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The effects of concurrent cognitive task load on recognizing faces displaying emotion

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Abstract

Two independent experiments (*N* = 30 and *N* = 24) investigated the effects of concurrent task loads on the recognition of faces displaying emotions. The study aimed to explore a possible resolution for an apparently discrepant finding in the literature regarding the impact of such loads on recognition of facial emotions. Faces displaying different emotions were presented, with or without a concurrent load, until the facial stimuli were correctly labelled to criterion in terms of the displayed emotion. Participants were then presented with elements from the faces (i.e. eyebrows, eyes, and mouth). When participants had to complete the concurrent task as well as the facial recognition task, they did not respond equally to the separate facial elements, and over-selected to the mouth when recognising facial expressions of emotion. The findings relating to the impact of the concurrent load tasks on correct labelling of the facial elements with respect to the emotional faces are discussed in terms of the impact of cognitive load on the production of over-selectivity and the recognition of faces displaying emotions in complex situations, and the implications for those with a developmental disability.

Keywords: over-selectivity; emotion recognition; face recognition; concurrent load; ASD.

Understanding how facial emotions are recognised is important for understanding social interactions, as such an ability allows individuals to accurately recognise the intentions of others, and to construct the appropriate responses (Bal, Harden, Lamb, Van Heckel, Denver, & Porges, 2010; Izard, Fine, Schultz, Mostow, Ackerman, & Youngman, 2001). Many individuals who are subject to difficulties in recognizing emotions from faces, are also subject to limits to their cognitive capacities, such as in ASD or intellectual disabilities (Bal, Harden, Lamb, Van Hecke, Denver, and Porges, 2010; Collin, Bindra, Raju, Gillberg, and Minnis, 2013; García-Rodríguez, Ellgring, Fusari, and Frank, 2009). The effect of disrupted cognitive processing capacity has been studied using cognitive loads in typically developing populations (e.g., Reed & Gibson, 2005), as it allows this aspect of the problem to be isolated from comorbid issues in atypical populations. Given this, the present research aimed to investigate the effects of concurrent cognitive loads on the ability to recognize faces displaying emotions.

The influence of disrupted cognitive capacity on recognizing emotions from faces has previously received some, but not extensive, research (Doherty-Sneddon, Bonner, & Bruce, 2001; Doherty-Sneddon & Phelps, 2005; Lim, Bruce, & Aupperle, 2014; Phillips, Channon, Tunstall, Hedenstrom, & Lyons, 2008; see Calvo & Nummenmaa, 2016, for an overview). Lim et al. (2014) found that concurrent working memory load by task-irrelevant distractors has an impact on affective perception of facial expressions, and Phillips et al. (2008) noted that concurrent working memory load substantially interfered with choosing which emotional label described a facial expression. However, these effects are not noted universally (see Tracy & Robbins, 2008), and depend on a range of factors (see Lin et al., 2014; Phillips et al., 2008). These effects seem to be greater in those with a cognitive deficit (García-Rodríguez et al., 2009), and are greater for faces displaying greater emotional intensity (Lin et al., 2014).

Apart from the potential importance of this line of investigation for understanding recognition of emotion-displaying faces in complex social situations, which may require concurrent processing of multiple sources of information and great cognitive effort, the literature leads to a number of potentially different suggestions about the predicted impact of additional concurrent tasks on recognition of facial emotions. Consistent with the view that recognising emotions displayed by faces is an automatic process, Tracy and Robbins (2008) noted no strong impact on the recognition of facial emotions when a cognitive load was added to the recognition task; participants were equally able to label emotions displayed by faces, either with or without performing a concurrent task. However, other studies related to the level of attention paid to faces (often measured by gaze variables), show that, as an additional task load increases, gaze aversion to faces increases (e.g., Doherty-Sneddon et al., 2001; Doherty-Sneddon & Phelps, 2005). The latter studies are also consistent with previous work conducted by May et al. (1990), which demonstrated that eye movements are impacted by the introduction of a cognitive load; specifically, that increased additional cognitive load reduces the number of eye movements across the face, suggesting that scanning is reduced under such circumstances. Thus, while there are a number of reports that suggest a cognitive load might reduce the attention paid to a face (see Doherty-Sneddon et al., 2001; Lin et al., 2014; May et al., 1990; Phillips et al., 2008), facial emotion-recognition appears to be only slightly impacted in such situations (Tracy & Robbins, 2008).

One possible explanation of this set of apparently discrepant findings is that accurate recognition of the emotions displayed on faces may be produced by an individual's sampling only a small subset of the facial features available. Even with reduced attention being paid to the entire facial stimulus, the emotion may still be recognised accurately from only a part of that face. Previous research on discrimination learning with a concurrent cognitive task has demonstrated that 'stimulus over-selectivity' occurs in non-clinical adult participants under such conditions of cognitive load (Leader, Loughnane, Mc Moreland, & Reed, 2009; Reed, 2006; Reed & Gibson, 2005), as it does under many conditions for those with an intellectual or developmental disability (Ploog, 2010). Stimulus over-selectivity refers to the phenomenon whereby only a small subset, of an equally important larger set of stimuli, controls behaviour (Leader et al., 2009; Reed et al., 2011). Such over-selectivity is most often seen in the failure to recognise the elements of a complex stimulus that has been learned previously in a discrimination-learning task.

