RUNNING HEAD: Lateralisation and emotional expression regulation

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Linking children's neuropsychological processing of emotion with their knowledge of emotion expression regulation

Dawn Watling *
Department of Psychology
Royal Holloway, University of London

Victoria J. Bourne
School of Psychology
University of Dundee

Author Note

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this article should be addressed to Dr. Dawn Watling, Department of Psychology, Royal Holloway, University of London, Egham Hill, Egham, Surrey, TW20 0EX, UK. Email: Dawn.Watling@rhul.ac.uk

Abstract

Understanding of emotions has been shown to develop between the ages of four and ten years, however, individual differences exist in this development. Whilst previous research has typically examined these differences in terms of developmental and/or social factors, little research has considered the possible impact of neuropsychological development on the behavioural understanding of emotions. Emotion processing tends to be lateralised to the right hemisphere of the brain in adults, yet this pattern is not as evident in children until around the age of ten years. One hundred and thirty six children between five and ten years were given both behavioural and neuropsychological tests of emotion processing. The behavioural task examined expression regulation knowledge (ERK) for prosocial and self-presentational hypothetical interactions. The chimeric faces test was given as a measure of lateralisation for processing positive facial emotion. An interaction between age and lateralisation for emotion processing was predictive of children's ERK for only the self-presentational interactions. The relationships between children's ERK and lateralisation for emotion processing changes across the three age groups, emerging as a positive relationship in the 10-year-olds. The 10-years-olds who were more lateralised to the right hemisphere for emotion processing tended to show greater understanding of the need for regulating negative emotions during interactions that would have a self-presentational motivation. This finding suggests an association between the behavioural and neuropsychological development of emotion processing.

Keywords: Chimeric faces, emotion processing, lateralisation, right hemisphere, self-presentation

Linking children's neuropsychological processing of emotion with their knowledge of emotion expression regulation

Past research has demonstrated that children between four and ten years of age develop an understanding of emotional display rules; in other words, they understand that there are rules which govern how and when emotions can be expressed, whereby one's outer facial display may not match their inner mental state (Gnepp & Hess, 1986). In an attempt to explain individual differences in this developmental trajectory, research has typically examined the contributions of developmental and social factors. However, it is possible that the way in which a child's brain develops may also contribute to their emotional understanding.

One aspect that researchers have focused on within children's understanding of emotional display rules, and which develops between early and middle childhood, is expression regulation knowledge (ERK) – knowledge that one must consider situational factors and regulate his/her expression of emotion accordingly (Garner, 1999). To explore the situational factors that may be particularly related to children's ERK researchers have focused on comparing prosocial factors (i.e., avoiding hurting someone's feelings) with self-protective factors (i.e., protecting oneself from negative consequences such as getting into trouble; Gnepp & Hess, 1986; Jones, Abbey, & Cumberland, 1998), and self-presentational factors (i.e., trying to control what others' think of the self; Banerjee & Yuill, 1999). In particular, children's understanding of prosocial and self-protective display rules, which involves having an understanding of the need for expression regulation and offering an appropriate justification for why the expression would be regulated, have been explained through different socialization processes by Gnepp and Hess (1986), while differences between performance on prosocial and self-presentational display rules have been explained partially through children's understanding of second-order representation (i.e., child understands that an individual is attempting to manipulate how his/her audience represents the self; Perner & Wimmer, 1985). Second-order representations have traditionally been assessed using false belief tasks, which is a measure of theory of mind understanding – the understanding that the self and others have mental states (e.g., beliefs, desires, intentions, etc.; Premack & Woodruff, 1978). Such tasks involve the child participant understanding that one person can have a representation about another person's incorrect beliefs (e.g., while person *A* knows that the ice-cream truck has moved to a new location, person *B* did not see it move, so *B* should believe that the ice-cream truck is in the original location, thereby having a false belief; Perner & Wimmer, 1985; Sullivan, Zaitchick, & Tager-Flusberg, 1994). Banerjee and Yuill (1999) found that children who passed a second-order false-belief task were more likely to perform well on the self-presentational display rule stories in comparison to those who did not pass, while their performance on this false-belief task was not a factor in their performance on the prosocial display rule stories. The present research focuses on children's ability to identify how a protagonist would feel on the inside and what emotion they would show on the outside, and to explore children's understanding of the need to regulate expression depending on whether the purpose of regulation was prosocial or self-presentational. More specifically, this research explores how individual differences in this knowledge may be explained by neuropsychological factors of emotion processing.

