

Disinhibited Reactive Attachment Disorder symptoms impair social judgements from faces

Running head: Trustworthiness and Reactive Attachment Disorder

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Summary

In typically developing populations, adults and children can come to a consensus regarding the trustworthiness of unfamiliar faces very rapidly. Maltreated children can have problems with trusting others, yet those with the disinhibited form of Reactive Attachment Disorder (dRAD) can be indiscriminately friendly. However, whether children with dRAD symptoms appraise and conform to typical judgements about trustworthiness of faces is still unknown. To address these questions, we recorded the eye movements of 10 maltreated dRAD children and 10 typically developing control children matched for age and gender while they made social judgements from faces. The children were presented with a series of pairs of faces that had been previously been judged by adults to have high or low attractiveness or trustworthiness ratings. As predicted, typically developing children, like adults in previous studies, reached a consensus regarding which faces were the most trustworthy and attractive. Interestingly, there was less agreement among the children with dRAD symptoms. Moreover, the judgments from the typically developing children showed, as for adults, a strong correlation between the attractiveness and trustworthiness tasks. This was not the case for the dRAD group, which showed less agreement and no significant correlation between trustworthiness and attractiveness judgments. Finally, both groups of children tended to generally appraise similar areas of the face in making their judgments. Both groups sampled preferentially the eye region to perform social judgments. Our data offer a unique insight in children with dRAD symptoms, providing novel and important knowledge for their rehabilitation.

Introduction

We present novel data regarding evaluation of faces in maltreated children suffering from symptoms of Reactive Attachment Disorder (RAD). A core clinical characteristic of RAD is indiscriminate friendliness and we wished to investigate whether or not this was associated with atypical appraisal of faces by these children – especially as regards the evaluation of trustworthiness, a key deficit in the RAD syndrome.

Reactive Attachment Disorder

Reactive Attachment Disorder (RAD) is a serious disorder of social functioning associated with maltreatment with two subtypes: Inhibited (wary, watchful behaviour) and Disinhibited (overfriendly behaviour)¹. The Disinhibited form (that we focus on in this paper) is known to be associated with significant psychiatric morbidity (Rutter et al. 2007) and can persist despite changes in care giving context (Gleason et al. 2011). The core characteristic of Disinhibited RAD (dRAD) is indiscriminate friendliness. We have already shown that children with indiscriminate friendliness can have complex neurodevelopmental problems including multiple psychiatric comorbidities (Kocovska et al. 2012). Children with indiscriminate friendliness are significantly socially impaired: despite being aware of the risks associated with speaking to strangers and the efforts made by their caregivers to protect them from danger, they demonstrate “a trust of new people and a craving for kindness from others” which may introduce them to further risky situations (Bennett et al. 2009).

How does trust develop in childhood?

Trust “is essential to initiate, establish, and maintain social relationships [and] encourages the initiation of mutual cooperative relationships” (Balliet and Van Lange 2012). A sense of trust develops in the context of a secure attachment relationship with parents (Corriveau et al. 2009).

Behavioural genetic research has shown that development of a sense of trust in family members and peers is based largely on environmental, rather than genetic factors. A sense of trust is an important buffer against life stressors and can reduce the likelihood of problems such as isolation or bullying in school and the development of depression (Sakai 2010). It is also associated with prosocial behaviour (Rotenberg *et al.*, 2004) and with academic achievement (Goddard 2003).

While very young children (aged 3 or 4) have difficulty discriminating between “helpers” and “trickers” in experiments, by age 5 typically developing children are systematically more likely to take advice from individuals who have previously proven helpful (Vanderbilt et al. 2011). By middle childhood, therefore, typically developing children are not indiscriminately trusting. Harris and Corriveau (Harris and Corriveau 2011) argue that “indiscriminate credulity is implausible, both biologically and psychologically”.

¹ Please note the dRAD is labelled Disinhibited Social Engagement Disorder in the DSM-V. We are keeping the appellation dRAD throughout the article for clarity and consistency with previous literature.

Yet indiscriminate behaviour is a relatively common phenomenon in children who have experienced maltreatment (Rutter et al. 2009). Lieberman has suggested that a basic problem for maltreated children is the sense of mistrust that has emerged from their lack of a predictable, loving caregiver in early childhood and that this lack of trust is associated with a range of difficult behaviours including indiscriminate friendliness (Lieberman 2003). We have previously suggested that indiscriminate friendliness might develop out of “discordant intersubjectivity” between a child and a maltreating caregiver in early life: in a secure attachment relationship, a largely concordant intersubjective relationship is likely to result in the development of “in-jokes” and other highly personal codes shared between the child and caregiver that will soon lead to a preference for that caregiver over strangers – who, in contrast, will consistently fail to mimic this satisfying intimate relationship. In a maltreating relationship characterised by discordant clashes and failed attempts at interaction, relationships with strangers may seem at least as satisfying – or even preferable (Minnis et al. 2006). A qualitative study of maltreated, indiscriminately friendly children supported this view: despite being grossly over-inclusive in those they regarded as “friends”, these children were also preoccupied with issues of trust. They described insecurity about relationships, particularly with peers, and therefore tended to prefer adults. They had various techniques for “checking” adult strangers to determine their trustworthiness. These checking strategies were not, however, effective and they tended to show little discrimination between people that would ordinarily be regarded as friends and strangers, whom they often quickly regarded as friends (Bennett, Espie, Duncan, & Minnis 2009).

These results are in line with prior research suggesting deficits (or specificities) in face processing, and particularly facial expression processing, in abused/neglected children (Pollak, Cicchetti, Hornung, & Reed, 2000 ; Pollak and Sinha, 2002). Moreover, abusive mothers have been found to produce less recognisable facial expressions relative to nonabusive mothers (Camras, Ribordy, Hill, Martino, Sachs, Spaccarelli & Stefani, 1990 ; Camras, Ribordy, Hill, Martino, Spaccarelli & Stefani, 1988). These findings are consistent with the idea that reduced family expressiveness is associated with poorer emotion understanding in children (Halberstadt & Eaton, 2002; Shackman, Fatani, Camras, Berkowitz, Bachorowski, & Pollak, 2010).