Cumming and Berryman (1965; Lovaas, Schreibman, Koegel, & Rehm, 1971; Schreibman & Lovaas, 1973; Thomas & Jordan, 2004) suggested that the capacity to attend to multiple stimuli, such as are present in recognising emotions displayed by faces, is essential in establishing understanding of many complicated social concepts. However, it may be that a detrimental impact of stimulus over-selectivity is noted only in situations where learning is poor, and not for well-learned, or automatic, responses (see Reed, 2011). Recognition of facial stimuli has long been taken to be an automatic process for typically-developing individuals (see Hanley, Pearson, & Young, 1990). In situations involving well-learned, or even automatic processing, sampling a single facial feature will be enough to correctly recognise an emotion, even though attention to the whole face is reduced. This line of reasoning would suggest that, under conditions of higher cognitive load, recognition of the emotions displayed on faces may not be strongly impacted, but that individuals may preserve this ability by focusing only on a subset of facial features, and, thus, when tested separately, the features would not be equally well recognised (see Reed, Petrina, & McHugh, 2011).

Given the impact of cognitive loads on simple recognition tasks following acquisition of a complex discrimination, it may well be the case that such concurrent loads would impact facial recognition related to the features of a face, while not necessarily impacting on emotional recognition when the whole face was present. The current studies explored this possibility using a variety of procedures to explore the ability to label faces according to the emotions that they display. Such a demonstration may offer insight into both the apparently disparate set of findings noted with typically developing populations when attempting to recognise emotions displayed on faces with a cognitive load, and into the processes involved in this ability for those with more limited cognitive capacities.

Experiment 1

The first study explored whether the presence of a cognitive load would impact recognition of emotion through particular features of the faces. That is, whether individuals given a concurrent task would show differential recognition of the facial elements. As previous studies have shown that the impact of such concurrent tasks on facial attention may be more strongly noted in discrimination learning tasks, rather than perception tasks (see Hanley et al., 1990; Tracy & Robbins, 2008), the study adopted a discrimination learning task, as also previously employed in studies of over-selectivity (Reed et al., 2011; Reed & Gibson, 2006). It also adopted a time limit on the recognition of the facial expressions of emotion, rather than allowing unlimited time to recognise the emotion, as suggested by Tracy and Robbins (2008).

Participants were first trained to match facial pictures to emotions to a criterion of accuracy, and were then presented with individual elements of the faces, and had to match these elements to the previously trained emotional labels. If over-selectivity of facial features were noted, initial learning of the emotions may be retarded under conditions of cognitive load (a verbal counting task as employed in previous investigations of over-selectivity; Reynolds & Reed, 2011, and cognitive load effects, Andersson et al., 2002), but asymptotic performance would be reached eventually. However, when presented with the features of the faces, only some of the features would be recognised when operating under conditions of cognitive load.

Method

Participants

Thirty participants were recruited from the student population, and were divided randomly into two groups of 15: Group Control (9 male, 6 female; mean age = 24.13 ± 9.5); Group Load (8 male, 7 female; mean age = 24.73 ± 10.17). No participant received any form of payment or course credit for volunteering. None of the participants reported any form of intellectual and developmental disability, and none reported any history of mental health problems. Ethical permission for the study was granted by the University's Psychology Department Ethics Committee.

Apparatus and Materials

Six A4 laminated cards (29 x 20.5 cm) each showing a different facial expression (happiness, sadness, surprise, fear, anger and disgust), taken from the set developed by Ekman and Friesen (1975), were used for each participant. In total, four faces (two male and two female) for each emotion were selected for the study, and one of these faces was selected for each emotion for each participant. The selection for each participant was initially random, but with the limitation that each participant received three male and three female faces. Thus, the male/female balance was identical for each participant, although the actual selection of emotion-displaying faces were random across participants.

Each face occupied the central portion of the card, and each of the faces occupied the same amount of the card as one another. Six laminated cards (21 x 5 cm), each displaying a word describing a facial emotion. Eighteen cards (15 x 2.5 cm) depicting a facial element (eyebrows, eyes or mouth) taken from the six emotional expressions. Each of these cards were laminated. The facial feature occupied the central portion of the card, and each of the facial features was approximately the same size as the other facial features. Figure 1 shows examples of these stimuli (not to scale).

