Neuropsychologia 63 (2014) 51–58

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Hemodynamic response of children with attention-deficit and hyperactive disorder (ADHD) to emotional facial expressions ☆

Hiroko Ichikawa [a,b,c,*], Emi Nakato [d], So Kanazawa [e], Keiichi Shimamura [f], Yuiko Sakuta [b], Ryoichi Sakuta [f], Masami K. Yamaguchi [a,b], Ryusuke Kakigi [g]

[a] Department of Psychology, Chuo University, Higashi-Nakano, Hachioji-shi, Tokyo 192-0393, Japan
[b] Research and Development Initiative, Chuo University, Chiyoda, Tokyo 112-8551, Japan
[c] Japan Society for the Promotion of Sciences, Chiyoda, Tokyo 102-8471, Japan
[d] Department of Clothing Science, Osaka Shoin Women's University, Higashi-Osaka, Osaka 577-8550, Japan
[e] Department of Psychology, Japan Women's University, Kawasaki, Kanagawa 214-8565, Japan
[f] Center for Child Development and Psychosomatic Medicine, Dokkyo Medical University Koshigaya Hospital, Koshigaya, Saitama 343-0845, Japan
[g] Department of Integrative Physiology, National Institute for Physiological Sciences, Okazaki, Aichi 444-8585, Japan

ARTICLE INFO

Article history:
Received 26 February 2014
Received in revised form
24 July 2014
Accepted 7 August 2014
Available online 23 August 2014

Keywords:
Face processing
ADHD
Near-infrared spectroscopy
NIRS
Occipito-temporal area

ABSTRACT

Children with attention-deficit/hyperactivity disorder (ADHD) have difficulty recognizing facial expressions. They identify angry expressions less accurately than typically developing (TD) children, yet little is known about their atypical neural basis for the recognition of facial expressions. Here, we used near-infrared spectroscopy (NIRS) to examine the distinctive cerebral hemodynamics of ADHD and TD children while they viewed happy and angry expressions. We measured the hemodynamic responses of 13 ADHD boys and 13 TD boys to happy and angry expressions at their bilateral temporal areas, which are sensitive to face processing. The ADHD children showed an increased concentration of oxy-Hb for happy faces but not for angry faces, while TD children showed increased oxy-Hb for both faces. Moreover, the individual peak latency of hemodynamic response in the right temporal area showed significantly greater variance in the ADHD group than in the TD group. Such atypical brain activity observed in ADHD boys may relate to their preserved ability to recognize a happy expression and their difficulty recognizing an angry expression. We firstly demonstrated that NIRS can be used to detect atypical hemodynamic response to facial expressions in ADHD children.
© 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).

1. Introduction

Social cognitive deficits have been reported in school-aged children with attention-deficit hyperactivity disorder (ADHD). ADHD is characterized by inattention, hyperactivity and impulsivity, and has recently become one of the most commonly diagnosed developmental disorders in children (American Psychiatric Association, 2000). Inattention, hyperactivity, and impulsive behavior in children with ADHD can result in social problems (for review, Nijmeijer et al., 2008; Uekermann et al., 2010). Children with ADHD experience seriously disturbed peer relations and tend to be excluded from peer activities (Hoza et al., 2005; Landau & Moore, 1991; Owens, Hinshaw, Lee, & Lahey, 2009).

Children with ADHD have been reported to have other social cognitive impairments besides inattention, hyperactivity and impulsivity. Although we still have limited knowledge about basic face processing in children with ADHD, Tye et al. (2013) demonstrated, as far as we know, the first study to investigate the face-inversion effect and gaze processing in children with ADHD using ERP. They found that the ADHD children showed a reduced face inversion effect on P1 latency compared to TD children. Yuill and Lyon (2007) demonstrated that children with ADHD performed as well as younger controls on a non-emotional task when examiners helped children inhibit impulsive responding. However, in the same study, children with ADHD still showed impairments in the emotion understanding task that required them to choose facial photographs corresponding to emotional descriptions. Furthermore, children with ADHD and its common comorbid disorder (oppositional defiant disorder; ODD) showed significantly lower performance on an emotional understanding task than typically developing (TD) children or children with autistic

