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The Categorical Structure of Knowledge for Famous People

(and a novel application of Centre-Surround Theory)

Anna Stone*

University of East London

and

Tim Valentine

Goldsmiths College

Running Head: Categorical knowledge of famous people

Corresponding author:

*Dr Anna Stone
School of Psychology
University of East London
Stratford Campus
Romford Road
London E15 4LZ

Email: A.Stone@uel.ac.uk

Phone: +44 (0) 208 223 4452

Abstract

Knowledge of familiar people is essential to guide social interaction, yet there is uncertainty about whether semantic knowledge for people is stored in a categorical structure as for objects. Four priming experiments using hard-to-perceive primes investigated whether occupation forms a category connecting famous persons in semantic memory. Primes were famous faces exposed for 17ms with masking, resulting in severely restricted awareness and thus precluding expectancy-based priming effects. Targets were consciously perceptible famous faces (Experiment 1-3), famous names (Experiment 3), or occupations (Experiment 4) representing either the same or different occupation to the prime. Significant priming demonstrated the operation of automatic processes, including spreading activation, among persons sharing a common occupation; this supports the categorical view. The direction of priming (faster / slower responses to same-occupation than different-occupation targets) was dependent on prime-target stimulus onset asynchrony (Experiment 1-3) and type of target (Experiment 4). This pattern of results is attributed to the Centre-Surround mechanism proposed by Carr and Dagenbach (1990). These results support (a) the categorical structure of semantic knowledge for famous people, and (b) the application of the Centre-Surround mechanism to the domain of person recognition.

Introduction

Knowledge of familiar people is essential to guide social interaction and so is indispensable in everyday life. However, there is uncertainty about how semantic knowledge for people is stored in long-term memory. One view (e.g. Johnston & Bruce, 1990) holds that semantic knowledge for people has a categorical structure, as has been demonstrated to exist for objects (e.g. Barry, Johnston & Scanlan, 1998; Humphreys, Riddoch & Quinlan, 1988; Huttenlocher & Kubicek, 1983; Lupker, 1988; Sperber, MacCauley, Ragain & Weil, 1979). This view holds that occupation, for example, exists as a node in a network and that all persons of a particular occupation are connected to the corresponding node. An important implication is that people would be assumed to inherit the properties and features of the category to which they belong; beliefs about a person's attributes depend on their category membership.

The other view holds that memory for people is different and that semantic knowledge is not structured according to categories (e.g. Barry, Johnston & Scanlan, 1998). In this view, relationships between people can be represented by networks of associative relationships but not by membership of a common category. Knowledge of people is individual and attributes cannot be automatically inferred from category membership.

In support of the categorical structure of semantic knowledge for famous persons, Johnston and Bruce (1990) reported that response times to decide that two persons possessed the same attribute were faster for the attribute of occupation than that of nationality or living/dead. On this basis, they defined occupation as a super-ordinate organising category, noting that occupation is probably the reason why a person is famous and is almost invariably produced when a participant is asked to describe a famous person.

A form of categorical structure is implicit in the Interactive Activation and Competition (IAC) model of person recognition (Burton, Bruce & Johnston, 1990). In this model, face recognition units (FRUs) match perceptual input to stored representations of familiar faces. If a match is made then activation spreads from the FRU to the corresponding person identity node (PIN). There is one PIN for each known person and the PIN is the single point of access to semantic knowledge. Activation spreads from the PIN to semantic information units (SIUs) containing information relating to the individual, e.g. information defining their occupation, nationality, and name. Each SIU is connected to the PINs of other persons who share the same attribute. For example, the SIUs representing occupation information are connected to all persons with similar occupation. The links between a FRU and its corresponding PIN, and between a PIN and relevant SIUs, are bi-directional and excitatory. In this way, when a familiar face is presented, activation can spread to the representations of other persons also linked to the same SIUs, e.g. persons with the same occupation.

Both the Johnston and Bruce (1990) definition of occupation as an organising category, and the IAC model, predict that priming should be observed between two persons sharing a common occupation. That is, the presentation of the face of a famous person should influence the speed of responses to a subsequently presented target person sharing a common occupation with the prime but not otherwise related. However, evidence from priming studies has been mixed.

On the one hand, Bruce (1983), Brennen and Bruce (1991), and Carson and Burton (2001) all reported significant categorical priming of person recognition: responses to famous target faces or names were faster when the prime face or name was a person of the same occupation compared to a person of a different occupation. Darling and Valentine (2005), using the paradigm of release from proactive interference, presented results supporting the concept that semantic memory for famous people has a categorical structure and that occupation is an important category.

On the other hand, there have been failures to observe categorical priming of person recognition. Barry et al (1998) reported significant associative priming of a face naming and a face familiarity decision (the prime was a close associate of the target person), but not categorical priming with occupation as the category (prime and target shared a common occupation but were not associates). Based on this pattern of results, they suggested that memory for famous persons is ordered according to networks of associative relationships between individuals and lacks any categorical structure. The observation by Young, Flude, Hellawell and Ellis (1994) of significant associative priming of person recognition combined with a failure to observe significant categorical priming based on shared occupation is consistent with the Barry et al (1998) proposal. Further, Brennen and Bruce (1991), although they observed significant categorical priming, argued that the mechanism of categorical priming was qualitatively different to the mechanism of associative priming. If these views are correct, then semantic knowledge for persons lacks a categorical structure, and thus differs from semantic knowledge for objects. This would be in keeping with a general view that “people are special”.

Further evidence that semantic knowledge for people may differ from semantic knowledge for objects arises from neuropsychological studies showing that semantic knowledge for persons and objects are stored in separate neural systems. For example, Lyons, Hanley and Kay (2002) reported a patient who could recall identity-specific semantic information about people, but failed to provide specific semantics for many objects. This forms a double dissociation with the patient studied by Sperber and Spinnler (2003) who was not impaired in general semantics but suffered a progressive deterioration in semantic knowledge of familiar persons.

Another problem for the categorical view of semantic knowledge for people is that studies supporting this view have all used clearly visible and recognisable stimuli, which allows the use of intentional strategies to assist performance in a priming task. Consider that any attribute can be used to organise items in semantic memory, including items that are not normally thought of as belonging to the same category (e.g. the ad-hoc category of “things to take on holiday”). The reported categorical priming effects in person recognition may have arisen because the cognitive system is able to organise items in an ad-hoc way to meet the demands of the current task. For example, participants in a priming experiment have ample opportunity to observe that prime and target persons on some trials belong to the same occupation (e.g. actors, politicians). When the prime is presented, with the knowledge that the target is likely to be a person of the same occupation, the cognitive system could organise items in an ad-hoc way to facilitate responses to persons of the same occupation. This could give rise to a priming effect without being informative about the underlying structure of semantic memory. Thus, these studies do not offer conclusive evidence that semantic knowledge for famous people is organised in a categorical structure.

The categorical view would be more strongly supported by empirical evidence derived from studies that preclude the use of intentional strategies. One way to achieve this is to present primes so that they cannot be consciously recognised; if there is no awareness of the prime then no ad-hoc organisation of potential targets is possible. Any observed priming effect can be attributed to automatic processes, e.g. spreading activation. This would suggest that semantic knowledge of persons is organised in a categorical structure.

The method employed in the present study precluded the use of intentional strategies. A priming paradigm was used in which primes were famous faces, presented for very brief duration (17ms) and forward- and backward-masked. Previous work (e.g. Stone & Valentine, 2004, 2005) has suggested that conscious recognition is near-zero under these conditions. Targets were clearly visible famous faces (Experiment 1-3) or names (Experiment 3) to which a familiarity decision was required. Targets had either the same or different occupation to the prime but were never associates. The lack of awareness of the occupation of the prime faces, and the withholding of information about the relationship between prime and target, renders the use of intentional strategies for predicting the targets unlikely. Thus, any observed priming effect can be attributed to automatic processes (e.g. spreading activation), which would provide strong support for the categorical structure of semantic memory for famous people.

It should be noted that perceptual thresholds can be expected to vary between participants, between stimuli, and (possibly) randomly between trials. Thresholds may also vary systematically during an experiment as practice renders stimuli more readily perceptible. In order to preclude the conscious perception of the masked stimuli, it is necessary to select an exposure duration that can be confidently assumed to be below the perceptual threshold for all (or almost all) participants, stimuli, and trials. The masked exposure duration of 17ms was chosen because previous work (e.g. Stone & Valentine, 2004, 2005) has suggested that conscious recognition is near-zero under these conditions.

Occupation was chosen as the category because it is usually the reason for a person's fame and so is a very salient item of semantic information. Johnston and Bruce

(1990) and Darling and Valentine (2005) both reported evidence suggesting that occupation is a particularly strong candidate for a categorical organising property for famous persons. Choosing occupation as the category for investigation has the added benefits of consistency with previous studies and being generally well-known to participants.