Individuals can evaluate faces based on various factors, and very rapid judgements are possible (after less than 100 milliseconds exposure to a face) for a range of judgments on factors such as trustworthiness, competence and aggressiveness (Willis and Todorov 2006).

Rapid appraisals of perceived facial attributes can have important long-term implications. For example, inferences of competence from facial appearance alone can predict election results (Todorov et al. 2005); an ability that is already present as early as five years old (Antonakis and Dalgas 2009). Oosterhof and Todorov argue that rapid judgements regarding the degree of trustworthiness of faces are based on judgements about facial expressions such as anger and happiness and that these cues, about whether to avoid or approach an individual, are

important in making social decisions, even though such decisions may be based on rather crude information (Oosterhof and Todorov 2008). The same authors have mapped the structure of face evaluation using principal components analysis and have shown that social judgments from faces can be accounted for by two dimensions: dominance and trustworthiness. Therefore, social judgements are strongly linked with each other, leading to high correlations (.75) between trustworthiness and attractiveness judgements in normal observers. The high correlations between these two social judgements can be considered as a landmark of normal evaluation of faces.

Despite the associations between maltreatment, lack of a sense of trust/indiscriminate friendliness and poor social, academic and psychological outcomes, little is known about the mechanisms involved during childhood. One possibility is that these difficulties originate in a basic problem with visual processing of faces. There is already a body of research investigating visual processing of faces in autism spectrum disorders. Indeed, in line with the difficulties children with ASD have in communicating and interacting with others, some eye-tracking studies have shown reduced fixations on socially salient aspects of visual scenes (Noris, Nadel, Barker, Hadjikhani, Billard, 2012; Pierce, Conant, Hazin, Stoner, Desmond, 2011; Riby and Hancock, 2009 ; Rice, Moriuchi, Jones & Klin, 2012). Using eye-tracking, some authors argue that individuals with ASD look less at facial features (eyes, nose, mouth) than typically developing peers (Chawarska and Shic, 2009; Pelphrey, Sasson, Reznick, Paul, Goldman & Piven, 2002) and more precisely, avoidance of eye contact is generally considered as a prominent feature of autism symptomatology (Dalton et al., 2005; Jones, Carr & Klin, 2008 ; Kliemann, Dziobek, Hatri, Steimke, Heekeren, 2010; Klin and Jones, 2008; Klin, Jones, Schultz, Volkmar, Cohen, 2002). However, this view is not consensual and some studies failed to show consistent atypical fixation patterns in ASD children during face processing (Carter, Williams, Minshew, Lehman, 2012; Fletcher-Watson, Leekam, Benson, Frank, Findlay, 2009; Freeth, Chapman, Ropar, Mitchell, 2010; Rutherford, Towns, 2008; van der Geest, Kemner, Verbaten & van Engeland, 2002; Wilson, Palermo, Brock, 2012). Other studies have shown a more complex picture with mixed results depending on the cognitive sub-phenotypes in ASD (Norbury, Brock, Cragg, Einav, Griffiths, et al. 2009; Rice, Moriuchi, Jones & Klin, 2012).

It is important to note that, in most of these studies, results were analysed using a “Regions-Of-Interest” (ROI) approach. The most critical limitations of such an approach rely on the fact that the subjective criteria used to define ROIs compromise the potential to replicate findings across studies (Caldara and Miellet, 2011). Other factors might explain inconsistencies across studies such as type of stimuli, task, subgroups of ASD observers, etc.. For instance, the atypical fixation pattern in children with ASD is more pronounced in natural social settings than in experimental settings with isolated stimuli. As yet, the precise impact of ASD on visual exploration of socially relevant stimuli is not completely understood.

In summary, the extant literature suggests that the ability to discriminate rapidly between trustworthy and untrustworthy individuals typically develops in the preschool period and the development of a sense of trust appears to be largely environmentally (rather than

genetically) determined. Maltreated children with indiscriminate friendliness are insecure about relationships, lack of trust and appear unable to make the correct judgements about who they should and should not trust. Our knowledge about the neurological mechanisms of trustworthiness judgements largely comes from studies in typically developing adults and it has been shown that such adults are able to rapidly come to a consensus, based on facial traits, about who should be judged trustworthy and who should not.

To the best of our knowledge, appraisals of trustworthiness in children with indiscriminate friendliness have not yet been investigated. In this study we wished to ask whether, like adults, typically developing children come to a consensus about which faces are trustworthy or untrustworthy; whether maltreated children with indiscriminate friendliness suffering from dRAD are able to make similar judgements and, lastly, whether typically developing and dRAD children differ in the way they appraise faces in making these judgements.

Importantly, atypical social judgements of faces in children with indiscriminate friendliness could originate from an inadequate strategy in facial feature sampling during social judgements (i.e., gaze avoidance to the eye region). Therefore, eye-movement recording is the method of choice to isolate the facial information sampled by the dRAD population compared to typically developing controls. Mapping eye movement fixation in dRAD children could thus provide invaluable insights into the mechanisms relating to their potential atypical social judgements of faces.

Materials and Methods

This study was carried out at the Department of Psychology, University of Glasgow between August 2010 and February 2012. There were 20 participants aged between 6 – 16 years: 10 children and adolescents with symptoms of Reactive Attachment Disorder (RAD) and 10 typically developing controls group-matched for age and gender. The study was approved by the Ethics Committee of the Department of Psychology, University of Glasgow.

For participant characteristics, see Table 1.

