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Absence of contagious yawning in children with autism spectrum disorder

Atsushi Senju [a*], Makiko Maeda [b], Yukiko Kikuchi [b], Toshikazu Hasegawa [b], Yoshikuni Tojo [c] & Hiroo Osanai [d]

[a] Centre for Brain and Cognitive Development, Birkbeck, University of London, Malet Street, London WC1E 7HX, UK; [b] University of Tokyo, Department of Cognitive and Behavioral Science, 3-8-1 Komaba, Meguroku, Tokyo 153-8902, Japan; [c] Ibaraki University, Faculty of Education, 2-1-1 Bunkyo, Mito, Ibaraki 310-8512, Japan; [d] Musashino Higashi Gakuen, 2-1-0 Midoricho, Musashino, Tokyo 180-0012, Japan;
* Author for correspondence (a.senju@bbk.ac.uk)

Summary

This study is the first to report the disturbance of contagious yawning in individuals with autism spectrum disorder (ASD). Twenty-four children with ASD, as well as 25 age-matched typically developing (TD) children, observed video clips of either yawning or control mouth movements. Yawning video clips elicited more yawns in TD children than in children with ASD, but the frequency of yawns did not differ between groups when they observed control video clips. Moreover, TD children yawned more during or after the yawn video clips than the control video clips, but the type of video clips did not affect the amount of yawning in children with ASD. Current results suggest that contagious yawning is impaired in ASD, which may relate to their impairment in empathy. It supports the claim that contagious yawning is based on the capacity for empathy.

Key Words:

yawning, contagious yawning, autism spectrum disorder, empathy, neuropathology

Introduction

Contagious yawning (i.e., yawning triggered by perceiving others' yawning) is a well-documented phenomenon (e.g. Anderson & Meno, 2003; Lehmann, 1979; Platek et al., 2003; Provine, 1986, 1989), but surprisingly little is known about the mechanisms underlying it. Contagious yawning is reported in humans and in only a few other primates such as chimpanzee (Anderson et al., 2004) and possibly in stamptail macaques (Paunker & Anderson, 2006), even though spontaneous yawning is widespread among vertebrate species (Baenninger, 1987). Some authors argue that contagious yawning is a response to an innate releasing mechanism (Provine, 1986, 1989), whereas others claim that it is based on the capacity for empathy (Lehmann 1979; Platek et al., 2003; Preston & de Waal, 2002).

Although various neurological or psychiatric disorders are known to cause abnormal patterns of spontaneous yawning (Daquin et al., 2001), no study has tested whether a neuropathology causes contagious yawning to be impaired. We predicted that individuals with Autism Spectrum Disorder (ASD) have impaired contagious yawning. ASD is a pervasive developmental disorder, which severely affects social and communicative development (America Psychiatric Association, 1994), including empathy (Baron-Cohen et al., 2005; Blair, 2005). If contagious yawning is related to the capacity for empathy, it is possible that individuals with ASD, who have impairment in empathy, show the disturbances in contagious yawning. In addition, a recent neuroimaging study (Schürmann et al., 2005) reported that observation of others' yawning and susceptibility to yawn in response are related to the activity of the superior temporal sulcus and periamygdalar regions. Since structural abnormalities of these regions are reported in ASD (Schumann et al., 2004; Zilbovicius et al., 2006), they should show disturbances in contagious yawning. However, to date, there are no empirical studies that systematically investigated contagious yawning in ASD.

The aim of this study is to assess the contagious yawning of children with ASD, using video clips of yawning as stimuli. Children at or over the age of 7 years participated in the study, because Anderson and Meno (2003) reported that children older than 4 years old reliably show contagious yawning. In addition to the yawning video clips, control video clips of mouth-opening action were also presented to the participants. If the children with ASD have disturbances specific to contagious yawning, observing yawning videos should elicit less yawning in children with ASD than in TD children, while the amount of yawning should not differ between groups during or after the observation of control videos.

