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Getting to know you: from view dependent to view invariant repetition priming for unfamiliar faces

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Abstract

Recent research suggests that repetition priming (RP) for unfamiliar faces is highly view dependent and is eliminated when the viewpoint of target faces changes between study and test. The current research examined whether increased familiarity with novel faces from a single viewpoint at study would support RP from an alternative viewpoint at test. Participants passively viewed novel face images from a single viewpoint at study (i.e., either front or ¾), with half of the images seen once and half seen on five occasions. During a sex classification task at test participants were faster to respond to face images seen from the same view as at study than previously unseen distracter faces for both single exposure faces and faces seen on five occasions (i.e., standard RP). When, however, face images at test were shown from a different viewpoint than at study RP only occurred for faces viewed on five occasions.

Getting to know you: from view dependent to view invariant face repetition priming

Repetition priming (RP) is a response facilitation effect – commonly speeded reaction time and/or increased accuracy – that occurs as a consequence of having previously encountered the same stimulus before (Ellis, Flude, Young, & Burton, 1996). RP effects for faces have been extensively demonstrated for both familiar (i.e., famous) and unfamiliar (i.e., previously unseen) identities, however, there is evidence to suggest that RP for these stimulus groups are not functionally equivalent. While RP for highly familiar identities is capable of surviving changes to the perceptual properties of a face image between study and test (Burton, Kelly, & Bruce, 1998; Ellis, Young, Flude, & Hay, 1987), RP for unfamiliar identities is highly view dependent, with even minor changes to face viewpoint (e.g., frontal to ¾ view) between study and test sufficient to eradicate priming effects (Martin et al., 2010).

The apparent view dependent nature of unfamiliar face RP has been attributed to its reliance on a single perceptual representation gleaned from a solitary static image of a face; it is thought that this structural record is insufficient to support RP from alternative viewpoints (Martin et al., 2010). There is, however, evidence from laboratory investigations to suggest that explicit memory for unfamiliar faces can survive such transformations, albeit to a level diminished relative to same viewpoint recognition accuracy (e.g., Patterson & Baddeley, 1977; for an overview see Liu & Chaudhuri, 2002). Why do the processes that support explicit face recognition memory not also sustain RP? The current investigation probed this question by examining whether seeing an unfamiliar face from a single viewpoint on multiple occasions at study is sufficient to support view invariant RP.

Unfamiliar faces were, for many years, believed to be incompatible with producing RP effects (Ellis, Young, & Flude, 1990). The lack of RP for unfamiliar faces is consistent with accounts of familiar face RP derived from the influential Interactivity Activation and Competition (IAC) model of person recognition (Burton, Bruce, & Johnson, 1990). The IAC model posits that when we view a face a structural representation of that perceptual encounter is stored as a pictorial code within distinct, view-invariant, Face Recognition Units (FRUs). When a familiar face is perceived again the same FRU is activated, leading to activation of identity specific information, which is stored in unique Person Identity Nodes (PINs). It is the re-activation and subsequent strengthening of the FRU-PIN link that is thought to underpin familiar face RP. Because response facilitation occurs due to a strengthened association between structural representations and the entry point of identification, the IAC model account predicts that RP should emerge for familiar faces irrespective of whether the same image of the person is viewed at study and test (Burton, Bruce, & Hancock, 1999). Equally, however, because there are no PINs associated with novel faces they are insufficient to support RP via this route (Burton et al., 1998).