It is relevant to consider why occupation should be an important organising principle for famous persons. The answer may be that celebrities are generally encountered in contexts that make their occupation obvious. For example, actors will be seen in films and fictional TV programmes, politicians will be seen on television and in newspapers in news items about political affairs, sports persons in sport programmes or in the sporting pages of the newspapers. The context in which a person appears will generally be known even before the person becomes familiar: when watching the TV news, or in the cinema, a particular face appears often enough for it to become familiar.

Before reporting the present study, a detour is necessary to consider what priming effects should be expected from very brief masked primes. It might be intuitively expected that priming would be positive in direction, i.e. responses would be faster to a target related to the prime than to an unrelated target, but in fact the literature contains examples of both positive and negative priming (faster responses to unrelated than to related targets). Dagenbach, Carr and Wilhelmsen (1989) and Carr and Dagenbach (1990) used masked exposures between 16.4 and 19.6ms that resulted in no conscious prime recognition, and both of these reported negative priming. In contrast, studies with exposure duration between 33ms and 40ms and levels of conscious prime recognition up to 6%, have reported positive priming (e.g. Dagenbach et al, 1989, Experiment 4; Durante & Hirshman, 1994, Experiment 1; Fischler & Goodman, 1978; Hirshman & Durante, 1992) with some exception (Durante & Hirshman, 1994, Experiment 2). For the present study, given the planned exposure of 17ms and the expectation that the level of conscious prime recognition would be zero or very near-zero, negative priming was predicted. It must be acknowledged that the studies cited above all used verbal stimuli, and timings for face stimuli may not be identical, but since the relevant studies using faces have not been reported the word literature remains the best guide.

Carr and Dagenbach (1990) offered Centre-Surround theory to account for their observations of negative priming of associated word pairs. This theory will be described in some detail since it is key to understanding the results of the present study. Dagenbach, Carr and Wilhelmsen (1989) presented participants with a lexical decision task in which target words were primed by associated or unrelated words with a stimulus onset asynchrony (SOA) of 1000ms. In Experiment 1, priming was positive (faster responses on related than unrelated trials) at supra-threshold prime exposure of 500ms. The interesting finding was that with very brief, masked prime exposure, priming was either positive or negative depending on the preceding task. The preceding task presented a masked word for very brief exposure that resulted in chance performance in one of three decisions. When the preceding task asked participants to say whether a specific word or a blank field had been presented (constrained detection), or to say which of two words had been presented (word-word discrimination), the subsequent priming task yielded positive priming. When the preceding task asked participants to decide which of two words was more similar in meaning to the presented word (semantic similarity), the subsequent priming task yielded negative priming. This result was replicated in Experiment 4, also a lexical decision task with very brief, masked primes: participants who performed a semantic similarity task before the priming task showed negative priming, and those who performed a presence-absence detection task before the priming task showed positive priming. Another replication was reported by Carr and Dagenbach (1990).

Carr and Dagenbach (1990) offered Centre-Surround theory to account for their observation of negative associative priming. According to this theory, an attention mechanism is invoked when participants attempt to extract into consciousness the meaning of a prime, and when the meaning is hard to extract. Difficulty could arise either because the prime is weakly activated, as with masked priming, or because the meaning itself is weakly activated, as with newly learned vocabulary words (e.g. Dagenbach, Carr & Barnhardt, 1990) or novel and arbitrary categories (Dagenbach & Carr, 1994). The attention mechanism boosts the degree of activation at the prime's semantic codes (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 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 can cross the threshold for conscious awareness, and then spreading activation to related codes ensures positive priming. When the attempt fails, the action of the attention mechanism that suppressed the degree of activation at related codes leads to slowed responses to related items and hence to negative priming.

Dagenbach *et al* (1989) and Carr and Dagenbach (1990) observed two critical conditions for negative priming to emerge. First, the primes' semantics must not be consciously accessible. Second, participants should be attending to the meaning of the primes. This was inferred from the observation that negative priming resulted only where participants had attempted to retrieve the meaning of primes in a preceding task. It was supposed that the attention to prime meaning in the preceding task had carried over into the experimental priming task. Note that participants were not asked to attempt to retrieve the meanings of primes in the experimental priming task. However, the second condition may not necessarily imply that participants' attention must be explicitly drawn to meanings of prime stimuli. It may be the case that the attempt to extract the meaning of a masked word or face is automatic, in the sense that it arises without deliberate intent, conscious or non-conscious, by the participant. In fact, there is ample evidence from investigation into the Stroop effect that activation of word meaning is non-intentional. It seems reasonable to suppose that faces, given their importance as social stimuli, are also analysed for meaning without deliberate attempt. This is supported by evidence of attention orientation towards facial expressions without awareness (e.g. Mogg & Bradley, 1999) when these were incidental to the main task. There is also evidence, from studies of prosopagnosic and unimpaired participants, that faces are automatically processed for identity and occupation even when this is detrimental to the overt task (e.g. de Haan, Bauer & Greve, 1992; de Haan, Young & Newcombe, 1987; Sergent & Signoret, 1992). These lines of evidence suggest that the attempt to extract the meaning of a prime word or face is non-intentional.

The conclusion that negative priming occurs only when participants' attention is specifically drawn towards the meaning of the primes arose from a comparison of conditions in Dagenbach *et al* (1989) and Carr and Dagenbach (1990). However, close examination of the methods suggests another possibility: that participants will attempt to process the meaning of the prime *unless* induced to direct attention to some subset of purely physical characteristics of the prime. Attention only to gross physical aspects of the prime will suffice to perform the presence-absence detection task and the constrained detection task. Attention only to the initial letter or to the length of the word will suffice for the word-word discrimination task, given that pairs of words were constructed with differing length and different initial letters. Altogether, it seems more likely that the second condition for negative priming to emerge should be that participants should not be diverted from the default direction of attention to the meaning of the primes.

A third condition for negative priming, added by Dagenbach and Carr (1994), is a minimum SOA, which is necessary because the attention mechanism will require some time to suppress the degree of activation at related codes. At short SOA only spreading activation can affect responses to targets. Therefore, positive priming should be observed at short SOA, becoming negative at longer SOA. This was investigated in Experiment 2 of the present study.

Although Centre-Surround theory was originally proposed to account for empirical results using verbal stimuli, Dagenbach and Carr (1994) reported a priming study using geometric shapes, which suggests that the Centre-Surround mechanism is not restricted to verbal stimuli but has more general application. Relatively novel stimuli (from the extended keyboard set of characters) were arbitrarily categorised into “fleps” and “gleps”. Although primes were clearly visible, those whose meaning (i.e. category) could be accessed only slowly yielded negative priming of a same-category target, compared to positive priming from those primes for which the category was more readily available. This study adds to the previous work in two important ways. It shows that the Centre-Surround mechanism can affect priming between items sharing only a common category and is not restricted to close associates. It also extends the previous work to visual, non-verbal material.

The present study investigated categorical priming of person recognition in 4 experiments. Primes were always masked 17ms faces of famous persons. In Experiment 1, targets were famous faces with the same or different occupation to the prime face and the prime-target stimulus onset asynchrony (SOA) was 1517ms. The Centre-Surround theory predicts negative priming. Experiment 2 examined a previously untested prediction of Centre-Surround theory, specifically, that the direction of priming would depend on the prime-to-target stimulus onset asynchrony (SOA) with positive priming at short SOA and negative priming at longer SOA. Experiment 3 investigated whether the locus of the priming effects lay within the semantic system. It should be noted that other theories have been proposed to explain negative priming from masked primes: the Retrospective Priming account of Durante and Hirshman (1994), and the Retrospective Prime Clarification account introduced by Kahan (2000). Experiment 4 investigated whether these might provide an explanation for the results of Experiment 1-3.

Experiment 1

Experiment 1 employed a priming paradigm in which primes were masked 17ms famous faces and targets were clearly visible famous faces to which a familiarity decision was required. Targets had either the same or different occupation to the prime but were never associates. The literature suggests that the result would be negative priming.

Method

Participants. Participants were 30 students, staff and visitors at Goldsmiths College, London. The participants were 18 female and 12 male, aged between 18 and 41, mean 23.5 years.

Stimuli. Twenty pairs of categorically related celebrities (sharing a common occupation but not associates) were created. The absence of an associative relationship between the celebrities in each pair was verified by 14 participants (7 male and 7 female, aged between 18 and 39, mean age = 25.75 years, all students staff and visitors at

Goldsmiths College, London) who were shown each name and asked to generate three associates. Participants all failed to generate the name of the paired celebrity as an associate of the referent celebrity, using either member of the pair as the referent. This is the procedure used by Brennen and Bruce (1991) with four participants, and by Carson and Burton (2001) with 8 participants (in Bruce, 1983, no specific method was reported for ascertaining the absence of an association between categorical pairs). The participants in this exercise were drawn from the same population as the experimental participants.