Figure 1 about here

Procedure

Whole Face Emotion Recognition Phase: The experiment took place in a quiet room with no distractions. Participants were seated facing the experimenter, and the card stimuli were placed on a table in between the participant and the experimenter. The participants were presented simultaneously with one full-face card, and the six cards that displayed the names of the emotions. These emotion-name cards were spread in a line on the table below the face card, randomly from left to right from trial to trial.

Participants were asked to point to the word-card containing the written word for the emotion displayed in the full-face card. If the participant pointed to the correct word-card, the experimenter said: “Yes”. If participants pointed to the incorrect card, the experimenter said: “No”. If no response had been given within 5s, the experimenter said: “No”. The trials were presented at approximately 5-10s intervals. The order of presentation of the full-face cards was randomised.

Participants were judged to have established discrimination once they had responded correctly to each facial stimulus for four consecutive trials each. When a full-face emotion card had been recognised correctly on four consecutive trials in which it appeared, it was withdrawn from the study. These were the only contingencies in operation for Group

Control. Group Load was given the same treatment with the exception that they were required to vocally count back in sevens from a random five-digit number throughout the experiment (Andersson et al., 2002). Participants were promoted to continue counting if they began to hesitate (Reynolds & Reed, 2011).

Part Face Emotion Recognition Phase: Participants in both groups were presented simultaneously with one card containing a picture of a facial-element (eyebrows, eyes, or mouth) taken from the previously presented six whole face emotion pictures. Participants were asked to point to the word card (from the six possible words) that they thought correctly matched the elementary stimuli, which were also presented. The participants were given 5s to perform this task. The order in which each facial-element card was presented was randomised, with each of the 18 cards (3 facial-elements from the 6 full-face emotions) being presented 4 times each. Thus, each group was given a total of 72 trials. There were four blocks of this phase, each consisting of 18 trials, in which each element of the facial stimulus was shown once. The only difference between the two groups during the part face phase was that Group Load was asked to continue to count back in sevens, whereas Group Control did not have to complete the task. No verbal feedback was provided to the participants as reinforcement during this phase.

Results and Discussion

Group Control took a mean of 24.73 $\pm$ 1.16 trials to reach criterion during the whole face emotion recognition phase (indicating almost perfect recognition of the emotions), whereas Group Load took a mean 38.00 $\pm$ 7.36 trials to reach criterion, $t(28) = 6.90$, $p < .001$, $d = 3.33$. Thus, participants had greater difficulty matching the emotions to the faces when they were required to complete a concurrent task, but all participants eventually reached the same criterion of performance as one another.

Figure 2 about here

Figure 2 shows the mean percentage of times that each element (eyebrows, eyes, mouth) was chosen correctly in the part face emotion recognition phase of the experiment for both groups. These scores were averaged across all emotions. For Group Control, there was only a small difference between the levels at which each the emotions were correctly recognized from each facial-element. Where a difference in the degree to which the facial elements allowed recognition of the emotions existed, 5 participants recognised the mouth better than any other element, and 3 recognised the emotion through the eyes. However, in Group Load, there was a considerable difference between the percentage times that each facial element was correctly matched to the emotion card: 14 participants recognised the emotion through the mouth better than any other element, and 1 recognised the emotion better through the eyes. Thus, the impact of the cognitive load was differential across the different facial-elements; with the mouth being least affected, but load impacting most to reduce emotional recognition through the eyes and eyebrows.

A two-factor mixed-model analysis of variance (ANOVA), with group (Control versus Load) as a between-subject factor, and facial element (eyes, eyebrows, and mouth) as a within-subject factor was conducted on the percentage times each element was selected. This ANOVA revealed statistically significant main effects of group, $F(1,28) = 140.65$, $p < .001$, $\eta^2_p = .834$, and element, $F(2,56) = 244.14$, $p < .001$, $\eta^2_p = .897$, as well as a significant interaction between the two factors, $F(2,56) = 76.27$, $p < .01$, $\eta^2_p = .731$. Simple effects comparing the two groups were conducted on each facial-element (eyes, eyebrows, and mouth). The analyses were significant for eyes $F(1,56) = 46.86$, $p < .001$, $\eta^2_p = .512$, and eyebrows, $F(1,56) = 312.58$, $p < .001$, $\eta^2_p = .903$, but not for mouth, $F < 1$, $\eta^2_p = .004$.

Table 1 about here

In order to analyse the degree to which any over-selectivity was noted, and whether this was different depending on the presence of a load (as might be predicted), these data were subject to the analyses typically performed in such studies (see Leader et al., 2009). Table 1 displays the mean percentage for the most-accurate, and the least-accurate, facial element (irrespective of the actual physical element). To calculate this, for each participant, the facial-element correctly identified the most number of times, and the element identified correctly the least number of times were identified.