Jones et al. (1998) demonstrated that although there is a general increase in ERK between early and middle childhood, this increase appears to plateau during middle childhood. Researchers have found that while 6 and 8-year-olds tended to report unregulated facial expressions over 80% of the time, 10- and 15-year-olds reported unregulated facial expressions around 50% of the time (Gnepp & Hess, 1986). Consistent with previous work, it is expected that children's recognition that facial expressions will be regulated will increase as children age; however, this may differ for the prosocial and the self-presentational scenarios. Children experience greater socialisation pressures to control their facial expressions in prosocial situations (Gnepp & Hess, 1986), while they are not directly taught how and when to regulate their emotional expressions for self-presentational motivations. Indeed, children's understanding of prosocial interactions is expected to become more age dependent due to being taught important social norms. In contrast, children's understanding of expression regulation for interactions where there are no social norms (i.e., during self-presentation) may be increasingly reliant on their neuropsychological processing of emotion.

When exploring the developmental trends in emotional understanding, researchers have recently focussed on individual differences in children's peer relations. Such work has shown developmental links between children's understanding of emotional displays (McDowell & Parke, 2000; Underwood, 1997) and intentional behaviours (Banerjee & Watling, 2005) with how preferred they are by their peers, whereby those who were more preferred by their classmates demonstrated a better understanding of emotional display rules and intentional behaviours. However, these studies have not been able to entirely account for the individual differences identified. Might these remaining individual differences be explained, at least to some extent, in terms of biological or neuropsychological factors? More specifically, might the development of children's ERK be related to the development of the child's brain for processing emotion, which would explain individual differences over and above how preferred they are by their peers?

A great deal of work has considered the way in which emotion is processed in the adult brain. Although there is evidence for emotion processing in both hemispheres (see Davidson, Shackman, & Maxwell, 2004), overwhelmingly evidence suggests that the right hemisphere is dominant for emotion processing (e.g., Nakamura et al., 1999; Bourne, 2005). In this paper we are exploring the association between children's ERK and their right hemisphere dominance for emotional processing using the chimeric faces test (CFT; Levy, Heller, Banich, & Burton, 1983). The CFT is a widely used behavioural test of lateralisation that has been validated in a study using patients with unilateral brain lesions (Kucharska-Pietura & David, 2003). Non-clinical and left hemisphere lesion patients showed a left visual field bias when inspecting chimeric face stimuli (which indicates right hemisphere dominance), whereas right hemisphere lesion patients showed a significantly reduced leftward bias. This finding has also been replicated in children with congenital unilateral brain damage (Bava, Ballantyne, May, & Trauner, 2005).

The CFT has been used to examine the development of lateralisation in children from the age of four years (Bava et al., 2005; Chiang, Ballantyne, & Trrauner, 2000; Failla, Sheppard, & Bradshaw, 2003; Levine & Levy, 1986; Workman, Chilvers, Yeomans, & Taylor, 2006). Typically these studies have shown that younger children show signs of being weakly lateralised, but this continues to strengthen and is clearly developed by 10 years. This developmental trajectory for the development of the brain for processing emotion seems to coincide with the developmental trajectories for the behavioural understanding of emotional display rules (including ERK). It is possible that these two developmental trends are associated: a child's brain may need to develop in order to adequately process emotion before the understanding of emotion can be achieved; alternatively, it is possible that as children develop an understanding of emotional display rules their brain may become more specialized in processing emotion. As such we predict that the association between neuropsychological and behavioural measures of emotion processing should increase with age.