Facial photographs of the selected celebrities were digitised to produce images of 16 greys, 150 x 200 pixels in size. The 20 pairs of celebrity faces with the same occupation (see Appendix A) were divided into groups 1 and 2 such that the groups had an approximately equal number of pairs from film stars, pop stars, sporting stars, politicians, the UK royal family, TV presenters and comedians. Set A comprised the stimuli from group 1 in their same-occupation pairs and the stimuli from group 2 jumbled to create pairs with different occupations; set B comprised the converse arrangement. Each famous face always occupied the same position, either prime or target. Half the participants received stimulus set A and the other half received set B. Twenty unfamiliar target faces were also obtained, primed by the same primes as the famous target faces. The unfamiliar condition was irrelevant to the experimental hypothesis and was included only to generate the task demand. Thus, each participant had 40 trials: 10 with same-occupation targets, 10 with different-occupation targets, and 20 with unfamiliar targets.

Apparatus. A personal computer running MEL2 software was used to display the faces at a screen resolution of 640 x 480. Response times and accuracy of response were measured and recorded by the computer.

Design. There was a single within-participant factor, the relationship between the prime and target faces (same-occupation, different-occupation, unfamiliar target). The same-occupation and different-occupation conditions each comprised 10 targets and the unfamiliar condition 20 targets. The trials for the unfamiliar condition were included only to generate the task demand and were not analysed, thus 20 trials for each participant were entered to the analysis. The 40 trials were presented in a different random sequence to each participant, following 10 practice trials. Participants were offered a two-alternative forced-choice of famous or unfamiliar on the target face. The dependent variable was response time, recorded from the onset of the target face.

In the experiments reported here, the *verbal report* approach was taken to detecting instances of awareness of masked primes. Participants were strongly encouraged to report *immediately* any conscious recognition of any of the prime faces and trials on which this occurred were excluded from statistical analysis. The prime exposure duration was maintained at 17ms throughout. It could be argued that the *verbal report* approach is inadequate and that participants might have experienced some conscious recognition that they failed to declare. The *verbal report* approach was chosen because the alternative approach of measuring individual exposure thresholds for each participant has distinct drawbacks. First, as shown by Dagenbach, Carr and Wilhelmsen (1989), participants' ability to perceive masked primes may improve during the course of an experiment, so a threshold measured pre-experimentally does not guarantee that primes went unrecognised during the experiment. Second, experiments using individually-measured thresholds have arrived at exposures much longer than the 17ms used in the present series of experiments (exposures of more than 65ms in Ellis, Young & Koenken, 1993, and Morrison, Bruce & Burton, 1999). Nonetheless, because it is impossible to prove that all consciously recognised primes were declared during the experiments and excluded from analysis, the term “severely restricted awareness” is used rather than the stronger claim that primes were recognised without awareness. The exposure duration of 17ms seems to justify the term “severely restricted awareness”.

Procedure. Participants carried out the task individually in a darkened, air-conditioned room. The participant initiated the sequence of trials by pressing a key. The sequence of presentation on each trial was as follows: 500ms fixation point, 500ms mask, 17ms prime face, 1500ms mask, and finally target face displayed until the participant responded. Where a prime face was consciously recognised, the participant reported this before making the famous / unfamiliar response to the target face, so there was unlimited time for making a report of conscious recognition. Each subsequent trial was initiated by the response to the previous trial.

Participants were informed that a series of faces would be displayed, half of them famous and half unknown. They were asked to respond by pressing the ’f’ (famous) key if they thought the face was famous and ‘n’ (not familiar) if they did not recognise it. Participants were asked to respond “as quickly as possible without making too many mistakes”. Participants were informed that before each target face they would see a rectangle of jumbled face parts, which would flicker, as the face of another person was displayed very briefly. They were told not to worry if they could not see any of these briefly presented faces clearly, and not to attempt to respond to them, but to attend carefully to the screen. It was emphasised that participants should declare *immediately* any awareness of any of the briefly presented faces, even if this was uncertain, and this report should be made before responding to the target. This procedure avoids the problem that adaptation to the dim lighting might have made the primes easier to perceive, since if this had occurred, instances of conscious recognition would still have been detected. At the end of the task, participants were asked again whether they had any idea about the identity of any of the briefly presented faces. None made any correct report and all stated that they had seen only vague impressions of the prime faces.

Finally, participants were debriefed and thanked for their participation.

Results and Discussion

One participant correctly recognised one prime face, on a trial where the target face was unfamiliar. Also, 4 participants incorrectly named 4 celebrities not used in the experiment. The observation of incorrect as well as correct prime identification suggests that participants were following instructions by reporting any instances of conscious recognition even if this was uncertain.

The responses relevant to the experimental hypothesis were the correct responses to famous target faces on same-occupation and different-occupation trials. Trials were excluded if the prime face was consciously recognised (none), if the response to the target face was incorrect (9.4% of trials), if the response time was more than 2.5 standard deviations above the mean for the participant (3.2% of trials), or if the response was faster than 200ms (none).

Responses were near-significantly faster on different-occupation trials (M = 931ms, SE = 44) than on same-occupation trials (M = 962ms, SE = 43), paired-samples $t(29) = -2.01$, MSE = 3666, $p = 0.054$ (two-tailed). It appears that negative categorical priming results from a single prime face, exposed for 17ms and masked, with a SOA of 1,517ms. Accuracy did not differ between same-occupation trials (M = 0.84, SE = 0.023) and different-occupation trials (M = 0.85, SE = 0.022), $t(29) = 0.65$, ns.

The possibility of undeclared conscious recognition of some of the prime faces must be considered. Two considerations make this unlikely: the brevity of exposure at only 17ms; and negative priming is a qualitatively different result to that expected with conscious prime perception and so is suggestive of different underlying processes (e.g. Merikle, 1992; Merikle & Daneman, 1998; Merikle & Reingold, 1991; Reingold, 1992).

There was no control condition using unfamiliar face primes for the famous face targets. Such a control condition is sometimes included in priming experiments (though not in Dagenbach et al (1989) or Kahan (2000)) in order to ascertain whether priming effects are due to speeding of responses to targets by related primes, or slowing of responses to targets by unrelated primes, compared to the speed of responses to targets preceded by unfamiliar primes. Negative priming makes the control condition redundant because it shows a slowing of responses to related targets compared to unrelated targets. This can only be attributed to the slowing of responses to related targets, since there is no mechanism that could produce a speeding of responses to unrelated targets.

The conditions required by Centre-Surround theory to produce negative priming appear to have been met in Experiment 1. These conditions were that the primes' semantics must not be consciously accessible, that participants should be attending to the meaning of the primes, and a minimum SOA. Exposure was 17ms (mean exposure 15.8ms to 19.6ms in Dagenbach *et al*, 1989) and reported prime identification was 0.08% (zero), which seems likely to have met the first condition that the primes' semantics were not consciously accessible. Regarding the second condition, participants were not diverted from the default process of attending to the identity of the prime and, if anything, were likely to have been drawn to the identity of the prime by the instruction to report immediately any primes that were recognised. The third condition was clearly met by SOA of over 1500ms compared to 1000ms in Dagenbach *et al* (1989). Altogether, Centre-Surround theory seems a plausible account of the negative priming observed here.

The argument that the Centre-Surround attention mechanism was operating would be strengthened if a prediction of Centre-Surround theory could be empirically confirmed. The prediction that negative priming requires sufficient SOA does not appear to have been investigated, and this was the purpose of Experiment 2.

Experiment 2

According to Centre-Surround theory, a condition for negative priming is a minimum prime-target SOA, because the attention mechanism will require some time to suppress the degree of activation at related codes (Dagenbach & Carr, 1994). This predicts that positive priming should be observed at short SOA, becoming negative at longer SOA.

The series of experiments reported by Greenwald, Draine and Abrams (1996) can be interpreted as consistent with this condition. In these experiments, prime exposure was 50ms and masked inter-stimulus interval varied from 17ms upwards so that SOA varied from 67ms upwards. Priming was “consistently strong” only at 67ms SOA, appeared to decrease to low levels at more than 100ms SOA, and at around 100ms SOA the picture was unclear. In terms of Centre-Surround theory, when the shortest SOA of 67ms was used, the presentation of the target interrupted the attention mechanism, and hence consistently strong priming was observed. A longer SOA allowed time for a more substantial effect of the attention mechanism and so priming decreased to low levels. Note that Greenwald *et al* (1996) never reported negative priming, even at their longer SOA. Centre-Surround theory can account for this as follows. With prime exposure duration of 50ms, the level of activation at the prime and related items was sufficiently high that it remained at or above resting level even after the attention mechanism. It is only with very little activation at related items (as results from very brief prime exposures) that the attention mechanism drives the activation at related items to below resting level.