Inspection of these data reveals a much greater difference between the most- and least-selected stimuli for Group Load compared to Group Control. Of course, it must be noted that such analysis will always produce a numeric difference between the most- and least-selected stimuli, however, the degree of difference demonstrates the relative difference between the most- and least-selected stimuli in the two conditions (Reed & Gibson, 2005; Reed et al., 2009). A two-factor mixed-model ANOVA with group (Control versus Load) as a between-subject factor, and stimulus) most-chosen versus least-chosen) as a within-subject factor was conducted, and revealed statistically significant main effects of group, $F(1,28) = 210.89$, $p < .001$, $\eta^2_p = .876$, and stimulus, $F(1,28) = 508.75$, $p < .001$, $\eta^2_p = .950$, as well as a significant interaction between group and stimulus, $F(2,36) = 154.27$, $p < .001$, $\eta^2_p = .852$.

Taken together, these results suggest that, while correct labelling of the emotions displayed on faces may be retarded by the presence of a cognitive load, similar levels of terminal performance can be reached irrespective of the cognitive load (see also Tracy & Robbins, 2008). However, the ability to match emotional labels to faces may be preserved by selectively attending to a subset of the particular features of the face (cf. Doherty-Sneddon &

Phelps, 2005; Reed et al., 2009); that is, over-selectivity occurred under conditions of cognitive load (Lovaas et al., 1971; Leader et al., 2009), despite the participants' ability to display correct matching of face to emotion card. Although there was some degree of idiosyncrasy in the individual elements attended to in the control group, on the whole, participants tended to recognise emotions expressed by the mouth, in preference to the eyes and, especially, in preference to the eyebrows, when under conditions of cognitive load.

Experiment 2

The second experiment attempted to expand the results of Experiment 1 by employing a within-subject design in order to study the effects increasing the cognitive load on recognition of the facial elements. To facilitate this investigation, a different form of cognitive load involving counting was employed - The Auditory Continuous Memory Task (ACMT; Engström, Johansson, & Östlund, 2005). In this task, participants listened to a recorded stream of sounds, and have to count the number of times that a specified target sound occurs. The number of target sounds that they have to count can be varied, hence, increasing the cognitive load of the task and allowing some control over the degree of load present, rather than just its presence or absence as in Experiment 1. Moreover, there has been some debate in related studies regarding whether purely verbal (semantic) or non-verbal (non-semantic) load impacts recognition of whole faces (Garcia-Rodriguez, Vincent, Casares-Guillen, Ellgring, & Frank, 2012). The adoption of a non-verbal load, as in this experiment, may extend the generality of the current findings.

All participants were treated as described in Experiment 1, but each participant received four different conditions, each condition with a different number of target sounds that participants had to identify (ranging from zero to three). In each condition, participants first matched facial pictures to emotions to a criterion of accuracy, as in Experiment 1. After this training, they were presented with the individual elements of the faces, and had to match these elements to the emotional labels, again, as in Experiment 1. If the results from Experiment 1 were to be replicated using a within-subject design, then all participants, irrespective of the load condition, would reach criterion for emotional recognition, but there would be greater levels of over-selectivity in the higher load conditions.

Method

Participants

Twenty-four participants were recruited from the student population (15 male, 9 female; mean age = 21.63 $\pm$ 3.36). No participant received any form of payment or course credit for volunteering. None of the participants reported any form of intellectual and developmental disability, and none reported any history of mental health problems. Ethical permission for the study was granted by the University's Psychology Department Ethics Committee.

Apparatus and Materials

Photographs as described in Experiment 1 were employed, except there were 24 photographs (4 photographs of each of the six emotions). In addition, each photograph had three elements taken from it (eyebrows, eyes, mouth), as described in Experiment 1. There were also six laminated cards each displaying a word describing a facial emotion, as in Experiment 1.

The Auditory Continuous Memory Task (ACMT; Engström et al., 2005) was employed, in which participants had to count the number of times that a target sound was presented among non-target sounds. There were four versions of the task. One in which there was no target sound identified, one in which one sound was identified, one in which two sounds were identified, and a condition in which three sounds were to be identified. Each target sound was counted separately, so the subject had to keep count of several targets. The current sum(s) of identified target sounds were spoken aloud after each new target presentation. The participants received training before the experimental trials about the target sounds.

Procedure

The whole-face emotion recognition phase, with the following part-face test phase, was conducted as described in Experiment 1, except that each participant conducted this process four times (i.e., the whole-face emotion recognition phase, then the part-face emotion recognition phase), with a 5 min break between each condition. The sets of photographs assigned to each condition (no load, 1 target, 2 targets, and 3 targets) were counterbalanced, and the order in which the four load conditions were presented to the participants was also counterbalanced. Different sets of emotion photographs were assigned to each of the load conditions for an individual participant, but the assignment was randomised across the participants.

