RUNNING HEAD: FACES ARE NOT ALWAYS SPECIAL FOR ATTENTION

Faces are not always special for attention: Effects of response–relevance and identity

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Abstract

Research over the past 25 years indicates that stimulus processing is diminished when attention is engaged in a perceptually demanding task of high 'perceptual load'. These results have generalized across a variety of stimulus categories, but a controversy evolved over the question of whether perception of distractor faces (or other categories of perceptual expertise) can proceed irrespective of the level of perceptual load in the attended task. Here we identify task-relevance, and in particular identity-relevance, as a potentially important factor in explaining prior inconsistencies. In four experiments, we tested whether perceptual load in an attended letter or word task modulates the processing of famous face distractors, while varying their task-relevance. Distractor interference effects on task RTs was reduced by perceptual load not only when the faces were entirely task-irrelevant, but also when the face gender was task relevant, within a name gender classification response-competition task, using famous female or male distractor faces. However, when the identity associated with the famous faces was primed by the task using their names, as in prior demonstrations that face distractors are immune to the effects of perceptual load, we were able to replicate these prior findings. Our findings demonstrate a role for identity-priming by the relevant task in determining attentional capture by faces under high perceptual load. Our results also highlight the importance of considering even relatively subtle forms of task-relevance in selective attention research.

Keywords: Attention, perceptual load, irrelevant distractor faces, attentional capture, response competition

Faces are not Always Special for Attention: Effects of Response–Relevance and Identity

Human faces are a highly important category of visual information, providing a means to discriminate between other members of our species, as well as conveying key social information. Over the past several decades, behavioural, neuropsychological and neuroimaging evidence has highlighted a range of differences between the processing of faces versus most other common objects (e.g. Farah, 1996; Kanwisher et al., 1997; Kanwisher, 2000; Tanaka & Farah, 1993; Suzuki & Cavanagh, 1995). These differences have also been extended to other object categories that like faces have a high level of perceptual expertise (Gauthier & Tarr, 1997; Gauthier et al., 2000). One important context in which faces have been proposed to hold special status is with respect to attention. Attention is a critical gateway to information processing, but various demonstrations have accumulated to suggest that faces may have prioritized access to attention, allowing them to be perceived even when not intentionally attended. For example, faces have been shown to be less prone to inattentional blindness and change blindness than other common objects such as clothes (Mack & Rock, 1998; Devue et al, 2009a; Ro et al., 2001). Face distractors have shown enhanced ability to to capture attention when appearing as a singleton distractor during a task of visual search (Ro, Friggel & Lavie, 2007), and disrupt target detection in an attentional blink task, relative to other abruptly onsetting distractors (Sato & Kawahara, 2015).

However, with the exception of change blindness (Ro et al., 2001), all these lines of evidence have not considered perceptual load - a major determinant of selective attention. This research has thus left open the possibility that the special attentional status of faces could be limited to situations when the attended task does not demand full attention. According to the Load Theory, perception is an automatic, mandatory process but with limited capacity. While the processing of attended task stimuli can be prioritised, perception of stimuli that people wish to ignore cannot be withheld at will, but will rather depend on whether attended task processing takes up full capacity or leaves spare resources which spill over to distractor processing (Note 1). Thus distractors that people attempt to ignore will nevertheless be perceived when the attended task conditions involve only low perceptual load (e.g. detection of a feature ‘pop out’), and will only be successfully ignored in conditions of high perceptual load (e.g. a fine discrimination between very similar features or a task requiring the processing of conjunctions of features). A wealth of studies provide support for the Load Theory of attention in demonstrating that tasks involving high perceptual load result in reduced irrelevant processing across a range of perceptual load manipulations, and using both neural and behavioural measures of distractor processing. For example, inattentional blindness rates have been shown to critically depend on perceptual load in the attended task (Cartwright-Finch & Lavie, 2007). Similarly, perceptual load has been established to determine the extent to which distractors interfere with visual search, (Lavie & Cox, 1997; Lavie & Fox, 2000), see Lavie, 2005; 2010; Lavie et al., 2014, for review). An important question is hence whether faces' prioritized access to attention persists even when perceptual capacity is fully occupied by a demanding task.

Striking support for this possibility was provided by Lavie et al., (2003), using a face-name response-competition distractor task. Participants made speeded responses to classify the names of famous celebrities as either politicians or rock-stars, while ignoring peripherally presented distractor faces. Perceptual load was manipulated by requiring participants to search for the name among a varying number of jumbled non-word letter strings. The distractor faces were those of the same politicians and rock-stars whose names were used as targets, either congruent or incongruent with the target response. In contrast to patterns seen with other non-face distractors, distractor faces produced congruency effects on the task response irrespective of the level of perceptual load in the task.

Thus while both face and non face distractors received the 'spill over' of attentional resources in conditions of low perceptual load, only face distractors could capture attention in conditions of high perceptual load. Indeed the aforementioned reduced vulnerability to change blindness for faces compared to other non face objects (Ro et al., 2001), has also been shown to hold when the displays were of high load including multiple competing objects for attention, while no difference was found in conditions of low load, further confirming the superior ability of faces to capture attention when competing with other objects.

The advantage for face distractors has been attributed by some (e.g. Gauthier & Tarr, 1997) to the high level of perceptual expertise that faces have. In support of this account, other objects of high perceptual expertise were found to also display similar ability to capture attention even in high load tasks. For example, singleton distractor images of body parts were shown to produce the same level of enhanced attentional capture as that found for singleton faces (Ro et al., 2007). Studies using a similar response competition word classification task as that used in Lavie et al., (2003) found that musical instrument distractors were immune to perceptual load effects for expert musicians (Ro et al., 2009). Parsons et al., (2017) extended this pattern to distractor stimuli relating to individual participants' strong personal interests and high level of expertise (e.g. images of motorbike for those with a strong interest in motorbikes, or Harry Potter logos and objects for Harry Potter fans), as long as the indviduals were 'neurotypical' (these effects did not extend to the autistic participants in the study). These findings parallel findings that the fusiform face area, a region activated in response to faces (Kanwisher et al., 1997), can also be activated by non-face stimuli falling within an area of expertise (Gauthier et al., 2000; 1999). Thoma and Lavie (2013) have further clarified that face processing can be modulated by perceptual load if the attended task involves faces, suggesting face processing is only prioritized for attention when competing with non-face stimuli, and concluding that face processing has its own separate capacity limits.