Clinical group: All clinical children were recruited from a pool of participants from a previous research study regarding neurodevelopmental difficulties in maltreated children with indiscriminate friendliness (Kocovska, Puckering, Follan, Smillie, Gorski, Barnes, Wilson, Young, Lidstone, Pritchett, Hockaday, & Minnis 2012). All participating children had experienced severe maltreatment in the early years, prior to being adopted (age of adoption range 16 months to 7 years), including emotional and/or physical neglect and/or physical abuse often in the context of parental mental illness and/or drug and alcohol problems. In addition, all participating children had indiscriminate friendliness as measured by standardised instruments (for detail regarding the sampling, please see (Kocovska, Puckering, Follan, Smillie, Gorski, Barnes, Wilson, Young, Lidstone, Pritchett, Hockaday, & Minnis 2012) and had cognitive functioning in the normal range.

Controls: 7 controls were recruited from the same sample as the clinical children and an additional 3 controls were recruited through outreach.

All cases and controls were screened using the Strengths and Difficulties Questionnaire (SDQ), that explores child and adolescent psychopathology and the Relationship Problems Questionnaire (RPQ) that explores Reactive Attachment Disorder symptoms (see Table 1).

Fully informed parental consent was obtained before each child participated and children were also asked to give verbal assent. Adolescents (aged 12 and over) were asked to give written consent before the start of the study. Participants were paid £20 to cover travel expenses and received a small token of thanks for their participation in the study at the end of the experiment.

Table 1- participant characteristics

	Controls	Clinical
Age (Mean, SD)	9.62 (1.41)	9.80 (2.74)
Gender	50% female	50% female
Mean (SD) SDQ Total Difficulties Score	4.10 (3.93)	19.50 (6.26)
Mean (SD) RPQ total score	1.0(2.83)	6.62(5.26)
History of abuse and/or neglect	0%	100%

Facial stimuli

Stimuli were obtained from the KDEF (Lundqvist and Litton 1998) databases and consisted, for each task (attractiveness and trustworthiness judgment), of 18 Western Caucasian identities containing equal numbers of males and females. Only neutral expression was used. For each task, the 18 identities were chosen, from an on-going study with adults (Lao et al. 2010), in order to form contrasted groups of low, medium and high attractiveness/trustworthiness. Thus, the 1st faces of the stimuli lists for both tasks were corresponding not because originating from the same identity but because they have been judged as being the most attractive and the most trustworthy according to the adult participants. We used those two highly correlated social judgements to further verify the normal evaluation of faces.

The individual face images were 382×390 pixels in size, subtending 15.6° degrees of visual angle vertically and 15.3° degrees of visual angle horizontally, which represents the size of a real face (approximately 19 cm in height). Faces from the original databases were aligned by the authors on the eye and mouth positions; the images were rescaled to match those facial features position and normalized for luminance. Images were viewed at a distance of 70 cm,

reflecting a natural distance during human interaction (Hall 1990). All images were cropped around the face to remove clothing and were devoid of distinctive features (scarf, jewelry, facial hair etc.).

For each trial, 2 faces were presented simultaneously on the screen, both centered vertically and each centered horizontally on the left or right half-screen. All the possible pairs were generated (combinations without repetition) leading to a total of 153 pairs for each task. The pairs order was randomized. The stimuli were presented on a 800×600 pixel grey background displayed on a Dell P1130 21" CRT monitor with a refresh rate of 170 Hz.

Apparatus

Eye movements were recorded at a sampling rate of 1000 Hz with the SR Research Desktop-Mount EyeLink 2K eyetracker (with a chin/forehead rest), which has an average gaze position error of about 0.25°, a spatial resolution of 0.01° and a linear output over the range of the monitor used. Only the dominant eye was tracked, although viewing was binocular. The experiment was implemented in Matlab (R2009b, The MathWorks, Natick, MA), using the Psychophysics (PTB-3) and EyeLink Toolbox extensions (Brainard 1997; Cornelissen and Peters 2002). Calibrations of eye fixations were conducted at the beginning of the experiment using a nine-point fixation procedure as implemented in the EyeLink API (see EyeLink Manual) and using Matlab software. Calibrations were then validated with the EyeLink software and repeated when necessary until the optimal calibration criterion was reached. At the beginning of each trial, participants were instructed to fixate a dot at the center of the screen to perform a drift correction. If the drift correction was more than 1°, a new calibration was launched to insure an optimal recording quality.

Procedure

All participants had normal or corrected vision and were performing the two experimental tasks successively: trustworthiness and attractiveness judgments. The task order was counterbalanced across participants. At the beginning of each task, the participants were informed that they would be presented with a series of face pairs on the screen and that they will have to indicate via button press which face they thought was the most attractive/trustworthy. They were also informed that there was no correct answer and that only their opinion was important. They were advised to go with their first choice without pondering too much on the task. The duration of testing ranged from 30 to 50 minutes. Each trial started with the presentation of a central fixation cross allowing for calibration check. When the participant was fixating the central cross, a face pair was presented until response. The participants were responding on a keyboard with their left (right) hand index if they thought that the face on the left (right) on the screen was the most attractive/trustworthy. Each trial was subsequently followed by a 2 seconds delay and the next trial was starting with the central fixation cross. Trustworthiness and attractiveness judgments were collected and analyzed for the purpose of the present experiment. Response times were not taken into account as the children were not instructed to answer fast.

Data analyses

The behavioral responses were coded in a dichotomous way for each face pair and each participant (1 for the face judged as the most attractive/trustworthy, 0 for the other face). The group results were then summarized as the proportion of participants in a given group judging one of the identities in the face pair more attractive/trustworthy than the other one. We then compared the global judgment agreement between participants between groups and tasks. If all the participants in a group converge to stereotypical attractive/trustworthy faces then the proportion of choosing a face rather than the other in the face pairs should be far from chance level (0.5). We thus performed a 2 (participants group: clinical/control) x 2 (task: attractiveness/trustworthiness) ANOVA on an agreement index defined as $\sqrt{(\text{prob}_{ij} - 0.5)^2 / 0.5}$ (normalized distance to chance) and ranging, for each face pair, from 0 for absence of agreement to 1 for a perfect agreement.