The prediction of positive priming at short prime-target SOA raises the question of how short the SOA can be: it seems reasonable to assume that there is some limit. The speed of spreading activation has not been examined with faces, so evidence must be sought from experiments using word stimuli. In fact, there is ample evidence that priming can be obtained with prime-to-target SOA between 30 and 40ms, when words or pictures of objects are used as primes and words are used as targets (e.g. Evett & Humphreys, 1981; Fischler & Goodman, 1978; Greenwald *et al*, 1996; Perea & Gotor, 1997; Sereno & Rayner, 1992). [With very short SOA the prime exposure duration is also very short. It is not claimed that primes were consciously undetectable in all of these experiments. However, it does appear from the exposure duration that it is likely that primes were hard to detect, and that many would have been consciously undetectable or detected with little confidence.] Only Sereno and Rayner (1992) reported a shorter SOA than 30ms, and they found no effect of priming at 21ms SOA. This last observation is important as it sets a lower bound on the SOA at which priming can be obtained. There is no equivalent evidence of spreading activation with short SOA from the face literature. Experiments on facial emotional expression are not comparable for at least two reasons: emotional expressions are associated with affective priming, which has a different time-course, and emotional expressions are a small set compared to the number of famous faces known by the average individual. The word literature appears to provide the best available estimate, and this suggests no priming with SOA below 30ms.

The purpose of Experiment 2 was to investigate the prediction derived from Centre-Surround theory that categorical priming should be positive at short SOA and become more negative as SOA increases. Prime exposure duration was 17ms and the SOAs tested were 33ms, 117ms, 217ms and 517ms. This range of SOAs was selected because of uncertainty about the SOA required to produce negative priming.

It should be noted that the time required by the Centre-Surround attention mechanism to suppress the degree of activation at related codes can be expected to vary between participants, between stimuli, and (possibly) randomly between trials. Thus, observed mean response times in each of the SOAs investigated in Experiment 2 may represent a mixture of effects. Nonetheless, if the prediction is correct, it should be possible to observe average differences between the shorter and longer SOAs in the direction of priming.

Method

Only differences from Experiment 1 will be noted here.

Participants. The prime-to-target SOA was varied between-participants. Each SOA condition comprised 30 students, staff and visitors at Goldsmiths College, London, with the exception of the 517ms SOA condition undertaken by 17 participants. In the 33ms SOA condition, there were 20 female and 10 male, aged between 18 and 34, mean = 22.3, s.d. = 3.7 years. In the 117ms SOA condition, there were 15 female and 15 male, aged between 19 and 33, mean 23.8, s.d. 4.0 years. In the 217ms SOA condition, there were 24 female and 6 male, aged between 19 and 34, mean 21.7, s.d. 3.1 years. In the 517ms SOA condition, there were 11 female and 6 male, aged between 19 and 35, mean age 25.1, s.d. 4.0 years. None had taken part in Experiment 1.

<u>Stimuli</u>. Thirty-two pairs of celebrity faces were selected (see Appendix A) such that the faces in a pair shared the same occupation but were not associatively related. Some of the pairs had been used in Experiment 1 and others were constructed from the stimuli employed by Carson and Burton (2001). Face pairs were divided into groups 1 and 2 such that the groups had an approximately equal number of pairs of film stars, pop stars, TV presenters, comedians, sport stars and politicians. Set A comprised the 16 pairs from group 1 in their same-occupation pairs and the 16 pairs from group 2 jumbled to create pairs with different occupations; set B comprised the converse arrangement. Within each SOA condition half the participants received stimulus set A and half received set B so that set was counterbalanced across participants. Each individual face always occupied the same position, either prime or target. A further 32 unfamiliar faces were selected as targets, primed by the same prime faces as the famous targets. Thus, each prime face appeared in each set with both a famous and an unfamiliar target face.

<u>Design.</u> There was one between-participant factor of prime-target SOA (33, 117, 217 or 517ms), and one within-participant factor of relationship between prime and target faces (same-occupation, different-occupation, unfamiliar target). There were 64 trials in each SOA condition: 32 with unfamiliar targets, 16 with famous targets and same-occupation primes, and 16 with famous targets and different-occupation primes. The prime face was presented for 17ms, followed by the mask from Experiment 1 for the remainder of the prime-target SOA, and finally the target face was presented until the participant responded.

There was no control condition with unfamiliar face primes for famous targets. Such a control condition is sometimes included in priming experiments in order to ascertain whether priming effects are due to speeding of responses to targets by related primes, or slowing of responses to targets by unrelated primes, compared to the speed of responses to targets preceded by unfamiliar primes. As was explained in the discussion of Experiment 1, the control condition would have been redundant for the interpretation of negative priming at longer SOA. Positive priming was predicted at short SOA, but the strategic processing necessary to inhibit responses to unrelated items requires a minimum SOA of around 200ms (e.g. Neely, 1991). Therefore, if positive priming is observed at 33ms or 117ms SOA, it implies a speeding of responses to related items, which must be due to automatic spreading activation.

Results and Discussion

Participants were strongly encouraged to guess at the identities of the prime faces but all insisted they had been unable to recognise any of the prime faces. This compares with one face recognised by one participant in Experiment 1, under the same presentation conditions (17ms exposure and the same mask). The responses relevant to the experimental hypothesis were the correct responses to famous target faces on same-occupation and different-occupation trials. Trials were excluded if the prime face was consciously recognised (none), if the response to the target face was incorrect (15.1% of trials), if the response time was more than 2.5 standard deviations above the mean for the participant (3.0% of trials), or if the response was faster than 200ms (none).

Analysis of Variance (ANOVA) was performed with one within-P factor of relation (same vs. different occupation) and one between-P factor of SOA (33ms, 117ms, 217ms and 517ms). The main effect of relation was non-significant, $F < 1$, as was the main effect of SOA, $F(3,103) = 1.7$, ns, but the interaction was significant, $F(3,103) = 3.38$, $MSE = 3447$, $p < 0.025$.

Comparisons between pairs of SOA showed the following pattern of results. The effect of relation differed between 33ms and 217ms SOA, $F(1,58) = 5.85$, $MSE = 4741$, $p < 0.02$, and between 33ms and 517ms SOA, $F(1,45) = 4.69$, $MSE = 4290$, $p < 0.04$. The effect of relation did not differ between 217ms and 517ms SOA, $F = 0$. The effect of relation at 117ms SOA did not differ significantly from any other SOA [$F(1,58) = 1.56$, $p > 0.2$, $F(1,58) = 3.03$, $p < 0.09$, and $F(1,45) = 3.45$, $p < 0.08$, for the comparison of 117ms with 33ms, 217ms and 517ms SOA, respectively]. This pattern suggests a difference in the direction of priming between the short SOA of 33ms and the two longer SOAs of 217 and 517ms. See Figure 1.

Figure 1 about here

Figure 1 suggests that priming was positive at 33ms SOA and negative at 217 and 517ms SOA, consistent with prediction. Paired-samples t-tests (one-tailed for directional predictions) support this conclusion. At 33ms SOA, priming was significantly positive, $t(29) = 1.94$, $p = 0.03$, showing faster responses on related trials ($M = 843$ms, $SE = 24.7$) than on unrelated trials ($M = 880$ms, $SE = 32.0$). At the two longer SOAs of 217ms and 517ms, priming was significantly negative, $t(46) = 2.03$, $p < 0.025$, showing slower responses on related trials ($M = 845$, $SE = 23.4$) than on unrelated trials ($M = 821$, $SE = 18.4$). Accuracy did not differ between related and unrelated trials for any SOA, all $t < 1.6$, $p > 0.14$.

Mean responses were numerically faster at 117ms SOA than at any other SOA, though the contrast did not reach statistical significance. Only a speculative explanation can be offered. Participants were aware of the mask flickering as the prime face was presented and this may have provided an alerting cue to the onset of the target; faster responses with 117ms SOA could have arisen if this is an optimal cue-to-target interval.

Certainly the 33ms SOA seems too brief to be useful as an alerting cue. Whatever the reason for the numerically faster responses at 117ms SOA, this does not detract from the key finding of positive priming at short SOA and negative priming at longer SOA.

The prediction of positive priming at short SOA, becoming negative with increasing SOA, was supported by the observation of positive priming at 33ms SOA and negative priming at 217ms and 517ms SOA. This experiment offers clear support to Centre-Surround theory.

Experiment 3

Experiment 1 and 2 both yielded negative priming at longer SOA; responses to famous target faces were slower when primed by a masked 17ms famous face of the same occupation compared to a different occupation. This is attributed to the Centre-Surround attention mechanism that suppresses the degree of activation at codes representing items related to a stimulus whose meaning is not consciously accessible. An interesting question concerns the locus of the inhibition mechanism applied to same-occupation persons, given that a person can be identified by either face or name. On the one hand, a name could interfere with the attempt to gain awareness of a hard-to-perceive face, so the inhibition mechanism could suppress activation at the names as well as the faces of same-occupation famous persons. On the other hand, a face and a name are different types of stimulus and it might seem that they could not be confused, in which case the inhibition mechanism would apply to faces only and not to names.