While the above findings have been taken as evidence for special attentional status for both faces and other stimuli of high expertise, evidence for the load immunity of faces has not always been consistent. In particular, several other studies have demonstrated reductions in some measures of face processing under high perceptual load. Jenkins and colleagues found that recognition memory for task-irrelevant distractor faces was modulated by perceptual load. This result was not only obtained for unfamiliar faces (Jenkins et al., 2005) but also for famous faces (Jenkins et al., 2002), similar to those used in Lavie et al.'s original study. Using a similar letter search paradigm to that originally designed by Lavie and Cox (1997) and employed in Jenkins et al (2002; 2005 studies), Mohamed et al., (2009) found perceptual load modulation of the face-sensitive N170 ERP component. In considering potential factors underlying this inconsistent pattern of findings, we note that both studies reporting load modulations have used the same letter search task to which the faces were entirely irrelevant, while in the previous studies the face distractors were relevant to some of the attentional settings in the task. For example a singleton search attentional settings could have been used to detect the target in Ro et al. (2007), making the singleton distractors potentially relevant to these attentional settings (e.g. Bacon & Egeth, 1994). The faces (or other objects of expertise) were semantically associated with the target classes (e.g. politican vs. popstars) in all the response competition flanker tasks reviewed above, (e.g. Lavie et al., 2003; Ro et al., 2009; Thoma & Lavie, 2013; Parsons et al., 2017).

Indeed, a line of studies assessing perception of emotional faces presented as entirely task-irrelevant distractors in non-face (typically letter search) tasks has demonstrated reduced processing of emotional face expressions in conditions of high perceptual load in the task. These results were established both for behavioural measures of irrelevant attentional capture by distractor faces of negative expression (e.g. Gupta et al., 2016) and for amygdala response to these irrelevant faces (e.g. Bishop et al., 2007; Pessoa et al., 2002).

The fact that the face distractors were entirely irrelevant to the task in these latter studies might point to the important role of the distractor relevance to the task or any of the attentional settings employed in the task processing in attentional capture (as we briefly review below). However, as the relevance of face distractors to any of the attentional settings used in the task has not as yet been directly varied within the same paradigm, it is not clear whether this is the critical distinguishing factor. In the present study we therefore directly focus on establishing whether the special attentional status of faces can be found when these are entirely irrelevant to the task, or depends on some form of relevance to the attention settings.

Task Relatedness

Our previous research has highlighted that many widely used selective attention tasks involve distractors that are in some manner related to the task – for example through being presented in a potential target location, sharing target characteristics or being associated with a task response (Forster & Lavie, 2008a;b; Forster, 2013). A growing body of evidence indicates that task-relatedness (of various forms) can be a powerful modulator of attentional capture effects, including those by proposed ‘special’ classes of stimuli. With respect to faces, Devue and Bredart (2008) have demonstrated that the distractor location in the centre of two flanking task-related items (digits) - right where subjects were requested to fixate - is important for finding attentional capture by familiar versus unfamiliar faces, to the extent that only when the distractor faces appeared in the central fixation position, highly-familiar faces produced capture, while no interference effects were observed when the face distractors are presented in task-irrelevant locations (in the periphery). Similar effects of location relevance to the task itself or any of the general task settings have been demonstrated with respect to capture by other personally significant stimuli such as one's own name, and those involving proposed pre-attentive processes such as scene gist perception and multisensory presentations (Gronau et al., 2003; Gronau & Izoutcheev, 2017; Lunn et al., 2019). Attentional capture by another proposed 'special' category of information – negatively valenced images - has also been shown to be depend on relevance conferred by affective overlap with the task target stimuli (Lichtenstein-Vidne et al., 2012). Notably, this effect was observed despite the affective properties of the target being irrelevant to the instructed task (which concerned vertical location judgement).

It has long been known that involuntary allocation of attention can be powerfully impacted by relevance to the attentional settings promoted by the task, to the extent that seemingly irrelevant distractor stimuli that are nevertheless task-related in some manner, can distract attention from the current task even when this undermines task performance (e.g. Folk et al., 1992; Folk & Remington, 1998; Folk et al., 2002), and when participants are aware that such attentional capture will lead them to loss of potential reward (Le Pelley et al., 2015; Pearson et al., 2015). Notably, the large literature on 'contingent attentional capture' highlights that these effects do not require direct relevance to the instructed task: Rather, it is sufficient for a distractor to share some features in common with those that may be considered part of the task settings to lead to attentional capture. For example, participants asked to search for a diamond among green circles might adopt an attentional setting for 'odd one out', rather specifically 'diamond' – such a setting could lead to involuntary attention to an 'odd one out' colour, despite colour being irrelevant to the instructed shape search task (see Bacon & Egeth, 1994). Even more broadly, it has been argued that any dynamic event associated with the presentation of the search display could potentially lead participants to monitor for such events, resulting in an attentional setting for (and hence involuntary capture by) any dynamic events (Burnham, 2007).

Given the significant role task relatedness plays in attentional capture, an important question is whether this could have contributed to demonstrations of the immunity of faces and other objects of high expertise to perceptual load effects (Lavie et al., 2003; Thoma & Lavie, 2013; Ro et al., 2009; Parsons et al., 2017), as we previously mentioned. The present research thus sought to establish whether the special attentional status of faces, as previously demonstrated with their immunity to the effects of perceptual load in non-face tasks, can be found when these are entirely irrelevant to the task (Experiment 1) or depends on some form of task relatedness.