We also correlated the groups' choice probability matrices between the two tasks for each group of participants. We then computed within-subjects correlation analyses in order to investigate whether the attractiveness and trustworthiness judgments were related *at an individual level*. For each participant we computed a first within-subject Pearson's correlation between the profile of responses for the attractiveness and the trustworthiness tasks. Since correlation coefficients are not additive, they must be z-normalized (Chung et al. 2005) before performing statistical analyses. We thus normalized the obtained correlation coefficients by using Fisher's transform $Z = 0.5 \cdot \log_e \left| \frac{1+r}{1-r} \right|$ and then performed a two-tailed *t*-test between groups.

Saccades and fixations were determined using a custom algorithm using the same filter parameters as the EyeLink software (saccade velocity threshold = 30°/sec; saccade acceleration threshold = 4000°/sec²) and merging fixations close spatially and temporally (<20ms, <0.3°). Fixation distribution maps were extracted individually for each observer. The statistical fixation maps were computed with the *iMap* toolbox, version 3 (Caldara and Miellel 2011). *iMap*3 uses pixelwise *t*-values and bootstrapped TFCE transformed scores to correct for multiple comparisons (TFCE: threshold-free cluster-enhancement; Pernet, Chauveau, Gaspar, Rousselet, 2011; Smith and Nichols, 2009). *iMap*3 computes the pixelwise *t*-values across participant on smoothed (0.5 degrees of visual angle according to the spatial resolution of the eye-tracker) Z-scored maps. Thus, each participant Z-map is normalized in the stimulus space in order to represent the individual fixation bias.

Results

Figure 1 shows the pairwise probability of choice matrices for both groups of children and both tasks. This representation suggests, for both tasks, more inter-participant agreement for the controls than for the clinical children (darker colors, dark red or dark blue corresponding

to more extreme probabilities). Figure 1 also shows, for both tasks, more structure in the judgments for the controls than for the clinical children. For instance, face number 8 has been consistently judged more attractive than any other face by the control children and, face 17 consistently less than any other face by controls.

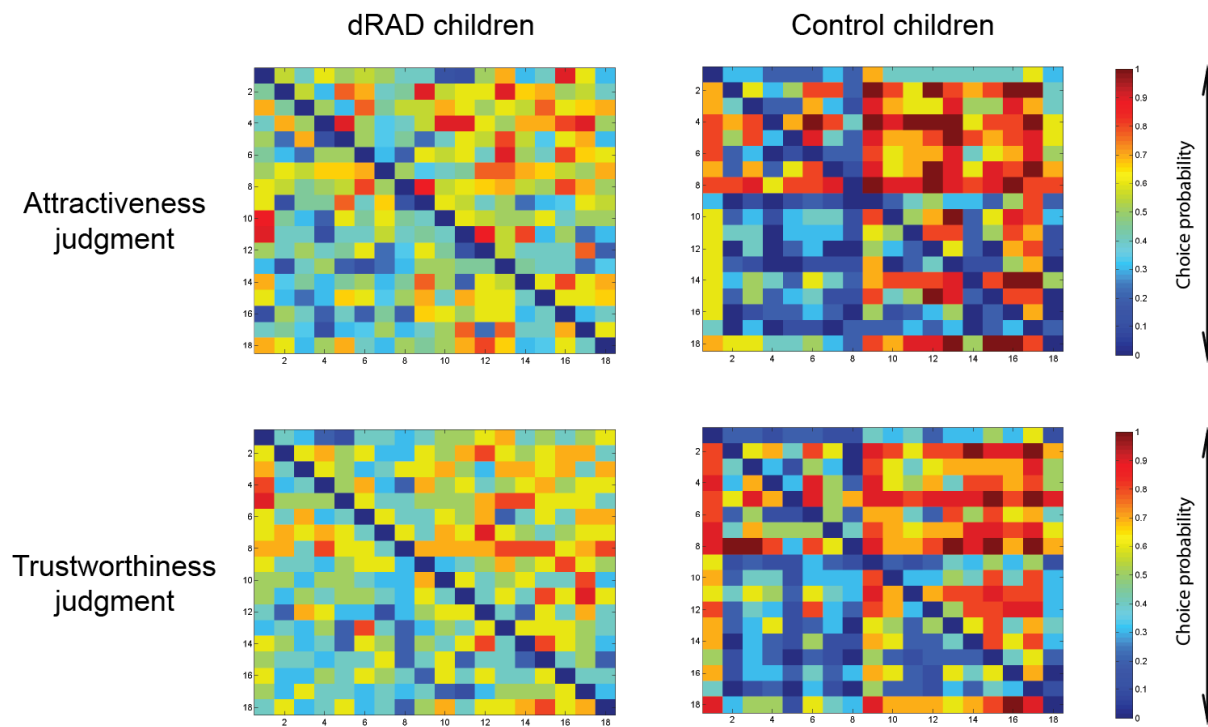


Figure 1. *Probability of choice matrices for both children groups (dRAD and controls) and both tasks (attractiveness and trustworthiness judgment). Each line of the matrices shows the probability of choosing a given face over all the remaining faces. The hot colors (yellow to red) indicate that the face corresponding to line number was chosen more (>0.5) than the face corresponding to the column number. The cold colors (light blue to dark blue) indicate that it has been chosen less (<0.5). The diagonal does not contain any value, as faces were never compared with themselves.*

The 2 (participants group: clinical/control) x 2 (task: attractiveness/trustworthiness) ANOVA on the agreement index revealed a main effect of the group ($F(1, 304) = 126.75, p < .0001, \eta^2 = .29$). This result confirms a stronger agreement between the control participants (average agreement across the face pairs: 0.54 and 0.49 for the attractiveness and trustworthiness task) than between the clinical participants (0.29 and 0.27). No other effect was significant. The choice probability matrices were strongly correlated between the attractiveness and trustworthiness tasks for the control participants ($r = 0.66, p < .0001$) but not the clinical participants ($r = 0.11, p = .19$). In order to confirm the previous result *at an individual level* (that the same control participants chose a given face in both tasks), we

performed within-subjects correlations. This analysis confirmed a stronger correlation between the two tasks for the control than for the clinical children (average normalized r : 0.4 and 0.09 respectively, $t(18) = 4.06$, $p < .001$). The correlation between the attractiveness and the trustworthiness task was significantly different from 0 for the control children ($t(9) = 6.64$, $p < .0001$) but not for the clinical children.

Figure 2 shows fixation maps and the regions significantly fixated above chance level according to *iMap* (version 3) for control and clinical children during both judgment tasks. The fixation maps show that both dRAD and typically developed children use the same sampling strategies to extract facial information during social judgment.

Note that the central fixation cluster is due to the first fixation of each trial. The presentation of the faces pair was preceded by a central fixation cross allowing for calibration check. Hence, when the recording started, as faces were presented, the participants' eyes were still fixating the center of the screen until the first saccade towards one of the faces.

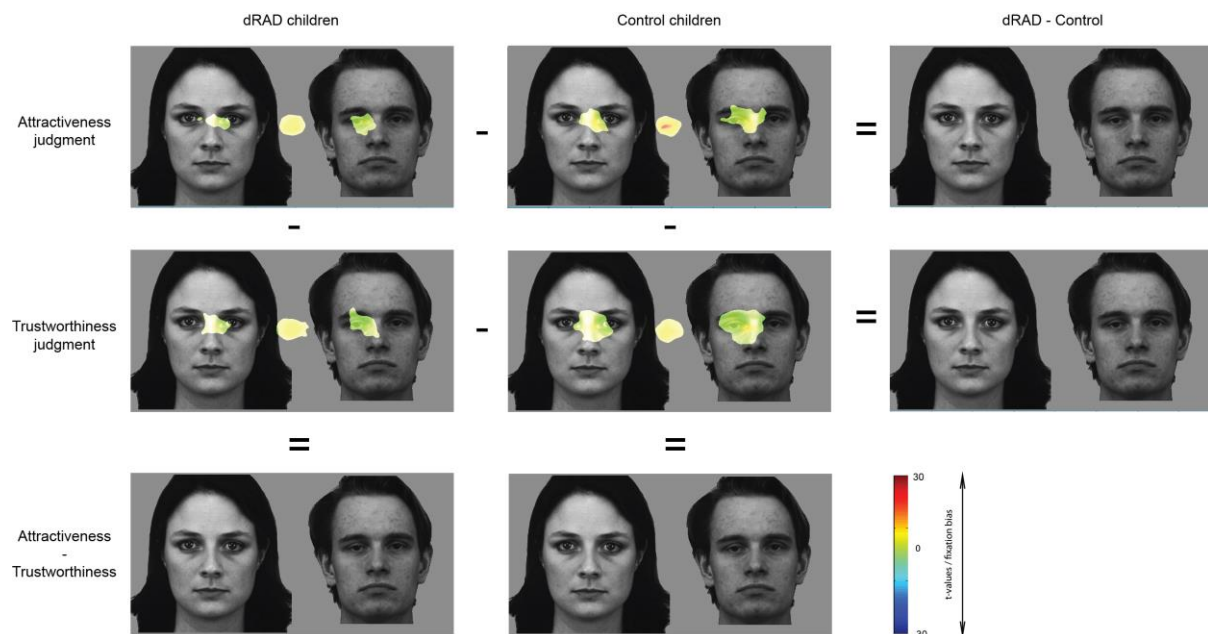


Figure 2: Fixation maps based on the fixation durations for each task and each children group. Subtracting the fixation maps for the control children from the fixation maps for the dRAD children resulted in the group difference maps for each task (third column). Similarly, subtracting the fixation maps for the trustworthiness task from the fixation maps for the attractiveness task resulted in the task difference maps for each group (third row). On the fixation maps, the colored clusters show areas that are fixated significantly longer than the average fixation duration. No significant areas are visible on the difference maps.

Discussion

Our findings show that, like adults, typically developing children show clear preferences and high inter-observers agreement while evaluating unfamiliar faces on both attractiveness and trustworthiness. In contrast, the dRAD group of maltreated children with indiscriminate friendliness showed less clear preferences on these tasks (lower inter-participant agreement and less structure in the pairwise choice matrices). Moreover, only the typically developing, and not the children with dRAD symptoms, show the expected strong correlation (at group and individual levels) in their trustworthiness and attractiveness judgments. This link between attractiveness and trustworthiness judgments has been clearly established in adults in previous studies (for instance Oosterhof & Todorov, 2008; Willis & Todorov, 2006). Hence, the control children display a pattern of results consistent with what is observed in adults and consistent with the findings of Antonakis & Dalgas (2009), which is not the case for the dRAD children. Finally, dRAD children use the same facial information sampling strategy than control children, with both groups of children looking preferentially in the eyes region, a fixation pattern that is not modulated by the task (trustworthiness vs. attractiveness judgment). Critically, this observation rules out that the impairment in making social judgments from faces in dRAD population is arising from an inappropriate fixation towards the diagnostic facial features. It should be noted that these findings apply to maltreated children who have the core symptom of dRAD, namely indiscriminate friendliness and may not apply to all maltreated children.

Considering that children with dRAD sample faces in a similar way to typically developing children, their atypical social judgments may result from a specific problem with processing the visual information available for social judgment. When designing, analysing and interpreting eye-movement studies it is crucial to keep in mind that eye movement recordings in natural viewing conditions do not provide unequivocal evidence on the measure of the visual information being used by observers. As a matter of fact, despite being tight, the coupling between fixated and processed information is not perfect (concepts of overt vs. covert attention, Posner, 1980). Hence, critical visual information is extracted from extrafoveal vision (see Mielle & Sparrow, 2004; Caldara, Zhou, & Mielle, S., 2010). Our results reveal that the scanning strategy adopted by RAD and control children is similar. However, they do not warrant that both populations use the same information in order to perform the task at hand. Future studies, using gaze-contingent techniques, would permit to

investigate more finely information use for social judgment in RAD children. Indeed, gaze-contingent techniques can overcome limitations inherent to simple eye-movement recording. By precisely controlling online the information projected in different parts of the visual field, the gaze-contingent techniques permit us to disentangle what is fixated and what is processed. Therefore, the gaze-contingent technique is a powerful method to control for the visual information feeding the visual system and to isolate information use (Miellet, Caldara & Schyns, 2011; Miellet, Vizioli, He, Zhou & Caldara, 2013).

Regardless of the inherent limitations of natural eye movement recordings, the present data provide an interesting contrast to children with ASD who show atypical gaze pattern towards social relevant stimuli and particularly during face exploration. Despite being an on-going debate, the fixation bias in ASD is replicated in a substantial number of studies (Noris et al., 2012; Nadel et al., 2012; Pierce et al., 2011; Riby and Hancock, 2009 ; Rice et al., 2012; Chawarska and Shic, 2009; Pelphrey et al., 2002 ; Dalton et al., 2005; Jones et al., 2008 ; Kliemann et al., 2010; Klin and Jones, 2008; Klin et al., 2002). Thus, it seems that, in contrast with children with ASD, the difficulties experienced by children with RAD are not linked to sampling of facial features but to a problem with specific processing of the very same visual information that is available to typically developed children. Various authors have described Reactive Attachment Disorder as a social impairment, rather than as a disorder of attachment (Green and Goldwyn 2002; Minnis, Marwick, Arthur, & McLaughlin 2006) and these results support this view: despite its environmental aetiology, it appears that neurological processes may have been set in train by the early environmental insult that are perpetuated through development.

Our findings are somewhat limited by our modest sample size, hence interpretations and generalizations of the present findings have to be made with caution given the potential heterogeneity of both causes and symptomatology in RAD. Although our main analyses were adequately powered it would be interesting in future research to recruit large enough samples to explore, for example, whether there are within group differences according to IQ or symptom severity.

Our findings have important implications for the way we understand indiscriminate friendliness in maltreated children. If these children are less effective than controls at using available information from faces, with similar results than children with ASD, although through different mechanisms, then treatment strategies such as those that are effective in ASD may be worth trialing in this group. For example, the “Lets Face It” program has been useful in working with children with ASD in both understanding the nature of the deficits and in effecting actual improvement in face recognition (Tanaka et al. 2013). Using similar programs with indiscriminately friendly children may help us better understand the nature of their problems in this domain and improve their functioning.

This study is a first step in teasing out the nature of the deficits in face processing in indiscriminately friendly children and there are various avenues for future research. fMRI studies will be important in identifying the brain regions associated with these difficulties and

may further deepen our understanding of the nature of the deficits. It will also be important to conduct detailed face processing studies comparing indiscriminately friendly children to maltreated children who do not suffer from indiscriminate friendliness, before we can be confident that the face processing deficits and clinical phenomenology are linked.

Comparisons with children suffering from other neurodevelopmental disorders such as ASD and William's syndrome may also help determine whether or not there is a signature "indiscriminate friendliness" syndrome as regards face processing deficits or whether these children are in fact suffering from similar difficulties to other groups of children.

Acknowledgements: RC was supported by the National Center of Competence in Research (NCCR) Affective sciences financed by the Swiss National Science Foundation (n° 51NF40-104897). We are grateful to all participating families, to Mrs. Fiona Lettice from Adoption UK for facilitating recruitment of our adoptive sample and to Dr. Jasmeet Bindra, Dr. Lisa Collin, Kay Foreman and Junpeng Lao for their help with data collection. The funding for the study came from the Weir Bequest for Child and Adolescent Psychiatric Research.

References

- Antonakis, J. & Dalgas, O. 2009. Predicting elections: Child's Play! *Science*, 323, (27 February) 1183 available from: www.sciencemag.org
- Balliet, D. & Van Lange, P.A.M. 2012. Trust, conflict, and cooperation: A Meta-Analysis. *Psychological Bulletin*, Dec 10,
- Bennett, J., Espie, C., Duncan, B., & Minnis, H. 2009. A Qualitative Exploration of Children's Understanding of Indiscriminate Friendliness. *Clinical Child Psychology and Psychiatry*, 14, (4) 595-618
- Brainard, D.H. 1997. The Psychophysics Toolbox. *Spatial Vision*, 10, (4) 433-436
- Caldara, R. & Mielliet, S. 2011. iMap: a novel method for statistical fixation mapping of eye movement data. *Behaviour Research Methods*, 43, (3) 864-878
- Caldara, R., Zhou, X., & Mielliet, S. (2010). Putting culture under the spotlight reveals universal information use for face recognition. *PLoS ONE*, 5 (3) pp e9708. doi:10.1371/journal.pone.
- Camras, L. A., Ribordy, S., Hill, J., Martino, S., Sachs, V., Spaccarelli, S., & Stefani, R. (1990). Maternal facial behavior and the recognition and production of emotional expression by maltreated and nonmaltreated children. *Developmental Psychology*, 26(2), 304-312.
- Camras, L. A., Ribordy, S., Hill, J., Martino, S., Spaccarelli, S., & Stefani, R. (1988). Recognition and posing of emotional expressions by abused children and their mothers. *Developmental Psychology*, 24(6), 776-781.
- Carter EJ, Williams DL, Minshew NJ, Lehman JF (2012) Is He Being Bad? Social and Language Brain Networks during Social Judgment in Children with Autism. *PLoS ONE* 7(10): e47241. doi:10.1371/journal.pone.0047241
- Chawarska K, Shic F. 2009. Looking but not seeing: atypical visual scanning and recognition of faces in 2 and 4-year-old children with autism spectrum disorder. *J Autism Dev Disord*. 39(12):1663-72. doi: 10.1007/s10803-009-0803-7. Chung, M.K., Kim, D.M., Kelley, D.J., Robbins, S., Evans, A.C., & Davidson, R.J. 2005. *Partial correlation mapping of anatomical and behavioural measures and its application to autism* Madison, University of Wisconsin.
- Cornelissen, F.W. & Peters, E.M. 2002. The EyeLink Toolbox: Eye tracking with MATLAB and the Psychophysics Toolbox. *Behavior Research Methods, Instruments and Computers*, 34, (4) 613-617
- Dalton KM, Nacewicz BM, Johnstone T, Schaefer HS, Gernsbacher MA, Goldsmith HH, Alexander AL, Davidson RJ. (2005) Gaze fixation and the neural circuitry of face processing in autism. *Nat Neurosci*.;8(4):519-26.

Fletcher-Watson S, Leekam SR, Benson V, Frank MC, Findlay JM (2009) Eye-movements reveal attention to social information in autism spectrum disorder. *Neuropsychologia* 47(1): 248–257. doi: 10.1016/j.neuropsychologia.2008.07.016.

Freeth M, Chapman P, Ropar D, Mitchell P (2010) Do Gaze Cues in Complex Scenes Capture and Direct the Attention of High Functioning Adolescents with ASD? Evidence from Eye-tracking. *Journal of Autism and Developmental Disorders* 40: 534–547. doi: 10.1007/s10803-009-0893-2.

Gleason, M.M., Fox, N.A., Drury, S., Smyke, A., Egger, H.L., Nelson, C.S., Gregas, M.C., & Zeanah, C.H. 2011. Validity of Evidence-Derived Criteria for Reactive Attachment Disorder: Indiscriminately Social/Disinhibited and Emotionally Withdrawn/Inhibited Types. *Journal of the American Academy of Child & Adolescent Psychiatry*, 50, (3) 216-231.e3

Goddard, R.D. 2003. Relational networks, social trust, and norms: a social capital perspective on students' chances of academic success. *Educational Evaluation and Policy Analysis*, 25, (1) 59-74

Green, J. & Goldwyn, R. 2002. Attachment disorganization and psychopathology: new findings in attachment research and their potential implications for development and psychopathology in childhood. *Journal of Child Psychology and Psychiatry*, 43, 835-846

Halberstadt, A. G., & Eaton, K. L. (2002). A metaanalysis of family expressiveness and children's emotion expressiveness and understanding. *Marriage and Family Review*, 34(1), 35–62.

Hall, E.T. 1990. *The Hidden Dimension* New York, Doubleday.

Harris, P.L. & Corriveau, K.H. 2011. Young children's selective trust in informants. *Philosophical Transactions of The Royal Society Biological Sciences*, 366, (1567) 1179-1187

Jones W, Carr K, Klin A. 2008. Absence of preferential looking to the eyes of approaching adults predicts level of social disability in 2-year-old toddlers with autism spectrum disorder. *Arch Gen Psychiatry*. 65(8):946-54. doi: 10.1001/archpsyc.65.8.946.

Kliemann D, Dziobek I, Hatri A, Steimke R, Heekeren HR. (2010). Atypical reflexive gaze patterns on emotional faces in autism spectrum disorders. *J Neurosci*.30(37):12281-7. doi: 10.1523/JNEUROSCI.0688-10.2010.

Klin A, Jones W (2008) Altered face scanning and impaired recognition of biological motion in a 15-month-old infant with autism. *Developmental Science* 11(1): 40–46. doi: 10.1111/j.1467-7687.2007.00608.x.

Klin A, Jones W, Schultz R, Volkmar F, Cohen D (2002) Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry* 59: 809–816. doi: 10.1001/archpsyc.59.9.809.

Kocovska, E., Puckering, C., Follan, M., Smillie, M., Gorski, C., Barnes, J., Wilson, P., Young, D., Lidstone, E., Pritchett, R., Hockaday, H., & Minnis, H. 2012. Neurodevelopmental problems in

maltreated children referred with indiscriminate friendliness. *Research in Developmental Disabilities*, 33, 1560-1565

Lao, J., Foreman, K., Zhou, X., Lages, M., Hillis, J., & Caldara, R. 2010. Social judgements from faces are universal. *Journal of Vision*, 10, (7 article 698)

Lieberman, A.F. 2003. The treatment of attachment disorder in infancy and early childhood: reflections from clinical intervention with later-adopted foster care children. *Attachment and Human Development*, 5, (3) 279-282

Lundqvist, D. & Litton, J.E. 1998. *The Averaged Karolinska Directed Emotional Faces - AKDEF* Stockholm, Sweden, Department of Clinical Neuroscience, Psychology Section, Karolinska Institutet.

Minnis, H., Marwick, H., Arthur, J., & McLaughlin, A. 2006. Reactive attachment disorder - a theoretical model beyond attachment. *European Child and Adolescent Psychiatry*, 15, 336-342

Norbury CF, Brock J, Cragg L, Einav S, Griffiths H, et al. (2009) Eye-movement patterns are associated with communicative competence in autistic spectrum disorders. *Journal of Child Psychology and Psychiatry* 50: 834–842. doi: 10.1111/j.1469-7610.2009.02073.x.

Noris, B., Nadel, J., Barker, M., Hadjikhani, N., & Billard, A. 2012. Investigating gaze of children with ASD in naturalistic settings. *PLOS one*, 7, (9 (e44144)) 1-11 available from: <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0044144>

Oosterhof, N.N. & Todorov, A. 2008. The functional basis of face evaluation. *Proceedings of the National Academy of Sciences (PNAS)*, 105, (32) 11087-11092

Pelphrey KA, Sasson NJ, Reznick JS, Paul G, Goldman BD, Piven J. (2002) Visual scanning of faces in autism. *J Autism Dev Disord*. 2002 Aug;32(4):249-61.

Pernet, C.R., Chauveau, N., Gaspar, C.M., & Rousselet, G.G. (2011). LIMO EEG: A Toolbox for Hierarchical Linear Modeling of Electroencephalographic Data. *Computational Intelligence and Neuroscience*. Article ID 831409, doi:10.1155/2011/831409

Pierce K, Conant D, Hazin R, Stoner R, Desmond J. (2011). Preference for geometric patterns early in life as a risk factor for autism. *Arch Gen Psychiatry*. 2011 Jan;68(1):101-9. doi: 10.1001/archgenpsychiatry.2010.113.

Pollak SD, Cicchetti D, Hornung K, Reed A. 2000. Recognizing emotion in faces: developmental effects of child abuse and neglect. *Dev Psychol*. 36(5):679-88.

Pollak SD, Sinha P. 2002. Effects of early experience on children's recognition of facial displays of emotion. *Dev Psychol*. 2002 Sep;38(5):784-91.

Riby DM, Hancock PJB (2009) Do faces capture the attention of individuals with williams syndrome or autism? evidence from tracking eye movements. *Journal of Autism and Developmental Disorders* 39: 421–431. doi: 10.1007/s10803-008-0641-z.

Rice K, Moriuchi JM, Jones W, Klin A. (2012). Parsing heterogeneity in autism spectrum disorders: visual scanning of dynamic social scenes in school-aged children. *J Am Acad Child Adolesc Psychiatry*. 51(3):238-48. doi: 10.1016/j.jaac.2011.12.017.

Rutherford MD, Towns AM (2008) Scan path differences and similarities during emotion perception in those with and without autism spectrum disorders. *Journal of Autism and Developmental Disorders* 38: 1371–1381. doi: 10.1007/s10803-007-0525-7.

Rutter, M., Kreppner, J., & Sonuga-Barke, E. 2009. Emanuel Millar Lecture: Attachment insecurity, disinhibited attachment, and attachment disorders: where do the research findings leave the concepts? *Journal of Child Psychology and Psychiatry*, 50, (5) 529-543

Rutter, M., Colvert, E., Kreppner, J., Beckett, C., Castle, J., Groothues, C., Hawkins, A., O'Connor, T.G., Stevens, S.E., & Sonuga-Barke, E.J.S. 2007. Early adolescent outcomes for institutionally-deprived and non-deprived adoptees. I: Disinhibited attachment. *Journal of the Child Psychology and Psychiatry*, 48, (1) 17-30

Sakai, A. 2010, "Children's sense of trust in significant others: genetic versus environmental contributions and buffer to life stressors," *In Interpersonal trust during childhood and adolescence.*, K. J. Rotenberg, ed., New York: Cambridge University Press, pp. 56-84.

Shackman, Jessica E. , Fatani, Serah , Camras, Linda A. , Berkowitz, Michael J. , Bachorowski, Jo-Anne and Pollak, Seth D.(2010) 'Emotion expression among abusive mothers is associated with their children's emotion processing and problem behaviours', *Cognition & Emotion*, 24 (8), 1421-1430. DOI 10.1080/02699930903399376

Smith S.M., & Nichols, T.E. (2009). Threshold-free cluster enhancement: addressing problems of smoothing, threshold dependence and localisation in cluster inference. *Neuroimage*, 44(1), 83-98. doi: 10.1016/j.neuroimage.2008.03.061.

Tanaka, J.W., Wolf, J.M., Klaiman, C., Koenig, K., Cockburn, J., Herlihy, L., Brown, C., Stahl, S., Kaiser, M.D., & Schultz, R.T. 2013. Using computerized games to teach face recognition skills to children with autism spectrum disorder: the Let's Face It! program. *Journal of Child Psychology and Psychiatry*, 51, (8) 944-952

Teicher, M.H., Andersen, S.L., Polcari, A., Anderson, C.M., Navalta, C.P., & Kim, D.M. 2003. The neurobiological consequences of early stress and childhood maltreatment. *Neuroscience and Biobehavioral Reviews*, 27, 33-44

Todorov, A., Baron, S.G., & Oosterhof, N.N. 2008. Evaluating face trustworthiness: a model based approach. *Social Cognitive and Affective Neurosciences*, 3, (2) 119-127

Todorov, A., Mandisodza, A.N., Goren, A., & Hall, C.C. 2005. Inferences of competence from faces predict election outcomes. *Science*, 308, (5728) 1623-1626

Vanderbilt, K.E., Liu, D., & Heyman, G.D. 2011. The development of distrust. *Child Development*, 82, (5) 1372-1380

van der Geest JN, Kemner C, Verbaten MN, van Engeland H (2002) Gaze behavior of children with pervasive developmental disorder toward human faces: a fixation time study. *Journal of Child Psychology and Psychiatry and Allied Disciplines* 43(5): 669–678. doi: 10.1111/1469-7610.00055. Willis, J. & Todorov, A. 2006. First impressions: making up your mind after a 100-Ms exposure to a face. *Psychological Science*, 17, (7) 592-598

Wilson CE, Palermo R, Brock J (2012) Visual Scan Paths and Recognition of Facial Identity in Autism Spectrum Disorder and Typical Development. *PLoS ONE* 7(5): e37681. doi:10.1371/journal.pone.0037681