with those that did not. This did not reveal any differences between patient groups.

Confusability. Further analysis were conducted determining the types of errors made on the tasks and the confusability matrices between different emotions analysed.

Discussion

The aim of the study was to investigate whether focal prefrontal cortical lesions impair the perception of emotional expression. The results suggest this to be the case and supports the presence of impairment with unilateral lesions. Furthermore, this impairment is not due to difficulties with basic face processing.

The results also showed specificity in relation to different types of emotions, but not consistently between tasks used. Across the main two techniques, the impairments were more widespread when the subjects were required to point to a particular expression, given a verbal prompt. This result may suggest that facial expression matching is a less sensitive measure in these patients. Possibly, the patients were able adopt ameliorative strategies more readily in this condition, for example, matching specific features of faces, without necessary encoding emotions.

The study also found no differences in the severity of impairment when comparing patients with lesions brain lesions in different locations. This either suggests that lesions in the patient groups may not have been sufficiently circumscribed to detect these differences; or alternatively, facial emotional processing incorporates a more widespread functional cortical network involving the prefrontal cortex.

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8. Deficits in facial emotion perception in recently traumatically brain injured adults

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The impaired ability to recognize emotion in faces (for example, an inability to distinguish a fearful face from an angry face) has significant implications for social and occupational functioning. To date, such impairments have been investigated primarily in neurological populations with focal lesions, but not in traumatic brain injury. In the present study, a group of recently traumatically brain-injured adults (**N = 17**) were assessed for deficits in facial emotion perception using the Florida Affect Battery-Revised. The group was significantly impaired on all facial emotion perception tasks relative to a neutral control task, when compared to an age and education matched control group. The present findings have clinical implications; they also provide preliminary evidence for the role of diffuse axonal injury in facial emotion perception.

Report

Deficits in facial emotion perception have been investigated for several decades (see Borod et al., 1998; Heilman & Gilmore, 1998, for reviews). Studies have focused primarily on a narrow range of patient populations, primarily stroke (Borod et al., 1998). These studies have generally implicated right posterior focal lesions (i.e. temporal, parietal, and occipital). Recent studies in this area have also implicated prefrontal lesions (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000; Hornak, Rolls, & Wade, 1996), though here, only a subset of facial emotion perception tasks were examined (i.e., those requiring verbal labeling of the emotion). Few studies have investigated facial emotion perception in traumatic brain injury (TBI) patients. TBI is ubiquitous, and because patients with TBI are well known for their difficulty in reintegrating into the community following injury, it is reasonable and important to ask whether part of this problem may be attributable to emotion perception deficits. Recent studies have suggested that a network of pathways underpinned by white matter tracts is necessary for the perception of emotion in faces (Adolphs et al., 2000). Thus, diffuse axonal injury, a hallmark of neurological injury in TBI, might therefore leave patients vulnerable to deficits in emotion perception.

In the present study, we asked whether TBI patients display deficits in facial emotion perception. Secondarily, we explored the question of the neurological underpinnings of facial emotion perception by dividing our patient group into those with and those without right posterior focal injury. Since facial emotion perception is compromised by right posterior focal lesions, we would expect that patients *without* such lesions would show lesser facial emotion perception impairment on our tests.

Predictions

1. TBI patients will demonstrate significant impairments on facial emotion perception tasks in comparison to age and education matched controls.
2. TBI patients without right posterior focal lesions will perform better on facial emotion perception tasks than TBI patients with such lesions.

Methods

Participants

Prediction 1: Patients ($N = 17$) were recruited from Toronto Rehab, and matched controls ($N = 17$) were recruited from the community. For the patients and controls, respectively, mean age was 45.0 ($SD = 15.1$) and 42.5 ($SD = 15.1$); mean years of education was 12.7 ($SD = 2.8$) and 14.4 ($SD = 2.4$). Average months post injury for the patients was 2.4 ($SD = 1.4$; range = 1–5). Controls had no history of psychiatric illness, neurological disease or previous brain injury. The two groups did not differ on age ($t = 0.264$, N.S.) or education ($t = -1.69$, N.S.).

Prediction 2: Patients from Analysis 1 above were assigned to one of two groups according to the presence of right posterior focal lesions (RtPL; i.e. temporal, parietal or occipital lesions) or the absence of

such lesions (non-RtPL) as indicated by CT findings. Because we were interested in lateralization of deficits, all patients who were not definitively right handed were excluded from the analysis.

The non-RtPL group ($N = 6$) and RtPL group ($N = 7$) did not differ significantly on mean age (41.7, $SD = 14.9$ and 49.0, $SD = 13.2$, respectively: $t = -0.94$, N.S.) mean years of education (13.3, $SD = 2.2$ and 11.1, $SD = 3.18$, respectively: $t = 1.42$, N.S.) or mean months post-injury (2.33, $SD = 1.51$ and 2.0, $SD = 0.82$: $t = 0.507$, N.S.).

Tasks

The tasks were selected from the facial affect section of the Florida Affect Battery Revised (FAB; Bowers, Blonder, & Heilman, 1991/1998).

Control task: Neutral face discrimination.