Support for a developmental relationship between lateralisation of emotion processing and factors that may underlie an understanding of emotional display rules can be taken from a number of sources. Children's understanding of "emotional and behavioural reactions are often contingent upon knowledge or belief" (Perner, Frith, Leslie, & Leekam, 1989, p. 689). Children's understanding of another's beliefs requires that the child has a theory of mind understanding, and in this case that they have second-order representation (as outlined above). Research has demonstrated that theory of mind understanding has been associated with right hemisphere activation in non-clinical participants (Gallagher, Happe, Brunswick, Fletcher, Frith, & Frith, 2000), and impaired theory of mind has been shown following right hemisphere lesions (Happe, Brownwell, & Winner, 1999). Additionally, right hemisphere dysfunction has been found in individuals with autism, which is a disorder with social and emotional deficits (Waiter, Williams, Murray, Gilchrist, Perrett, & Whiten, 2005; see also Sabbagh, 2004). In line with the research on theory of mind, a recent study has provided strong support and justification for the proposed development of a relationship between lateralisation and understanding of emotion. Workman et al. (2006) primarily examined the development of lateralisation using the chimeric faces test. However, they also considered whether the degree of lateralisation is associated with a child's ability to identify emotions on faces. A significant correlation was found between the two variables, suggesting a relationship between the behavioural and neuropsychological development of emotion processing.

The present research goes beyond previous research in exploring the role of development of brain lateralization for emotion processing on children's understanding of regulating emotions in both prosocial and self-presentational interactions. It is expected that while age will be an important predictor of children's ERK, their degree of right hemisphere lateralization for emotional processing will also be a significant predictor, after controlling for how preferred children are by their classmates. As discussed above, previous research has shown that children who are more preferred by their classmates have a more advanced understanding of display rules (a form of emotional understanding; McDowell & Parke, 2000; Underwood, 1997) and intentions (Banerjee & Watling, 2005). In light of this, this research was designed to assess the role of development of brain lateralization, over that of children's social preference, in children's understanding of the need to regulate emotions.

Importantly, as outlined earlier, given the similarity in developmental trajectories of both the development of the brain for processing emotion and children's understanding of emotions, it is anticipated that there will be an interaction between the children's age and the strength of lateralization for processing emotion, whereby as children age and their right hemisphere dominance for emotional processing becomes stronger, there will be improved performance on the ERK task.

Method

Participants

One hundred and thirty six children from two British schools, one in a primarily working class neighbourhood (approximately 45% were White British, 40% Black British, 10% Asian, 5% other) and one in a middle-class neighbourhood (approximately 90% White British, 10 % other) participated in this research. There were 29 six-year-olds (*M* = 6.41, *range* = 5.93 – 7.47, 15 girls), 54 eight-year-olds (*M* = 8.4, *range* = 7.79 – 9.16, 29 girls), and 55 ten-year-olds (*M* = 10.32, *range* = 9.82 – 10.81, 23 girls). Due to the differing number of participants in each age group, a chi-squared analysis was used to examine the frequency distribution of males and females across the three age groups. The distribution of the sample showed no significant bias ($\chi^2(2) = 1.7$, p = .430).

Materials

Four tasks were used in this research: the CFT, an ERK task, sociometric nominations, and the British Picture Vocabulary Scale (BPVS II). All tasks were administered on a laptop. Children were simultaneously presented with the stories on the screen and could hear the audio of the task instructions, stories and questions via a set of headphones. Children's responses were recorded by the software as they clicked on their response.

Design and Procedure

Participants were seen in groups of 1 – 4. They were seated in front of a laptop computer and asked to put on the headphones. The tasks were divided over two sessions, with the BPVS II and the Sociometric nominations in one session, and the CFT and the ERK task in a second session. The order of the sessions was counterbalanced amongst the children in each class. The order of the tasks within each session and within each task was randomly assigned through the computer program. Children completed both the first and second session within 48 hours.

The British Picture Vocabulary Scale: Second Edition (BPVS II). The BPVS II, developed by Dunn, Dunn, Whetton, and Burley (1997), was used as a measure of children's receptive vocabulary. Following the procedure set out by Dunn et al. a basal set and a ceiling set were established, and the number of errors were calculated. From this each child's raw score was calculated, and with their age information we were able to obtain each child's standardized score on this assessment. As children were responding to information presented in stories (ERK task), their performance on the BPVS II was used to control for individual levels of receptive vocabulary in the statistical analyses.

