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Interference with facial emotion recognition by verbal but not visual loads

Phil Reed and Ian Steed

Swansea University

Correspondence address: Phil Reed,
Department of Psychology,
Swansea University,
Singleton Park,
Swansea, SA2 8PP, U.K.

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Abstract

The ability to recognize emotions through facial characteristics is critical for social functioning, but is often impaired in those with a developmental or intellectual disability. The current experiments explored the degree to which interfering with the processing capacities of typically-developing individuals would produce a similar inability to recognize emotions through the facial elements of faces displaying particular emotions. It was found that increasing the cognitive load (in an attempt to model learning impairments in a typically developing population) produced deficits in correctly identifying emotions from facial elements. However, this effect was much more pronounced when using a concurrent verbal task than when employing a concurrent visual task, suggesting that there is a substantial verbal element to the labelling and subsequent recognition of emotions. This concurs with previous work conducted with those with developmental disabilities that suggests emotion recognition deficits are connected with language deficits.

Key words: emotion recognition; over-selectivity; facial elements

Emotional recognition has been suggested to be impaired across a wide range of developmental and intellectual disabilities (see Gross, 2004; Collin, Bindra, Raju, Gillberg, and Minnis, 2013). For example, deficits in recognizing emotions from the faces of others have been found in individuals with Autism Spectrum Disorders (Bal, Harden, Lamb, Van Hecke, Denver, and Porges, 2010; Harms, Martin, and Wallace, 2010; Hobson, Ouston, and Lee, 1989), Down syndrome (Dimitriou, Leonard, Karmiloff-Smith, Johnson, and Thomas, 2014; Kasari, Freeman, and Hughes, 2001), intellectual disabilities and impairments (Gross, 2004; Loveland, Tunali–Kotoski, Chen, Ortegon, Pearson, Brelsford, and Gibbs, 1997; Moore, 2001), and Williams syndrome (Dimitriou et al., 2014; Williams, Wishart, Pitcairn, and Willis, 2005). Problems with emotional recognition are associated with a range of further difficulties for these individuals, including social functioning (e.g., Jawaid, Riby, Owens, White, Tarar, and Schulz, 2012), social isolation (Bauminger, 2003; Howlin, Mawhood, and Rutter, 2000), mental health and well-being (Baker, Montgomery and Abramson, 2009; Denham and Holt, 1993), and they also provide an indicator of academic success (Raver and Knitzer, 2002; Reed and Osborne, 2014). Thus, understanding the factors that contribute to facial emotional recognition deficits is of some theoretical and practical importance.

There are many individual differences in the pathways that allow or hinder facial emotional recognition, including cognitive processing, motivation, and emotional state (see Adolphs, 2001). In terms of developmental disabilities, deficits in intellectual (Harms et al., 2010; Moore, 2011) and language (Loveland et al., 1997; Nelson, Welsh, Trup, and Greenberg, 2011) ability have been implicated in causing emotional recognition deficits. For example, Moore (2001) suggested that emotional-recognition deficits may be primarily due to associated intellectual problems involving memory and attention in individuals with developmental disorders. In support of this suggestion, it has been found that differences in facial emotional recognition between those with Autism Spectrum Disorders (ASD) and comparison groups are less pronounced when intellectual functioning across the groups is matched (see Loveland et al., 1997; Harms et al., 2010). Alternatively, differences in facial emotion recognition have been found to depend upon the level of verbal ability of the individual in question (Harms et al., 2010). Braverman, Fein, Lucci, and Waterhouse (1989), and by Ozonoff, Pennington, and Rogers (1990) observed no differences in recognizing facial emotions by children with ASD and controls when each group was matched for verbal ability. Moreover, strong reliance on verbal information in recognizing facial emotions has also been noted in low-functioning individuals with ASD by Loveland et al. (1997), and impairments in the ability to label emotions have been thought to be a driver of emotional recognition deficits in individuals with ASD (Hale and Tager-Flusberg, 2003; Sigman, Kasari, Kwon, and Yirmiya, 1992). However, as these two abilities are often strongly associated with one another, it is difficult to tease them apart in terms of their impact on facial emotion recognition.

Individuals with developmental disorders often have deficits in multiple domains, and it could be that it is the summed impact of these deficits, or interactions between them, that produces attenuation of facial emotional recognition. Consideration of such potential confounds can make using such a sample problematic for the investigation of which aspects of cognitive processing are implicated in these deficits. The importance of both intellectual and verbal ability to the recognition of facial emotions has also been noted for individuals who do not have a developmental or intellectual disability (see Edmonds, Glisky, Bartlett, & Rapcsak, 2012; Nelson et al., 2011). It may be that manipulating the degree to which individuals are able to engage in particular cognitive processing activities by imposing different types of cognitive loads, could facilitate understanding about the processing requirements for facial emotion recognition. For example, if a load that impacts verbal functioning has an impact on facial emotion recognition, but another type of load that requires processing capacity but which does not impact verbal processing does not, then this might suggest that verbal processing skills are more important than general cognitive resources. In turn, this may help to highlight the problems that might be experienced by individuals with complex developmental delays (see Broomfield, McHugh, & Reed, 2008; Reed & Gibson, 2005, for discussions of this potential approach).