Methods

Participants

Data from 24 children with ASD (4 female) and 25 age-matched TD children (11 female) were included in the analyses (Table 1). All the children with ASD have been diagnosed with an autistic disorder by a clinician according to DSM-IV (American Psychiatric Association, 1994). In addition, parents of all the participants completed a Japanese version of the Autism Screening Questionnaire (ASQ-J; Berument et al., 1999, Dairoku et al., 2004), and only the children who scored above the cut-off point (13) were included in the analysis. Four additional children did not meet this criterion and were excluded from the analyses. Note that all TD children scored well below the cut-off in ASQ-J. An abbreviated version of Japanese WISC-III (Japanese WISC-III Publication Committee, 1998) was also administrated to measure IQ. Informed consent was obtained both from the children and their parents. The study was approved by the University of Tokyo Research Ethics Committee.

Table 1. Participants' Age, Verbal, Performance and Full IQ and Score on the Japanese version of Autism Screening Questionnaire (ASQ-J)

	Group			
	ASD (n = 24)		TD (n = 25)	
	M	SD	M	SD

Age (years)	11.6	2.3	11.0	2.2
Range	7.0 – 15.9		8.0 – 14.9	
Verbal IQ	83.0	30.1	111.5	17.0
Range	46 - 136		88 - 154	
Performance IQ	81.3	23.3	100.7	17.3
Range	46 - 124		70 - 130	
Full IQ	82.1	25.7	106.1	14.9
Range	46 – 127		85 – 142	
ASQ-J	23.3	5.2	2.3	2.5
Range	16 – 33		0 – 9	

ASD: children with Autism Spectrum Disorders, TD: Typically Developing children, IQ: Intelligence Quotient

Stimuli and Procedure

The stimuli consisted of six video clips of yawning faces (7 seconds each) taken from different adult models, and six control video clips (mouth opening, 7 seconds each) of the same six models. All the models were unfamiliar to the participants. Stimuli were presented in a pseudorandom order, with one-minute inter stimulus interval between stimuli. During the interval, a silent cartoon animation was presented to keep the participants' attention toward the display. Stimulus sequences were presented on the 12-inch LCD monitor of a laptop computer, and the face that appeared measured 10 x 15 cm on the monitor.

All the participants viewed the movies by themselves in a soundproofed room, and were asked to count the number of female faces that appeared during the movie. All the children correctly counted the faces, which ensured that they attended to the display. The faces of the participants were recorded using a custom-built hidden video recorder. The videos were coded off-line. The coder was blind to the stimulus the children were watching. After the coding, the number of yawns during or after the observation of each stimulus (and before the onset of the following stimulus) was calculated and analyzed. Two independent coders coded the entire dataset, and inter-rater reliability was high ($\kappa = 0.83$).

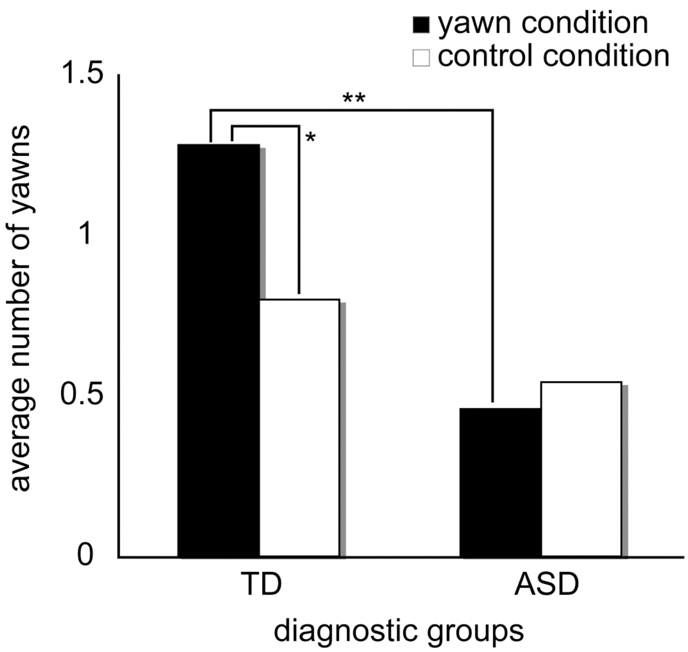

Figure 1. Average frequency of yawns of participants during or after the observation of yawn and control conditions. TD: typically developing children, ASD: children with Autism Spectrum Disorder, **: $p < .01$, *: $p < .05$.