Results and Discussion

For the whole-face emotion recognition phase, the participants took a mean of: 24.75 ($\pm$ 1.11) trials to reach criterion during the no target condition; 29.56 ($\pm$ 4.12) trials to reach criterion during the 1 target condition; 39.17 ($\pm$ 6.19) trials to reach criterion during the 2 target condition; and 43.54 ($\pm$ 6.59) trials to reach criterion during the 3 target condition. These date were averaged across all emotions. These data were analysed by a repeated-measures ANOVA, which revealed a statistically significant difference between the conditions, $F(3,69) = 95.75$, $p < .001$, $\eta^2_p = .806$. The linear trend was statistically significant, $F(1,23) = 168.24$, $p < .001$, $\eta^2_p = .880$. These data suggest that increasing the concurrent size of the load impeded the recognition of whole-face emotions.

Figure 3 about here

Figure 3 shows the mean percentage of times that each element (eyebrows, eyes, mouth) was chosen correctly in the part-face emotion recognition phase of the experiment for all conditions. When there was no load, there was a small difference between the levels at which the emotion displayed by each facial-element was recognised. Where a difference in the degree to which the facial elements allowed recognition of the emotions existed, 9 participants recognised the mouth better than any other element, and 8 participants recognised the emotion through the eyes. As the cognitive load increased, the difference between the elements became more pronounced with each successive increase. In the highest cognitive load condition (3 targets), there was a considerable difference between the percentage of times each facial element was correctly matched – all participants recognised the mouth better than any other element. Thus, the impact of the cognitive load was differential across the different facial-elements; with the mouth being least effected, but the load impacting most on recognizing emotions through the eyes, and especially on the eyebrows.

A two-factor repeated-measures ANOVA (condition x facial element) was conducted on the percentage times each element allowed emotions to be correctly identified, and revealed a statistically significant main effects of load condition, $F(3,69) = 89.96$, $p < .001$, $\eta^2_p = .796$, and element, $F(2,46) = 148.95$, $p < .001$, $\eta^2_p = .866$, as well as a significant interaction between the two factors, $F(6,138) = 16.93$, $p < .001$, $\eta^2_p = .425$. Simple effects comparing the load conditions were conducted on each facial-element (eyes, eyebrows, and mouth). The analysis was statistically significant but smallest in size for mouth, $F(3,138) = 5.56$, $p < .05$, $\eta^2_p = .179$, but larger for eyes, $F(3,138) = 51.54$, $p < .001$, $\eta^2_p = .659$, and largest for eyebrows, $F(3,138) = 80.11$, $p < .001$, $\eta^2_p = .726$.

Table 2 about here

Table 2 displays the mean percentage times for the most-accurate, and the least-accurate, facial element (irrespective of the actual physical element) in each condition, calculated as described in Experiment 1. These data show that, as the cognitive load increased, the difference between the most- and least-accurate facial elements increased; an effect produced by a reduction in the times that the least-selected element was recognised. A two-factor repeated-measures ANOVA (condition x stimulus) was conducted on these data, and revealed a statistically significant main effects of condition, $F(3,69) = 25.87$, $p < .001$, $\eta^2_p = .529$, and stimulus, $F(1,23) = 225.18$, $p < .001$, $\eta^2_p = .907$, as well as a significant interaction between the two factors, $F(3,69) = 10.72$, $p < .001$, $\eta^2_p = .318$. To analyse the interaction the linear trends for the most and least selected stimuli were analysed. For the most-accurate facial stimulus, there were no statistically significant linear trend, $F(1,69) = 3.06$, $p > .05$, $\eta^2_p = .355$. For the least-selected stimulus, there was a strong-sized statistically significant linear trend, $F(1,69) = 119.13$, $p < .001$, $\eta^2_p = .879$.

These results corroborate what was apparent in Experiment 1, and suggest that correct labelling of facial emotions from a whole face is retarded by the presence of a cognitive load, and, furthermore, this retardation increases with increasing cognitive load. However, in all cases, similar terminal performance can be reached (Tracy & Robbins, 2008). This was achieved, apparently, by selectively attending to particular features of the face (cf. Doherty-

Sneddon & Phelps, 2005; Reed et al., 2009). As in Experiment 1, although there was some idiosyncrasy in the individual elements attended to, participants tended to recognise emotions expressed by the mouth, and by the eyes (see also Ekman, 1977), when under conditions of cognitive load.

General Discussion

The present research aimed to investigate the effect of concurrent task load on recognition of facial expressions of emotion. Some previous research has suggested that the impact of such loads is negligible on the recognition of emotions displayed in faces (Tracy & Robbins, 2008), but that eye-gaze patterns between the features are impacted under these conditions (cf. Doherty-Sneddon & Phelps, 2005). It was suggested that a likely solution to these apparently discrepant results was that concurrent loads introduce over-selectivity (see Leader et al., 2009; Reed & Gibson, 2005) when exposed to a whole face, and that only some aspects of the facial stimuli are attended under such conditions, which preserves the ability to recognise emotions.