If novel faces are insufficient to produce RP in the same way as familiar faces, how do such effects occur for unfamiliar faces? Rather than emanating from a strengthening relationship between stored structural representations and (non-existent) PINs, unfamiliar face RP appears to be driven by a reactivation of pre-semantic structural records (Kirsner & Dunn, 1985). This explanation of unfamiliar RP aligns it with an account of other implicit memory phenomena – the *perceptual representation system* model (PRS model; Tulving & Schacter, 1990). Goshen-Gottstein & Ganel (2000) suggested that a single, brief, perceptual encounter with a 2D image of an unfamiliar face is sufficient for the formation of a perceptual record that is functionally independent from other information that may be related to the stimulus. When the same face is encountered on a subsequent occasion this representation is reactivated and facilitates perceptual processing (Goshen-Gottstein & Ganel, 2000); however, as such RP is entirely reliant on the reactivation of a single structural record it is thought these effects are hyper-specific in visual form. Indeed, recent research suggests that unfamiliar face RP is completely eliminated when the viewpoint from which a face is viewed changes between study and test (e.g., from frontal to ¾ view) or when the identity of a face is morphed by a relatively modest amount (Martin et al., 2010).

The apparent perceptual specificity of unfamiliar face RP is congruent with research examining the processes that support implicit memory for other stimulus classes (e.g., Marsolek, 1999; Marsolek et al., 1992). For example, RP for words can be significantly reduced merely by changing the letter case of primed words (e.g., from upper to lower) between study and test (Marsolek et al., 1992). Evidence that some forms of RP are less resistant to visual transformation than others has led to suggestions that there are multiple subsystems that support form-specific (i.e., view dependent) and abstract-form (i.e., view invariant) recognition (Cooper, Harvey, Lavidor, & Schweinberger, 2007; Marsolek, 1999; Martin, Nind & Macrae, 2009). Indeed, there is evidence these subsystems may be neuroanatomically distinct, with recognition of identical exemplars supported by a right-lateralised form-specific subsystem (Cooper et al., 2007; Marsolek, 1999), and identification of different images of the same object optimized in a left-lateralised abstract-form subsystem (Marsolek, 1999).

The differences between unfamiliar and familiar face RP are not limited to relative view dependence; RP effects for unfamiliar faces are typically of a lesser magnitude than those for familiar faces (Goshen-Gottstein & Ganel, 2000). It is likely that the size of these effects differ due to the divergent demands associated with the tasks typically used in familiar and unfamiliar face RP paradigm (i.e., identity judgements and sex judgements respectively; Ellis et al., 1987). In addition, however, it has been suggested that unfamiliar faces result in less RP because the abstract structural records that form following a single encounter with a novel face are much weaker than those formed for faces that have been seen on many occasions (Goshen-Gottstein & Ganel, 2000). Certainly, there is evidence that behavioural responses to unfamiliar faces change as relative experience with them increases. For example, using a face matching task Clutterbuck & Johnston (2005) found that as the number of exposures to a single view of unfamiliar face increased responses to these faces began to resemble those for familiar faces (i.e., faster responses and greater use of internal features). Similarly, Hay (1999) found that the magnitude of unfamiliar face RP effects increased as participants became more familiar with previously unseen faces.

As, following repeated exposure, responses to unfamiliar faces begin to resemble those for familiar faces (Clutterbuck & Johnston, 2005; Hay, 1999), is it not possible that increased experience with novel faces would result in unfamiliar RP that resembles that for familiar faces – capable of surviving image transformation? To explore this possibility we used a standard RP paradigm and manipulated the number of times participants were exposed to unfamiliar faces at study (i.e., once or five times), the view of faces at study (i.e., front or ¾) and the visual form of faces between study and test (i.e., same or different viewpoint). We hypothesised that when faces had been seen once at study, there would only be evidence of RP when faces appeared in the same view as they were at study (Martin et al., 2010). When, however, faces had been seen five times at study, we predicted there would be evidence of RP irrespective of viewpoint (Clutterbuck & Johnston, 2005; Hay, 1999).

Experiment 1

Method

Participants and Design

Forty-eight undergraduates (32 female) from Northumbria University completed the experiment. The experiment had a 2 (Study View: front or ¾) X 3 (Face Exposure: unstudied, seen once, seen five times) X 2 (Test View: same or different) mixed design with repeated measures on the second and third factors.

