Three-quarter views of depth-rotated faces induce face-specific capacity limits in visual search

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Abstract

Processing capacity for famous faces is impaired when target faces are presented in a small crowd of anonymous frontal faces. The present experiments tested whether this finding extends to three-quarter views of faces. Participants made speeded categorization decisions regarding a famous person (politician or film star) accompanied by a peripheral distracter face (either the same or from the opposite target category). The first experiment replicated the finding that processing of a peripheral distracter face is independent of load when the search set contains name strings. The search set in the second experiment consisted of faces. Interference effects between target face and distracter face were found under low load, but not under high load. This was true for both unfamiliar frontal and three-quarter view non-target faces. However, search performance was better for the three-quarter view load conditions. These results indicate that capacity limitations are face-specific and relatively independent of view changes.

Faces are harder to identify in a crowd than when shown alone. In typical experimental studies participants have to identify target faces that are shown in isolation or with other faces (either as part of the relevant search set, so-called non-targets, or as to-be-ignored distracters). Target face recognition performance usually drops in the presence of other faces (e.g., Louie, Bressler, & Whitney, 2007; Thoma & Lavie, 2013). There are two main reason for this: when the search set has more faces accompanying the target face, these non-targets make visual search more difficult, so it takes more time to find the target face. Second, the fact that in a crowd situation many different faces have to be processed almost simultaneously may tax or obstruct the processing of the target face, or indeed of additional other familiar faces. This may be the result of a number of reasons, e.g., because of depleted perceptual or cognitive resources when faces compete for processing, or it may be due to interference effects between face stimuli present in the display.

The mechanism to disentangle this latter effect can be investigated using the flanker paradigm (Eriksen & Eriksen, 1974), measuring the effect on face recognition when presenting peripheral distracter faces that are either compatible or incompatible with the current target (e.g., belonging to the same or different category to the target face). Previous research has shown that adding unfamiliar faces to a search set with a familiar face reduces the processing of distracters that are linked to the target (Thoma & Lavie, 2013). The current study asks whether distracter interference is still observed when unfamiliar faces in the search set are shown in a different orientation than the target and distracter.

According to predictions of perceptual load theory (Lavie, 1995, 2005) processing of stimuli irrelevant to a task at hand depends on the limited attentional capacity of the visual system, as well as on the processing demands of the task. In visual search situations, for example, target stimuli (e.g. looking for the letter “N” vs “Z” in a circle containing non-target letters “W”, “M”, Z” etc.) will always be processed as a priority, which means non-relevant information (any letter outside the search ring, even if it is the same as the target) will not be processed. However, in conditions of low perceptual load (looking for “N” in a circle among a number of “O”s) attentional capacity will not be consumed completely by the main task. Therefore, ‘spare’ perceptual resources are available, and these are used involuntarily to automatically process task-irrelevant distracter stimuli, such as flanker stimuli in the periphery. There is ample evidence for perceptual load determining capacity limits using stimuli such as letters (Lavie, 1995; Lavie, Ro, & Russell, 2003) or objects (Lavie et al., 2009).

Predictions from perceptual load theory, however, have not always been born out by the data when faces were used as stimuli. Lavie and colleagues (2003) had participants searching for the name of a famous pop-star or politician among displays that varied in load (few or many name-like strings, low load or high load, respectively), while ignoring a peripheral distracter face. The peripheral distracter face was either congruent (e.g. the same person) or incongruent with the central target name (a face from the opposite category). Whereas for non-face objects (or letters) in such situations interference effects from peripheral distracters were diminished or eliminated, in the case of face distracters they were unaffected by any increase in load on the name search task. These results seem to contradict the claim made by perceptual load theory that increased perceptual load should necessarily lead to a reduction in distracter processing, and instead suggest that faces may be a special stimulus category that are less sensitive to limitations in perceptual processing capacity. Using an event-related potentials (ERP) repetition paradigm Neumann, Mohamed, and Schweinberger (2011) found similar effects when a letter search task was superimposed over unfamiliar faces, hands, and houses as distracters. ERP correlates of repetition priming for non-face objects were modulated by load, but there was no ERP modulation for the ignored face stimuli. Indeed, the majority of the research literature seems to show that in many situations face processing is not drawing on substantial amounts of attentional resources (see Palermo & Rhodes, 2007, for a review).

However, there is an alternative interpretation for the apparent resistance of face distracters to the effects of perceptual load. In face processing tasks, face-specific resources may be used for face processing, explaining why there are no load effects from non-face stimuli, such as string targets and non-targets. This interpretation fits with evidence that processing of face distracters is diminished if an additional distracter face is presented (Jenkins, Lavie, & Driver, 2003). Furthermore, Bindemann, Burton, and Jenkins (2005) demonstrated that when participants categorised centrally shown names of famous people or national flags (either belonging to the UK or US), famous distracter faces produced response competition effects, but these were eliminated when a face had to be categorised (as a famous UK or US citizen) as a central target. This would suggest that face processing may rely on specialized module (Fodor, 1983) that operates in a mandatory fashion in the presence of face input (Farah, Wilson, Drain, & Tanaka, 1998; Kanwisher, McDermott, & Chun, 1997).

Recently, visual search experiments with faces as targets and non-targets have shown that this explanation can be corroborated. Thoma and Lavie (2013) tested the hypothesis of face-specific attentional resources by letting participants search a central vertical array of either faces or letter-strings for a famous pop star versus a politician’s face (or name) which had to be identified by a speeded button press. Perceptual load was manipulated by varying the relevant search set size, adding anonymous non-target faces (in the face search condition) or non-target strings (in the name search condition). As in Lavie et al. (2003; see also Thoma & Lavie, 2013) a target category-congruent or incongruent peripheral distracter face was also shown. While target-distracter interference was found in low load (target face only shown plus distracter) this distracter effect was eliminated when two anonymous (non-target) faces were added to the search set. In contrast, in the name search task the response competition effects were unaffected by perceptual load, replicating the Lavie et al. (2003) results. Search slopes between string search and face search were similar, so face-specific perceptual load effects were not due to possible differences in the effectiveness of the load manipulations.

Recent experiments have corroborated the evidence for face-specific capacity limits. Thoma (2014) confirmed the face-specific aspect of load capacity in similar experiments using upright and upside down non-target faces (in addition to the target and distracter faces that were always shown in an upright view). Surprisingly, when the central task was loaded with inverted non-target faces (while searching for an upright famous target face) the congruency effects were still reduced. This finding seems to suggest that face-specific capacity limits are determined by non-holistic properties of a face, rather than by holistic processing (Tanaka and Farah, 1993, Maurer et al., 2002). This finding was extended Thoma, Ward, and de Fockert (2016) to conditions in which non-target faces were replaced with images that consisted of two horizontally misaligned face-parts - these also eliminated distracter processing. Similar results were found when the polarity of a non-target face image was reversed, so that non-target faces were shown as ‘negatives’. Thus, a number of manipulations affecting the holistic configuration of non-target faces proved to be effective in inducing load on target-distracter processing. Only low-level phase-scrambled versions of non-target faces did not exhaust perceptual capacity (Thoma & Lavie, 2013). Thoma et al. (2016) concluded that - taken together – the results of these studies were in line with the idea that face-specific capacity limits are not driven by holistic properties of face processing, but may be based on parts or features.

The studies described above by Lavie and Thoma and colleagues have all used frontal views (that were sometimes manipulated for non-targets). A body of research has investigated processing performance for so-called three-quarter views (upright faces rotated in depth by 45˚). Whereas complete side profile views (90˚ rotation) produced poor recognition, performance for full-face (0˚) and three-quarter (45˚) views did not differ significantly (Hill, Schyns, & Akamatsu, 1997; Newell, Chiroro, & Valentine, 1999). Some research even suggests that three-quarter views are superior to frontal full views (e.g. see Perrett, Oram, & Ashbridge, 1998) but Bruce, Valentine and Baddeley (1987) found a three-quarter view advantage only for matching unfamiliar faces. Similar results were reported by Baddeley and Woodhead (1983) and Krouse (1981) who also reported a similar view advantage for recognition of unfamiliar faces (McKone, 2008; O'Toole, Edelman, & Bülthoff, 1998). Therefore, based on previous studies, it is predicted that including three-quarter views of faces in a search set should also produce a high load condition, and eliminate target-distracter interference.