☆This study was supported by Grant-in-Aid for Scientific Research on Innovative Areas, 'Face perception and recognition' from MEXT KAKENHI [20119002 to M. K. Y.]; Grant-in-Aid for Scientific Research on Innovative Areas, "Sparse Modeling" from JSPS KAKENHI (26120529 to H. I.); and Grant-in-Aid for Scientific Research by JSPS Research Fellowships for Young Scientists [24 7809 to H. I.] from the Japan Society for the Promotion of Science. The authors report no biomedical financial interests.
* Corresponding author at: Department of Psychology, Chuo University, Higashi-Nakano, Hachioji-shi, Tokyo 192-0393, Japan. Tel./fax: +81 42 674 3843.
E-mail address: ichihiro@tamacc.chuo-u.ac.jp (H. Ichikawa).

http://dx.doi.org/10.1016/j.neuropsychologia.2014.08.010
0028-3932/© 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).

disorder (Downs & Smith, 2004). These studies indicate ADHD children's possible cognitive difficulty in emotion understanding.

School-aged children with ADHD have been found to have impaired recognition of emotional expression (Cadesky, Mota, & Schachar, 2000; Corbett & Glidden, 2000; Pelc, Kornreich, Foisy, & Dan, 2006; Sinzig, Morsch, & Lehmkuhl, 2008; Williams et al., 2008). Previous studies examined the recognition accuracy of children with ADHD using facial expressions of basic emotions such as anger and happiness (Cadesky et al., 2000; Corbett & Glidden, 2000; Kats-Gold, Besser, & Priel, 2007; Pelc et al., 2006; for review, Dickstein & Castellanos, 2012). In these studies the ADHD children recognized angry expressions less accurately than the TD children, yet recognized happy expressions as accurately as the TD children (Kats-Gold et al., 2007; Pelc et al., 2006; Williams et al., 2008, but see also Cadesky et al., 2000). Pelc et al. (2006) asked ADHD children and TD children to identify the emotions portrayed in facial photographs of anger, happiness, disgust and sadness. Compared with the TD children, the decoding accuracy of the ADHD children was equivalent for happiness and disgust, but significantly lower for anger and sadness. Pelc et al. attributed ADHD children's difficulty in recognizing angry expressions to both the complex dynamics of the self-perception of anger and to a “distorted empathy” in ADHD children. Guyer et al. (2007) supported this attribution, although they found that adolescents (who were 12-years or older) with ADHD or conduct disorder performed face-emotion labeling tasks similarly to control participants, and concluded that preadolescent ADHD children could have greater difficulty recognizing facial emotions than older ADHD children. Based on these studies and the aforementioned literature reporting that school-aged ADHD children have experienced angry expressions from their peers more often than TD children (Hoza et al., 2005; Landau & Moore, 1991), we can suppose that their biased experience may result in them processing angry expressions and happy expressions differently.

The neural basis of ADHD children's processing of emotional expression is also different from that of TD children. When ADHD children observed a neutral expression and rated the intensity of a fearful expression, their left amygdala hyperactivated relative to that of the TD children (Brotman et al., 2010). Marsh et al. (2008) reported that when ADHD children implicitly processed a fearful expression in the gender-judgment task, their amygdala responded to a fearful expression as strongly as those of TD children, but that their posterior cingulate cortex and middle frontal gyrus hyperactivated for an angry expression. While the amygdala is recruited for the ‘amygdala network’ that is involved in triggering emotional responses to detected social stimuli, the posterior cingulate cortex and the superior temporal sulci (STS) are involved in the ‘mentalizing network’ (Kennedy & Adolphs, 2012). The STS is well-known to play important role in processing biological motion and dynamic facial movement (Allison, Puce, & McCarthy, 2000; Pelphrey, Morris, McCarthy, & Labar, 2007). Also, STS is responsible for recognizing facial expression that inherent in even static image of facial expression (Andrews & Ewbank, 2004; Engell & Haxby, 2007; Narumoto, Okada, Sadato, Fukui, & Yonekura, 2001; Said, Moore, Engell, & Haxby, 2010). The ERP study has revealed atypical neural response in the temporal region around the STS in ADHD children to an angry expression, but typical neural response to a happy expression (Williams et al., 2008). However, the spatial location of brain activity cannot be accurately drawn with ERP. To further investigate the neural activity around the STS, we can use near-spectroscopy (NIRS), which has a much more reliable spatial resolution than ERP.