In the Burton et al (1990) model of person recognition, activation spreads from the visual input of the prime face to the corresponding Face Recognition Unit (FRU), to the unique Person Identity Node (PIN), to the Semantic Information Units (SIUs) representing the occupation, and then to the PINs of persons sharing the same occupation, and on to their FRUs and Name Recognition Units (NRUs). (This activation does not generally reach the threshold for becoming consciously accessible from a masked 17ms presentation of the prime face). The Centre-Surround attention mechanism suppresses the level of activation at codes representing items related to the prime, so the question is whether the suppression takes place at the PINs or at the FRUs. If the activation at related PINs is suppressed then there should be inhibition of a familiarity decision to either the face or the name of a related person. If the suppression of activation takes place at the FRUs, then a familiarity decision will be inhibited only to the face of a related person and not to the name, which has its own Name Recognition Unit.

Experiment 3 investigated this question by replacing the target famous faces with the equivalent names for half the participants. Primes were always famous faces. If face and name targets were to receive equivalent amounts of negative priming, this would suggest that the Centre-Surround attention mechanism had suppressed the degree of activation at the PIN. If faces were to receive negative priming but names were to receive positive priming, then this would suggest that only FRUs of related persons are suppressed by the attention mechanism.

Method.

Only the differences from Experiment 1 will be noted.

Participants. Participants were 20 students at Goldsmiths College, London, 13 female and 7 male, with ages ranging from 18 to 41 years, mean = 22.1, s.d. = 6.2 years. Two participants were excluded, one with very slow response times, and the other with low accuracy, and both were replaced.

Stimuli. Thirty pairs of celebrity faces were selected from Experiment 2 (see Appendix A). Face pairs were divided into groups 1 and 2 such that the groups had an approximately equal number of pairs of film stars, pop stars, TV presenters, comedians, sport stars and politicians. Set A comprised the 15 pairs from group 1 in their same-occupation pairs and the 15 pairs from group 2 jumbled to create pairs with different occupations; set B comprised the converse arrangement. Half the participants received stimulus set A and half received set B so that set was counterbalanced across participants.

For half the participants in each stimulus set, famous target faces were replaced by their corresponding names, and unfamiliar target faces were replaced by non-famous names. Primes were always famous faces. In a change from Experiments 1 and 2, a new set of 30 famous faces were selected to prime the unfamiliar target faces / names, so that each prime appeared only once.

Design. There was one within-participant factor of relationship between prime and target (same-occupation, different-occupation, unfamiliar target) and one between-participant factor of target type (face or name). There were 60 trials: 30 with unfamiliar targets, 15 with famous targets and same-occupation primes, and 15 with famous targets and different-occupation primes. The prime face was presented for 17ms and the target face or name was presented after 1500ms, the interval being filled with the mask previously used. The target face or name remained on the screen until the participant responded.

Results and Discussion

Six participants correctly recognised a total of 11 prime faces, 7 prime faces on trials with an unfamiliar target, and 4 prime faces on trials with an unrelated target. Trials on which a prime was recognised were excluded from the analysis. The responses relevant to the experimental hypothesis were the correct responses to famous target faces/names on same-occupation and different-occupation trials. Trials were excluded if the prime face was consciously recognised, if the response to the target face/name was incorrect (12.8% of trials), if the response time was more than 2.5 standard deviations above the mean for the participant (2.4% of trials), or if the response was faster than 200ms (none).

Analysis of variance was performed with one within-participant factor of relation (same-occupation vs. different-occupation) and one between-participant factor of target type (face or name). The main effect of relation showed negative priming, $F(1,18) = 6.97$, $MSE = 1022$, $p < 0.02$, with faster responses on different-occupation trials (M = 817ms, SE = 26.2) than same-occupation trials (M = 843ms, SE = 25.8). The main effect of target type was non-significant, $F < 1$, and the two-way interaction was non-significant, $F < 1.9$, $p > 0.19$. See Figure 2.

Figure 2 about here

ANOVA with the same independent factors and dependent variable of mean accuracy revealed a main effect of target type, $F(1,18) = 5.31$, $MSE = 0.020$, $p < 0.04$, showing higher accuracy to name targets (M = 0.917, SE = 0.032) than to face targets (M = 0.813, SE = 0.032). There was no effect of relation and no interaction, both $F < 1$.

The non-significant interaction of relation with target type indicates that priming of face and name targets were statistically equivalent. It is noted that power to detect an interaction is lower than power to detect a main effect (Lewis, 2004) but even so, the interaction did not come close to significance ($p > 0.19$). [Face targets, different-occupation M = 815ms, SE = 33.6; same-occupation M = 828ms, SE = 32.9; Name targets, different-occupation M = 819ms, SE = 40.3; same-occupation M = 859ms, SE = 39.7].

The observation that faces and names received statistically equivalent amounts of negative priming suggests that the Centre-Surround attention mechanism had suppressed the degree of activation at the Person Identity Node. The alternative possibility was that the attention mechanism would suppress the degree of activation at the Face Recognition Unit rather than at the PIN, which would result in negative priming only for face targets and not for name targets. Since the priming of name targets was numerically more negative than the priming of face targets, this alternative possibility is clearly not supported.

It should be noted that the Burton et al (1990) model does not incorporate the Centre-Surround mechanism. It does include Within-Pool Inhibition, which states that an activated item in a pool (e.g. the pool of Person Identity Nodes) inhibits all other items in the same pool. The Centre-Surround mechanism is conceived as a targeted form of inhibition applied only to items likely to be confused with a hard-to-perceive prime rather than being applied indiscriminately to all items in the pool. It would be interesting to see if the Burton et al (1990) model could be updated to incorporate the targeted form of inhibition, but that lies beyond the scope of this article.

Experiment 4

While the results of Experiment 1-3 are compatible with the Centre-Surround attention mechanism, there are two alternative explanations that should be considered. One of these is regarded as implausible on conceptual grounds and the other will be examined in Experiment 4.

Retrospective Priming. Durante and Hirshman (1994) proposed that when a prime is masked, but achieves an activation level not too far short of the threshold for conscious perception, activation spreading from a subsequent related target back to the prime -

retrospective priming - can result in the prime reaching its threshold. The effect for the participant is that after the target is presented there is awareness of the identity of the prime. The distraction this causes results in a slowing of response to the target, and the net effect is slower responses to related than to unrelated targets, yielding negative priming. Durante and Hirshman (1994) presented evidence from three experiments using words as primes and targets that as retrospective priming increased across conditions, the magnitude of priming decreased and became negative.

An essential condition does not appear to have been met in the present study. Negative priming can be explained by this account only when there is substantial awareness of primes, with more occurring on related than on unrelated trials, because it is the act of realising the identity of the prime that slows responses to the target. That was not the case in Experiment 1-3, in which no primes were reported on related trials, and so Retrospective Priming does not appear to apply.

Retrospective Prime Clarification. Kahan (2000) proposed an account somewhat similar to that of Durante and Hirshman (1994), in that the representation of a target interacts with the previously activated representation of a prime. The key difference is that a slowed response to a related target is attributed to the effort involved in attempting to achieve awareness of the masked prime, but does not require success on every trial. When a masked prime is presented, a weak memory will be formed containing partially activated codes, which could be used to help identify the prime. Participants in a priming experiment have opportunity to learn how to disambiguate the prime using a combination of information from the target and expectations of the prime-target relation. When the target is presented, codes representing the expected prime-target relation are examined, and if a match is found, this is used to try to clarify the prime. If no match is found, the attempt to clarify the prime is abandoned. The key point is that more effort is expended when prime and target match in the expected manner, and this effort leads to delayed response on related trials compared to unrelated trials, causing an observed effect of negative priming. For example, when the prime is a masked famous face, this activates weak visual and semantic codes including the codes representing the occupation. If the target face is recognised clearly then codes representing its occupation are examined to see if there is a match with the weak memory of occupation codes partially activated by the prime face. If a match is found, then this is taken as indicating the occupation of the prime face, and the combination of a weak memory of visual codes and knowledge of the occupation can help to clarify the prime.

According to Kahan (2000) the key condition that must be met before Retrospective Prime Clarification will operate is that participants have expectations of the prime-target relationship, because the codes searched will be those representing the expected relationship. A participant with no expectation will not use the RPC strategy. Kahan (2000) used words as primes and targets, and the related pairs were either close associates or repetitions in each of two experiments. Two methods were used to encourage participants to expect either an associative or repetition relationship. In Experiment 1, participants were trained to expect the relationship in a training task before the priming task. Experiment 2 had no training task, instead 75% of all trials in the priming task were either associated or repeated (and the other 25% represented the other relationship), with the assumption that participants would learn to expect the relationship that was represented in the majority of trials. Kahan (2000, p1401) states that participants must have awareness of some masked primes in order to generate an expectation of the prime-target relationship.

It seems unlikely that participants in the present study could have learnt to expect the relationship of same occupation: there was no preceding training task, and only 25% of trials in the priming task represented the relationship. The observation that none of the masked prime faces were reported on related trials renders it unlikely that participants had learned the relationship through conscious perception.