Results

The yawning videos elicited more yawning in TD children than in children with ASD (Mann-Whitney test: $z = -2.80$, $p = .01$), but the control movies had no difference between groups in the number of yawns (Mann-Whitney test: $z = -1.28$, $p > .1$) (Figure 1). Within-group analyses also revealed that in TD children, yawning videos elicited more yawning than control videos (Wilcoxon's signed rank test: $z = -2.07$, $p = .038$, one-tailed). However, children with ASD did not show any difference between yawning and control videos (Wilcoxon's signed rank test: $z = -0.43$, $p > .1$).

Both in children with ASD and in TD children, the number of yawns did not correlate with age, IQ or scores of ASQ-J (Spearman: all *rho* $< .31$, $p > .1$). The effect of gender on the frequency of yawning in the yawn and control conditions was examined both in ASD and TD group, and no significant effect of gender was found. In addition, group differences in the yawning condition remained significant when only male participants were compared (Mann-Whitney test: $z = -2.01$, $p = .044$, one-tailed). Again, the control condition did not show a significant group effect in this subgroup (Mann-Whitney test: $z = -1.69$, $p > .1$).

To further examine the effect of IQ, an additional group comparison was conducted with the IQ-matched subgroups of 16 TD children (7 females) and 16 children with ASD (3 females) (see Supplementary Table). Results confirmed the main findings: TD children elicited more yawns than children with ASD in the yawning condition (Mann-Whitney test: $z = -2.39$, $p = .034$), but not in the control condition (Mann-Whitney test: $z = -.79$, $p > .1$).

Note that bonfferoni corrections were applied to all multiple comparisons.

Discussion

This study is the first to demonstrate an impairment in contagious yawning in children with ASD. During or after observation of a video of a yawning adult, children with ASD yawned significantly less than TD children. This cannot be attributed to the overall differences in the frequency of spontaneous yawning, because the amount of yawning did not differ between groups during or after they observed mouth-opening, control, videos. In addition, the results of typically developing children replicated a previous study (Anderson & Meno, 2003) that TD children yawn more during the observation of others' yawning than other mouth movements. However, others' yawning did not modulate the frequency of yawns in children with ASD.

To the best of the authors' knowledge, this is the first report to demonstrate that a neurodevelopmental disorder can lead to an impairment specific to contagious yawning, and not spontaneous yawning. Since atypical development of empathy is reported in ASD (Baron-Cohen et al., 2005; Blair, 2005), current results support the claim that contagious yawning and the capacity of empathy share common neural and cognitive mechanisms (Lehman, 1979; Platek et al., 2003; Preston & de Waal, 2002). To further examine the involvement of empathy in contagious yawning, it will be important to investigate whether contagious yawning is impaired in other 'empathy disorders' (Preston &de Waal, 2002) such as psychopathy, prefrontal damage or front-temporal dementia.

One might argue that impaired contagious yawning in ASD relates to the dysfunction of the mirror-neuron system (MNS), as is their imitative impairment (Ramachandran & Oberman, 2006). However, this argument needs to be treated with caution. For example, Schürmann et al. (2005) did not find selective activation of Broca's area, the essential component of MNS (Rizzolatti & Craighero, 2004), during observation of others' yawning. It suggests "*the non-imitative nature of the yawn contagion that can occur without detailed action understanding*" (Schürmann et al., 2005, p.1264).

Individuals with ASD are known to fixate more to the mouth than to the eyes when watching dynamic facial stimuli (e.g. Klin et al., 2002). Since the perception of the eye region of yawning people is a potent stimulus for yawn contagion (Provine, 1989), it is possible that less fixation to the eyes of yawning stimuli may impede the contagious yawning in children with ASD. Further studies will be beneficial to examine whether the atypical pattern of face fixation contributes to the impairment in contagious yawning.

As mentioned above, little is known about the mechanism and development, as well as the function, of contagious yawning. Further studies are required to investigate the relation between contagious yawning and other symptoms of ASD, such as empathy, imitation and/or face fixation. In addition, further studies will be beneficial to explore the developmental course of contagious yawning in ASD. Although we did not find any effect of age or IQ in the current age group, it is still possible that chronological or mental age would affect the manifestation of contagious yawning in other age groups. These would be fruitful lines of research, not only in order to clarify the mechanism and function of yawning but also to better understand the nature of social and communicative impairment in ASD.

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