The results from the experiments reported here broadly supported the above view. The introduction of a concurrent load task made it harder for participants to recognise emotions, but their performance, eventually, was similar both with and without the load. However, when the individual elements of the face were presented, participants were less able to recognise the emotions displayed in all of the elements if they had a concurrent load. In particular, the upper parts of the face are less likely to be used in determining emotional expressions. This result was observed despite the similar overall performance of facial recognition with the whole-face stimuli obtained at the end of the initial training phase.

Thus, it might be said that over-selectivity was noted, and that this may well represent an adaption to preserve overall performance in a complex situation (see Reed et al., 2011).

The suggestion that stimulus over-selectivity occurs in emotional face processing relies on the notion that a face is not a single stimulus, but is composed of several individual parts. Stimulus over-selectivity implies we are able to ignore parts of faces, and focus on one feature. This view is somewhat at odds with the widely-accepted view that faces are processed holistically, and processed as one stimulus rather than a conglomeration of separate parts. However, that such stimulus over-selectivity for faces only occurs under conditions of cognitive load suggests that the whole-face view may be the default processing strategy unless this is disrupted. The precise aspect of the load used in the current studies that produced this effect is unclear, whether it was verbal or nonverbal, or, indeed, has something to do with the time-constraint given to the participants for the task, which might have interacted with the concurrent load. These suggestions should remain tentative until further experimental work has been conducted.

The precise pattern of facial-feature recognition obtained in the current studies suggested that participants tended to favour recognition of emotions by focusing on the mouth and eyes, and, under ideal circumstances, could also recognise emotions reasonably well through other facial features as well (e.g., the eyebrows). However, when a cognitive load was introduced, recognition of emotions displayed in the mouth remained high, while that using the eyes, and the eyebrows, decreased. This pattern of data is consistent with the results of eye-tracking studies, which have noted that the introduction of concurrent loads disrupts facial scanning (e.g., May et al., 1990). This pattern of gaze aversion from the eyes has also been noted in previous studies of the impact of cognitive load on face recognition (Doherty-Sneddon & Phelps, 2005). One issue that needs to be made explicit in this regard is that not each part of the face contributes to the same extent to emotional expressions. In the current studies, the part face stimuli were not matched with one another according to intensity of the action (see Ekman, Friesen, & Hager, 2002). Although, the fact that different facial stimuli were used across different emotions and participants may have helped to mitigate the effects of such differential intensities, future studies could attempt a better matching procedure.

Notwithstanding the above proviso, there may be a number of potential explanations for this observation (noted in both of the current experiments). There is a growing literature on facial-emotion recognition in various groups who experience learning or developmental disorders such as ASD (e.g., Bal et al., 2010). These groups are especially prone to over-selective responding (Lovaas et al., 1971), and have been noted to avoid examination of the eyes when presented with facial stimuli (see Graham & LaBar, 2012). In groups with ASD, it is thought that eye contact may be avoided, as eye stimuli can be threatening to those individuals. However, it may be that those stimuli carry with them an increased information load that makes them strong candidates to be ignored in participants with limited processing abilities, or under conditions of increased cognitive stress, as in the current study (see also Edwards, Perlman, & Reed, 2012). Alternatively, and more simply, it may be that concurrent loads alter the direction of eye-gaze toward the bottom of any visual array, and this explanation may go some way to explaining the current pattern of results.

There are a number of potential problems with the current study that should be mentioned, and addressed in future studies. For example, there was a difference in the number of trials taken to learn to criterion in the learning phase depending on the presence or not of a verbal load (Experiment 1) and in the number of targets to be identified (Experiment 2). Although this finding demonstrates the actual impact of the load, showing it was effective, this differences means that participants received differential exposure to the stimuli before the part face phase, which may have played a role in the findings. Also, the face parts shown during the part face phase were from the same whole face stimuli used for the whole face phase. Therefore, it is not certain whether the participants were learning perceptual features or emotions; participants may have learned to recognise pictorial cues from those particular face images, rather than learning to recognise emotional cues from that particular person.

It is unclear whether the pattern of results is specific to emotion, or would be found with any judgment regarding the face (e.g., identities). Therefore, these results may tell us something about the operation of memory for complex pictorial images, such as emotion, but it may be useful to use different examples of mouths, eyes, and eyebrows, reflecting the same emotions, during whole and part face phases in future research. If the latter were to be the case, then similar effects may be expected for other complex visual patterns aside from faces, which is what is obtained (Reed & Gibson, 2005; Reed et al., 2009).

There have been suggestions that there could be male versus female differences in recognition of such emotions. Exploration of this issue was not a purpose of the current studies, so was not analysed in detail, and sample size to do so would be too small to place reliance on the results. However, examination of the trials to criteria data revealed a bias towards superior male performance in Experiment 1, but no significant differences in Experiment 2, in neither case did gender interact with the results analysed in the study.