Chimeric faces test (CFT). The task was administered in the same way as in previous research (Bourne, 2005). Children were presented with pairs of chimeric faces where one was placed above the other (see Figure One). The faces were created from greyscale photographs of adult males posing positive and neutral expressions. One face showed a positive expression in the left visual field and a neutral expression in the right visual field, whereas the other was an exact mirror image showing a neutral expression in the left visual field and a positive expression in the right visual field. Each face subtended approximately 6.5º horizontally and 9.25º vertically. The distance between the two faces was 0.5º, consequently the stimuli presented in each trial subtended approximately 6.5º horizontally and 19º vertically. Placement of the two types of chimeric face was counterbalanced and randomised across the experiment and between participants. Children were asked to decide which face looks happier. They responded by clicking on the face that they thought looked happier. When each pair of faces was presented a cursor was positioned in the middle of the two pictures, both horizontally and vertically, so upward movement would allow the children to click on the top face and downward movement would allow the children to click on the bottom face. The faces remained on the screen until a response was made. Five practice trials were given before completing twenty experimental trials. From the children's responses a laterality quotient (CFT-LQ) was computed ranging from -1 (always choosing the face with the positive expression in the right visual field indicating left hemisphere dominance) to +1 (always choosing the face with the positive expression in the left visual field indicating right hemisphere dominance).

[Insert Figure One about here]

Expression Regulation Knowledge (ERK). Before hearing the stories, children were first introduced to the notion that an individual could be feeling one feeling on the inside, and could show the same or a different feeling on the outside. Children were introduced to four emotions (happy, just ok, sad, and angry) that were depicted in pictures (similar to those used in Jones et al., 1998). Using stories provided by Banerjee and Yuill (1999), children heard six stories. Three of the stories were prosocial (e.g., stating to their audience how much they liked a gift that they clearly did not like), and three were self-presentational (e.g., telling their peers that they really enjoyed climbing when they really did not), each story was accompanied by a cartoon-style drawing of the interaction. Each story involved an event occurring which would result in the protagonist feeling negative emotions (e.g., sad or angry), but making a positive statement to their audience. Children were then asked to click on the face that showed: 1) how the protagonist would feel on the inside; 2) how the protagonist would look on the outside. Children always heard stories with protagonists that matched their own sex.

Children received a score of 1 on a story if they stated that the protagonist was feeling either sad or angry on the inside but showing either a happy or just ok emotion on the outside. Their performance was then scored according to the total number of correct responses for the three prosocial stories (ERK-Pro) and the three self-presentational stories (ERK-SP) separately. Hence possible total scores ranged from 0-3.

Sociometric Nominations. This type of nomination procedure is used widely in research investigating children's social relationships. Coie and Dodge (1998) and subsequent research (for a review of sociometric techniques, see Merrell, 1999) has demonstrated that sociometric nominations are very well characterised and validated with aged 6 years and older (this includes when nominations are made using a class roster). There were two 6-year-olds (one girl), one 8-year-old (a girl), and two 10-year-olds (both boys) who were missing on the days of testing and made no nominations. Additionally, there was one 8-year-old boy who was not given permission to take part in the research study. All of these children's names were included on the class list from which their classmates made their nominations.

In this research each participant was shown a list of names of all the children in their class on the computer screen and asked to nominate three children who they would really like to play with in their class and three children who they would really not like to play with. To nominate classmates, children were asked to click on the name of the three classmates they wished to nominate. Following Coie and Dodge (1988), each child's number of positive nominations received and number of negative nominations was standardized within each class. A social preference score was calculated for each child as the difference between the standardised positive score and the standardised negative score.

Results

Table one shows the mean number of times each response was chosen by children for the ERK task, demonstrating that for each question children were using the range of responses. Additionally, preliminary analyses on the total number of correct stories (range 0 – 6) were completed to check if children's performance between the schools was significantly different. The two schools performance was not found to be significantly different after controlling for children's BPVS scores and year group (F (1, 131) = 2.28, p = .130; school one: mean = 2.42 (SE = .22); school two: mean = 2.97 (SE = .27)).

[Insert Table one about here]

Table two presents the descriptive statistics of the behavioural and neuropsychological measures as a function of age group.

[Insert Table two about here]

Two hierarchical linear regressions were conducted one using ERK-SP as the outcome variable and the other using ERK-Pro as the outcome variable. Table three gives the zero order correlations between all continuous measures entered into the regression model. The entry of predictor variables into the model was identical for each of the outcome variables. The first block contained the potential covariates of sex and BPVS II performance. As past research has demonstrated that both children's age group and social preference are related to their understanding of emotional display rules and intentions, these were entered into the second block of the model. CFT-LQ was entered into the third block to examine the overall relationship between lateralisation of emotion processing in the brain and understanding of emotional behaviour in children, over and above that which is explained by age and social preference. Finally the interaction between CFT-LQ and age group was entered into the fourth block of the model (see Table four for full details of analyses).

[Insert Table three about here]

ERK-SP

None of the initial covariates were significantly associated with ERK-SP. Social preference and age group did not significantly improve the model nor did CFT-LQ. However, the interaction between CFT-LQ and age group was a significant predictor of ERK-SP accounting for around 4% of variance in ERK-SP scores. This interaction suggests an association between ERK-SP and lateralisation of processing emotional stimuli that varies according to age.

[Insert Table four about here]

In order to break down and interpret this interaction, partial correlations between CFT-LQ and ERK-SP were conducted for each age group separately, partialling out the effects of the covariates included in our model: sex, BPVS II and social preference score. None of these correlations were significant (6-year olds: r(23) = -.227, p = .138; 8-year olds: r(48) = -.224, p = .059; 10-year olds: r(49) = +.105, p = .232). However, the important analysis is statistical comparison of the correlation coefficients to determine whether the magnitude of the relationship between ERK-SP and CFT-LQ differs between age groups. There was no significant difference in the magnitude of the correlation between 6- and 8-year-olds (*z* = 0.013, *p* = .495). The partial correlation for 10-year-olds was positive and larger than the partial correlations in each of the other age groups. The difference in the size of the partial correlations between the 6- and 10-year-olds was approaching significance (z = 1.423, p = .077) and the difference between the 8- and 10-year-olds was significant (z = 1.699, p = .045). Taken together these results suggest a relationship between ERK-SP and CFT-LQ that is mediated by age, with the relationship emerging at around 10 years.

ERK-Pro

Within the initial covariates block neither sex nor BPVS II were significant predictors of ERK-Pro. However, age group was a significant predictor with increasing performance on ERK-Pro with age explaining 5.2% of the variance. In the additional blocks including social preference, CFT-LQ, and the interaction between CFT-LQ and age group there were no significant predictors of ERK-Pro.

Discussion

This research has provided preliminary evidence that neuropsychological development may contribute to the development of children's understanding of the need for expression regulation. Children who were more strongly lateralised to the right hemisphere for processing positive facial emotion tended to judge that emotional expressions would be more likely to be regulated in self-presentational interactions. Importantly, this association only emerged in the 10-year-old age group. This finding is consistent with previous research that has suggested that the strength of lateralisation for emotion processing increases through childhood, with significant right hemisphere lateralisation found in 10-year-olds (Bava et al., 2005; Chiang et al., 2000; Failla et al., 2003; Levine & Levy, 1986; Workman et al., 2006). Importantly, this pattern of hemispheric development may be associated with behavioural development of ERK. Theory of mind understanding has been associated with right hemisphere function in varying populations (Gallagher et al., 2000; Happe et al., 1999; Waiter et al., 2005). Our finding of a relationship between strength of lateralisation for processing emotion and children's ERK complements such research. The result is also consistent with the finding that the lateralisation of emotion is associated with children's ability to correctly identify emotions (Workman et al., 2006).

Whilst our findings were consistent with our hypotheses for the self-presentational motivation task, we found no association between cerebral lateralisation and children's ERK for interactions that have a prosocial motivation. It is possible that this discrepancy may be attributable to differences between the prosocial and self-presentation tasks. First, as highlighted earlier, the social pressure to use prosocial display rules (Gnepp & Hess, 1986) may result in the development of children's knowledge for emotion regulation in these types of situations being more age dependent. However, as children are not explicitly taught self-presentational display rules, this may be more dependent on learning from their experiences and their brain development for emotion processing. This fits with our finding of a developmental trend for prosocial ERK in children aged between 5 and 10 years, while children's understanding of self-presentational ERK could be predicted from children's increasing right-hemisphere laterality of emotion processing, such as that which we found between the 6-, 8- and 10-year-old groups of children. Second, it may be that the need for expression regulation in prosocial and self-presentational interactions may be reliant on different underlying mechanisms, which consequently show different brain-behaviour relationships. Banerjee and Yuill (1999) showed a relationship between the understanding of self-presentational display rules and theory of mind, but not between understanding of prosocial display rules and theory of mind. Given the previous research associating theory of mind with right hemisphere function (Gallagher et al., 2000; Happe et al., 1999; Waiter et al., 2005), it is perhaps not entirely surprising that we found a relationship with self-presentational ERK only.