Experiment 1

In Experiment 1 we adapted the irrelevant distractor task (Forster and Lavie, 2008a), using face distractors instead of the cartoon images used in the previous research. In this task, participants are asked to search for a target letter (X or N) among either small Os (low load condition) or a heterogeneous set of angular letters (high load condition). In order to provide the strongest test for perceptual load modulation, we used the faces of well-known celebrities as distractors: Famous faces were used in the previous studies demonstrating face immunity to perceptual load effects (Lavie, Ro and Russell, 2003; Thoma & Lavie, 2013), and some recent theoretical perspectives have questioned whether the ‘special’ face expertise might be limited to familiar faces only (typically of a famous identity) (Young & Burton, 2018). The faces were presented on a low frequency of trials, in a peripheral location that is never occupied by task stimuli. As such, the face distractors were entirely irrelevant to the task in terms of their location, visual appearance, response relevance and meaning. Furthermore, the task does not involve retrieving the identities associated with the faces. In this task, the presence versus absence of salient irrelevant distractors typically produces a robust interference effect in the low load condition, which is eliminated in the high load condition. However, if the special attentional status of faces does not depend on task-relevance, the reaction time slowing should be similar in both load conditions (i.e. reflecting immunity to perceptual load effects).

Method

Experiment 1 was approved by the University College London Ethics Committee (Project ID Number: 2296,001).

Participants. Participants in all experiments were volunteers with normal or corrected-to-normal vision, recruited from either University College London or the University of Sussex, aged 18-35. Power analysis using G*Power (Faul et al., 2007) based on Forster and Lavie (2015) indicated for an 85% power to detect the effect of perceptual load on irrelevant distractor cost a sample size of 19 (α = .05, dz = .74) is required. In Experiment 1, two extra participants were tested for scheduling reasons. The sample for Experiment 1 hence comprised of twenty-one participants (four males) aged 19-29 (*M* = 22.48, S.D. = 2.79).

Stimuli and procedure. All stimuli were presented on a computer screen using E-Prime, at a viewing distance of approximately 57 cm (maintained using a chin-rest). Testing was conducted in a dimly lit testing room so as to avoid any glare or reflection on the computer screen which might interfere with visibility of the task stimuli, with screen brightness set sufficiently low so as to avoid any perceptual aftereffects (e.g. afterimage effects). Each trial began with a 500 ms presentation of a fixation dot in the centre of the screen. This was immediately followed by a 100 ms presentation of the stimulus display, which consisted of six letters arranged to form an imaginary circle (radius subtending 1.6°). Participants were instructed to search this display for a target letter (0.6° by 0.4°), which was either an X or N, and to respond by pressing 0 if the target was X, and 2 if the target was N. Participants were instructed that they should make these responses as fast as possible while maintaining high accuracy. It was strongly emphasized that, in order for their data to be usable, it was critically important that participants do not sacrifice accuracy in order to achieve faster responses. Participants were also emphatically instructed to ignore any stimuli that appeared onscreen other than the letter circle.

The target letter was equally likely to appear in any of the six possible locations around the circle. In the high load condition, the remaining five non-target locations were occupied by other angular letters of equivalent size to the target letters, selected in a random manner from the set (H, K, M, Z, W, V). In the low load condition, the remaining five non-target locations were occupied by small Os (0.15°). All letter stimuli were either presented in light grey on a black background (14 participants), as in the original version of the task, or black on a grey background (seven participants), as in Lavie et al.,'s (2003) task (Note 2).

On 10% of trials a famous face distractor, subtending 4^{o} by 3^{o}, was displayed in a task-irrelevant location centered at 4.6° from fixation. The images included the hair as in Lavie et al. (2003). This distractor was selected from a set of six faces of celebrities who were well-known at the time of testing (and it was verbally confirmed at the end of the session that participants were able to recognize the faces). The distractor was presented either above or below the letter circle for the first six participants, and to the left or right of the letter circle for the remaining 14 participants. The distractor remained onscreen until response. A beep was heard following incorrect responses or if no response was made within a 2000ms response window. Participants completed 3 slowed down example trials and 12 practice trials for each load condition. They completed eight blocks of the main task (four low load and four high load). Load conditions were equally likely to be presented in the order LHHLLHHL or HLLHHLLH. All combinations of load, target position, target identity were fully counterbalanced across blocks for distractor present and distractor absent trials, with distractor identity also being fully counterbalanced with load, target position and target identity for the distractor present trials.

Results

[INSERT FIGURE 1]

RT analysis, in this experiment as well as the rest of the experiments we report, was performed on correct responses only. In addition to the null hypothesis significance testing (NHST) results, we report Bayesian statistics for key contrasts in order to assess evidence for and against the null hypothesis of immunity to perceptual load effects. Given our directional hypotheses, Bayes factors were calculated using a half-normal distribution with a mean of zero (e.g. Dienes, 2008). Prior plausible effect sizes for the distractor cost in high and low load respectively were based on those of the closely matched Experiment 2B in Thoma & Lavie (2013), which replicated Lavie, Ro and Russell’s (2003) original findings of face distractor immunity to perceptual load during a face-name response competition task. The mean observed low load distractor cost was used as the prior plausible effect size for the key test of perceptual load modulation of distractor interference (Note 3).

A 2 x 2 ANOVA with the factors of load (high, low) and distractor condition (distractor, no distractor) revealed significant main effects of load, $F(1, 20) = 134.48$, $p < .001$, $\eta_p^2 = .871$, and distractor condition, $F(1, 20)= 5.27$, $p =.033$, $\eta_p^2 = .209$. Critically, the interaction of load by distractor condition was significant, $F(1, 20) = 14.36$, $p =.001$, $\eta_p^2 = .418$, $B_{H(0, 40)} = 407.57$. As can be seen in Figures 1 and 2, this interaction reflects the reduction in the effect of the distractor faces from the low load (in which distractor presence vs. absence produced a significant RT cost, *M* = 40ms, $t(20) = 4.53$, $p < .001$, dz = 0.99, $B_{H(0, 45)} > 1000$), to the high load condition (in which this distractor RT cost was eliminated, *M* = -4 ms, $t < 1$, dz = .08, $B_{H(0, 53)} = .15$).

[INSERT FIGURE 2]

The above ANOVA was repeated for percentage error rates revealing a significant main effect of load, $F(1, 20) = 75.53$, $p < .001$, $\eta_p^2 = .791$ reflecting increased errors in the high load condition (M = 21.02%) compared to the low load condition (M = 5.88%). Neither the main effect of distractor condition, nor the load x distractor interaction, were significant, for the main effect of distractor condition, $F(1, 20) = 2.94$, $p =.102$, $\eta_p^2 = .128$; for the interaction, $F(1, 20) = 1.66$, $p = .213$, $\eta_p^2 = .076$.

