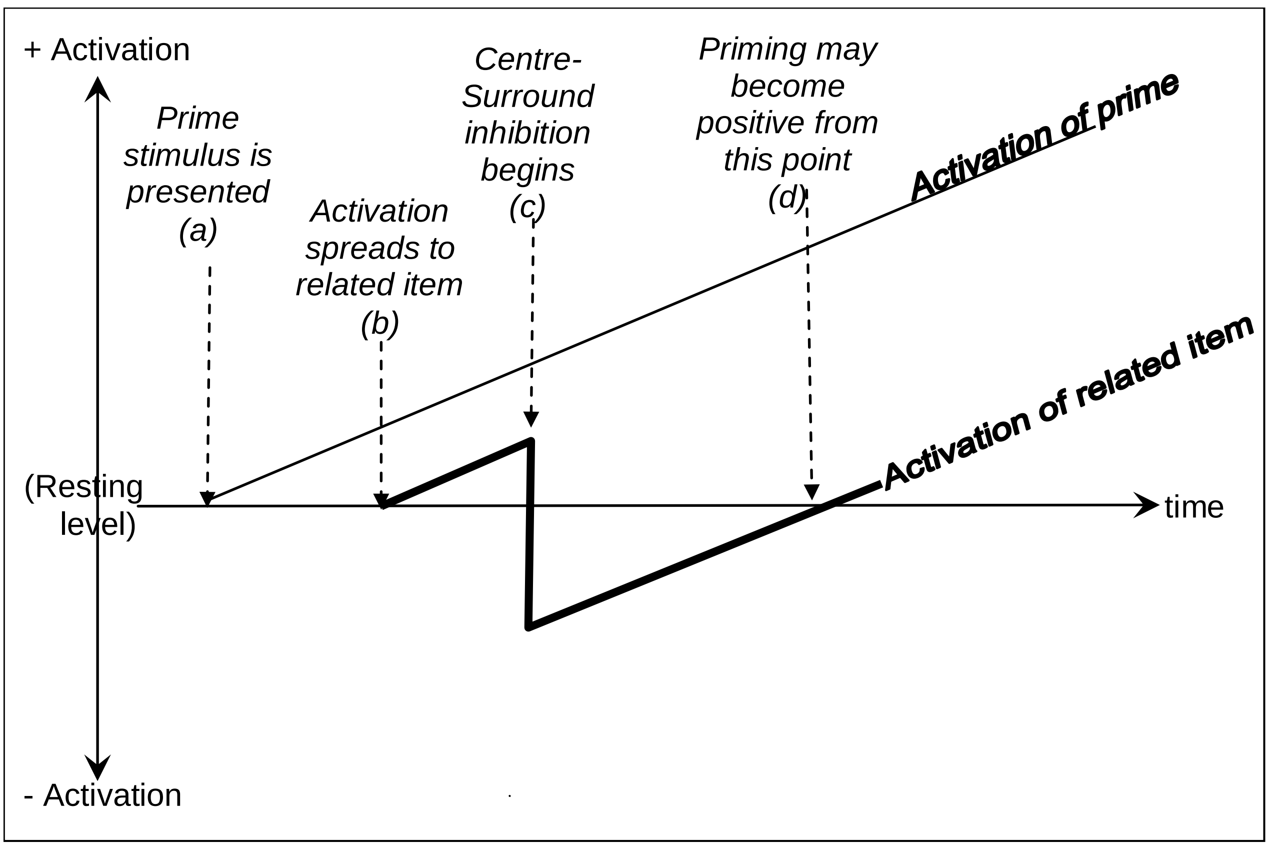

Figure 3: Conceptual representation of the proposed modified mechanism of Centre-Surround inhibition in the categorical priming of famous names. Between (a) and (b) there is no priming of responses to a related name; between (b) and (c) activation at the related name is above resting level and positive priming may be observed; between (c) and (d) activation at the related name is below resting level and negative priming may be observed; after (d) activation at the related name is above resting level and priming may become positive again. Centre-Surround inhibition is shown as having immediate rather than gradual effect for representational simplicity.

Consistent with this reasoning is the observation by Alario, Segui and Ferrand (2000) of negative priming from clearly visible primes at 114ms SOA and then a null priming effect at longer SOA of 234ms; a longer SOA was not tested so we do not know whether priming would have become positive in direction.

If this modified form of Centre-Surround inhibition is part of the normal visual processing of famous names, this begs the question of why negative semantic priming from clearly visible primes is not more commonly observed. There are three plausible answers to this. One: negative priming will be observed only for items that are relatively weakly activated by spreading activation from the prime stimulus, e.g. members of the same category that are not repeated during the experimental task (or masked and briefly exposed primes, or visible primes whose meanings are hard to retrieve). In contrast, unmasked and highly familiar close associates, or targets used repeatedly, will be more strongly activated by spreading activation from the prime. Although the Centre-Surround mechanism will still operate it will not drive the level of activation of these targets to below their resting level and so there will be no observed effect of negative priming. Two: negative priming from clearly visible primes will be observed only for a certain time window, so studies using a longer SOA will not observe negative priming. Three: negative priming may indeed have been observed in previous studies, but in the absence of an explanation, it may have been interpreted as a null priming effect.