Procedure and Stimulus Materials

The experiment comprised two blocks (i.e., study and test).The stimuli were 144 greyscale digital headshots of 72 unfamiliar people (36 female) displaying neutral expressions, depicted in both a frontal and a ¾-profile pose; all traces of hair was cropped from images using a standardized oval mask (Goshen-Gottstein & Ganel, 2000).

Participants were randomly assigned to either the front-view or ¾-view study condition. During the study phase randomly selected faces appeared individually in the centre of the screen and the task was simply to passively view each face. Study trials entailed the appearance of a central fixation cross, for 500ms, followed by the presentation of a single face image for 3000ms. The inter-trial interval was 1500ms. Participants completed 144 trials comprising images of 48 separate identities (24 were seen once and 24 were seen on 5 separate occasions). There was an interval of approximately 3 minutes between the study and test phases.

Before the test phase participants were informed that should indicate, as quickly and accurately as possible via a key press, the sex of presented faces. The test phase consisted of the presentation of 72 faces, 24 studied once (12 same viewpoint, 12 different viewpoint), 24 studied 5 times (12 same viewpoint, 12 different viewpoint), 24 unstudied (12 from the same viewpoint as studied faces and 12 from the different viewpoint as studied faces). The order of trial presentation was randomized and the computer measured the accuracy and latency of each response. The response key mappings and the identity, viewpoint and studied/unstudied status of face images were all counterbalanced across conditions and participants.

Results

The dependent measure of interest was the median time taken to identify the sex of faces at test. Error trials (12%) were excluded from the analysis. A 2 (Study View: front or ¾) X 3 (Face Exposure: unstudied, seen once, seen five times) X 2 (Test View: same or different) mixed design analysis of variance (ANOVA) with repeated measures on the second and third factors was undertaken on the data. The analysis revealed a main effect of Face Exposure [$F(1, 92) = 8.29$, $p < .001$; $\eta p^2 = .150$], with participants faster to classify faces seen five times than either unstudied faces or those seen once. There was also a main effect of Test View [$F(1, 46) = 5.51$, $p < .05$; $\eta p^2 = .105$], with participants responding faster to faces when presented in the same view as study than those presented from a different view. These effects were subsumed in a Face Exposure X Test View interaction [$F(2, 92) = 4.03$, $p < .05$; $\eta p^2 = .079$; see Figure 1]. To further explore this interaction the data were collapsed across Study View and separate single factor repeated measures ANOVAs were conducted on the data from each Test View.

Analysis of the same view condition revealed a main effect of Face Exposure [$F(2, 94) = 8.31$, $p < .001$; $\eta p^2 = .150$]. Pairwise comparisons[1] indicated that there was no difference in response latency between faces seen once and those seen five times [$t(47) = 1.14$, $p = .26$]. There was evidence, however, that participants were faster to respond to faces seen once than unstudied faces [$t(47) = -2.89$, $p < .01$], and were also faster to respond to faces seen five times than unstudied faces [$t(47) = -3.86$, $p < .001$].

Analysis of the different view condition also revealed a main effect of Face Exposure [$F(2, 94) = 5.27$, $p < .01$; $\eta p^2 = .101$]. Pairwise comparisons indicated that there was no significant difference in response latency between faces seen once and unstudied faces [$t(47) = 1.17$, $p = .25$]. There was evidence, however, that participants were faster to respond to faces seen five times than faces seen once [$t(47) = -2.85$, $p < .01$], and were faster to respond to faces seen five times than unstudied faces [$t(47) = -2.62$, $p < .05$].

Also of interest were pairwise comparisons of the same view vs. different view conditions at each level of Face Exposure. These analyses revealed that while there was a significant difference between same view and different view in the seen once condition [$t(47) = -3.05$, $p < .01$], no such difference between same view and different view was apparent in either the seen five times [$t(47) = -1.37$, $p = .18$] or unstudied conditions [$t(47) = -0.08$, $p = .94$].