There are some experimental investigations of facial emotion recognition that have employed typically-developing individuals, and have manipulated their cognitive capacity by the application of a concurrent task (e.g., Doherty-Sneddon, Bonner, and Bruce, 2001; May, Kennedy, Williams, Dunlap, and Brannan, 1990). These studies have noted that while a concurrent task does not reduce the ability to identify emotions from whole faces (e.g., Doherty-Sneddon et al., 2001), it does result in the reduced ability to recognize emotions from facial elements (May et al., 1990). In particular, May et al. (1990) noted that increased additional cognitive load reduced the number of eye movements across a face resulting in reduced sampling of elements. This latter phenomenon is highly similar to that observed in the sampling of any complex stimulus under conditions of reduced cognitive capacity (see Reed and Gibson, 2005), and is referred to as over-selectivity (e.g., Broomfield et al., 2008; Cumming and Berryman, 1965; Reed, Broomfield, McHugh, McCausland, and Leader, 2009; Thomas and Jordan, 2004). Cumming and Berryman (1965; see also Thomas and Jordan, 2004) suggested that the capacity to attend to the multiple stimuli present in facial emotions is essential for understanding social concepts, but that over-selective responding may impede this ability.

The over-selectivity literature allows a suggestion to be made regarding the discrepancies in the impact of cognitive loads on facial emotion recognition. When the emotional recognition process is well-learned, sampling one facial feature may be enough to correctly recognize an emotion. However, when this ability is less developed, as in developmental disorders and intellectual disabilities (e.g., Gross, 2004; Collin et al., 2013; Harms et al., 2010), or when cognitive resources are taken up by a concurrent load and an unhelpful facial element is selected by which to recognize the emotion, then facial emotional recognition may be impaired. This might explain why some reports suggest unimpaired whole face recognition with concurrent load (Doherty-Sneddon et al., 2001), but others report impaired elemental recognition (May et al., 1990). This literature also points to the role of language difficulties rather than intellectual impairment as a key factor in producing over-selective responding (see Kelley et al., 2015), but it is not known if this would also apply to recognition of facial emotions.

In terms of the elements of the face that may or may not be helpful in recognizing emotion, emotional recognition deficits in typically developing individuals are greatest when individuals are asked to recognize the emotions from the upper portion of faces, and that this holds for most types of emotion (Bassili, 1979; Dunlap, 1927). This effect is also noted for individuals with developmental delays and ASD, particularly when asked to recognize emotions from the eyes (Gross, 2004), which they have been noted to avoid (Graham and LaBar, 2012). A similar effect has been noted with individuals with other forms of developmental disability such as Down and Williams syndromes (see Annaz, Karmiloff-Smith, Johnson, and Thomas, 2009). Thus, it may be that particular areas of the face are differentially selected by those with reduced cognitive processing capacities.

Given all of the above considerations, the current study had two main aims. The first aim was to examine the effects of different types of cognitive load on facial emotional recognition in order to examine the different cognitive systems that may be implicated in this process. Whereas it is known that the presence of a cognitive load sometimes impacts ability to recognize facial elements (May et al., 1990), it is not known which types of cognitive load will have this impact, and which potential systems are responsible for such an impact. Therefore, the impacts of two different cognitive loads were compared – a verbal load and a concurrent visual load – in order to assess which would impact facial emotion recognition to a greater extent. The second aim was to explore whether particular facial elements were differentially impacted by an increased cognitive load, and to see if these effects were similar to those noted from individuals with a developmental delay. To these ends, Experiment 1 directly compared the impacts of verbal and visual loads on facial emotion recognition, and Experiment 2 compared the effects of different levels of visual load. While there are no a priori hypotheses, a number of alternative possibilities exist for these studies. It may be that all loads impact on the ability to recognize emotions from various facial features, suggesting that this is the product of general cognitive interference rather than of an impact on a particular system. Alternatively, if emotional recognition through facial features is differentially impacted by verbal but not visual loads, then it may be that this process is driven largely by the ability to label emotions, as has been suggested in the literature relating to those with ASD.

Experiment 1

The current literature in regard to developmental disorders is ambiguous as to whether levels of intellectual functioning (Loveland et al., 1997; Moore, 2011), verbal functioning (Braverman et al., 1989; Ozonoff et al., 1990), or both (see Harms et al., 2010), predict ability to accurately recognize emotions. Experiment 1 examined the effects of different concurrent tasks on the recognition of facial emotion in order to see if selectively interfering with one set of processes would differentially impact facial emotion recognition. To this end, a verbal counting task as employed as a verbal load in previous investigations (Andersson, Hagman, Talianzadeh, Svedberg, and Larsen, 2002; Reynolds & Reed, 2011), and a visual task previously employed by Reed and Gibson (2005) was also employed.

Previous studies have demonstrated that concurrent tasks impact discrimination learning tasks (see Hanley, Pearson, and Young, 1990; Tracy and Robbins, 2008). The current study adopted a discrimination learning task as previously employed in studies of over-selectivity (Reed et al., 2009). Participants were taught to match facial pictures to emotions. They were then shown the individual facial elements of the faces, and had to match these elements to the previously trained emotional labels.