Participants always solved the two phases (whole face and part face) in that order, and further studies could adopt a 2x2 design (i.e. Load v No Load X Whole face v Part face) to further support the contention that load can impact recognition of facial elements without impacting on recognition of the whole face.

It is also worth noting that the current study did employ a ‘table-top’ procedure rather than a computerised methodology. It is possible that this might have introduced some slight differences in the timings of the stimuli that were presented between and within participants, and would have allowed for more variability in the stimuli used, and future studies could consider using a computerised task.

Emotional recognition can be impaired across many developmental and intellectual disabilities (Collin et al., 2013). Deficits in recognizing emotions from faces has been found for individuals with Autism Spectrum Disorders (ASD; Bal et al., 2010; Hobson, Ouston, and Lee, 1989), Down syndrome (Dimitriou, Leonard, Karmiloff-Smith, Johnson, and Thomas, 2014), intellectual disabilities and impairments (Gross, 2004; Moore, 2001), and Williams Syndrome (Dimitriou et al., 2014; Williams, Wishart, Pitcairn, and Willis, 2005). Such difficulties with recognizing emotions can lead to further problems with social functioning (e.g., Jawaid, Riby, Owens, White, Tarar, and Schulz, 2012), social isolation (Bauminger, 2003), and a range of additional mental health and well-being problems (Baker, Montgomery and Abramson, 2009). Many of these populations experience difficulties with over-selective responding (Ploog, 2010), and the current results may have implications for understanding the nature of this deficit in social/emotional recognition.

Whatever the eventual mechanism responsible for these findings, the current report has established that facial-emotion recognition is impacted under conditions of concurrent cognitive load by the introduction of over-selective focus to particular facial elements. Although this does not remove the ability to recognise emotions in the faces when presented with the full face, it does impact the ability to recognise individual elements, especially after whole face emotion recognition – in particular, the upper parts of the face (eyes, eyebrows) are least likely to be used in determining emotional expression.

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Figure Captions

Figure 1. Photographs used in the whole face and part face phase of the experiment. The photographs display Fear facial expression of emotion and their respective facial elements. Not to scale.

Figure 2. Results from the part face phase of Experiment 1. Mean percentage of correctly matched elements from Group Load and Group Control (no cognitive load) for the mouth, eyes, and eyebrow elements.

Figure 3. Results from the part face phase of Experiment 2. Mean percentage of correctly matched elements from the No Load, 1 Target, 2 Target, and 3 Target conditions for mouth, eyes, and eyebrow elements.