An identical 2 (Study View: front or ¾) X 3 (Face Exposure: unstudied, seen once, seen five times) X 2 (Test View: same or different) ANOVA was also conducted on the error data. The only significant effect to emerge was a Study View X Test View interaction [$F(1, 46) = 19.48$, $p < .001$; $\eta p^2 = .298$]. Pairwise comparisons indicated that participants were more accurate in their responses to face images presented in ¾ than frontal viewpoint independent of study view [frontal study view: $t(23) = -3.77$, $p < .01$; ¾ study view: $t(23) = 2.48$, $p < .05$; see Table 1].

Discussion

[1]Alpha levels for pairwise comparisons were Bonferroni corrected

Previous research suggests that the mechanism underpinning RP for unfamiliar faces may be distinct from that for familiar faces (Burton et al., 1998; Goshen-Gottstein & Ganel, 2000). In everyday life, however, our experiences with other people are not dichotomously limited to faces that are highly familiar and faces that are entirely novel. By examining the influence of moderate familiarity with ostensibly unfamiliar faces the current results support and extend previous examinations of RP. They provide further corroboration that while a single encounter with an unfamiliar face is sufficient to support RP (Goshen-Gottstein & Ganel, 2000; Henson et al., 2003; Martin et al., 2009), any resultant response facilitation is dependent on viewing an image of the face that is identical to that seen previously (Martin et al., 2010). Importantly, however, the current findings also suggest that viewing a face multiple times at study enables view invariant RP when the same identity is subsequently encountered once again.

As with previous demonstrations of unfamiliar RP our results suggest that a single, brief exposure to an unfamiliar face is sufficient to create a perceptual record that, when subsequently reactivated, can result in a speeded response to that stimulus (Goshen-Gottstein & Ganel, 2000; Martin et al., 2009; Martin et al., 2010). This is in line with the memory-systems account of RP, which suggests that following the detection of an object, perceivers retain a pre-semantic, abstract structural record of the stimulus in one of a number of domain-specific perceptual representation systems (Tulving & Schacter, 1990). Thus, when an unfamiliar face is encountered twice, access to an existing perceptual representation facilitates processing of the stimulus on the second occasion (Kirsner & Dunn, 1985). The fact that RP was eliminated when the viewpoint changed between study and test also supports the PRS contention that the structural representations that support such priming are hyper-specific in visual form and thus require an identical image be encountered before reactivation occurs (Schacter, 1994).

Notably, the current findings also indicate that when an identical 2D image of a previously unseen face is viewed multiple times, it is possible to get response facilitation to a different view of the same person. While this finding is contrary to previous theoretical and empirical scrutiny, which suggests that RP for unfamiliar faces is view dependent (Goshen-Gottstein & Ganel, 2000; Martin et al., 2010), there is experimental evidence that previously unseen faces studied from a single viewpoint can be explicitly recognised when seen from an alternative pose (Patterson & Baddeley, 1977; Liu & Chaudhuri, 2002). There is a long-running debate as to whether viewing a face from a ¾ viewpoint at encoding increases the likelihood of subsequent recognition (Liu & Chaudhuri, 2002); examination of reaction time data in the current results suggests no advantage for either front or ¾ viewpoints when face recognition is probed implicitly. There was, however, evidence that sex classifications were more accurate in ¾-view than frontal-view. Such a finding is not unsurprising given that there is considerable, if not conclusive, evidence that ¾-viewpoints are superior to either frontal or profile views for other face processing tasks (Liu & Chaudhuri, 2002).

Why is RP from a single encounter with unfamiliar faces view dependent yet RP from multiple exposures appears relatively view invariant? One possible explanation for this disparity is that abstract records formed following a single processing encounter are weaker than those formed following multiple exposures (Goshen-Gottstein & Ganel, 2000). If this is the case it may explain reported variability in the magnitude of face RP effects that occur as a function of task context and presentation duration at study (Goshen-Gottstein & Ganel, 2000; Henson et al., 2003). Indeed it is possible that viewing a novel face on multiple occasions bridges the gap between the PRS and IAC model accounts of face RP, with perceptual representations making the transition from pre-semantic, hyper-specific, abstract structural records to distinct, identity specific, view invariant representations. Given the distinctions drawn between familiar and unfamiliar identities in models of both face processing and social cognition (Brewer, 1988; Burton et al., 1990; Fiske & Neuberg, 1990), determining the transitional boundary conditions of view dependent/view invariant face representations should be a priority for future research.