Experiment 2

Experiment 1 found that interference from task-irrelevant famous face distractors was eliminated by higher perceptual load in a letter search task. This contrasts with previous findings using response competition tasks (e.g. Lavie et al., 2003; Thoma & Lavie, 2013), in which famous distractor faces have been found to be immune to effects of non-face perceptual load. In Experiments 2-4 we examined the role of task relevance further within the response competition paradigm. More specifically, we sought to determine which form of task-relevance is key to facilitating the 'special' pattern of immunity to perceptual load effects. In earlier demonstrations of face-name response competition immunity to load, the distractor faces were task-relevant not only in terms of their association with a task response (e.g. being a politician in a politician vs. popstar classification task), but also in terms of their identity (which is shared with the names used as targets). We hypothesized that identity relevance might be a particularly important factor for the attention capturing potency of faces. As mentioned in the introduction, some theoretical perspectives attribute the special attentional status of faces to the high level of expertise associated with face stimuli, and indeed, immunity to load effects has also been demonstrated for other objects of high expertise. It has further been argued recently that expertise in faces applies only to familiar faces (Young & Burton, 2018). Regardless of whether or not one takes the strong latter position, one could conceive that famous faces are stimuli of super expertise (e.g. due to their high level of exposure). As such, identity relevance might be a particularly important factor in the extent to which distractor faces capture attention, in that the unique identity associated with a famous face is part of what makes these an object of super expertise.

To test this possibility, Experiments 2-4 adapted the response competition task originally used by Lavie et al. (2003), using the same famous face distractors as in Experiment 1 but with a gender classification task (male vs. female) on given names. In this manner we were able to examine two forms of task relevance: Gender relevance and identity relevance. In Experiments 2-3 the task involved making male/female judgements on generic names which did not match any of the famous face identities, meaning that while some aspects of the faces (gender influenced features) were task-relevant, specific expertise about the face identity was task-irrelevant. By contrast, in Experiment 4 participants performed the same male/female judgements on the famous names associated with the distractor faces, with the effect that face specific expertise (i.e. identity) became task-relevant.

Method

Experiments 2-4 were approved by the University of Sussex School of Psychology Ethics Committee (project numbers ER/GW72/1, ER/KT271/1).

Participants. Power analysis using G *Power indicated that a sample size of 21, as used in Experiment 1, would have 95% power to detect the effect size revealed in Experiment 1 (α = .05, dz = .84) for perceptual load modulation of face distractors. Two extra participants were tested for scheduling reasons, leaving a final sample size of twenty-three participants (9 male), aged between 20 and 35 years old (M = 23 .09, S.D = 4.27).

Stimuli and Procedure. The computer set up and software was similar to Experiment 1. Participants performed a name categorization task. Each trial consisted of a 500ms presentation of a central fixation dot, followed immediately by a two second stimulus display. Participants were instructed to search the letter strings in the centre of the stimulus display for a name and to indicate by keypress whether the name was typically male (pressing 0) or female (pressing 2), while ignoring a distractor face of a famous celebrity. The target names were selected with equal probability from a set of twelve first names, selected on the basis of being common among young adults, not associated with the face distractors, and not specifically associated with any popular celebrity at the time of testing (e.g. names such as Harry were precluded due to association with Prince Harry). Half of the names were typically male and the other half were typically female. The names were 5-7 letters long, each letter subtending approximately 0.5° horizontally and 0.3°- 0.4° vertically, and together with the spaces between letter the names subtended 1.3°- 2.2° horizontally. The names were presented in light grey on a black background, in one of six possible locations, extending a vertical array subtending 4.6° vertically, placed in the display centre (three positions above and three below fixation) In the low load condition the target name appeared alone, while in the high load condition the remaining five positions were filled by jumbled letter strings of the same length as the target names. Both names and letter strings were presented in sentence case (i.e. first letter only capitalized).

A face distractor subtending approximately 4° vertically by 2.5°-4° horizontally was presented to the left or right of the display (centre point 4.25° from fixation, minimum of 0.8° edge to edge between face distractor and name array). The faces were six male and six female celebrities (film stars, popstars and political figures) well known at the time of the experiment. The faces appeared with the hair as in our Experiment 1 and matching the presentations used in Lavie et al. (2003), which also kept the hair in the face images. However we note that any interference effects on the gender classification of the names is unlikely to be due to the processing of the famous faces involving only their hair, since previous work has indicated automatic gender processing for famous faces even when the hair is not shown (Yan et al., 2017). The distractor face gender was equally likely to be congruent with the correct target response (e.g. a picture of Brad Pitt and the name 'Thomas') or incongruent (e.g. a picture of Brad Pitt and the name 'Sarah'). Participants performed two practice blocks, each of 24 trials, followed by eight blocks of the main task. Load conditions were equally likely to be presented in the order LHHLLHHL or HLLHHLLH. All combinations of load, target position, target identity, distractor position and distractor identify were fully counterbalanced.

Results

Mean RTs of the correct responses and percentage error rates are presented in Table 1. A 2 x 2 ANOVA with the factors of load (high, low) and distractor condition (congruent, incongruent) revealed significant main effects of both load, $F(1, 22) = 1323.45$, $p < .001$, $\eta_p^2 = .984$, and distractor condition, $F(1,22) = 17.87$, $p < .001$, $\eta_p^2 = .448$. The interaction between load and distractor condition just fell short of the significance threshold, $F(1,23) = 4.25$, $p = .051$, $B_{H(0, 30)} =$

4.26, η_p^2 = .162, although the Bayesian evidence provided substantial support for load modulation. Planned comparisons revealed a pattern consistent with load modulation of the face distractor interference: The face distractors produced highly significant interference from incongruent versus congruent distractors under low load, $t(22) = 5.78$, $p < .001$, $B_{H(0, 45)} > 1000$, dz = 1.21. However, as in Experiment 1, and in contrast to Lavie, Ro and Russell's (2003) findings, this interference was eliminated under high perceptual load, $t(22) = 1.023$, $p = .318$, $B_{H(0, 53)} = .43$, dz = 0.21.

The above analysis was repeated for percentage error rates, revealing a similar pattern of load modulation. There was a significant main effect of load, $F(1, 22) = 11.01$, $p = .003$, $\eta_p^2 = .334$, no main effect of distractor condition, $F(1, 22) = 2.50$, $p = .128$, $\eta_p^2 = .102$, and a significant load by distractor condition interaction, $F(1, 22) = 6.952$, $p = .015$, $\eta_p^2 = .240$. As with RTs, significant interference from incongruent versus congruent distractors was observed under low load, $t(22) = 2.83$, $p = .010$, $B_{H(0, 0.6)} = 5.48$, dz = 0.59, but eliminated under high load, $t < 1$, $B_{H(0, 1)}$ = dz = 0.54.

Thus the pattern of results of Experiment 2 appears in line with perceptual load modulation of face distractor interference, as seen in Experiment 1, rather of face distractor immunity to perceptual load effects: Both NHST and Bayesian analyses concurred in finding face distractor interference only in the low load condition, and these effects were abolished under high load. In keeping with this pattern, the Bayesian analysis supported load modulation of face distractor interference.

Table 1

Mean Reaction Times (RT, SE In Parentheses) and Percentage Error Rates as a Function of Distractor Congruency and Perceptual Load in Experiments 2-4.

	Load		Incongruent	Congruent
Experiment 2	Low	RT	669 (23)	639 (23)
		% Error	*9 (1)*	*7 (1)*
	High	RT	1115 (25)	1106 (22)
		% Error	*11 (1)*	*11(2)*
Experiment 3	Low	RT	904 (20)	878 (21)

		% Error	*9 (1)*	*8 (1)*
	High	RT	1112 (19)	1102 (23)
		% Error	*12 (1)*	*12 (1)*
Experiment 4	Low	RT	913 (17)	860 (16)
		% Error	*6 (1)*	*6 (1)*
	High	RT	1133 (16)	1085 (16)
		% Error	*9 (1)*	*9 (1)*

Experiment 3

The pattern of results in Experiment 2 was consistent with load modulation of the distractor effects, with significant effects on both RT and error rates observed under low load and eliminated under high load. This could imply that, even when faces are relevant to task responses, they are not granted special access to attention. Experiment 3 sought to replicate this finding, while also addressing a possible alternative explanation of our findings so far. As our low load conditions in Experiments 1 and 2 involved search for a single angular letter (Experiment 1) or word (Experiment 2), it might be argued that participants could adopt a 'singleton detection' search strategy in the low load condition, but not the high load condition, making the singleton face distractor more relevant to the attention task settings in the low load than in the high load conditions (Bacon & Egeth, 1994). By this account, the reduced distractor interference seen in the high load conditions of our previous experiments could result from reduced task relevance rather than from reduced availability of perceptual capacity. We have previously ruled out this alternative explanation of our findings regarding load modulation of irrelevant distractor effects, by demonstrating that this effect persists when the low load set size is increased to three items, precluding the use of a singleton detection search strategy in either load condition (Forster & Lavie, 2008). As perceptual capacity in visual search has been shown to typically accommodate at least four items (e.g. Fisher, 1982; Kahneman et al., 1992; Lavie & Cox, 1997; Lavie & Fox, 2000; Torralbo et al., 2016), a set size of three items still leaves spare capacity for distractor processing and hence is still considered low perceptual load. We therefore similarly increased the low load set size to three items in the present experiment.

Method

Participants. Thirty-four participants (22 females) aged between 19 and 38 years (*M* = 22.59, *SD* = 3.38 years) participated in Experiment 3. Participants were volunteers with normal or corrected-to-normal vision, recruited from the University of Sussex or University College London. To provide a more sensitive test for not only the presence, but also the absence of perceptual load effects, we now based our stopping rule on Bayesian analyses. The stopping rule for Experiments 3 and 4 was based on finding a Bayes factor either > 3 (indicating substantial evidence for load modulation) or < .33 (indicating substantial evidence for the absence of load modulation) for the key comparison of the distractor effect (mean RT for incongruent minus congruent trials) under low load versus high load (Note 4). We note that unlike null hypothesis significance testing (NHST), the Bayesian analysis of the results does not depend on the stopping rule. The Bayesian stopping rule equally considers the two possible outcomes (i.e. finding an effect, H1, or the absence of an effect, H0) and Rouder (2014), for example, demonstrates through simulation that the Bayes factor is consistent in reflecting the strength of evidence for H1 versus H0 regardless of whether or not optional stopping is used (see also Dienes, 2014). Bayes factors were checked against the stopping rule at convenient intervals (e.g. at the end of a day of testing) rather than after every subject.

Stimuli and Procedure. All stimuli and procedure was similar to Experiment 2, with the following exception: In the low load condition, two non-target locations contained jumbled letter strings selected from the same set as the high load non- targets.

Results

As can be seen in Table 1, the RT results closely resembled those of Experiment 2, despite the increase in low load set size. Critically, the key Bayesian test revealed substantial evidence in favor of the alternative hypothesis of load modulation of face distractor interference, $B_{H(0, 26)} = 3.50$, dz = .34. Further Bayesian paired t-tests indicated that, as in Experiment 2, the face distractors produced decisive evidence of interference from incongruent versus congruent distractors under low load, $B_{H(0, 45)} > 1000$, dz = .93. However, as in Experiments 1 and 2, and in contrast to Lavie et al.’s (2003) findings, no substantial evidence for interference was seen under high perceptual load, $B_{H(0, 53)}$ = 0.61, dz = .23, with the Bayes factor indicating anecdotal evidence favouring the null hypothesis. (See also Note 3).

Although a weak numerical trend paralleling the RT data was seen in the error data, Bayesian paired t-tests did not reveal any substantial evidence regarding effects of the distractor on error rates: The low load distractor interference effect anecdotally favoured the alternative hypothesis, $B_{H(0, 0.6)}$ = 2.94, dz = .32; while the high load distractor interference effect anecdotally favoured the null hypothesis, $B_{H(0, 1)}$ = 0.67, dz = 0.07. The difference between these distractor interference effects was insensitive, $B_{H(0, 0.6)}$ = 1.70, dz = .22.

Experiment 4

Experiments 1-3 consistently show that perceptual load can modulate (or indeed eliminate) interference from famous face distractors under some circumstances. Moreover, Experiments 2-3 demonstrated load modulation of distractor faces in a face-name response competition task similar to that used in demonstrations of the ‘load-resistant’ special attentional status of faces (Lavie, et al., 2003; Thoma & Lavie 2013), or other objects of exceptional expertise (Ro et al., 2009; Parsons et al., 2017). Hence, the results of Experiments 2-3 imply that even when certain aspects of facial features (i.e. characteristic gender features) become task-relevant, faces can still be modulated by perceptual load.

One potentially important difference remains between the present task and those used in these previous studies: While our target stimuli were generic names that had no connection to the distractors other than the fact that both faces and names could be associated with a particular gender, the target stimuli in the previous studies were the names of the same celebrities (or objects of expertise) whose faces or pictures served as distractors. As noted earlier, it has been recently argued that the most compelling evidence for ‘special’ expertise in relation to faces has been in relation to familiar (typically famous) faces, and that unfamiliar faces may not be subject to such expertise (Young & Burton, 2018). In this respect, the specific identity which made the faces objects of super expertise was task-related (and hence primed by the task) in the original studies, but irrelevant in our Experiments 2-3. Our final experiment therefore sought to test for the potential importance of task-relatedness of the face identity in achieving face immunity to load effects (as in Lavie et al., 2003), by using the celebrity names as targets. To this end, we repeated the paradigm of Experiment 3 with the change that the target names were now the same names of the 12 celebrities whose faces served as distractors. All other aspects of the task remained the same, including the instruction to classify the gender of the target names.

Method

Participants. Forty participants (26 females) aged between 18 and 31 years (*M* = 21.75, *SD* = 2.60 years) participated in Experiment 4. Participants were volunteers with normal or corrected-to-normal vision, recruited from the University of Sussex or University College London. As in Experiment 3, the stopping rule was based on finding a sensitive Bayes factor for the key comparison of the distractor effect under low load versus high load.

Stimuli and procedure. The stimuli and procedure were similar to Experiment 3, with the following exception: The target stimuli were changed, such that instead of searching for a generic male or female names, the participants were now searching for the names of the same male and female celebrities whose faces were used as distractors. As first names were used in Experiments 2 and 3, only the first names of the celebrities were used in the task in order to maintain similar search demands. However, the full names of the celebrities were presented during the task instructions so that participants linked the first names with the specific celebrities (as would have been the case in Lavie et al., 2003, where full names were used in the task). The task was the same, to classify the target name as male or female. The length of the non-target jumbled letter strings was altered so that the target and non-target letter strings were matched for length.

Results

As can be seen in Table 1, and in contrast to Experiments 1-3, the face distractors produced decisive evidence of RT interference from incongruent versus congruent distractors under not only low load, $B_{H(0, 45)}$ >1000, dz = 1.58; but also high load, $B_{H(0, 53)}$ > 1000, dz = 1.00. Critically, the key Bayesian test for load modulation of face distractor interference revealed substantial evidence in support of the null hypothesis, $B_{H(0, 53)}$ = 0.30, dz = .09 – replicating the prior findings of both Lavie et al. (2003) and Thoma and Lavie (2013).

Percentage error rates did not show any discernable effect of distractor congruency in either load condition (see Table 1), with the Bayesian t-tests producing insensitive evidence in both cases (low load $B_{H(0, 0.6)}$ = 1.58, dz = .18; high load $B_{H(0, 1)}$ = 1.44, dz = .20). The difference between distractor interference in low versus high load anecdotally favoured the null hypothesis: $B_{H(0, 0.66)}$ = 0.78, dz =0.02.

General Discussion

The present study demonstrates that interference from famous face distractors can be subject to modulation by perceptual load, even when the attended task involves only non-face stimuli (cf. Thoma & Lavie, 2013). Indeed, substantial evidence for perceptual load modulation was found both when the distractor faces were entirely task-irrelevant (Experiment 1), and in a response competition paradigm to which the distractors were response-relevant on the basis of their gender (Experiments 2-3). The only case in which interference from face distractors persisted regardless of perceptual load was when the names associated with the famous distractor faces were used as search targets (as in Lavie et al., 2003; Thoma & Lavie, 2013) even though the task remained gender classification. Here we not only replicated, but also extended these prior findings by confirming the sensitivity of the evidence for a null effect of perceptual load (based on the Bayes factors). Taken together, our results suggest that previous claims that attentional capture by faces is free from generalized (non-face) capacity limits require moderation. Specifically, our results suggest that some relevance of face identity to the attentional settings used in the processing of task stimuli is critical for the ability of distractor faces to compete with the task targets when the attended task is more demanding (under higher perceptual load), even with non-face task stimuli (name search among letter strings).

Thus, even in non-face tasks, face perception does depend on the level of perceptual load in the same manner as other non-face distractor stimuli as long as the attention settings render the face either entirely irrelevant or just relevant on its gender dimension. In addition, since the famous faces used in the task could be conceived as objects of “super expertise”, these results suggest that in order to remain more competitive than the attended task stimuli, for limited resources (as in high load task conditions) the super expertise aspect of face distractors, namely their highly familiar identity (e.g. as George Clooney or Angelina Jolie) needs to be relevant to the attentional settings of the task.

These findings concur with those of a number of previous studies using measures of face processing that do not rely on their ability to capture attention and produce a cost to task performance. As mentioned in the introduction, perceptual load has also been found to modulate both recognition memory and neural activity underlying face perception (Jenkins et al., 2002; Jenkins et al., 2005; Mohamed et al, 2009), as well as the neural response to emotional facial expressions (Bishop et al., 2007). They are also consistent with the findings of Gupta et al. (2016) who established that irrelevant attentional capture by anonymous faces displaying a negative emotional expression is modulated by perceptual load. Note that all of these prior demonstrations of load modulation of face processing used a letter search perceptual load manipulation, as in our first experiment, meaning that the faces were task-irrelevant. Our second and third experiments extend this previous research by demonstrating that load modulation can apply within a face-name distractor interference task, to faces whose gender was associated with a potential task response. Only once their names were used as task targets (Experiment 4), their processing was unaffected by perceptual load. The fact that the only change between the experiments was the use of the famous names as the attended task targets, clearly points to the 'load-free' attentional capture by faces being contingent on the face identity forming part of the target stimuli. We next discuss the potential underlying mechanisms and how these may account for other findings.

Potential Role for Identity Priming in the Special Attentional Status of Faces

The importance of inclusion of the distractor faces names (rather than just gender) in the attended task for their immunity to load effects could point to a critical role played by the (highly familiar) face identity. One potential mechanism that led to the processing of the face identity when only when their names were attended is through priming. Several studies using perceptual load manipulations in letter search tasks have found that behavioral or ERP measures of repetition priming for task-irrelevant faces persist regardless of load level (Jenkins et al., 2002; Neumann & Schweinburger, 2008; Neumann, Mohamed & Schweinburger, 2011). For example in Jenkins et al.'s (2002) study, contrasting effects of perceptual load were found on two measures of face processing, in the context of a single task: While incidental measures of explicit memory for faces was modulated by load, repetition priming for the same faces was not.

These results contrast with other studies demonstrating that perceptual load eliminates repetition priming effects from a variety of ordinary familiar non face objects (e.g. car, chair, rabbit, pineapple, images taken from the Snodgrass and Vanderwart (1980) object list) even when these are measured immediately in a prime-probe trial pair paradigm (Lavie, Lin, Zokaei & Thoma, 2009). The related neural signal to repetition suppression for images of 'places' was also found to be reduced in conditions of high perceptual load in the task (Yi et al. 2004).

The contrasting findings demonstrate an advantage for faces as compared with familiar non-face objects. It is plausible that these findings reflect the impact of the well-known facilitation of perceptual processing found for faces and other objects of particularly high expertise on their ability to produce a trace that is sufficient for repetition priming effects. Such facilitation effects may be sufficient for faces to produce effects of repetition priming and the associated neural signal even in conditions of reduced processing resources (high perceptual load). However, as noted above, this facilitation may not always be sufficient to allow for irrelevant attentional capture (as in our Experiment 1, or in affective attention capture paradigms, see Gupta et al. 2016), distractor interference effects, or explicit memory, nor to produce the N170 ERP in response to an irrelevant face, or the amygdala response related to irrelevant emotional face expressions (Bishop et al, 2007; Jenkins et al, 2002; Neumann & Schweinburger, 2008; Neumann et al, 2011).

Importantly the present findings indicated that once the face identity could be primed by its inclusion in the task (in our Experiment 4), attentional capture by the faces was found even when perceptual resources are scarce (under high perceptual load). Thus an account accommodating all of these prior findings can be proposed in terms of the facilitation of the special category of faces producing perceptual evidence which also lasts as a weak memory trace, that is sufficient to produce repetition priming (rather than explicit recognition), but not to produce an effect of attention capture. For the latter, the small perceptual 'evidence' of the face requires identity priming through the inclusion of their names in the attended task. Our proposal of partial but not full preservation of face processing even under high load is also consistent with the results of a recent study comparing the ERP response to familiar and unfamiliar faces (Wiese et al, 2019): Here load modulated the later SFE

ERP component – proposed to reflect the linking of the face to amodal identity-specific information - yet the earlier N252 response to familiarity was preserved.

An interesting question for future research is whether these load-immune attentional capture effects reflect fully preserved face perception or allow for a weaker face identity signal that is sufficient to produce response competition effects, but not explicit face recognition for example. The former possibility could imply that the inclusion of the names as targets causes some form of priming (which facilitates their perception and thus allow faces to avoid being filtered by the early selection mechanism engaged by high perceptual load tasks. If this were the case, explicit memory measures may also be immune to perceptual load when the face identity is primed by the task. Alternatively it is possible that face perception is reduced by load, but that the weaker face identity signal when paired with the strong learned association between a person’s face and their name is sufficient to trigger response competition effects. Future research could address this issue by adapting the tasks used in our Experiments 3 and 4 to neuroimaging measures of neural markers of face processing (e.g. activation in the fusiform face area, or the N170 ERP component) in addition to explicit face recognition measures. A particularly interesting question would be whether the distractor faces in Lavie, Ro and Russell’s original politican versus rockstar name-face distraction task would produce an SFE ERP component even under high perceptual load – such a result, taken together with the identity-based response competition interference, would support the interpretation of the SFE as reflecting the accessing of amodal identity-specific knowledge.

Top-down Attentional Settings of ‘Famous Identity’ Detection

The effects of the appearance of the face distractor names as the task targets can also be attributed to this inclusion promoting a potential attentional setting of a ‘famous identity’detection mode, since such a detection mode could facilitate both the search for the name among nonwords, and the required classification of their gender in the task response. In other words, while it would be possible to perform the task by searching for any word among non-words, and then making a separate judgement about the gender typically associated with that name, participants might conceivably adopt a more integrated strategy of searching for the specific male and female celebrity names and using the gender associated with these identities to inform their response judgement. If an amodal ‘famous identity' detection mode was used in the name search, then this could lead to the contingent attentional capture by the famous distractor faces too. This account would extend the well established phenomenon of contingent attention capture (Folk et al., 1992; Folk & Remington, 1998; Folk et al., 2002) to account also for the load-immune contingent attentional capture by famous faces. Contingent capture effects have been demonstrated so far in relation to conceptual object categories such a dessert food, scary animals or alcoholic beverages (Wyble et al., 2013; Brown et al., 2018, 2020) – famous identities, of a particular class (e.g. politicians, actors etc) may also form such a semantic class. Such identity-based face-name contingent capture would be a particularly strong example of purely conceptual contingent capture, in that it cannot be alternatively explained by the common visual features within each semantic category (cf. Daffron & Davis, 2016; Yang & Zelinsky, 2009).