However, there are reasons to expect that three-quarter views of unfamiliar face non-targets may not exhaust face-processing capacity when presented with frontal (0˚ view) target faces and distracters, but rather produce a congruency effect even in such particular 'high load' situations. According to Theory of Visual Attention (TVA, Bundesen, 1990; Bundesen, Habekost, & Kyllingsbæk, 2005) perceptual capacity is allocated simultaneously (in one step) for both task-relevant stimuli and task-irrelevant distracters (this would include non-targets in a visual search, although TVA does not necessarily distinguish between non-targets and distracters, see e.g, Kyllingsbæk, Sy, & Giesbrecht, 2011). This is in contrast to perceptual load theory, in which allocation of attention in a visual search set is by automatically prioritizing target and non-targets, and then - if there is spare capacity left – in a second step allows processing of the distracter (what Kyllingsbaek et al. call a "two-step" allocation model). Therefore, TVA predicts that if there are reductions in the 'attentional weights' of the task-irrelevant distracters this would result in an increase of the relative attentional weights for the task-relevant stimuli. Consequently, this should lead to more capacity being allocated to the task-relevant stimuli when task-irrelevant stimuli are easy to distinguish from the target stimuli, e.g. when task-relevant and task-irrelevant stimuli are of a different colours (see Chen & Cave, 2013).

In theory, TVA would therefore also predict that in a display that shows target and distracter in one view and non-targets in another, attentional weights would be adjusted in favour of target and distracter face. In such displays we would then expect a congruency effect, i.e. similar to a low load condition. The same prediction can be made based on known effects of perceptual grouping on selective attention. Driver and Baylis (1989) showed that attention can be selectively directed to letters that are distant but form a perceptual group (for example on the basis of colour similarity or common motion), at the expense of nearer letters that are not perceived as being part of the same perceptual group. In the case of faces of different views, it may be that the faces that share a view are readily grouped and selectively attended to. By contrast, if face-specific capacity is allocated automatically across views of faces, as predicted by perceptual load theory, then we would expect that even with non-targets shown in a different view, distracter congruency effects are reduced.

There is another reason why one may expect different orientation of faces not to load the central search task in a way that reduces distracter processing. Since 45˚ rotations present new parts (e.g., hairline of the back, ear) and also a different overall shape compared to full frontal views, the latter could simply ‘pop out’ in a search array, and consequently make it into a ‘low load’ situation which would allow processing to be distinct from that for an equivalent full frontal distracter face. This is reflected in the “salience” hypothesis of selective processing which predicts that interference should occur sometimes even in high load conditions when the distracter (and sometimes target) are salient – e.g. when they appears as an onset during the search, or occurs for distracter offsets when the target was also an offset (Eltiti, Wallace, & Fox, 2005).

In two experiments we test these predictions of face-specific capacity. In Experiment 1 we replicate with new face stimuli the findings of Lavie et al. (2003) that processing of distracter faces is independent of load when non-face stimuli are determining the search task. In Experiment 2 we use faces as target, and test whether adding non-target faces in the same and different orientation as the target and distracter face produce face-specific capacity effects.

Experiment 1

In Experiment 1 observers were given a visual search task. Participants classified the name of a famous male politician or film star in displays with either low (target name plus two non-target name-like letter strings) or high (target name plus five non-target name-like letter strings) perceptual load (Lavie et al., 2003; Thoma & Lavie, 2013, Experiment 2). In addition, to the strings presented along a central axis, the image of a face of a famous politician or film star was presented in the periphery. Response times and accuracy were measured for classification of the target name (politician/film star) as a function of whether the distracter face was congruent or incongruent with the target name.

Method

Participants. Twenty unpaid University of East London (UEL) students participated (mean age 26.4 years, SD= 1.86, ten male). They all reported normal or corrected to normal vision. Participants were shown an information leaflet and gave their written consent before the experiment. They were then asked to name photographs of the famous faces used later in the experiment (see Appendix A).