The extent that the cognitive load impacted on accurate recognition of the emotions was taken to give an indication of the level of involvement of that system in the emotional recognition process –i.e. whether impairments to the verbal or visual processing systems would most affect emotional recognition. Moreover, even if facial recognition is unimpaired by a cognitive load when a full face is employed (Doherty-Sneddon et al., 2001), recognition may be produced by processing only some features of the face (May et al., 1990). This strategy may overcome the impact of the concurrent load on processing capacity (see Bassili, 1979). If this were the case, then it may be that specific facial features would be differentially attended to under different conditions of cognitive load. Furthermore, it might be expected that upper portions of the face may be differentially impacted by the load – as seen in individuals with developmental disorders (see Annaz et al., 2009; Graham and LaBar, 2012).

Method

Participants

Forty-five participants were recruited from the student population. All were university students, and none of the participants reported any psychological or developmental disorders. No participant received any form of payment or course credit for volunteering. The participants were randomly allocated to the three groups. Group Control comprised of 15 participants (9 males and 6 females) aged between 19 and 24 (mean = 21.13) years. Group Visual Load consisted of 15 participants (9 males and 6 females) aged between 19 and 24 (mean = 20.87) years. Group Verbal Load comprised 15 participants (10 males and 5 females) aged between 19 and 23 (mean = 20.13). Ethical approval was obtained from the Department of Psychology, Swansea University, Ethics Committee.

Apparatus and Materials

Four photographs depicting different facial expressions of emotions were taken from Ekman and Friesen (1975). The facial expressions of emotion displayed were Anger, Disgust, Fear and Sadness. These stimuli were chosen as they represent basic emotions that are typically easily recognized and easily discriminated from one another (Ekman & Friesen, 1975). The four emotions selected from the original Ekman six have been used together in studies, and have been shown to be similarly identified to one another across cultures (Sauter, Eisner, Ekman, & Scott, 2010). Each photograph was in high resolution 1442 x 1800 (pixels). The photographs were then edited to increase resolution and for size purposes to 645 x 800 (pixels). The photographs were then further edited to include high resolution pictures of three separate structures of the faces. These included the eyebrows, eyes and mouth. In total, there were 12 photographs of the separate features of the four facial expressions (see Figure 1 for an example).

Figure 1 about here

All stimuli were presented using the software program E-Prime version 1.0. The training stimuli (full face) were displayed in the center of a computer screen on a Lenovo G550 2958; Pentium 2.3 GHz (resolution = 1366 x 768). Photographs of each complete facial expression of emotion displayed measured 15.5x19cm. The rest of the computer screen was black to increase the visibility of the photographs. The test stimuli (facial elements) were also displayed in the center of the computer screen.

The concurrent cognitive task loads involved the verbal exercise described in Experiment 1, and a visual memory task (a variation on the one used in the study of over-selectivity reported by Reed and Gibson, 2005). For the latter task, visual interference was provided by presentation of a picture (displayed on an A4 piece of paper) of a 4 x 4 grid with four different shapes, each positioned in one of the 16 squares, with four different colors inside the shapes to increase visual memory during the task (see Figure 2).

Figure 2 about here

Procedure

The experiment took place in a quiet room with no noise or distractions, in which participants sat facing the computer monitor.

Training Phase: Stimuli were presented binocularly on a LCD flat screen, approximately 50cm from the observers' eyes. Participants were instructed that they would see first a set of four photographs of facial expressions illustrating four different emotions (anger, disgust, fear, and sadness). Participants were instructed to judge the emotion displayed by pressing one of the four response keys on the keyboard. The four response keys used were: Z, X, N, and M. Each key was covered by a 1.5x1.5 cm label with the first letter of each emotion (i.e. A for Anger; D for Disgust; F for Fear; S for Sadness). When a face was matched with the correct letter; positive feedback was given on the screen (“correct”). When a face was matched with the incorrect letter, or no response was detected, negative feedback was given on the screen (“incorrect”). Participants were instructed to respond as accurately and quickly as possible. Each stimulus appeared for 5s, and, in-between each stimulus, a fixation cross appeared briefly for 500ms. The order of stimuli was randomized in order to ensure each facial expression of emotion appeared in a different position in each trial. This trial procedure was implemented until each complete facial expression of emotion had been distinguished correctly five times in a row, and the number of trials each participant took to reach that criterion was recorded.

Test Phase: Participants were instructed that they would see a set of three photographs of facial structures (eyebrows, eyes, and mouth) from the previous four facial expressions of emotion. Therefore, the test phase consisted of four facial expressions of emotion, and each of their respective three facial elements. Participants were instructed to judge the correct emotion displayed in each of the facial elements by pressing one of the four response keys as in the training phase. No feedback was given in this phase of the experiment. Each stimulus appeared for 5s, with a fixation cross appearing for 500ms between each stimulus. Each facial element stimulus (12 in total) was presented 5 times; thus, the test phase of the experiment involved 60 trials. The order in which each type of facial element, and the emotion it belonged to, was randomized during the test phase. The response made by the participants was recorded for each trial. This was scored as correct if they pressed the letter corresponding to the emotion from which the element was taken, and incorrect if the participant pressed any of the other keys.

For Group Control these were the only contingencies in operation. Group Visual Load was given the same procedure, except that, prior to training, they were presented with the grid shown in Figure 2, and allowed 20s to memorize the grid. They were informed that they would be required to replicate the grid by drawing it on paper at the end of the experiment. Group Verbal Load was given the same procedure as Group Control except that they were required to count back in sevens out loud from a random five digit number. Group Load was given the same training with the exception that they were required to vocally count backwards in sevens throughout the practice and test phases of the experiment, from a random five-digit number given to them at the start of the experiment, by the experimenter (see Andersson et al., 2002). Participants were prompted to continue counting if they began to hesitate (Reynolds & Reed, 2011).

Results and Discussion

Group Control took a mean of 25.13 trials ($\pm$ 2.39) to reach criterion during training. For Group Visual Load the mean was 26.07 trials ($\pm$ 2.94), and Group Verbal Load took a mean 35.67 trials ($\pm$ 6.33) to reach criterion. A one-way between-subjects analysis of variance (ANOVA) revealed a statistically significant effect of group, $F(2,37) = 28.11$, $p < .01$, *partial* $eta^2 = .572$. Tukey's Honestly Significantly Difference (HSD) tests indicated that Group Verbal Load differed from Group Control, and Group Visual Load group, *p*s < .05. No other comparisons were statistically significant. These results showed that the verbal concurrent load interfered with recognition of emotion, but that the visual load had no effect

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Figure 3 about here

Figure 3 shows the mean percentage of correct responses for the three facial elements (eyes, mouth, and eyebrows) for each of the three groups averaged across all four emotions during test. Groups Control and Visual Load showed accuracy scores that were fairly consistent across the mouth and eye elements, with a slightly worse accuracy for eyebrows. For Group Control, where a difference in the degree to which the facial elements allowed correct labeling of the emotions existed, eight participants recognized the mouth better than any other element, and five recognized the emotion label through the eyes. For Group Visual Load, seven participants recognized the mouth better than any other element, and six recognized the emotion label through the eyes. However, Group Verbal Load produced lower levels of recognition for all elements, but with a larger difference across the elements: ten participants recognizing emotions in the mouth best, and three recognizing emotions in the eyes best. This implies the verbal task was having a significant effect on the ability of the participants to accurately judge the facial features of the previously learned facial expressions of emotion.

A two-factor mixed-model ANOVA (group x facial element) was conducted on these data, and revealed statistically significant main effects of group, $F(2,42) = 11.86$, $p < .001$, *partial* $eta^2 = .357$, and facial element $F(2,84) = 62.30$, $p < .001$, *partial* $eta^2 = .597$, as well as a statistically significant interaction between the two factors, $F(2,84) = 5.20$, $p < .01$, *partial* $eta^2 = .189$. Simple effect analyses were conducted to compare the groups on each of the facial stimuli, which revealed statistically significant simple effect of group for eyes, $F(2,84) = 11.04$, $p < .01$ (Tukey's HSD: Verbal Load < Visual Load and Control), eyebrows $F(2,84) = 27.87$, $p < .001$ (Tukey's HSD: Verbal Load < Visual Load and Control), but not for mouth, $F < 1$.

Table 1 about here

Table 1 shows the mean percentage times that the most-selected and least-selected facial elements (irrespective of what they actually were) were chosen during the test by the three groups. The percentage of times that each element was correctly identified at test as being from an emotion was calculated, and the most and least correctly-selected element were identified for each participant. The difference between these scores gives an indication of the level of over-selective responding, and the most-least difference has been used widely as measure of this phenomenon (see Reed and Gibson, 2005). For Group Control, and Group Visual Load, there were similar, but smaller, differences between the levels of most-chosen and least-chosen facial-element stimuli compared to Group Verbal Load. For the latter group there was a substantial difference between the number of times the correctly matched facial element stimuli was chosen relative to that of the least correctly matched stimuli. A two-way mixed-model ANOVA (group x stimulus) was conducted on these data and revealed statistically significant main effects of group, $F(2,42) = 10.13$, $p < .001$, *partial* $eta^2 = .325$, and stimulus, $F(1,42) = 198.54$, $p < .001$, *partial* $eta^2 = .825$, and there was a statistically significant interaction between the two factors, $F(1,42) = 6.77$, $p < .01$, *partial* $eta^2 = .224$. Simple effect analyses comparing the groups for the stimuli revealed no statistically significant simple effect for the most-selected stimulus, $p > .20$, but there was a statistically significant simple effect of group for the least-selected stimulus, $F(2,84) = 27.93$, $p < .001$. Tukey's HSD tests revealed that there were significant differences between Group Verbal Load and each of the other two groups, *p*s < .05, but that Groups Control and Visual Load did not differ from one another, $p > .05$.

The pattern of results obtained was broadly similar to those noted in previous experiments; under conditions of cognitive load, the emotions associated with the face were recognized (Doherty-Sneddon et al., 2001), but participants found it harder to identify all of the facial features associated with those emotions (e.g., May et al., 1990). This suggests that, as in other situations where a cognitive load is present, over-selectivity occurs (see Reed et al., 2009). In particular, correct matching of the emotional label portrayed by the mouth tended to preserved, but participants found it harder to recognize emotional labels displayed in the eyes, and, especially, by the eyebrows.

In the current experiment, the visual load did not impact on emotional recognition as did the verbal load. There are several potential reasons why this could have been the case. For example, it may simply have been that the visual load task employed was not effective in producing any degree of cognitive burden to the participants – although it might be noted that this same task has been shown to produce over-selective responding is simple discrimination tasks (e.g., Reed & Gibson, 2005). Alternatively, the two tasks may impact different cognitive functions; for example, the verbal load task may more strongly address working memory and divided attention than the visual load task, which may be implicated in performing the current task. Finally, it may be that the current task relied on a large extent on verbal processing (e.g., labeling of the emotions), which was impacted by the verbal but not the visual task.

Experiment 2

The results from Experiment 1 imply that reducing available cognitive capacity through the imposition of a concurrent verbal task did reduce ability to recognize previously learned facial emotions through specific facial features. That such an effect was not observed using the visual task suggests that this process relies heavily on verbal labeling of the emotions (see also Loveland et al., 1997). However, a further explanation of this pattern of results is that the visual task employed in Experiment 1 may not have been sufficiently difficult to produce interference with recognizing emotions from facial elements. Experiment 2 sought to address this by manipulating the degree of difficulty of the visual task, by introducing more items in the grid to be recalled.

Method

Forty-five participants were recruited as described in Experiment 1 (these were different from the participants in Experiment 1), and were divided randomly into three groups of 15: Group Control (8 male, 7 female; mean age = 20.67 $\pm$ 1.72); Group Simple Load (8 male, 7 female; mean age = 20.87 $\pm$ 2.59); Group Complex Load (8 male, 7 female; mean age = 20.40 $\pm$ 2.17). The apparatus was as described in Experiment 1, except that the complex visual load had 8 items to remember, the simple load was as described for the visual load task stimulus used Experiment 1. The procedure was as described in Experiment 1.

Results and Discussion

Group Control took a mean of 25.20 $\pm$ 2.73 trials to reach criterion during the training phase (indicating almost perfect recognition of the emotions without training). Group Simple Load took a mean of 28.80 $\pm$ 5.36 trials to reach criterion, and Group Complex Load took a mean 36.93 $\pm$ 7.76 trials to reach criterion, $F(2.42) = 7.24$, $p < .01$, *partial eta*^{2} = .256. Tukey's HSD tests revealed that all groups differed significantly from one another, all *p*s < .05. Thus, participants had greater difficulty learning to match the emotions to the faces when they were required to complete a concurrent task, and that this reflected the assumed difficultly of that concurrent task. However, all participants eventually reached the same criterion of performance as one another.

Figure 4 about here

Figure 4 shows the mean percentage of times that each element (eyebrows, eyes, mouth) was chosen correctly in the test phase of the experiment for both groups. For Group

Control there was a only small difference between the levels at which each facial-element was recognized. Where a difference in the degree to which the facial elements allowed recognition of the emotions existed, six participants recognized the mouth better than any other element, and eight recognized the emotion through the eyes. In Group Simple Load, five participants recognized the mouth better than any other element, and six recognized the emotion through the eyes. In Groups Complex Load, there was a slightly larger difference in the degree to which the elements were recognized; seven participants recognized the mouth better than any other element, and 4 recognized the emotion through the eyes.

A two-factor mixed-model ANOVA (group x element) was conducted on the number of times that each element was selected, which revealed a statistically significant main effect of element, $F(2,84) = 65.08$, $p < .001$, *partial* $eta^2 = .608$, but not of group, $F(2,42) = 1.33$, $p > .20$, *partial* $eta^2 = .059$, nor was there a significant interaction between the two factors, $F(4,84) = 1.09$, $p > .80$, *partial* $eta^2 = .014$. Protected t-tests (using a p criterion of .05/3 = .016) were conducted on the difference between the elements, and revealed that the eyebrows were selected less than the eyes, $t(44) = 8.50$, $p < .001$, $d = 1.26$, and less than the mouth, $t(44) = 8.04$, $p < .001$, $d = 1.20$, but the difference between the eyes and mouth did not reach the required level for statistical significance, $t(44) = 2.43$, $p > .019$.

Table 2 about here

Table 2 displays the mean percentage of times that the most-selected, and the least-selected, facial element (irrespective of which element they actually were) were chosen by each group. 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. These data show little difference between the groups in terms of the level of overs-selectivity observed. A two-factor mixed-model ANOVA (group x stimulus) was conducted on these data, and revealed a statistically significant main effect of stimulus, $F(1,42) = 129.71$, $p < .001$, *partial* $eta^2 = .755$, but not for group, $F(2,42) = 1.91$, $p > .10$, *partial* $eta^2 = .083$, nor was there a statistically significant interaction between group and stimulus, $F < 1$, *partial* $eta^2 = .006$.

Taken together, these results corroborate the data from Experiment 1, which suggest that a visual load does not impact on recognition of emotion through facial features. This was true even of a visual load of greater complexity, and which did impact on initial acquisition of the task.

General Discussion

The current experiments sought to examine the impact of different types of concurrent task loads on ability of individuals lacking a developmental or intellectual disability to recognize facial emotion from the elements of those faces. The results with respect to the impact of a verbal load replicated previous studies (e.g., May et al., 1990), in that this research has noted that concurrent loads have little impact overall on the recognition of emotions from full faces (Tracy and Robbins, 2008), but recognition from facial elements can be disrupted under these conditions (Doherty-Sneddon and Phelps, 2005).

The current studies also suggested that participants recognized emotions mainly by focusing on the mouth and eyes, and, under ideal circumstances, could also recognize emotions reasonably well through other facial features as well (e.g., the eyebrows). The introduction of a concurrent verbal load differentially impacted ability to recognize emotions in the upper part of the facial stimuli (eyes and eyebrows), whilst it was preserved for the lower part of the face. 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., Doherty-Sneddon et al., 2001; May et al., 1990), and is also consistent with what is known about patterns of facial element recognition in those with developmental and intellectual disabilities (see Annaz et al., 2009; Graham and LaBar, 2012). Certainly, in groups with ASD, eye contact can be avoided (see Graham & LaBar, 2012), and 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, and Reed, 2012).

There was no such interference with emotional recognition with the imposition of a visual concurrent load. Of course, as noted above, it may be that the visual load task was ineffective as a cognitive load, certainly when compared to the verbal task. It is difficult to get comparative data on the impacts of such loads. However, it was the case that the visual load did impact initial learning about the stimuli (Experiments 1 and 2), and that increasing the complexity of the visual load task also made learning the emotional-recognition task more difficult. Hence, these data suggest that, whether or not the concurrent visual load task was as effective as the verbal task, it did have a noticeable impact on learning the target emotion-recognition task. Despite this, the visual task did not impact on the subsequent ability to recognize emotions from the facial features. There is always the possibility that the null effects noted when the visual task was employed resulted from a lack of power. However, the same number of participants was sufficient to produce an effect with a verbal load, suggesting that, at best, the visual load task is not as effective in impacting facial emotional recognition as a verbal load. These considerations suggest that problems with verbal processing of such emotional stimuli may be paramount to emotion recognition, as has been suggested previously (Braverman et al., 1989; Harms et al., 2010; Ozonoff et al., 1990). One possibility to explain the differential impact of verbal and visual loads on emotional recognition is that labeling of emotions as required in the test phase of the current study is verbally mediated in a way that the initial learning task in not. If this were the case, then the verbal load, but not the visual load, might interfere with the concurrent use of verbal labels for the emotions in the test, and reduce the ability to use accurately label these emotions. This suggestion chimes with the view that individuals with developmental disorders and ASD may be less deficient at recognizing emotions than originally suggested, but instead may be impaired by a lack of appropriate language through which to talk about emotional and cognitive states (Conallen and Reed, 2012; Sigman et al., 1992).

Of course, in addition to the potential differential impact on language abilities, the verbal and visual load tasks might have had differential effects on facial emotion recognition through their impact in other cognitive mechanisms. As noted above, the verbal task might have had a greater impact on working memory or divided attention than the visual task – although the fact that both impacted on the ability to initially learn the tasks suggest that they both have some impact on executive functioning. Also, it might have been that one concurrent task was performed more accurately than another, and this may also have had an impact on the effects of the concurrent load (unfortunately no data was collected on task accuracy).

There are a number of limitations that should be noted to the current study. For example, the degree to which these data obtained from typically developing participants can be generalized in terms of mechanism to those with complex developmental and intellectual disabilities is still to be established. It has been noted that increasing cognitive load in typically developing individuals does produce similar over-selectivity effects on processing cues to that seen in individuals with a developmental disorder (see Broomfield et al., 2008; Doherty-Sneddon et al., 2001; Reed & Gibson, 2005). It has also been noted that language skills are important in emotion recognition for those with a developmental disability (Hale and Tager-Flusberg, 2003; Lohmann and Tomasello, 2003; Sigman et al., 1992). However, whether the mechanisms are identical in populations with and without a developmental disability is not yet established. In the current procedure, the character keys 'A', 'D', 'F', and 'S' were used to allow the participants to indicate their response. This might have produced a further cognitive load on the participants, involving verbal processing, and future studies might include response keys that are not ‘verbally’ labelled. It should also be noted that even typically-developing individuals have variability in emotion recognition ability. It would have been helpful to screen to measure this ability prior to introducing the cognitive loads, and examining how this ability interacted with the experimental manipulations. Another aspect of the impact of concurrent loads on facial emotion recognition that would be useful to study in further work is whether these loads impact differentially on different type of emotions. It may be that different emotions are recognised most effectively by different facial elements, and the impact of loads would be different for these different emotions. Finally, the degree to which the current experimental task captures everyday processing of emotions is unclear. It may well be the case that some emotions are recognized primarily through facial features, and that individuals may adopt this strategy to varying degrees. However, there are a range of other ways in which emotions can be recognized (see Adolphs, 2001), and these might limit to ecological validity of the current findings.

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 recognize emotions from faces when presented with the full face, it does impact the ability to recognize individual elements – in particular, the upper parts of the face (the eyebrows in particular, and, as verbal cognitive loads increase, the eyes) are least likely to be used in determining emotional expression. However, this interference is much more pronounced when employing a verbal compared to a visual concurrent task, which implies a strong role for language processing in respect to emotional recognition. If this conclusion were generalizable to populations with a developmental disorder, then it does have some clinical implications. In this respect, there are studies which suggest a language deficit is important for understanding of emotions in individuals with a developmental disability (see Hale and Tager-Flusberg, 2003; Lohmann and Tomasello, 2003; Sigman et al., 1992). These findings imply that interventions targeted at teaching the appropriate language by which to label emotions would be beneficial to this skill to some people with such developmentally disabilities (see Conallen and Reed, 2012; Hale and Tager-Flusberg, 2003).

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Correspondence concerning this manuscript should be addressed to: Phil Reed, Department of psychology, Swansea University, Singleton Park, Swansea, SA2 8PP, UK, e-mail: p.reed@swansea.ac.uk.

Figure Captions

Figure 1. Photographs used in the training and test phase of the experiment. The photographs display Fear facial expression of emotion and their respective facial elements.

Figure 2. Grid used for the concurrent memory task for participants in Group-Visual Concurrent Task Load.

Figure 3. Results from the test phase of Experiment 1. Average score of correctly matched facial elements from Group-No Concurrent Task Load, Group-Visual Concurrent Task Load, and Group-Verbal Concurrent Task Load. * = significantly different from control and visual groups.

Figure 4. Results from the test phase of Experiment 2. Mean score of correctly matched facial elements from Group Control, Group Simple Load, and Group Complex Load. * = significantly different from mouth and eyes.

Figure 1

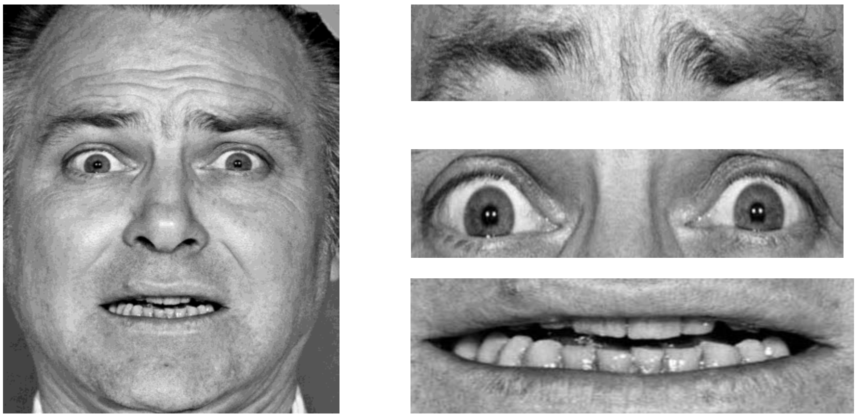


Figure 2

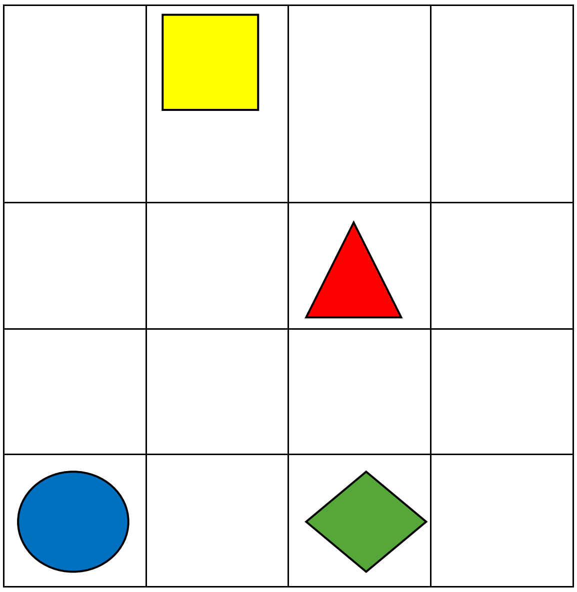
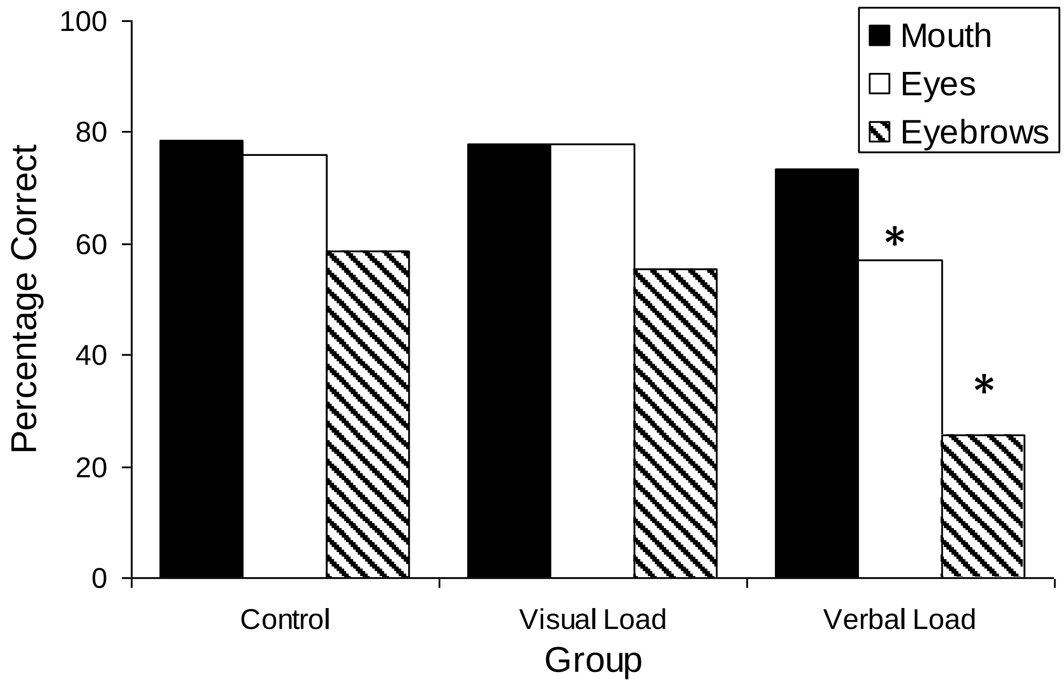