Overall, either account of priming or fame-detection mode can accommodate a number of findings reported in studies using face-name (or picture-name) response-competition tasks, in which interference from both faces and other objects of high-expertise appeared to be immune to perceptual load effects (Ro et al., 2007, 2009; Lavie et al., 2003; Parsons et al., 2017; Thoma & Lavie, 2013). In all of these prior studies the names associated with the faces (or objects of expertise) served as task targets, thus making their identity task-related as in the present study. An interesting question for future research would be to test whether the effects demonstrated here can apply to other objects of exceptional expertise. For example, the present findings suggest that load should modulate interference from objects of expertise as those used in the aforementioned studies, provided that their names are made task-irrelevant.

The Role of Familiarity

The present study used exclusively famous face distractors as these appeared the strongest candidate for immunity to perceptual load effects. As mentioned earlier, the strongest evidence for special attentional status of faces has been collected in relation to familiar faces (either famous or personally familiar, see Palermo & Rhodes, 2007, for review), leading to recent suggestions that this special status may even be limited to familiar faces (Young & Burton, 2018). Furthermore, famous faces were used in both of the prior demonstrations of Lavie et al. (2003) and Thoma & Lavie (2013), while the majority (although not all) of prior studies demonstrating load modulation of faces have used unfamiliar faces. Our use of familiar faces was also important in relation to our specific measure of gender-based response competition: Categorical perception of gender, as well as automatic processing, of gender, has been found for familiar faces, but not unfamiliar faces (Bülthoff & Newell, 2004, Yan et al., 2017). For example, Yan et al. found that participants were equally accurate in matching the gender or identity of a pair of famous faces, irrespective of whether a pre-cue or post-cue indicated which face property they need to be matched on – in contrast, matching of unfamiliar faces properties, including gender, was facilitated by pre-cues. Our findings qualify this prior evidence by demonstrating that the processing of gender characteristics even for familiar faces may nevertheless be subject to perceptual capacity limits, with the result of not being processed under high load.

We note also that the attentional status of familiar faces has been most commonly studied using famous faces rather than personally familiar faces. However, there is some evidence to suggest that personally familiar faces might produce even stronger effects on attention (e.g. Devue et al., 2009b), due to both increased familiarity and increased availability of person knowledge (Ramon & Gobbini, 2018). As such an interesting question is whether even personally familiar faces, such as those of yourself, close friends and family, would require some task relatedness or priming in order to capture attention under high load, or whether their strong personal relevance might serve this function. In support of the former possibility, Devue and Bredart (2008) have previously found that even a person's own face may not capture attention beyond unfamiliar faces when presented in a task irrelevant location. Taken together with the present findings, these results suggest that familiar faces may have priviledged access to attention, but this effect requires some task relatedness either through location relevance, or through the identity associated with the faces being connected to the task. Overall, an important goal for future research will be to establish the interactive effects on attention to distractor faces, of the key factors of perceptual load, familiarity levels and type (personal or generalised) and task-relatedness.

Summary and Conclusions

In summary, the present research provides clear evidence that behavioral distractor interference from familiar faces can be, contrary to previous suggestions, subject to powerful modulation by perceptual load – indeed, in our first three experiments no statistical evidence for face distractor interference was observed in the high load condition. Our findings point to a resolution for an inconsistency among previous findings in proposing that the special attentional status of faces may not be sufficient to overcome the impact of perceptual load even when perceptual load is varied in a non-face task, without some additional facilitation through task relatedness or priming of the associated identity. On a methodological note, the present work adds to a growing trend in attention research highlighting the importance of considering potential effects of task-relevance. As noted in the introduction, it has been increasingly noted that the strongest evidence for attentional capture by other proposed 'special' categories of stimuli (e.g. multisensory stimuli) has been in the contexts in which the stimulus itself is task-relevant (e.g. either appearing as a search target, in an attended location, or sharing features with the target stimuli - for similar findings in relation to the affective attentional capture literature see also Brown et al, 2020; Lichenstein-vidne, Henik and Safadi, 2012; Vogt et al., 2013). By directly examining the influence of task-relevance on face distractor processing, the present study results substantially qualify earlier proposals regarding the special attentional status of faces. Broadly speaking, our results highlight that unless distractor stimuli are entirely task-irrelevant, it must always be considered that some aspect of task relevance may be inadvertently boosting attention to the distractor.

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Notes

1. We note that in load theory the spill over process is described as occurring in parallel rather than serial manner (e.g. Lavie & Torralbo, 2010) and thus any distractors that are perceived are capable of concurrently competing with the task target for response selection
2. Note that these minor variations did not influence the results. Indeed, the key load by distractor interaction was significant (ps < .023) within each of the two subsets of participants.
3. This is based on the assumption that the interaction should be terminative in nature (and so should theoretically equal the low load distractor effect).
4. We note that our use of Bayes based optional stopping rule in Experiments 3-4 makes the reporting of NHST inappropriate, hence these are not reported.

Figures

Figure 1. Mean RT as a function of perceptual load and distractor condition in Experiment 1 (error bars show SE).

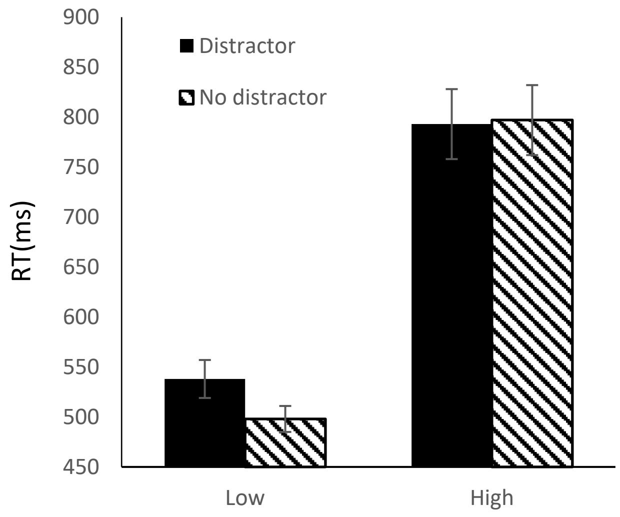

Figure 2. Mean RT distractor cost as a function of perceptual load in Experiments 1-4. *Note* In Experiment 1 distractor cost = Mean RT for irrelevant distractor present-absent. In Experiments 2-4 distractor cost = Mean RT for incongruent-congruent distractors. Error bars show SE.