Stimuli and Procedure. Participants sat in front of a 15” CRT monitor at a distance of ca 60 cm (no headrests were used but chair and armrest brought into a standard position).

They were asked to attend to the vertical centre area of the display and classify a target name which would be either that of a famous politician or a film star using one of two keyboard keys, whilst ignoring a peripheral distracter face. In the low load condition, the target name would be accompanied by two additional non-target letter strings in the search area. The target name of the famous person was displayed in one of six vertical positions, and two of the other (adjacent, i.e. above or below) vertical positions were filled by name-like nonsense letter strings. In the high load condition, the famous name was displayed in one vertical position and all five other rows were filled by nonsense letter strings. The non-targets consisted of nonsense letter strings in a name like format, e.g. ‘Cgerth Jnfedgsa’. The distracter face either matched the target name (congruent condition) or was one of the faces from the other category (incongruent condition). E-prime 1.1 was used to run the experiment. Counterbalancing ensured that each target identity and position was presented equally often, as was each distracter identity and position (left vs right). These conditions were randomly presented in each block. Trial displays remained visible for a maximum of 3 seconds or until the participant responded. Each participant completed a practice block of 72 trials followed by 6 experimental blocks of 92 trials each, creating a total of 368 test trials.

Results

Out of the twenty participants four had mean accuracies that were at chance level (between 47% and 53% correct). These participants were excluded from the analysis, while all others had mean accuracies of 60% or more. Only correct responses were analysed and of these only those that had latencies greater than 150 ms, the latter filter excluding 0.087% of all trials. Figure 1 presents the mean RTs as a function of the experimental conditions. A within-subject Analysis of Variance (ANOVA) was performed with congruency (congruent, incongruent) and set size (3= low, 6 = high) as independent variables. The results revealed a significant main effect for set size, $F (1, 15) = 6.29$, $p < .024$, partial $eta^2 = .296$, indicating that response latencies were significantly higher in the high load search set size. The average search slope was 243 ms. This result shows that processing demands increased following an increase in the string search set size, indicating that the manipulation of perceptual load was successful. There was also a main effect of congruency, $F (1, 15) = 116.58$, $p < .001$, partial $eta^2 = .886$, with congruent trials being responded to faster than incongruent ones (see Figure 1). Crucially, there was no interaction between congruency and load, $F < 1$. Error rates were analysed in an equivalent ANOVA, revealing no significant effects, for congruency, $F(1, 15) = 2.76$, $p = .118$, partial $eta^2 = .155$, for the other effects, F’s < 1. In summary, the results of Experiment 1 confirmed the results of Thoma and Lavie (2013) and Thoma (2014) showing that processing of distracter faces is not bound by increasing perceptual load when the central task is loaded with strings.

>> Insert Figure 1 about here <<

>> Insert Table 1 about here <<

Experiment 2

Experiment 1 showed that distracter faces (that were irrelevant for the central task) were processed despite the increased attentional demands of a relevant task that involved processing of non-face stimuli. Experiment 2 was designed to test whether displays with face images as target and non-targets increase the perceptual load in the central task such that the distracter face cannot be perceived anymore (Thoma and Lavie, 2013; Thoma, 2014). Specifically, we also sought to test whether increasing perceptual load by adding depth-rotated (three-quarter view) face stimuli to the display significantly diminishes congruency effect between target and peripheral distracter faces (shown in frontal views). In line with

Thoma and Lavie (2013), we predicted that if face representations underlying the capacity limits are based on face-parts or face-specific view-generalisations (rather than strictly frontal face templates) then depth-rotated three-quarters non-target faces would eliminate the congruency effect produced by peripheral distracter faces. This is because three-quarter faces usually generalise well between frontal views (e.g., Hill et al., 1997), and therefore depth-rotated non-target faces should put a perceptual ‘load’ on the processing of target faces (and therefore eliminate distracter processing).

Furthermore, displays with non-targets shown in three-quarter views are likely to produce faster search slopes than displays with only frontal faces in the search set. One reason is that three-quarter faces have been found to be ‘special’ (Bruce et al., 1987) and advantageous in processing of unfamiliar faces. Alternatively, or in addition, the visible parts and outline of depth-rotated faces are somewhat different from the target and distracter shown in frontal view (see Figure 2), and so three-quarter views should group together. If such an advantage or grouping effect is observed, then Experiment 2 allows in principle to separate perceptual load predictions from those of TVA (Bundesen, 1990; Kyllingsbæk et al., 2011). According to the former, face-specific capacity-limits should be observed even if perceptual grouping allows faster search times for displays with depth-rotated faces than in a typical high load display (as long as there is a substantial increase compared to low load conditions). According to the latter, if perceptual grouping means faster search slopes for one condition and consequently changes in attentional weights allocated to the relevant target (and distracter) face view, this should benefit processing of target and distracter and hence predict increased congruency effects compared to the high load condition with frontal faces as non-targets.

Method

Participants. Thirty unpaid students from the University of East London (17 male, mean age 29.06 years, SD = 6.94) participated. All reported normal or corrected-to-normal vision. As in Experiment 1, they were asked to name photographic frontal images of the famous faces used in the experiment, and proceeded if they identified the faces correctly.

Stimuli and Procedure. The frontal face stimuli were the same as in Experiment 1, but an additional set was made with frontal and three-quarter views of neutral (unfamiliar) non-targets. The stimuli and trial procedure were similar to Experiment 1, except that the central task now comprised of a target face (low load) accompanied in some trials by two non-target faces (high load). Each display comprised the target face at fixation or with its center 3 cm above or below fixation. In the low load condition, the target face was presented alone at one of these positions. In the frontal high load condition and the three-quarter condition the target face was shown with two other anonymous non-target faces (both as normal frontal images in high load, or both three-quarter face versions in the three-quarter condition). As in Experiment 1 participants had to indicate with a speeded key press (the ‘1’ and the ‘2’ keys on the right number block of the keyboard) whether the famous face was a politician or a film star. Targets and non-targets depicted males of an apparent age between approximately 40 and 55 years, with no apparent features such as glasses or beards (see Lavie et al., 2003). Four faces of famous politicians and four famous film stars were used (the same as in Experiment 1). Examples of politicians are David Cameron or George Bush, and examples of film stars were Daniel Craig and Brad Pitt. Target category (politician or film star), target position, target identity and distracter position (left or right of the screen) were counterbalanced within a block. The allocation of target face identities was randomized for each trial. Each participant ran through a practice block of 72 trials followed by six experimental blocks, again with 72 trials per block, resulting in a total of 432 trials. The two non-famous male faces which were used as non-targets (in the high load and rotated conditions) in the high load conditions were from a pool of twelve non-famous faces (taken from the FERET face database, Phillips, Moon, Rizvi, & Rauss, 2000). See Figure 2 for an example display.

>> Insert Figure 2 about here <<

Results

One participant was removed as their mean accuracy was identified as an outlier with 58% correct. Latencies below 150 ms were counted as errors (0.1% of all trials) and omitted from further analysis. Figure 3 shows the mean RTs as a function of the experimental conditions (see also Table 2). A 3 x 2 within participants ANOVA (load type by congruency) was performed on the latencies of correct trials. Mauchly's test for sphericity was significant for the factor load type, and therefore Greenhouse-Geisser corrected degrees of freedom are reported. There was a significant main effect of load type, $F(1.03, 36.49) = 119.59$, $p < .001$, partial $eta^2 = .810$, with a significant increase in latencies between low load and frontal conditions, ($p < .001$), as well as a significant difference between the frontal and three-quarter high load conditions ($p < .001$), indicating that search slopes were steeper in the frontal high load condition. There was a significant main effect of congruency, $F(1, 28) = 6.61$, $p = .016$, partial $eta^2 = .191$, but more importantly there was a significant interaction between congruency and load type, $F(2, 56) = 4.66$, $p = .013$, partial $eta^2 = .143$. Planned comparisons showed that the congruency effect was significantly different between low load condition and the frontal high load condition, $F(1, 28) = 5.47$, $p = .027$, partial $eta^2 = .164$, and between low load and three-quarter high load conditions, $F(1, 28) = 8.73$, $p = .006$, partial $eta^2 = .238$, but not between frontal and three-quarter high load conditions, $F(1, 28) < 1$. Mean error rates (between 7.5% and 11.3%) were also analysed: there were no significant main effects of congruency, $F(1, 28) < 1$, or loadtype, $F(2, 56) = 2.59$, $p = .084$, partial $eta^2 = .085$. The interaction was also not significant, $F(2, 56) = 2.09$, $p = .133$, partial $eta^2 = .070$ (see Table 2).