Figure 3



Mouth
Eyes
Eyebrows
Percentage Correct
100
80
60
40
20
0
*
*
Control
Visual Load
Verbal Load
Group

Figure 4

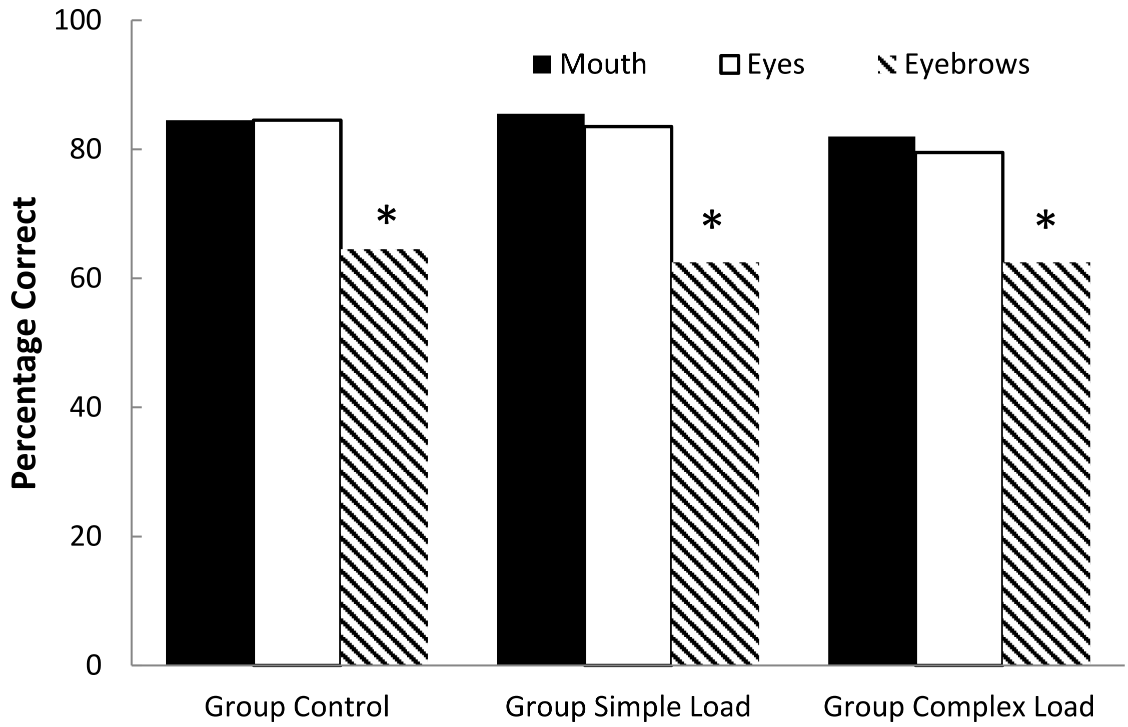

100
80
60
40
20
0
Percentage Correct
Mouth
Eyes
Eyebrows
*
*
*
Group Control
Group Simple Load
Group Complex Load

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

	Group Control	Group Visual Load	Group Verbal Load
Most	84.00 (11.83)	83.67 (9.90)	75.00 (12.96)
Least	53.00 (25.62)	55.33 (17.77)	25.33 (11.09)

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

	Group Control	Group Simple Load	Group Complex Load
Most	88.66 (8.33)	88.33 (7.12)	85.33 (7.43)
Least	65.67 (10.83)	62.67 (9.98)	60.67 (10.83)