In this study, we used NIRS to investigate the neural basis of school-aged ADHD children's processing of facial expressions. NIRS has several clear advantages for studying children with developmental disorders (Ernst, Schneider, Ehlis, & Fallgatter, 2012; Fukuda, 2009; Ichikawa et al., 2014). Compared to other neuroimaging techniques such as fMRI, NIRS is completely silent, providing a non-intrusive environment and requiring less stabilization of the body and head. NIRS has been utilized in revealing the brain activity of ADHD children for executing cognitive tasks (Ehlis, Bähne, Jacob, Herrmann, & Fallgatter, 2008; Monden et al., 2012; Weber, Lütschg, & Fahnenstich, 2005). These studies measured the hemodynamic response in the prefrontal area. However, as mentioned above, the most important region in processing facial expressions is the occipital temporal area, including the superior temporal sulcus (STS) (Andrews & Ewbank, 2004; Said et al., 2010). Our group previously applied NIRS to measure the brain activity in the bilateral occipital temporal area overlying the STS of 6- to 7-month-old infants while they viewed facial expressions and found face-related cerebral hemodynamic response (Nakato, Otsuka, Kanazawa, Yamaguchi, & Kakigi, 2011). For typically developed adults, it has been reported that the processing of facial expression occurs dominantly in the right hemisphere (Etcoff, 1984; Gainotti, 2012; Nakamura et al. 1999; Tsuchiya, Kawasaki, Oya, Howard, & Adolphs, 2008).

To investigate the neural basis of ADHD children's recognition of facial expression, we used NIRS to measure the hemodynamic responses of ADHD children and TD children to the facial expressions of happiness and anger. This is the first attempt to reveal the hemodynamic response in the bilateral occipital temporal area of ADHD and TD children to facial expressions using NIRS.

2. Methods

2.1. Participants

The participants were 13 Japanese boys (mean age, 10 years 0 months; SD=1 year 3 months, range, 8–12 years) with ADHD (5 combined, 6 inattentive, and 2 hyperactive/impulsive subtype) and 13 typically developing (TD) boys (mean age, 9 years 8 months; SD=1 year 3 months; range, 8–12 years)[1]. An additional five boys with ADHD and two TD boys participated, but were excluded from the final analysis because they either failed to look at the face stimuli for more than three trials during the presentation of faces (two ADHD boys), or exhibited large body movements during the experiment (the three other ADHD boys and the two TD boys).

All diagnoses were based on the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, Text Revision (DSM-IV-TR) and were made by two pediatric neurologists. Averaged ADHD-Rating Scale scores were 30.9 (SD=11.7; range, 8–52) for the ADHD boys and 12.3 (SD=5.9; range, 6–25) for the TD boys. Seven of the ADHD boys received methylphenidate, one received atomoxetine and the other five ADHD boys were not medicated. It is unclear whether medication affects the recognition of facial expression in ADHD children. Two previous papers reported that medication did not improve the recognition of facial expression in ADHD children (Schwenck et al., 2013) or slightly normalized it (Williams et al., 2008), although these other studies did not test the effect of medication (Cadesky et al., 2000; Da Fonseca, Seguier, Santos, Poinso, & Deruelle, 2009; Miller, Hanford, Fassbender, Duke, & Schweitzer, 2011; Pelc et al., 2006). In this study, because we found a consistent tendency of hemodynamic

[1] According to the Wechsler Intelligence Scale of Children-Third Edition (WISC-III), the IQ scores of 11 of the ADHD boys and 12 of the TD boys were assessed. The full IQ scores of these boys were over 75. When the missing IQ scores of two ADHD and one TD boy were replaced by means of their clinical group respectively, the full IQ scores of the ADHD participants (mean=108.38; SD=5.8) were significantly lower than those of the TD boys (mean=89.8; SD =12.8), $t(24)=4.78$, $p<.000$. However, the performance IQ, which was related more to emotion recognition ability than full IQ (Buitelaar, Wees, van der Swaab-Barneveld, & van der Gaag, 1999), was not significantly different between the ADHD (mean=92.2; SD=12.4) and TD groups (mean=99.5; SD=8.6), $t(24)=1.75$, $p=.09$.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات