

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/267394965>

# Facial mimicry interference affects reaction time but not accuracy on an emotion–recognition task in children, adolescents, and adults

Article in *Irish Journal of Psychology* · December 2014

DOI: 10.1080/03033910.2014.982145

CITATIONS

3

READS

84

2 authors, including:



Elizabeth Nixon

Trinity College Dublin

95 PUBLICATIONS 1,040 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Peer-to-peer motivational interview intervention for smoking, alcohol and physical activity among at-risk adolescents in low SES communities: A feasibility trial. [View project](#)



Caregivers and peers as support-givers: An exploration of responses to adolescents showing signs of depression [View project](#)



## Facial mimicry interference affects reaction time but not accuracy on an emotion recognition task in children, adolescents and adults

David M. Lydon\* and Elizabeth Nixon

*School of Psychology, Trinity College Dublin, Dublin, Ireland*

*(Received 26 September 2013; accepted 14 October 2014)*

Adults display superior performance on tasks of facial expression recognition when compared to children and adolescents. Embodied simulation strategies contribute to emotion recognition performance in adults. To date however, the use of such strategies in children and adolescents has not been examined. The present study investigated the development of facial expression recognition from an embodied perspective in a sample of 43 children (Mean age = 8.02 years), 35 adolescents (Mean age = 12.69 years) and 39 adults (Mean age = 19.92 years). In a three-alternative forced-choice emotion recognition task, children and adolescents were less accurate at recognising faces displaying sadness than they were at recognising happiness. Adults were equally as accurate at identifying happiness and sadness. All groups were less accurate at recognising fear than recognising both happiness and sadness. In trials in which the emotions were accurately recognised, all age groups were significantly slower at recognising fear than happiness. A non-linear developmental trend was observed for trials involving sad faces suggesting the need to consider pubertal status in future studies of facial expression recognition. A facial mimicry interference condition significantly interfered with the speed, but not the accuracy, of recognition of all emotions in all three groups. These findings converge with findings in the literature on emotion recognition by replicating performance differences in facial expression recognition across age groups. They also provide the first evidence for the use of embodied simulation strategies in children and adolescents during emotion recognition tasks.

**Keywords:** emotion recognition; facial mimicry; embodiment; age-related change

Studies have revealed the important role played by facial expression recognition in social functioning (Carton, Kessler, & Pape, 1999; Shimokawa et al., 2001). Emotions are frequently expressed through eye contact and changes in facial expression (Ruffman, Henry, Livingstone, & Phillips, 2008) and the effective recognition of facial expressions allows individuals to modify their behaviour to suit the social environment (Campbell, Walker, & Baron-Cohen, 1995).

Research indicates that facial expression recognition abilities develop early in infancy and continue to be refined beyond adolescence. Infants aged between 4 and 9 months can discriminate between facial expressions of emotions such as happiness, sadness, anger and fear (Caron, Caron, & MacLean, 1988; Serrano, Iglesias, & Loeches, 1992). Increases in emotion recognition performance in children between preschool and early primary school years have also been reported (Camras & Allison, 1985). Researchers have

---

\*Corresponding author. Email: [dlydon@tcd.ie](mailto:dlydon@tcd.ie)

suggested that few changes occur in facial emotion recognition after early childhood (Harrigan, 1984; Kirouac, Dore, & Gosselin, 1985). However, using more sensitive measures by incorporating emotions of lower intensities, Thomas, De Bellis, Graham, and LaBar (2007) tested the emotion recognition abilities of older children (7- to 9-year-olds), adolescents (14- to 18-year-olds) and adults (25- to 57-year-olds). Results revealed that adults were better at recognising emotions than both older children and adolescents, suggesting that the ability to recognise facial expressions does not reach adult-like levels of competence until late in adolescence.

Studies have reported differences in the development of emotion recognition abilities across emotions. Among adults, happiness is the most accurately identified emotion while negative emotions, especially fear, are recognised with lower levels of accuracy (Calvo & Lundqvist, 2008; Montagne, Kessels, De Haan, & Perrett, 2007). Gao and Maurer (2009) examined the accuracy of facial emotion recognition among children for happiness, sadness and fear. Five-year-old children were found to be as accurate as adults at recognising happiness at low as well as high intensities. All of the children often confused sad faces with fearful faces and did not reach accuracy levels similar to adults until 10 years of age. Thus, the ability to recognise happiness appears to be developed at an early age but accurate recognition of sadness and fear develops later in childhood, findings which are consistent with earlier research (e.g., Camras & Allison, 1985; Walden & Field, 1982). Thomas et al. (2007) found that the accurate recognition of fear improved steadily from childhood to adolescence to adulthood.

The focus of the current study was to determine whether embodiment theories of emotion could provide more insight into the differences in emotion recognition across age groups. Various reasons have been suggested for the differences in performance on facial emotion recognition tasks across these age groups, such as developmental changes in the reliance on configural and featural facial information in recognising facial emotions (Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007) and the continued development of brain areas implicated in facial expression processing throughout late childhood and adolescence (Thomas et al., 2007). Embodied perspectives of emotion recognition have provided insights into facial expression recognition in adults but to date they have not been applied to children and adolescents.

### **Emotion recognition from an embodied perspective**

Facial emotion recognition has received substantial attention from embodied cognition perspectives in recent years. Embodiment theories challenge traditional Cartesian reductionism, which treats the mind and body as independent, by proposing that the body helps to constitute the mind (Feldman & Lindquist, 2008). In the context of emotion recognition, embodiment theories propose that the body plays a key role in the recognition of observed facial expressions. Embodied simulation theories posit that observed facial expressions trigger a simulation of the state of the observed individual in the motor, affective, somatosensory and reward systems of the perceiver which is then used to infer the emotional state of the other person (Goldman & Sripada, 2005; Niedenthal, Mermillod, Maringer, & Hess, 2010). Thus, to use an example put forward by Niedenthal (2007), observing an angry face may trigger the embodiment of anger in the perceiver which might involve forming a scowl on the face, tension in muscles used to strike and perhaps even a rise in diastolic blood pressure. This bodily feedback is then used by the observer to identify the observed emotion.



In accordance with embodied simulation theory, adults spontaneously and rapidly produce facial movements congruent with observed facial expressions (Dimberg, 1982). These rapid facial reactions occur automatically, even when participants are not instructed to mimic the emotions presented to them (Dimberg, 1982). They also occur when the facial expressions are presented subliminally (Dimberg, Thunberg, & Elmehed, 2000). Simulation theories suggest that these rapid and automatic reactions reflect a simulation of the observed emotion in order to facilitate emotion recognition (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001).

Behavioural evidence for this proposed role for facial mimicry in emotion recognition has been provided by a number of studies which have interfered with facial mimicry. In one such study, Niedenthal et al. (2001) presented participants with emotion movies in which the facial expression of an actor was digitally blended to change from one emotion to another (e.g., from happiness to sadness). Participants were instructed to stop the emotion movie when they perceived that the face was no longer expressing its initial emotion. One group of participants undertook the task with no manipulation while a second group held a pen between their teeth, a manipulation which disrupted facial mimicry. Results showed that participants in the facial mimicry manipulation were significantly slower than the control participants at detecting expression change suggesting a role for facial mimicry in the recognition of emotion.

A study by Oberman, Winkielman, and Ramachandran (2007) extended these findings by examining the effects of facial mimicry interference on different emotions. The interference condition was similar to that of Niedenthal et al. (2001) except participants were instructed to exert a constant pressure on the pen. A similar effect was achieved such that participants in the facial mimicry interference condition were less effective at recognising emotions. Furthermore, the recognition of happiness was most affected by the manipulation. There are several potential reasons for this. Firstly, happiness showed the strongest muscle activations during imitation which suggests that the simulation of happiness draws more on proprioceptive feedback from facial muscles than the simulation of other emotions which may draw on different types of somatosensory resources such as interoceptive states (Wicker et al., 2003). Secondly, it may be that the facial mimicry manipulation was more successful at interfering with the muscles related to happiness than those associated with other emotions.

Hennenlotter et al. (2009) further highlighted the role of facial mimicry in emotional experience by injecting Botulinum Toxin (BOTOX) into the corrugator muscles (i.e., frown muscles) to interfere with the facial mimicry of participants. BOTOX is a neurotoxin that prevents the release of acetylcholine from presynaptic vesicles at the neuromuscular junction leading to decreased extrafusal muscle fibre activity and muscle strength resulting in temporary muscular denervation (Simpson, 1981). When participants imitated angry facial expressions, the reduced facial feedback due to BOTOX treatment attenuated activation of the left amygdala and its functional coupling with regions of the brain stem involved in autonomic manifestations of emotional states. This demonstrates that neural activity in central emotion circuits may be modulated by the level of facial feedback, a finding in line with embodied simulation theory's suggestion that facial mimicry may facilitate emotion recognition via internal simulation of the observed emotion (Niedenthal, 2007).