Although we have provided some evidence that a relationship may exist between the development of brain and behaviour for emotion processing, a far more detailed examination is necessary to further characterise the relationship. It is possible that the use of different emotions in the CFT could lead to alternative findings; Workman et al. (2006) found different developmental trajectories across six key emotions. It might also be interesting to examine the relationship using non-face emotional stimuli, such as scenes or words. Such stimuli would enable us to examine whether the behavioural understanding of emotion is associated with the neuropsychological processing of emotional face stimuli specifically, more generalised right hemisphere emotion processing mechanisms, or even the development of lateralisation for cognitive processing across all domains. Furthermore, the choice of behavioural tasks included in this study could also be expanded in future research. It has already been suggested that our finding of a relationship with self-presentational understanding, but not prosocial understanding, may be explained in terms of reliance on theory of mind understanding. Consequently, subsequent research into this area might consider theory of mind more specifically. Future research should also focus on using a greater number of prosocial and self-presentational stories to increase the sensitivity of our measure.

There are some alternative interpretations of our findings and some limitations of the work presented here. Between the ages of 5 and 10 years children learn to read and their reading abilities substantially improve. Might the development of reading, for which sentences in Roman script are read from left to right, contribute to changes in leftward bias in a perceptual task? Heath, Rouhana, and Ghanem (2005) examined directional script reading bias on the CFT and concluded that, while script directionality can influence the magnitude of the leftward bias in the CFT, the leftward bias primarily reflects right hemisphere mechanisms. Therefore, it is unlikely that the development of reading and leftward scanning bias contributed to our findings to any great extent. One considerable limitation of our study is its cross-sectional design and the inferences about developmental trajectories that we infer. It is obvious that a longitudinal design is necessary to accurately characterise the developmental relationship.

While we have suggested that there may be an association between the development of emotion understanding and lateralised processing of facial emotion, the nature of this relationship requires discussion. It is possible that these processes have coincidentally parallel trajectories, rather than there being any direct relationship between them. However, given the amount of converging evidence regarding right hemisphere involvement in emotional behaviour (Gallagher et al., 2000; Happe et al., 1999; Waiter et al., 2005; Workman et al., 2006) it is likely that, at least to some extent, the two processes are interrelated. If this is the case, a further question can be posed regarding the direction of the relationship. Does the brain develop to process emotional stimuli in response to emotional experiences (i.e., an experience-dependant system), or does the development of emotion processing mechanisms in the right hemisphere influence a child’s ability to understand emotions (i.e., an experience-expectant system)? From our data it is impossible to distinguish between these two possibilities, however, for a more detailed discussion of the relationship between behavioural and neuropsychological development, please see Nelson and Bloom (1997).

We have provided preliminary evidence that suggests an association between the processing of facial emotion in the right hemisphere and of the behavioural understanding of self-presentational motivations, which only emerges once a child has reached the age of around 10 years. To gain a clearer understanding of this relationship it is important to explore links between the development of the brain and additional emotion related tasks. Gaining a greater understanding of the links between the development of the brain and emotional understanding has important implications not only for understanding children’s general development of emotional processing, but also for increasing our understanding of children who have deficits in emotion understanding, such as children with an autistic spectrum disorder (Dennis, Lockyer, & Lazenby, 2000).

References

Banerjee, R., & Watling, D. (2005). Children's understanding of faux pas: Associations with peer relations. *Hellenic Journal of Psychology, 2(1),* 27-45.

Banerjee, R., & Yuill, N. (1999). Children's understanding of self-presentational display rules: Associations with mental-state understanding. *British Journal of Developmental Psychology*, 17, 111-124.

Bava, S., Ballantyne, A. O., May, S. J., and Trauner, D. A. (2005). Perceptual asymmetry for chimeric stimuli in children with early unilateral brain damage. *Brain and Cognition, 59,* 1-10.