Nonetheless, because Retrospective Prime Clarification cannot be completely ruled out, Experiment 4 employed an experimental design in which Centre-Surround and Retrospective Prime Clarification make opposing predictions. The target was changed, from the face (or name) of a famous person with the same or different occupation to the prime, to the occupation itself. Centre-Surround predicts that semantic information about the prime will not be inhibited because such information is part of the Centre and not part of the Surround. So, spreading activation from the masked prime face should result in faster responses to its occupation than to an unrelated occupation, yielding positive priming. In contrast, Retrospective Prime Clarification predicts that responses to the prime's occupation should be slowed compared to an unrelated occupation, yielding negative priming, because the occupation can be used to attempt to clarify the prime (assuming that a match on semantic codes is found). Thus, Centre-Surround predicts positive priming of the prime's occupation while Retrospective Prime Clarification predicts negative priming.

The aim was to investigate whether Retrospective Prime Clarification could explain the negative priming of Experiment 1-3 and so conditions were kept the same as far as possible. The same prime stimuli were used as in Experiment 3; the proportions of related, unrelated, and unfamiliar targets were as before (25 / 25 / 50%); and the SOA was 1517ms that produced significantly negative priming in Experiment 1 and 3. The major change was to the target, which became the occupation of the prime face on related trials, a different occupation on unrelated trials, and an occupation not associated with fame on “unfamiliar” trials. Each occupation target was a unique short phrase that clearly defines the occupation, e.g. “has starred in films”, “is a TV presenter”, “often appears in TV comedy”, “makes hit pop records”, “is a leading politician”.

These occupation targets were created after a pilot study found that a simple occupation name e.g. “film star” or “politician” yielded extremely fast responses. This was attributed to the simplicity of the target and its repetition. The drawback is that repeated targets can result in the word reading - response generation process becoming so highly automated that other automatic processes can have no influence, precluding any priming effect from becoming apparent (e.g. Moore & Valentine, 1998; Hermans, de Houwer & Eelen, 2001). Therefore, the targets were designed to be unique on every trial.

Method.

Only the differences from Experiment 1 will be noted.

Participants. Participants were 24 students of Goldsmiths College, London, 16 female and 8 male, aged between 18 and 44 years, mean 23.0, s.d. 6.4 years.

Stimuli. The primes were those used in Experiment 3, and the targets became the occupation of the prime face on related trials, a different occupation on unrelated trials, and an occupation not associated with fame on “unfamiliar” trials. See appendix A for a complete list of occupation definitions.

Procedure. On every trial, participants were asked to decide whether the occupation was one associated with fame or not.

Results and Discussion

One participant recognised 1 prime face on a trial with a related target, and 1 prime face on a trial with an unrelated target. A further 13 faces were recognised on trials with an “unfamiliar” target.

The responses relevant to the experimental hypothesis were the correct responses to targets on related and unrelated trials. Trials were excluded if the prime face was consciously recognised (0.3% of trials), if the response to the target was incorrect (4.0% of trials), if the response time was more than 2.5 standard deviations above the mean for the participant (2.0%), or if the response was faster than 200ms (none).

A paired-samples t-test revealed that responses were faster on related trials (M = 1127ms, SE = 40.5) than on unrelated trials (M = 1183ms, SE = 47.1), $t(23) = 3.11$, $p = 0.005$, an effect of positive priming. Accuracy did not differ on related and unrelated trials, $t(23) = 0.7$, ns.

Positive priming is consistent with the prediction of Centre-Surround theory. It appears that activation had spread from the prime face to semantic codes representing the occupation, and that the activation at these codes facilitated responses to the targets. Positive priming contradicts RPC, which predicts slower responses to related than unrelated targets, i.e. negative priming, because the occupation can be used to attempt to clarify the prime face.

The observation that RPC did not appear to have been used to a detectable degree in Experiment 4 suggests that it was unlikely to have been used in Experiment 1-3. The procedure in Experiment 4 was similar to previous experiments, with the same prime faces, the same prime exposure duration of 17ms, the same mask, and a prime-to-target SOA of

1517ms that yielded negative priming in Experiment 1 and 3. Further, a direct specification of the occupation was a good clue to the identity of the prime face, perhaps a better clue that the face (or name) of a famous person with the same occupation as the prime face. Therefore, if RPC was responsible for the negative priming observed in Experiment 1-3, it should have produced negative priming in Experiment 4. The observation that it did not argues that RPC was not used in Experiment 1-3.

The argument could be advanced that the nature of the required response could have prevented the application of the RPC strategy in Experiment 4. Perhaps the decision as to whether an occupation is associated with fame was more complex than the familiar/unfamiliar decision required in Experiment 1-3. This seems unlikely, given the extremely high accuracy of responses in Experiment 4 (96% correct). The overall slower response times in Experiment 4 compared to previous experiments is readily attributable to the additional time required to read the somewhat longer targets. In any event, if RPC can be used only where a simple decision to a target is required, this strategy has little applicability.

General Discussion

In Experiment 1-3, a single famous prime face affected responses to the face (or name) of a target famous person sharing the same occupation but not otherwise related. (The precise pattern of facilitation and inhibition is attributed to Centre-Surround theory, discussed later). The brevity of prime exposure at 17ms and masking prevented all participants in Experiment 1-3 from reporting any prime face on a trial where the target was related to the prime. This renders very unlikely the possibility that participants detected the prime-target relationship and thus precludes the use of intentional strategies to facilitate responses to the targets. This permits the attribution of the observed priming effects to automatic processes, including spreading activation and the Centre-Surround attention mechanism. The implication is that famous persons sharing a common occupation, but no association, are linked together in semantic memory. This supports the categorical structure of semantic knowledge for famous persons with occupation as an important category.

The results of the present study are consistent with the proposal of Johnston and Bruce (1990) that occupation is an super-ordinate organising category in the structure of semantic knowledge for people, and with the Burton et al (1990) model of person recognition that represents information about occupation (and other semantics) as distinct nodes in a network. They contradict the alternative proposal of Barry, Johnston & Scanlan (1998) that memory for famous persons is ordered according to networks of associative relationships between individuals, lacking any categorical structure. It seems that, in this sense, people are not "special" and that semantic knowledge for people is stored and accessed in similar ways to semantic knowledge for objects.

It seems plausible that occupation is an important category for famous persons, because celebrities are generally encountered in contexts that make their occupation obvious. This suggests an interesting contrast between famous and personally familiar people, for example one's relatives, one's neighbours, people who attend the same evening class, etc. Unlike celebrities, the occupation of personal acquaintances is not the reason for their familiarity, and may not even be known. Thus, it is less likely that personal acquaintances will be categorised by occupation. There is, however, a general principle that may apply to both celebrities and personal acquaintances: this principle being "where do I know this person from?" or "why do I know this person?" Answers could be "she's my neighbour" or "I've seen her in films". This is entirely consistent with the idea that semantic knowledge for people, including categorical knowledge, is built up from episodic encounters. Future research could investigate whether personal acquaintances are also organised in a categorical structure with "where do I know this person from" as the category rather than occupation. This lies beyond the scope of the present paper.

The recent phenomenon of celebrity television shows (e.g. celebrity Big Brother in the UK) may open up the possibility of a new category – those persons who are famous for being on celebrity shows, or "famous for being famous". If a person is encountered for the first time in such a context, then their actual occupation is less immediately apparent and may form a weaker organising principle. This could be an interesting avenue for future investigation.

The application of Centre-Surround theory to the results of Experiment 1-4 will now be considered. Experiment 1 yielded negative priming at long SOA of 1500ms (slower responses on related than unrelated trials), attributed to Centre-Surround theory. The theory states that an attention mechanism is invoked when participants attempt to bring into consciousness the weakly accessible meaning of a stimulus. The attention mechanism boosts the degree of activation at the prime's semantic codes (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 of the prime from surrounding codes in an attempt to make the meaning of the prime consciously accessible. When the attempt fails, the suppression of activation at related codes leads to slowed responses to related items and hence to negative priming.

Centre-Surround theory predicted positive priming at short SOA becoming negative at longer SOA, because the attention mechanism would require some processing duration to suppress the degree of activation at codes representing items related to the prime. This previously untested prediction was confirmed in Experiment 2; priming was positive at 33ms SOA and negative at 217ms and 517ms SOA, strengthening support for the application of Centre-Surround theory to the present study.

Experiment 3 replicated the negative priming at 1500ms SOA that had been observed in Experiment 1. The degree of domain specificity of the Centre-Surround mechanism was investigated by comparing priming of face recognition with priming of name recognition. Statistically equivalent negative priming of target faces and names suggested that the Centre-Surround attention mechanism was operating at the level of the person (the Person Identity Node in the Burton et al (1990) model of face recognition) rather than at the level of the specific stimulus domain of faces vs. names.

Experiment 4 yielded evidence of positive priming of the occupation of the prime face, consistent with the Centre-Surround mechanism that is theorised to boost the degree of activation at the prime's semantic codes (the Centre). This observation rules out the possibility that the results of Experiment 1-3 can be explained by the alternative theory of Retrospective Prime Clarification.