It could be argued that in order to claim that CS inhibition is automatic the experimental design should hold SOA constant while varying the aspect of prime visibility, for example by using a mixture of masked and unmasked trials. Priming could be compared between trials where the prime was recognised and trials where it was not recognised for a fixed SOA. If an equivalent degree of priming were to be observed this would indeed establish that CS inhibition occurs whether the prime is visible or not. The problem with this argument, however, is that if a different degree of priming were to be observed for masked and unmasked primes this could be related to the difference in stimulus energy and it would not necessarily be informative about the presence or absence of a Centre-Surround process. [1]

The present study has reported negative categorical priming from clearly visible primes only in the domain of famous person names. There is evidence

[1] It is relevant to note that negative categorical priming of 33ms in the present Experiment 1 was similar to negative categorical priming of 24ms in Experiment 2 of Stone and Valentine (2007) in which famous faces were used instead of famous names. In the present Experiment 1 primes were presented for 150ms followed by a blank screen for 50ms, and in the previous study primes were presented for 17ms and followed by a mask for 200ms (SOA was 200ms vs. 217ms). This does tend to suggest that negative categorical priming of famous persons depends more on a particular SOA than on prime visibility, although the comparison of two separate experiments does limit the strength of the conclusion that can be drawn.

that knowledge for famous persons is structured similarly to word and object knowledge (e.g. Carson & Burton, 2001; Darling & Valentine, 2005; Stone & Valentine, 2007) so a similar result might be predicted in these domains. Future studies could confirm whether the modified Centre-Surround mechanism appears to operate in other domains of semantic knowledge but that was outside the scope of the present study.

In conclusion, the present study has supported the key function of Centre-Surround inhibition, i.e. helping to distinguish a perceived stimulus from related items in the semantic neighbourhood. Three experiments have offered evidence that Centre-Surround inhibition may be a normal, automatically invoked part of the semantic processing of visual stimuli.

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Appendix A – stimuli in Experiment 1, 2 and 3.

These are the prime-target pairs with the same occupational category. Pairs with different occupations were formed by shuffling these pairs.

Film actors

Leonardo DiCaprio & Wesley Snipes
Hugh Jackman & Daniel Craig
Heath Ledger & Nicholas Cage
Catherine Zeta-Jones & Humphrey Bogart
Denzel Washington & Kate Winslet
Jude Law & Sandra Bullock
Kevin Spacey & Clint Eastwood
Gwyneth Paltrow & Harrison Ford
Keanu Reeves & Michelle Pfeiffer
Uma Thurman & Will Smith
Al Pacino & Hugh Grant
Jodie Foster & Mel Gibson
Orlando Bloom & Samuel Jackson
Ben Affleck & Cameron Diaz
Katie Holmes & Robert di Niro
Angelina Jolie & Jim Carrey
Marilyn Monroe & Matt Damon
Bruce Willis & Sharon Stone
Sigourney Weaver & George Clooney
Keira Knightly & John Travolta
Michael Douglas & Nicole Kidman
Scarlett Johansson & Brad Pitt
Tom Cruise & Liz Hurley
Halle Berry & Pierce Brosnan

Film directors

Ridley Scott & Alfred Hitchcock
Francis Ford Coppola & Quentin Tarantino
Walt Disney & Steven Spielberg

Comedy

John Cleese & David Walliams
Matt Lucas & Victoria Wood
Jack Dee & Billy Connolly
Neil Morrissey & Angus Deayton
Rowan Atkinson & Ricky Gervais
Martin Clunes & Dawn French

Popular Music

Missy Elliott & Sean Combs
Britney Spears & Gwen Stefani
Mariah Carey & Will Young
Noel Gallagher & Madonna
Christina Aguilera & Justin Timberlake
Michael Jackson & Tina Turner
Shania Twain & Beyonce Knowles
Kylie Minogue & Posh Spice
Robbie Williams & Janet Jackson
Elvis Presley & Whitney Houston
Lionel Ritchie & Mick Jagger
Jimi Hendrix & Bob Marley

Royal Characters

Prince Charles & Henry the Eighth
Prince Albert & Anne Boleyn
Prince William & Camilla Parker-Bowles
Kate Middleton & Diana Spencer
Prince Andrew & Queen Elizabeth
Prince Philip & Queen Victoria

TV Presenters

Michael Parkinson & Bill Oddie
David Attenborough & Trevor McDonald
Richard Madeley & Simon Cowell
Judy Finnegan & Sharon Osborne
Phillip Schofield & Anne Robinson
Oprah Winfrey & Cilla Black

Politicians

Gordon Brown & David Cameron
Bill Clinton & Tony Blair
Margaret Thatcher & George Bush