Bourne, V. J. (2005). Lateralised processing of positive facial emotion: Sex differences in strength of hemispheric dominance. *Neuropsychologia, 43,* 953-956.

Bourne, V. J. (2006). The divided visual field paradigm: Methodological considerations. *Laterality, 11*(4), 373-393.

Chiang, C. H., Ballantyne, A. O., & Trauner, D. A. (2000). Development of perceptual asymmetry for free viewing of chimeric stimuli. *Brain and Cognition, 44,* 415-424.

Coie, J. D., & Dodge, K. A. (1983). Continuities and changes in children's social status: A five-year longitudinal study. *Merrill Palmer Quarterly, 29(3),* 261-282.

Coie, J., & Dodge, K. (1988). Multiple sources of data on social behaviour and social status in school: A cross-age comparison. *Child Development, 59(3)*, 815-829.

Davidson, R. J., Shackman, A. J., & Maxwell, J. S. (2004). Asymmetries in face and brain related to emotion. *Trends in Cognitive Sciences, 8(9),* 389-391.

Dennis, M., Lockyer, L., & Lazenby, A. L. (2000). How high-functioning children with autism understand real and deceptive emotion. *Autism, 4,* 370-381.

Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, J. (1997). *The British Picture Vocabulary Scale (BPVSII)* Second edition. Windsor: NFER-Nelson.

Failla, C. V., Sheppard, D. M., & Bradshaw, J. L. (2003). Age and responding-hand related changes in performance of neurologically normal subjects on the line-bisection and chimeric-faces tasks. *Brain and Cognition, 52*(3), 353-363.

Gallagher, H. L., Happe, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: an fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia, 38*(1), 11-21.

Garner, P. W. (1999). Continuity in emotion knowledge from preschool to middle-childhood and relation to emotion socialization. *Motivation and Emotion, 23(4),* 247-266.

Gnepp, J., & Hess, D. L. R. (1986). Children's understanding of verbal and facial display rules. *Developmental Psychology, 22(1),* 103-108.

Heath, R. L., Rouhana, A., & Ghanem, D. A. (2005). Asymmetric bias in perception of facial affect among Roman and Arabic script readers. *Laterality, 10*(1), 51-64.

Happe, F., Brownell, H., & Winner, E. (1999). Acquired 'theory of mind' impairments following stroke. *Cognition, 70*(3), 211-240.

Jones, D. C., Abbey, B. B., & Cumberland, A. (1998). The development of display rule knowledge: Linkages with family expressiveness and social competence. *Child Development, 69(4),* 1209-1222.

Kucharska-Pietura, K., & David, A. S. (2003). The perception of emotional chimeric faces in patients with depression, mania and unilateral brain damage. *Psychological Medicine, 33*(4), 739-745.

Levine, S. C., & Levy, J. (1986). Perceptual asymmetry for chimeric faces across the life span. *Brain and Cognition, 5,* 291-306.

Levy, J., Heller, W., Banich, M. T., & Burton, L. A. (1983). Asymmetry of perception in free viewing of chimeric faces. *Brain and Cognition, 2*, 404-419.

McDowell, D. J., & Parke, R. D. (2000). Differential knowledge of display rules for positive and negative emotions: Influences from parents, influences on peers. *Social Development, 9(4),* 415-432.

Merrell, K. W. (1999). *Behavioral, social, and emotional assessment of children and adolescents.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc. pp. 133 – 151.

Nakamura, K., Kawashima, R., Ito, K., Sugiura, M., Kato, T., Nakamura, A., Hatano, K., Nagumo, S., Kubota, K., Fukuda, H., & Kojima, S. (1999). Activation of the right inferior frontal cortex during assessment of facial emotion. *Journal of Neurophysiology, 82*(3), 1610-1614.

Nelson, C. A., & Bloom, F. E. (1997). Child development and neuroscience. *Child Development, 68*(5), 970-987.

Perner, J., Frith, U., Leslie, A. M., & Leekam, S. R. (1989). Exploration of the autistic child's theory of mind: Knowledge, belief, and communication. *Child Development, 60(3),* 689-700.

Perner, J., & Wimmer, H. (1985). 'John thinks that Mary thinks that …': Attribution of second-order beliefs by 5 to 10-year-old children. *Journal of Experimental Child Psychology, 39,* 347-371.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral Brain Sciences, 1,* 515-526.