Centre-Surround theory has previously been applied to verbal stimuli and to geometric shapes, so the experiments reported here extend the Centre-Surround mechanism to a new area of person recognition. The observation that the same automatic process is applied to assist in the retrieval of semantic knowledge for famous people and for words and geometric shapes further strengthens the argument that the structure of semantic knowledge is similar across different domains.

With regard to categorical priming of person recognition, there are inconsistencies within the existing literature that need to be explained. In particular, why some studies have succeeded but others have failed to observe statistically significant categorical priming for famous persons using occupation as the category. A related issue is why categorical and associative priming have been attributed to different causes (Brennen & Bruce, 1991).

Young et al (1994) and Barry et al (1998) both observed significant associative priming of a face naming and a face familiarity decision (the prime was a close associate of the target person) but not categorical priming (same occupation). Each study presented participants with a set of trials in which 25% of familiar targets were primed by close associates and 25% of familiar targets were primed by persons of the same occupation. It seems plausible that the associated pairs would have caught participants' attention due to their obvious salience, leading participants to expect this relationship. There is empirical evidence that the magnitude of priming depends on expectations of the prime-target relation (as well as on automatic spreading activation) with larger priming effects when participants expect a particular relationship and smaller priming effects when they do not (e.g. Huttenlocker & Kubicek, 1983; McKoon & Ratcliff, 1995; Neely, 1977; Posner & Snyder, 1975; see Neely, 1991, and Hutchison, Neely & Johnson, 2001, for reviews). Of particular relevance, Schweinberger, Pfutze and Sommer (1995) found no effect of associative priming in a task with associated pairs and repeated pairs. The absence of associative priming was attributed to its suppression by the presence of the repeated pairs that dominated participants' expectations. It seems plausible that the observation of associated pairs in the Young et al (1994) and Barry et al (1998) studies may have dominated participant expectations, and so reduced the magnitude of the potential categorical priming effect.

In contrast, the studies reporting significant categorical priming used only same-category prime-target pairs with no associated pairs (Brennen & Bruce, 1991, Experiment 1, 2 and 4; Carson & Burton, 2001), or varied type of relationship as a between participant factor (Brennen & Bruce, 1991, Experiment 5) or presented participants with only 2 or 3 associated prime-target pairs embedded among 60 trials (Bruce, 1983). None of these studies encouraged participants to expect a relationship of associated prime-target pairs. Altogether, it seems plausible that occasional failures to observe categorical priming of person recognition have arisen because participant expectations were dominated by the observation of a more salient relationship of close association.

Brennen and Bruce (1991) observed that associative priming tended to be facilitation dominant (responses to related targets much faster than unprimed targets, responses to unrelated targets little slower than unprimed), while categorical priming tended to be inhibition dominant (responses to related targets little faster than unprimed, responses to unrelated targets much slower). From this pattern of results they inferred that associative and categorical priming depend on different mechanisms.

An alternative explanation, based on the concept that a person will have only a small number of close associates but will share their occupation with many other famous persons, is offered by Becker (1980). The key concept is that when a prime is presented, a set of likely targets will be generated. The set of likely targets could consist of associates or same-category members depending on the expected relationship. A set of associates will be smaller than a typical set of same-category members. When the target is presented, the set of likely targets will be searched first to find a match, and then the remainder of semantic memory. On related trials the target will be found in the set of likely targets and on unrelated trials it will not. When the set of likely targets is small, as is the case with associates, responses will be greatly speeded on related trials because the target will be found quickly, and only a little slowed on unrelated trials because little time will be wasted in searching the set of likely targets; the result is facilitation-dominant priming. When the set of likely targets is large, as is more likely to be the case with same-category members, responses will be less speeded on related trials because a larger set will be searched, and more slowed on unrelated trials because more time will be wasted in searching the set of likely targets; the result is inhibition-dominant priming. Thus, the pattern of results observed by Brennen and Bruce (1991) does not necessarily lead to the conclusion that associative and categorical priming stem from different mechanisms. The results are consistent with the simple observation that a famous person will tend to have only a small number of close associates and a larger number of persons sharing the same occupation.

The present study differs from previous work in that primes were presented very briefly (17ms) and masked, so that participants had severely restricted awareness, rendering the use of intentional anticipatory strategies unlikely. This raises the interesting possibility that very briefly exposed and masked primes might give rise to statistically significant effects of categorical priming as well as associative priming when both types of relationship are mixed in the same task. This could be an interesting avenue for further exploration. Centre-Surround theory predicts that priming of associated targets will be positive at short SOA and will become more negative with increasing SOA, as occurred for same-category targets. However, since associated targets are more strongly connected with the prime than same-category targets, the priming observed at both short and long SOA should be stronger for associated targets than for same-category targets.

An alternative to exposing primes very briefly in order to preclude an intentional anticipatory strategy would be to explore the effects of such a strategy directly. Consider an experiment in which prime category predicts the target on some trials, and one group of participants are informed of this and instructed to use the information while another group are not. If occupational categorization is entirely strategic, then no priming should be observed in the early trials for the uninformed participants who cannot apply a predictive strategy until they have observed the category relationship. Priming might be observed in the later trials for the uninformed participants, and should be observed in early and late trials for the informed participants. In contrast, if occupational categorization is a fundamental property of semantic knowledge for famous persons, then priming should be observed in the early trials for the uninformed participants. Note that priming might still be stronger for informed participants who are able to use an intentional predictive strategy. This could be an interesting line for research but lies beyond the scope of the present paper.

In summary, the conclusion may be drawn that occupation is detected from masked 17ms exposures of famous faces under severely restricted awareness of facial identity. It appears that semantic knowledge for famous people is stored in a categorical structure and is accessed in a similar way to semantic knowledge for objects. A previously untested prediction of Centre-Surround theory was supported, strengthening this theory and its application to the domain of person recognition.

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Appendix A – stimuli.

Expt 1: Group 1	Leonardo Dicaprio	Humphrey Bogart	Actors
	Sylvester Stallone	Russell Crowe	Actors
	Tom Cruise	Michael Douglas	Actors
	Shania Twain	Madonna	Pop Stars
	Elvis Presley	Mick Jagger	Pop Stars
	Paul Gascoigne	David Beckham	Sport Stars
	Richard Nixon	George W Bush	Politicians
	William Hague	John Prescott	Politicians
	Oliver Hardy	Griff Rhys-Jones	Comedians
	Rowan Atkinson	Eddie Izzard	Comedians
Group 2	Anthony Hopkins	Sean Connery	Actors
	William Shatner	Ross Kemp	Actors
	Robert De Niro	Julia Roberts	Actors
	Sting	Paul McCartney	Pop Stars
	Damon Albarn	Robbie Williams	Pop Stars
	Boris Becker	Tim Henman	Sport Stars
	Ronald Reagan	Bill Clinton	Politicians
	Prince Phillip	Princess Diana	UK Royal Family
	Billy Connolly	Harry Enfield	Comedians
	Jeremy Paxman	Terry Wogan	Chat Show Hosts
Expt 2: Group 1	Tom Cruise	Michael Douglas	Actors
	Sylvester Stallone	Russell Crowe	Actors
	Anthony Hopkins	Sean Connery	Actors
	William Shatner	Ross Kemp	Actors
	Robert DeNiro	Julia Roberts	Actors
	Liam Neeson	Mel Gibson	Actors
	Jeremy Beadle	Clive James	TV presenters
	Zoe Ball	Judy Finnegan	TV presenters
	Rowan Atkinson	Eddie Izzard	Comedians
	Billy Connolly	Harry Enfield	Comedians
	Bob Monkhouse	Paul Merton	Comedians

	Elvis Presley	Mick Jagger	Pop stars
	Damon Albarn	Robbie Williams	Pop stars
	Bob Marley	Paul McCartney	Pop stars
	Tina Turner	Madonna	Pop stars
	William Hague	John Prescott	Politicians
Group 2	Tom Hanks	Hugh Grant	Actors
	Kevin Kline	Bruce Willis	Actors
	Bob Hoskins	Arnold Schwarz.	Actors
	Tommy Lee-Jones	Paul Newman	Actors
	Alec Guiness	Patrick Swayze	Actors
	Jeremy Paxman	Terry Wogan	TV presenters
	Bob Holness	Philip Schofield	TV presenters
	Ulrika Jonssen	Gloria Hunniford	TV presenters
	Frankie Howerd	Dawn French	Comedians
	Jennifer Saunders	Victoria Wood	Comedians
	Ronnie Barker	David Baddiel	Comedians
	Whitney Houston	Cher	Pop stars
	Rod Stewart	Prince	Pop stars
	Lisa Stansfield	Bob Geldoff	Pop stars
	Paul Gascoigne	David Beckham	Sport stars
	Ronald Reagan	Bill Clinton	Politicians

Experiment 3 and 4.

All the faces from Experiment 2 were used, except for Alec Guiness, Patrick Swayze, Lisa Stansfield, and Bob Geldoff.