Figure 1

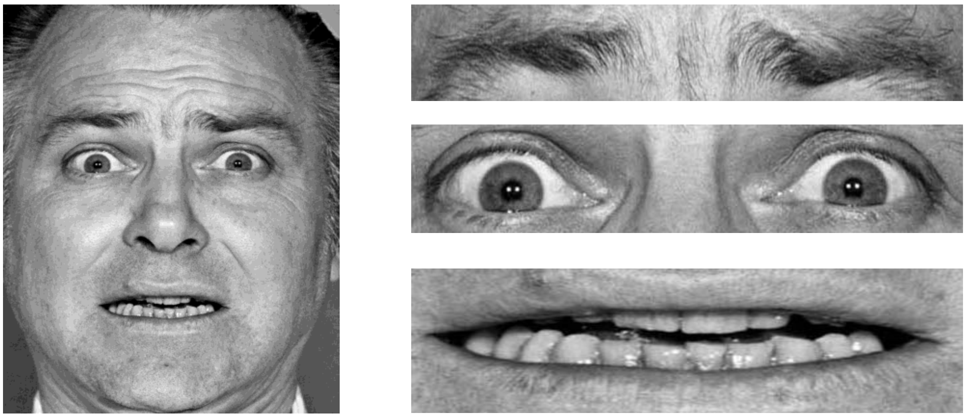

Figure 2

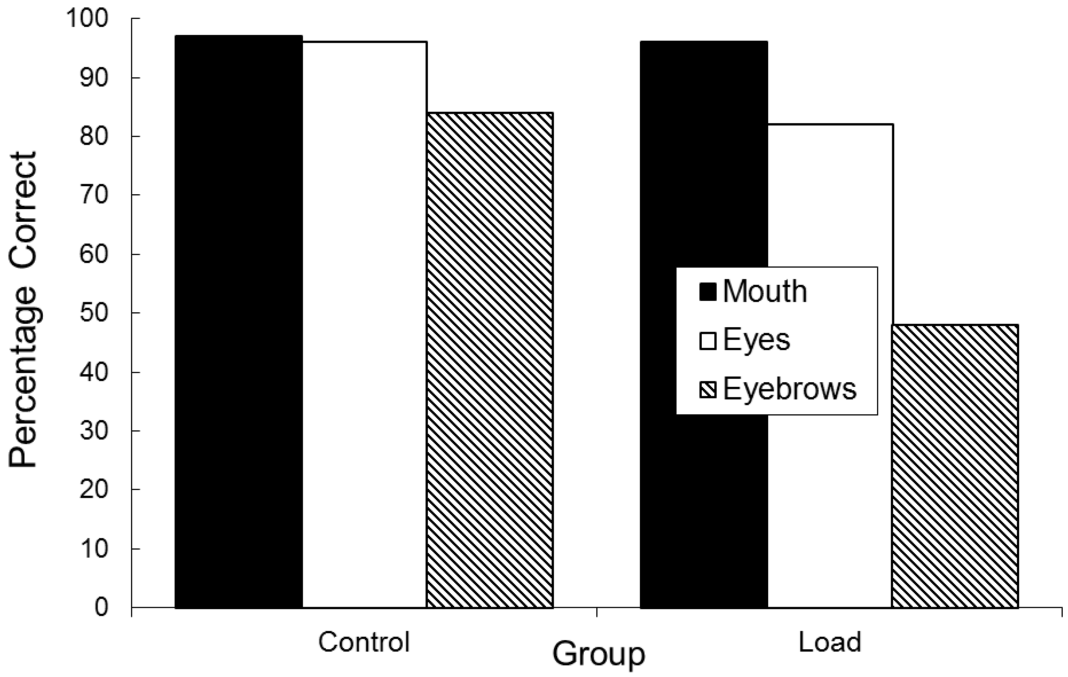
100
90
80
70
60
50
40
30
20
10
0
Percentage Correct
Mouth
Eyes
Eyebrows
Control
Group
Load

Figure 3

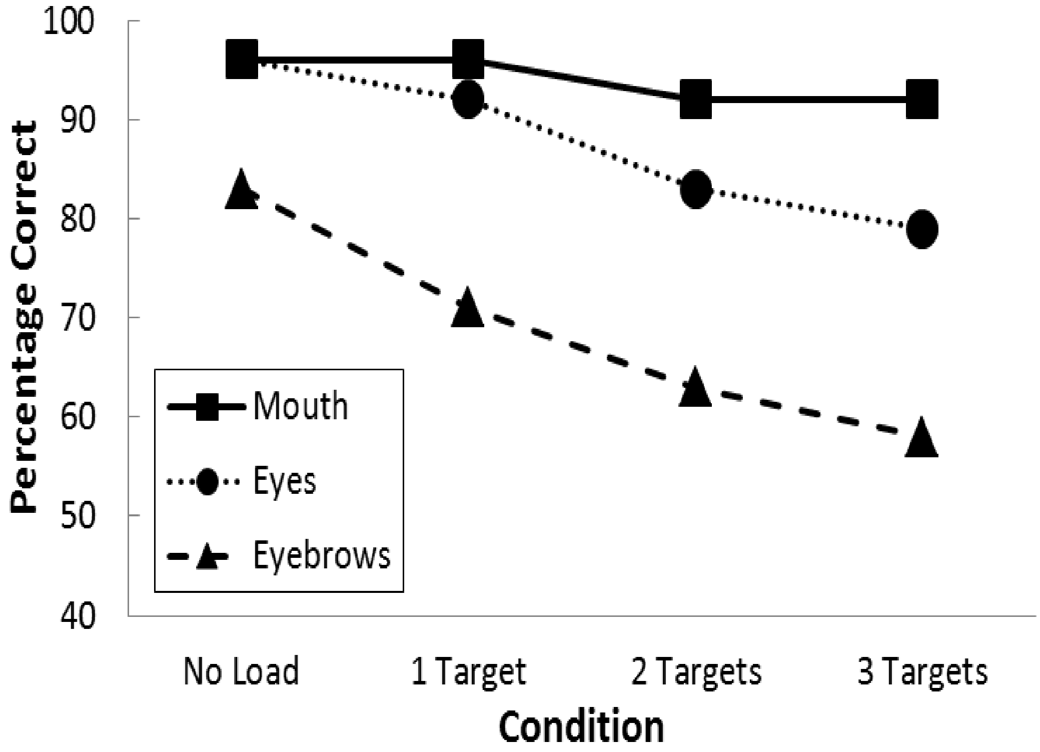
100
90
80
70
60
50
40
Percentage Correct
Mouth
Eyes
Eyebrows
No Load
1 Target
2 Targets
3 Targets
Condition

Table 1. Mean (standard deviation) percentage times the most- and least-selected element were chosen in both groups in Experiment 1.

	Group Control	Group Load
Most	98.04 (2.7)	96.38 (5.21)
Least	83.88 (5.21)	47.50 (7.00)

Table 2. Mean (standard deviation) percentage times the most- and least-selected element were chosen in both groups in Experiment 2.

	No Load	1 Target	2 Targets	3 Targets
Most	23.50 (0.66)	22.88 (2.81)	22.29 (2.39)	21.83 (2.10)
Least	20.30 (1.12)	17.42 (2.70)	15.83 (2.21)	14.96 (2.23)