Puce, A., Allison, T., Asgari, M., Gore, J. C., & McCarthy, G. (1996). Differential sensitivity of human visual cortex to faces, letterstrings, and textures: A functional magnetic resonance imaging study. *Journal of Neuroscience, 16*(16), 5205-5215.

Sabbagh, M. A. (2004). Understanding orbitofrontal contributions to theory-of-mind reasoning: Implications for autism. *Brain and Cognition, 55*(1), 209-219.

Sullivan, K., Zaitchik, D., & Tager-Flusberg, H. (1994). Preschoolers can attribute second-order beliefs. *Developmental Psychology, 30(3),* 395-402.

Underwood, M. K. (1997). Peer social status and children's understanding of the expression and control of positive and negative emotions. *Merrill-Palmer Quarterly, 43(4),* 610-634.

Waiter, G. D., Williams, J. H. G., Murray, A. D., Gilchrist, A., Perrett, D. I., & Whiten, A. (2005). Structural white matter deficits in high-functioning individuals with autistic spectrum disorder: A voxel-based investigation. *Neuroimage, 24*(2), 455-461.

Workman, L., Chilvers, L., Yeomans, H., & Taylor, S. (2006). Development of cerebral lateralisation for recognition of emotions in chimeric faces in children aged 5 to 11. *Laterality, 11*(6), 493-507.

Figure One: Example of chimeric face stimuli. In the example, the top face is expressing positive emotion in the left visual field and the bottom face is expressing positive emotion in the right visual field.

Table one: Mean (SE) number of times each response was chosen for the two questions on the expression regulation knowledge task

	Happy	**Just OK**	**Sad**	**Angry**
Internal feeling	0.78 (.10)	1.49 (.11)	2.95 (.12)	0.77 (.07)
External expression	2.96 (.16)	1.48 (.10)	1.18 (.12)	0.38 (.06)

Table Two: Descriptive statistics (mean and SE) summarising performance in the behavioural and neuropsychological measures as a function of age group.

	6-year-olds	**8-year-olds**	**10-year-olds**	**All participants**
BPVS	102.50 (2.43)	100.42 (1.79)	106.72 (1.44)	103.37 (1.06)
Social preference	0.00 (0.18)	-.02 (0.14)	-0.01 (0.13)	-0.01 (0.08)
ERK: Self presentation	1.40 (0.25)	1.13 (0.16)	1.46 (0.16)	1.32 (0.10)
ERK: Prosocial	0.97 (0.20)	1.09 (0.13)	1.57 (0.13)	1.26 (0.09)
Chimeric faces test	-0.03 (0.04)	-0.01 (0.04)	0.09 (0.04)	0.02 (0.02)

BPVS = British Picture Vocabulary Scale.
ERK = Emotion Regulation Knowledge.

Table Three: Zero order correlations between behavioural and neuropsychological measures.

	Social preference	**ERK: Self presentation**	**ERK: Prosocial**	**Chimeric faces test**
BPVS	**.357 ****	-.041	.127	.020
Social preference	-	.042	-.009	-.014
ERK: Self presentation		-	**.532 ****	-.033
ERK: Prosocial			-	.004
Chimeric faces test				-

BPVS = British Picture Vocabulary Scale.
ERK = Emotion Regulation Knowledge.
** = p < .010.

Table Four: Results of the hierarchical regression analyses.

		ERK-SP			ERK-Pro		
		β	t	p	β	t	p
Block 1	Sex	.050	.236	.814	.091	.528	.599
	BPVS II	-.004	-.469	.640	.010	1.469	.144
Block 2	Age group	.042	.585	.560	**.153**	**2.664**	**.009**
	Social preference	.080	.667	.506	-.067	-.703	.483
Block 3	CFT-LQ	-.201	-.511	.610	-.165	-.530	.597
Block 4	CFT-LQ * Year group	**.597**	**2.191**	**.030**	.179	.815	.417

ERK-SP = Expression Regulation Knowledge – Self-presentation
ERK-Pro = Expression Regulation Knowledge - Prosocial
BPVS = British Picture Vocabulary Scale
CFT-LQ = Chimeric Faces Test – Laterality Quotient