To investigate whether the side on which the distracter appeared played a role in any of the simple effects or interactions, we performed a further ANOVA including side as another within factor. There was a main effect of side, $F(1, 28) = 8.00$, $p = .009$, partial $eta^2 = .222$, with faster RTs for the trials in which the distracter appeared on the left (M = 963 ms, SD = 34 ms) compared to the right side (983ms, SD = 35ms). There were the usual effects of load type, $F(1.23, 34.47) = 93.49$ $p < .001$, partial $eta^2 = .77$, congruency, $F(1, 28) = 6.36$, $p = .018$, partial $eta^2 = .185$, and an interaction between load type and congruency, $F(1.99, 55.84) = 5.20$, $p = .008$, partial $eta^2 = .157$. Crucially, there were no other interactions involving side, such as hemisphere by congruency, $F(1, 28) = 2.60$, $p = .12$, partial $eta^2 = .085$, or any other combinations, all Fs < 1.

>> Insert Figure 3 about here <<

>> Insert Table 2 about here <<

General Discussion

In a visual search task with faces as targets and non-targets, we report interference from distracter faces when the search task included one face, but was eliminated when the face search task was made more difficult by adding two anonymous faces as non-targets. There was no load effect for distracter faces when the search task contained name-like letter strings (Experiment 1). Importantly, Experiment 2 showed that face-specific perceptual load effects were evident when the central search task contained non-target faces in depth-rotated orientations different to the frontal view of the target (and distracter) face. Thus, these capacity limits appear not to be bound by frontal full-view face templates.

The present data are in line with previous work suggesting that processing of a peripheral face has no general capacity limits (Lavie et al., 2003; Neumann et al., 2011), but that distracter processing is diminished or eliminated when the search set contains additional faces other than the target face (Thoma & Lavie, 2013; Thoma, 2014; Thoma et al. 2016). The suggestion of face-specific capacity limits concurs with the notion of a 'face module' (Fodor, 1983; Kanwisher, 2000) which operates automatically and involves processes which are qualitatively different from processing of other non-face stimuli (Kanwisher et al., 1997; Perrett, Hietanen, Oram, & Benson, 1992; Puce, Allison, Gore, & McCarthy, 1995; Farah, Wilson, Drain, & Tanaka, 1995, though see e.g., Gobbini & Haxby, 2006).

There is a potential alternative to perceptual load in explaining the effects observed here. While perceptual load proposes that limited attentional resources determine distracter processing in high load, so called dilution accounts (Tsal & Benoni, 2010; Wilson, Muroi, & MacLeod, 2011) explain reduced distracter processing effects differently. According to these accounts adding more items to a search display is "diluting" the processing for all stimuli (non-targets and distracters) in the response competition paradigm because of crosstalk among stimulus features. The current observations in Experiments 2 of diminished distracter processing in high load conditions could therefore be interpreted as the result of simply adding any stimulus, in this case frontal or rotated faces, which all diminish distracter processing. However, Thoma and Lavie (2013; Experiment 4), using the same experimental design and very similar stimuli, showed that the results for a face-specific load situation could not be explained by a dilution account, as adding phase-scrambled non-target versions of faces did not diminish (i.e. 'dilute') distracter face processing. It seems therefore unlikely that feature crosstalk among stimulus features is driving the observed set size effects for face stimuli.

Previous research on distracter processing using non-face stimuli (e.g., Bundesen, 1990; Driver & Baylis, 1989) arguably would have suggested a different result for distracter processing in the three-quarter condition: The rotated non-target faces should have allowed for distracter interference because of accentuating the similarity between target and distracter (the only two being in frontal view in the high load display). This would therefore increase perceptual grouping between the similar target and distracter views and attenuate the attentional weights of the non-targets or. Similarly, other work (Eltiti et al., 2005) also suggested that distracter saliency – rather than perceptual load – determines interference effects. Indeed, in the present experiment overall search times were significantly lower in the three-quarter condition, indicating an increased salience (or attentional weight) for frontal-view targets - and presumably distracters in the same view. But importantly, this was not associated with an increase in the distracter effect. Thus, although the study here was not designed to comprehensively test perceptual load theory predictions versus those of other accounts, face-specific category limitations as predicted by Thoma and Lavie (2013) seem to be the most parsimonious explanation of the current results.

In conclusion, the present data confirm previous observations that faces are perceived in an automatic manner as long as there is sufficient processing capacity for their perception. Face recognition in visual search seems to be limited by the amount of face-specific resources (Thoma & Lavie, 2013), and this study shows for the first time that these capacity limits are independent of 3D view (at least for 45 degrees of rotation in depth). Future research will need to test the limits of view generalization in face-specific resource limitations.

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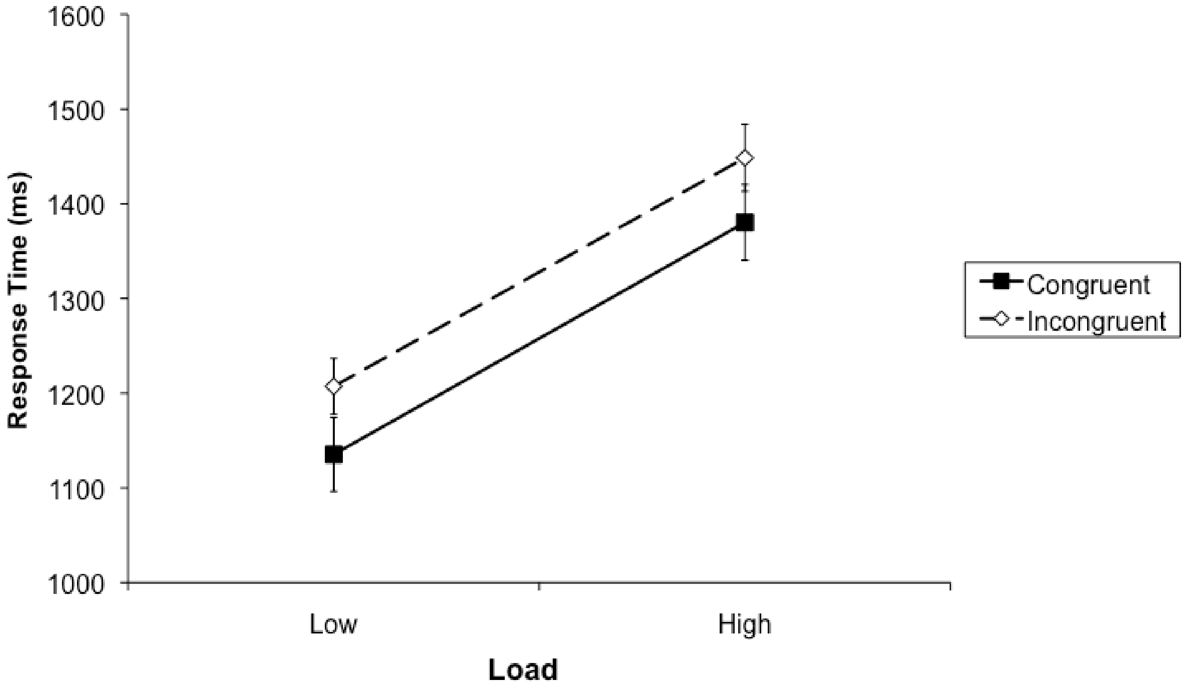

Figure 1.

Mean response times to classify the target name for congruent and incongruent conditions as a function of set size in Experiment 1 (and standard errors of the mean).

Figure 2.

Example of a stimulus display with two three-quarter non-target faces (set size 3) and the distracter (appearing to either the left or right side of fixation) in Experiment 2.

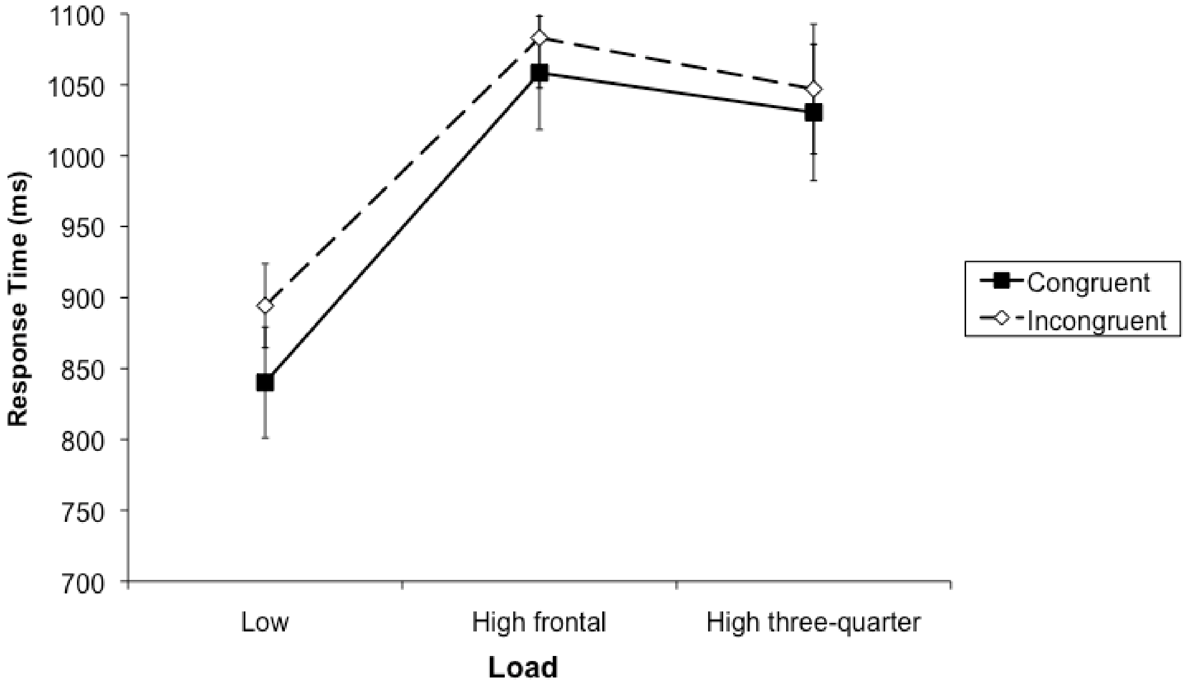

Figure 3:

Mean response times to classify the target face (and standard errors of the mean) for congruent and incongruent conditions as a function of set size in Experiment 2.

Table 1

Experiment 1: Mean Response Time to Classify the Target Name and Standard Errors (ms) and Percentage Errors (and their Mean Standard Error) as a Function of Set Size and Congruency in Experiment 1.

	Set size 3	Set size 6
Congruent		
M	1135 (140)	1380 (188)
% error	11.94 (7.58)	11.44 (6.85)
Incongruent		
M	1207 (143)	1449 (147)
% error	20.00 (20.20)	20.24 (21.50)

Table 2.

Experiment 2: Mean Response Time to Classify the Target Face (ms) and Percentage Errors (and their Mean Standard Errors) as a Function of Set Size and Congruency in Experiment 2

	Target only	Set size 2	Set size 3
Congruent			
M	840 (153)	1058 (183)	1030 (189)
% error	7.59 (4.98)	9.62 (7.86)	9.72 (5.96)
Incongruent			
M	894 (199)	1083 (212)	1047 (207)
% error	8.55 (5.13)	11.31 (10.10)	9.03 (8.71)

Appendix A

Face images of the following famous persons were used in both Experiments 1 and 2:

Famous politicians:

Tony Blair, David Cameron, George W. Bush, Ed Milliband

Famous film stars:

Robert de Niro, Brad Pitt, Hugh Grant, Daniel Craig