Thus, research suggests that interfering with facial mimicry modulates the simulation of an observed emotion which in turn reduces the effectiveness of its recognition suggesting that simulation is an emotion recognition strategy that is used by adults. Populations exhibiting impaired social functioning and facial emotion recognition

abilities have been found to have deficits in facial mimicry. For example, a study employing facial electromyography to detect rapid facial reactions to observed facial expressions found that adults with autistic spectrum disorder, a disorder characterised by impaired interpersonal abilities (Lord & Bailey, 2002) did not automatically mimic facial expressions like typical adults (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006).

Embodied simulation, however, is not the only strategy used to recognise emotions, and emotion recognition can occur without facial mimicry. Bogart and Matsumoto (2010) studied the emotion recognition abilities of individuals with Moebius syndrome, a congenital condition characterised by complete and bilateral facial paralysis, normal health and typical cognitive function. The study found that the emotion recognition accuracy of individuals with Moebius syndrome did not differ from that of typical controls. This suggests that facial mimicry is not necessary for emotion recognition and that compensatory strategies may be implemented in cases in which facial mimicry is impaired, especially in cases where facial paralysis has been experienced over a long period of time. However, Stel and van Knippenberg (2008) have distinguished between a faster route of emotion recognition involving simulation and a slower route involving other strategies such as matching visual input with stored knowledge about emotions. Thus, individuals with impaired facial mimicry may be slower, but not necessarily less accurate, at recognising emotions than typical individuals.

### **The current study**

Research into embodied simulation theory has mostly focused on adults with little attention being given to the status of embodied simulation as an emotion recognition strategy in children and adolescents. While it has been shown that children aged between 7 and 12 years produce rapid facial reactions (Beall, Moody, McIntosh, Hepburn, & Reed, 2008), no study, to the knowledge of the authors, has investigated whether or not interference with facial mimicry in children and adolescents affects their emotion recognition abilities. By integrating the findings from research into embodied simulation theories of facial emotion recognition with findings from the developmental literature, the current study aimed to examine whether or not children and adolescents use simulation strategies when recognising emotions.

The current study addressed two research questions. This study attempted to replicate findings from the developmental literature that have illustrated differences in emotion recognition performance between children, adolescents and adults. In line with Gao and Maurer (2009) and Thomas et al. (2007) it was hypothesised that children and adolescents would perform as well as adults on tasks involving images of positive facial expressions (i.e., happiness) and that they would perform significantly worse than adults on tasks involving negative facial expressions (i.e., sadness, fear).

The second question addressed whether or not blocking facial mimicry interferes with the emotion recognition of children and adolescents as it does in adults. It was hypothesised, in line with previous research (e.g., Niedenthal et al., 2001), that interfering with facial mimicry would impede emotion recognition performance in adults. As no previous study has examined the use of embodied simulation in children and adolescents, and because they exhibit inferior emotion recognition performance relative to adults, it was hypothesised that, unlike adults, children and adolescents do not use embodied simulation strategies during facial expression recognition and that this could account for their poorer performance on emotion recognition tasks.



The research questions led to the following hypotheses across metrics of accuracy rates and reaction times on the emotion recognition task employed in this study. We hypothesised that, in terms of accuracy rates, adults would demonstrate higher rates of accuracy relative to the other age groups across negative emotions but not for happiness. We also hypothesised that interfering with facial mimicry would not affect rates of accuracy. In terms of reaction times, we hypothesised a linear developmental trajectory with adults performing the task faster than adolescents across all emotions, who in turn would perform the task faster than children. Finally, we hypothesised that the interference condition would impact upon reaction times for happy faces and that this effect would be restricted to the adult sample.

## **Method**

### *Research design*

A mixed subjects design was used. The independent variables for the study were age, facial condition and emotion, and the dependent variables were speed and accuracy of recognition of emotion. Age (child 7–10 years, adolescent 12–14 years, adult 18–25 years) and facial condition (facial mimicry interference, no interference) were the non-repeated between-subject factors and emotion (happiness, sadness, fear) was the repeated within-subject factor.

### *Participants & recruitment*

Ethical approval to conduct the study was obtained from the School of Psychology Ethics Committee within the university. Two schools (one primary school and one secondary school) known to the researcher were approached to participate in the study. In both schools, host school staff members distributed letters of parental consent containing information about the study to all students in two classes containing participants of the desired ages. Participants with letters confirming parental consent, who also signed letters of assent on the day of the study, were recruited. Recruitment of the adult population involved posting flyers with information about the study in the School of Psychology at the university.

Forty-three children (20 male, 23 female) were recruited from one primary school in Ireland and ranged in age from 7 to 10 years ( $M = 8.02$ ,  $SD = 0.83$ ). Thirty-five adolescents (12 male, 23 female) were recruited from one secondary school in Ireland and ranged in age from 12 to 14 years ( $M = 12.69$ ,  $SD = 0.58$ ). