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Social attention in children with epilepsy

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ABSTRACT

Children with epilepsy may be vulnerable to impaired social attention given the increased risk of neurobehavioural comorbidities. Social attentional orienting and the potential modulatory role of attentional control on the perceptual processing of gaze and emotion cues have not been examined in childhood onset epilepsies. Social attention mechanisms were investigated in patients with epilepsy (n = 25) aged 8–18 years old and performance compared to healthy controls (n = 30). Dynamic gaze and emotion facial stimuli were integrated into an antisaccade eye-tracking paradigm. The time to orient attention and execute a horizontal saccade toward (prosaccade) or away (antisaccade) from a peripheral target measured processing speed of social signals under conditions of low or high attentional control. Patients with epilepsy had impaired processing speed compared to healthy controls under conditions of high attentional control only when gaze and emotions were combined meaningfully to signal motivational intent of approach (happy or anger with a direct gaze) or avoidance (fear or sad with an averted gaze). Group differences were larger in older adolescent patients. Analyses of the discrete gaze emotion combinations found independent effects of epilepsy-related, cognitive and behavioural problems. A delayed disengagement from fearful gaze was also found under low attentional control that was linked to epilepsy developmental factors and was similarly observed in patients with higher reported anxiety problems. Overall, findings indicate increased perceptual processing of developmentally relevant social motivations during increased cognitive control, and the possibility of a persistent fear-related attentional bias. This was not limited to patients with chronic epilepsy, lower IQ or reported behavioural problems and has implications for social and emotional development in individuals with childhood onset epilepsies beyond remission.

1. Introduction

The neurobehavioural comorbidities associated with childhood onset epilepsies include neurocognitive deficits, psychiatric disorders and possible long-term difficulties with social adjustment (Hermann, Seidenberg, & Jones, 2008). Behavioural and neuroimaging work with neurodevelopmental and neuropsychiatric populations has identified aberrant integration of the social perceptual processing of gaze and emotion signals with higher order attentional control as a core mechanism underlying social impairments (Itier & Batty, 2009; Nummenmaa & Calder, 2009). As yet however it is unclear whether children with epilepsy will show typical responding to gaze and emotion cues, or if impaired social attention processes are evident and associated with epilepsy related factors, cognitive deficits and behavioural problems.

Prior pediatric research on social perceptual skills remains limited and has focused mainly on patients with temporal lobe epilepsies (TLE) (Monti & Meletti, 2015). Studies report aberrant face processing mechanisms (Taylor, Mills, Smith, & Pang, 2008) and gaze direction and emotion recognition deficits (Golouboff et al., 2008; Laurent et al., 2014). Patients often present with broader neurocognitive dysfunction (Hermann et al., 2002), attributed to a generalized impact of early onset on neurodevelopment, and impairment is often found across different patient groups when compared with healthy controls. Few studies have addressed the link between social perceptual skills and behavioural difficulties. Golouboff et al. reported impaired fear recognition predicted behavioural problems in a subset of TLE patients, and perceptual theory of mind deficits were shown to correlate with social and attention problems in a heterogeneous patient group with below average IQ (Lunn, Lewis, & Sherlock, 2015). Overall, findings indicate a high

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degree of individual variability, and deficits not isolated to the social perceptual domain. The prevalence of neurobehavioural problems in complicated and uncomplicated epilepsies is well recognized (Aaberg et al., 2016) yet the integrity of core social processes that include attentional orienting to gaze and emotion cues remains to be addressed in children with epilepsy.

Extensive research on social attention has observed facilitation of attentional orienting to locations cued by gaze, attributed to a possibly reflexive social orienting mechanism to follow others' gaze and emotion expressions are shown to differentially modulate this attentional orienting (Friesen & Kingstone, 1998; Frischen, Bayliss, & Tipper, 2007). This response modulation has been used to index skills in the perceptual decoding of facial cues that scaffold inference on communicative intent in typical and atypical populations. Notably, the potentiated attentional orienting to fear cues, interpreted as evidence of an adapted mechanism for identifying environmental threat (Neath, Nilsen, Gittsovich, & Itier, 2013) as well as threat-related attentional biases implicated in the development and maintenance of anxiety disorders (Mathews, Fox, Yiend, & Calder, 2003). Further work has also identified gaze direction and emotional expression reciprocal interactions, whereby specific configurations (shared signals) enhance recognition when consistent with motivational intent of approach (a direct gaze with happy and anger) and avoidance (averted gaze with fear or sad) (Adams & Franklin, 2009; Adams & Kleck, 2005). This preferential processing of shared signals has been observed by late childhood in typical development, whereas such response patterns are reportedly absent in similar aged children with autistic spectrum disorders, leading to the hypothesis that a weakened integration of multiple social cues underlies social impairments in ASD (Akechi et al., 2009).

Studies have also manipulated the level of cognitive control required for a successful response in order to assess more complex cognition-emotion interactions underpinning behavioural regulation (Mueller et al., 2012; Tottenham, Hare, & Casey, 2011; Wolohan & Crawford, 2012). Behavioural studies report continued improvement in both emotion discrimination abilities and integration with inhibitory control processes, consistent with neuroscientific evidence of a protracted developmental course of social attention networks throughout childhood and adolescence (Hare et al., 2008; Scherf, Behrmann, & Dahl, 2012; Thomas, De Bellis, Graham, & LaBar, 2007).

Children with epilepsy without global developmental delay are at risk of disrupted developmental integration of attention and inhibitory control with other domains (Kellermann, Bonilha, Lin, & Hermann, 2015). It is important to determine if there is a vulnerability to the developmental integration of social perceptual processes and cognitive control that underlies socio-emotional and behavioural regulation. The aims of the study are to compare social attentional orienting under low and high cognitive control to gaze cues and meaningful social signals, using a modified gaze emotion antisaccade eye-tracking paradigm. Analyses will compare age-related changes in social attention between patients and controls, and assess if observed deficits are associated with epilepsy-related factors, cognitive deficits and behavioural problems.

2. Materials and methods

2.1. Participants

The study involved a total of 55 children aged 8–18 years old, 25 patients and 30 healthy control children. The inclusion criteria for patients were children with epilepsy (CWE) in mainstream education with presumed genetic or unknown etiology without identifiable structural or metabolic abnormalities. The research program's recruitment strategy has been previously described (Lunn et al., 2015). At recruitment to the research program a pediatric neurologist classified patients in accordance with the revised terminology proposed by the International League Against Epilepsy (ILAE) 2005–2009 (Berg et al., 2010). Recent classifications of drug resistant epilepsy (Kwan et al., 2010) or resolved epilepsy (Fisher et al., 2014) were not available at the time of recruitment to the research program. Therefore the broad terms 'chronic' and 'controlled' have been adopted here. In the present sample of children, who agreed to continue to participate in research, there were fourteen (57%) patients in receipt of antiepileptic drugs ('chronic' epilepsy) whereas eleven children were unmedicated with four who had never taken AEDs ('controlled' epilepsy). Of the eleven unmedicated children, 9 had no reported seizures in the previous 12 months. Patient IQs ranged between 60 and 121 with eight children in the mild intellectual disability range of 60–80 IQ points (3 children IQ < 70). Table 1 displays summary data on clinical variables and more detailed clinical information on individual patients is reported in the Supplementary materials (Table S1).

The healthy control group (HC) was recruited via a university research database. All 55 children had normal or corrected to normal vision and none had received a diagnosis of a learning disability or a neurodevelopmental disorder. No IQ estimates were collected from controls as this group was recruited from a typical population and would not have matched those patients who had a below average IQ. Participant information is displayed in Table 1.

2.2. Dynamic gaze emotion task

Static colour images of 2 male and 2 female Caucasian models with five expressions of happy, sad, anger, fear and neutral (Matsumuto & Ekman, 1988) were modified to create a dynamic change from a neutral face with a direct gaze to a full expression with either a direct gaze or a simultaneous shift to averted gaze. This produced the four gaze and emotion conditions consistent with approach (happy and anger with direct gaze) and avoidance (fear and sad with averted gaze) motivations, in addition to a neutral condition. The stimuli subtended a visual angle of 12° × 18°, approximate to the dimensions of an average face viewed from a distance of 1 m, and were 1200 ms in duration (see Fig. 1). Full details on the production of the dynamic stimuli are described in the Supplementary methods.

A fixation cross displayed for a variable duration followed by the dynamic stimuli for 1200 ms that consisted of an initial static display of a neutral face with direct gaze followed by the morphed sequence followed by the final static face display for the respective

Table 1
Participant information.

	Controls (n = 30)	Children with epilepsy (n = 25)
Gender (M:F)	19:11	10:15
Age (years, SD)	13.1 (2.8)	12.9 (2.5)
Attention problems (SD)[a]	54.2 (6.0)	59.4 (11.0)
Anxiety problems (SD)	53.2 (5.2)	56.2 (8.3)
IQ (SD)		90.4 (16.1)
Age at onset (years, SD, range)		7.3 (2.2)
Duration (years, SD)		3.9 (2.9)
None/mono/poly therapy (N)		11/10/4
Epilepsy seizure type/syndrome		
Generalized		8
Focal		6
Mixed		5
BECTS		5
CAE		1

[a] Epilepsy patients had higher reported attention problems than healthy controls t (df = 36.2) = 2.08, p = 0.045, d = 0.59.