The primes for unfamiliar targets were chosen to reflect the same proportion of different occupations as the primes for famous targets: Jennifer Aniston, Victoria Beckham, Cilla Black, Tony Blair, Kate Blanchet, George W Bush, Jim Carrey, John Cleese, Martin Clunes, Paul Daniels, Angus Deayton, Jack Dee, Eminem, Harrison Ford, Bruce Forsyth, Richard Gere, Geri Halliwell, Ian Hislop, David Jason, John Lennon, Jennifer Lopez, Richard Madeley, John Major, Jack Nicholson, Gwynneth Paltrow, Brad Pitt, Britney Spears, John Travolta, Carol Vordeman, Catherine Zeta-Jones

Experiment 4 occupations.

Famous occupation	**Non-famous occupation**
has starred in films	provides catering for films
has starred in movies	provides catering for movies
plays major roles in films	does casting for films
plays major roles in movies	does casting for movies
is a film star	is a film camera operator
is a movie star	is a movie camera operator
is a well-known figure in films	is an extra in films
is a well-known figure in movies	is an extra in movies
is a popular film actor	does makeup for film actors
is a popular movie actor	does makeup for movie actors
presents TV programmes	edits TV programmes
is a TV presenter	is a TV scheduler
hosts TV programmes	produces TV programmes
is a TV programme presenter	is a TV programme critic
has presented many TV programmes	has directed many TV programmes
is an award-winning comedian	is an award-winning bus conductor
has their own comedy show	has their own bus company
often appears in TV comedy	often works in the bus depot
has won awards as a comedian	has won awards as a bus driver
appears in many TV comedy shows	works in many bus depots
is a TV comedian	is an experienced bus driver
makes hit pop records	manufactures records and CDs
sells millions of records	manufactures millions of CDs
appears on Top of the Pops	does lighting for Top of the Pops
frequently appears on MTV	builds sets for MTV
is often seen on MTV	is often employed by MTV
wins popular music awards	designs popular music awards
is a leading politician	is a local counsellor
is a well-known figure in politics	is a local politician
is a sports personality	is a manufacturer of sports clothing

Figure Captions

Figure 1: Mean response time on same-occupation and different-occupation trials in the 33ms, 117ms, and 217ms / 517ms SOA conditions of Experiment 2. Note the decrease in priming with increasing SOA. Bars represent 95% confidence intervals.

Figure 2: Mean response time on same-occupation and different-occupation trials for face targets and name targets in Experiment 3. Bars represent 95% confidence intervals.

Figure 1

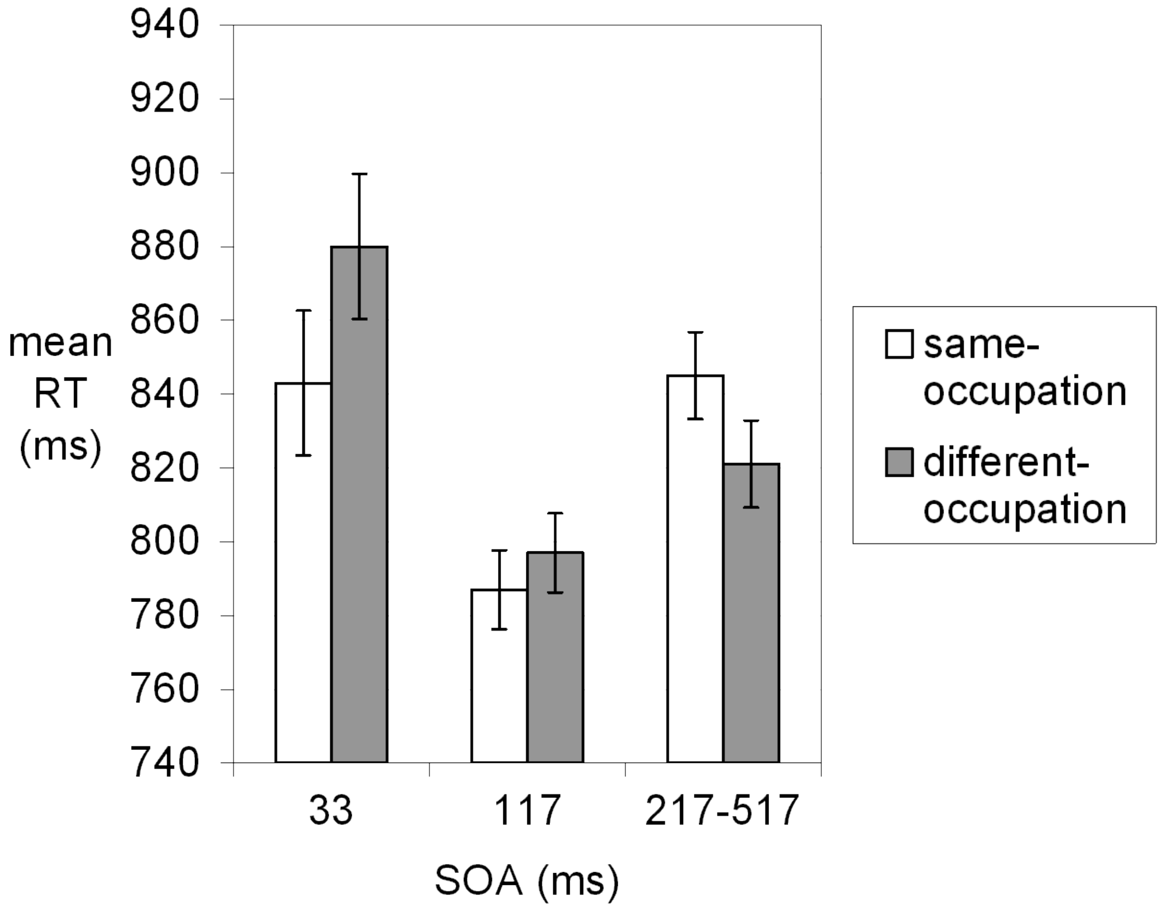
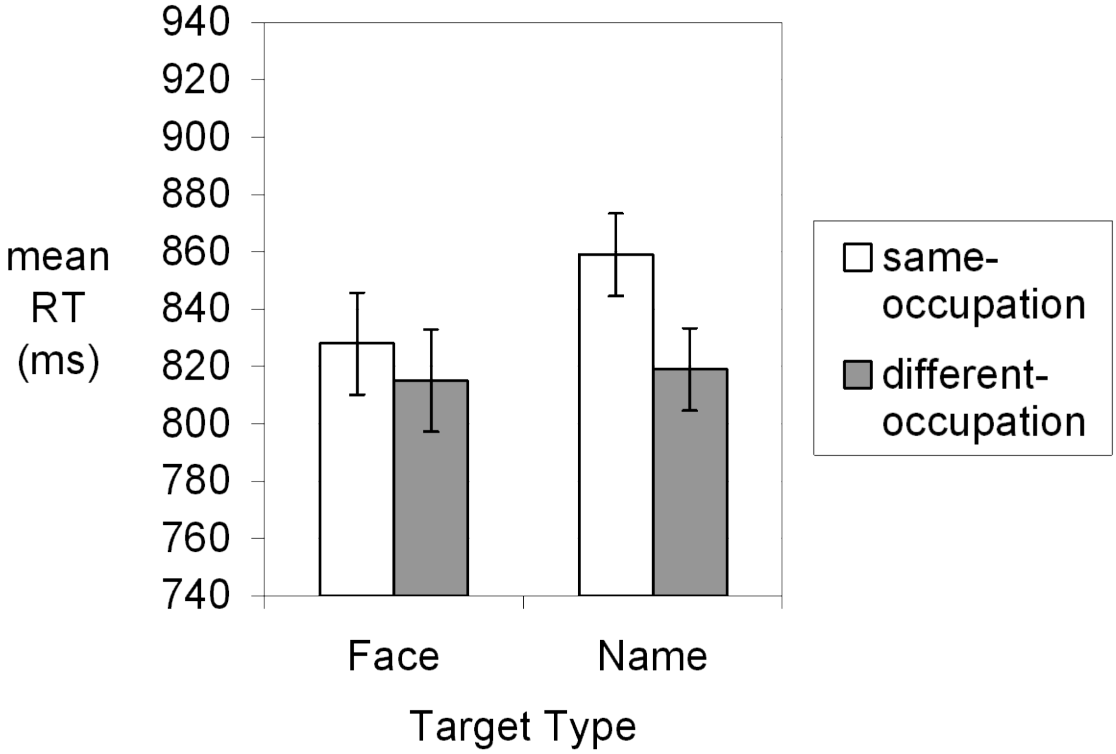

940
920
900
880
860
840
820
800
780
760
740
mean RT (ms)
33
117
217-517
SOA (ms)
same-occupation
different-occupation

Figure 2


940
920
900
880
860
840
820
800
780
760
740
mean RT (ms)
same-occupation
different-occupation
Face
Name
Target Type