It seems that, in the current task context at least, perceptual experience with a face may determine whether it is perceived as representing the same or a different person following a change in viewpoint. One intriguing possibility is that it is not perceptual experience of the face per se that is the key to this view invariance, rather it is the conceptual experience of encountering the same identity on more than one occasion that is critical (Clutterbuck & Jonston, 2005). There may be something intrinsically important about perceiving another individual on more than one occasion that results in the creation of person-specific but view-invariant representations.

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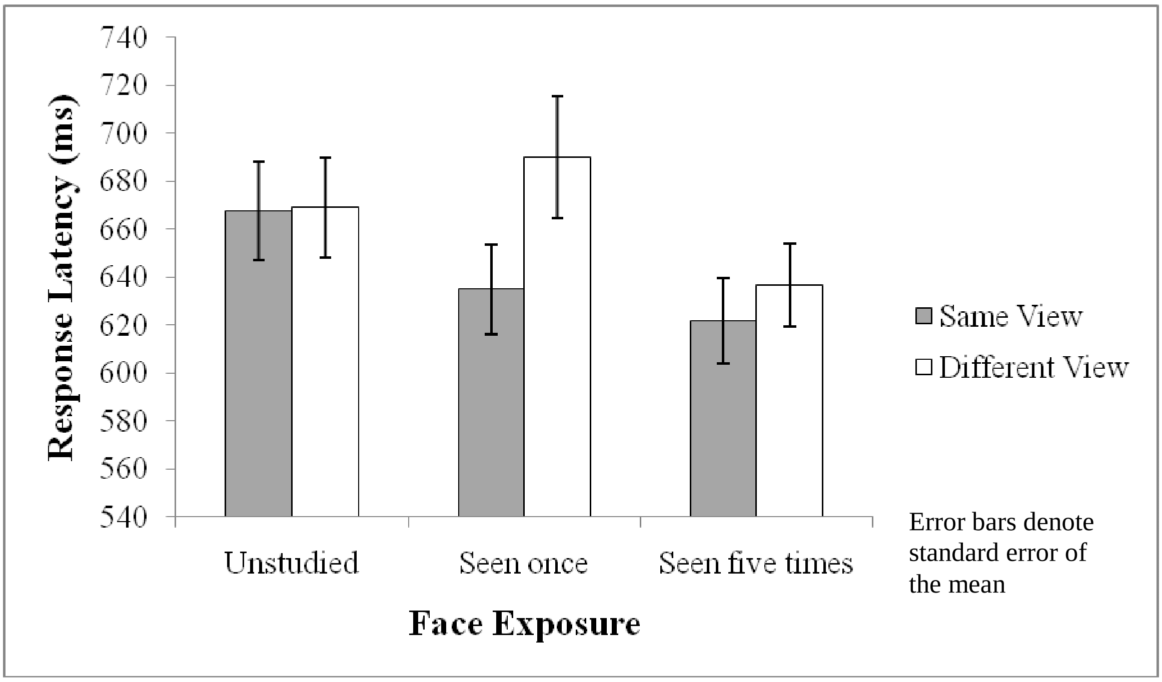

Figure 1. Mean Response Latency as a Function of Face Exposure and Test View

Table 1. Mean Percentage Errors as a Function of Study View and Test View

Study View	**Front**			**3/4**		
Test View	**Same**	**Different**	**Overall**	**Same**	**Different**	**Overall**
Mean	15.4	9.7	12.6	9.1	12.5	10.8
SE	*1.2*	*1.0*	*1.1*	*1.2*	*1.0*	*1.1*