- Photographs of two female faces of the same woman or two different women presented.
- Participants decide whether photographs represent the same or different people.

Emotional face labeling.

- Photographs of faces, each expressing one of five different emotions (happiness, sadness, anger, fear or neutrality) shown.
- Participants asked to name the emotion.

Emotional Face Discrimination.

- Pairs of photographs presented displaying two different female faces expressing either same or different emotions.
- Participants decide whether emotions expressed are the same or different.

Emotional Face Matching.

- One face expressing one of five emotions presented on one card. On a second card, five faces presented each displaying a different emotion.
- Participants asked to match emotion on first card with same emotion on second card.

Design

Factorial 2×4 with group (TBI and matched controls) and task (the 4 FAB tasks) as independent variables, and percent correct (on the FAB tasks) as dependent measure.

Results

Prediction 1: *TBI patients will demonstrate significant impairments on facial emotion perception tasks in comparison to matched controls.* A two-way analysis of variance (ANOVA) comparing patients and controls on the FAB tasks yielded a significant main effect of group, $F(1, 32) = 9.12$, $p = .0049$ and task, $F(3, 96) = 17.38$, $p < .001$. Importantly, a significant group-by-task interaction was observed, $F(3, 96) = 4.12$, $p = .0085$. Planned comparisons revealed that while performance in the control task did not differ between the patients and matched controls ($t(32) < 1.0$; N.S.), the patients performed significantly worse than the matched controls on each of the three emotion tasks: labeling ($t(32) = 3.49$, $p = .001$); discrimination ($t(32) = 3.16$, $p = .003$); and, matching ($t(32) = 2.03$, $p = .05$). Moreover, the patient group performed significantly worse on each of the emotion tasks than on the control task: control task vs. emotion-labeling ($t(16) = 7.32$, $p < .001$); vs. emotion-discrimination ($t(16) = 4.17$, $p < .001$); and, vs. emotion-matching ($t(16) = 4.93$, $p < .001$) (see Fig. 1a).

The distribution of the data showed a negative skew, and the sample size was not large enough to compensate for this violation of the normality assumption. Therefore, non-parametric Kruskal–Wallis analyses were conducted to verify the above findings. Patients and matched controls showed significant between-group differences for each of the three emotion-perception tasks (Kruskal–Wallis H values > 6, $p < .01$ for each task), but no significant between-group difference was obtained for the control task ($H = .002$, N.S.).

These converging results on parametric and non-parametric analyses supported Prediction 1.

Prediction 2: *Non-RtPL will perform better on facial emotion perception tasks than RtPL patients.* A two-way ANOVA comparing the Non-RtPL and RtPL groups on all four tasks yielded a significant main-effect of task, $F(3, 33) = 9.00$, $p < .001$. However, no main-effect of group ($F(1, 11) < 1.0$, N.S.) nor group-by-task interaction ($F(3, 33) < 1.0$, N.S.) was obtained, with the means illustrating indicating comparable degrees of impairment between the groups relative to the control task (see Fig. 1b).

In a second ANOVA comparing the two groups on the three emotion-perception tasks *only*, the main effect of task ($F(2, 22) < 1.0$, N.S.) disappeared, and again, there was no main effect of group ($F(1, 11) < 1.0$, N.S.), nor group by task interaction ($F(2, 22) < 1.0$, N.S.). This finding provided further evidence of comparable performances across the experimental tasks, in contradiction of our prediction.

Violation of the normality assumption was addressed by conducting non-parametric analyses to verify the above findings. Between-group comparisons revealed no significant differences for any of the three emotion-perception tasks or the control task (for each, Kruskal–Wallis H values < 1, N.S). Within-groups, Wilcoxin Signed Ranks Tests were conducted to compare performances on the emotion-perception tasks with the control task in the non-RtPL group: emotion-labeling and emotion-matching performances were significantly worse

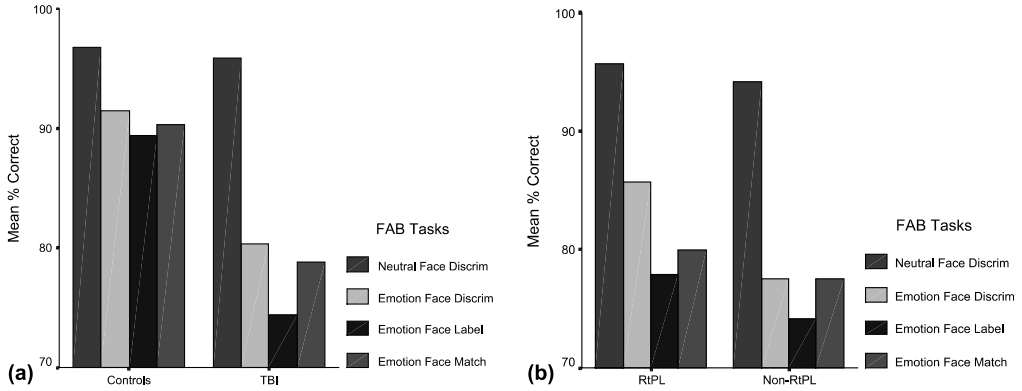

Fig. 1. Mean performance on measures of facial emotion perception. (a) *Prediction 1:* Normal control versus TBI participants ($N = 17$). (b) *Prediction 2*: Performance of right-lateral dominant TBI participants with evidence of right, posterior lesions (RtPL; $N = 6$) and without damage in these regions (non-RtPL; $N = 7$). FAB, Florida Affect Battery-Revised.

than control task performance ($z = -2.21$, $p < .05$; $z = -2.21$, $p < .05$, respectively), but there was no significant difference between the control task and the emotion-discrimination task ($z = -1.47$, $p > .05$) despite equivalent means between the matching and discrimination tasks (mean = 77.5% correct for both). Overall, the findings suggested that performance in the non-RtPL group was compromised, nearly to the level of the RtPL group.

Discussion

Prediction 1: *TBI patients will demonstrate significant impairments on facial emotion perception tasks in comparison to matched controls.* It is clear from Fig. 1a that our patients performed significantly worse on emotion-perception tasks than did matched controls. This discrepancy was found even though both groups performed at similar levels on a neutral control task. Therefore, prediction 1 was supported by these findings. These results, obtained in a sub-acute, but recently brain-injured population undergoing rehabilitation, suggest an important area in which to focus rehabilitation therapies.

Prediction 2: *Non-RtPL will perform better on facial emotion perception tasks than RtPL patients*. This prediction was largely unsupported in that performances between the two patient groups did not significantly differ, and that performances on the emotion-labeling and emotion-matching tasks were significantly impaired relative to the control task in the Non-RtPl group.

There are several possible explanations. The most interesting is that it was the presence of diffuse axonal injury in the non-RtPL group that gave rise to their impaired performances. Such an explanation is compatible with the notion that networks of white matter tracts underlie emotion perception in faces (Adolphs et al., 2000). However, two other explanations must be ruled out. First, the small sample size of the group limited power and thereby limited the ability to detect significant differences between the groups. Secondly, a small number of studies (e.g. Hornak et al., 1996) have demonstrated facial emotion perception deficits in patients with frontal lobe lesions (in facial emotion labeling tasks). Patients with pre-frontal lobe lesions were not excluded from either of our groups; therefore, it is possible that frontal lobe lesions were responsible for the impaired performances.

In conclusion, the present study illustrated that facial emotion perception deficits are a robust feature of a recently traumatically brain injured adult population. The study has also provided some evidence of a role for diffuse axonal injury in the perception of emotions in faces. We are currently undertaking to (a) replicate these findings with a larger sample size and (b) examine a non-TBI, focal pre-frontal group employing the same test battery.

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9. Reduced facial muscle movements in Autism: Evidence for dysfunction in the neuromuscular pathway?

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The present study examined facial muscle movements during the expression of emotion in young children with autism. The main question of interest was whether the lack of facial expressiveness that has been documented in children with autism might reflect some deviation in the neuromuscular pathway of the face. This question was addressed by conducting a microanalysis of facial muscle movements (Izard, 1979) from videotapes taken during a semi-structured play situation. Relative to both language-delayed and normally developing children, children with autism were found to exhibit reduced and weak muscle movements in the eye and mouth regions, but not the brow region of the face. The findings are discussed with reference to the possibility of injury to the motor nuclei of cranial nerves from the brain stem.

Report

A lack of facial expressiveness is well documented in young children with autism (e.g., Yirmiya, Kasari, Sigman, & Mundy, 1989). Findings consistently indicate that children with autism express less positive affect and more neutral or "flat" affect compared to normally-developing and mentally-impaired children. The facial expressions of children with autism have also been described as "mechanical" and not resembling any of the discrete expressions observed in others (Loveland et al., 1994). Such atypicalities have generally been viewed as communicative at root, although an alternate possibility is provided by the recent neuroembryological theory of autism.

Rodier, Ingram, Tisdale, Nelson, and Romano (1996) have proposed that the critical period for susceptibility to autism occurs in the embryo during closure of the neural tube, thus resulting in an early injury to the brain stem. Evidence for this comes from a population study of individuals exposed to thalidomide during closure of the neural tube and in whom autism was identified in 33% of cases. The period of neural tube closure coincides with the production of the first neurons that eventually form the motor nuclei of the cranial nerves. Evidence from the thalidomide cases with autism implicates an injury to the motor nuclei of cranial nerve VII (facial nerve). This begs the question of whether faulty innervation of the face might underlie previous reports of flat and ambiguous expressions in autism.

The present study explored this possibility by systematically examining the functional integrity of the individual muscle movements necessary for the expression of facial emotion. Children were videotaped in a play situation designed to elicit spontaneous facial emotion. Using Izard's (1979) coding system, we conducted a detailed analysis of facial muscle movements in three regions of the face ("upper"/brow, "middle"/eye, and "lower"/mouth), with special reference to both duration and intensity. Data from young children with autism were compared to that from normal and language-delayed children.

Method

Participants

These included 15 children with autism (12 males; M age = 70.1 mos; $SD = 16.5$), 14 children with a specific language disorder, none of which showed any signs of autism (11 males; M age = 65.4 mons;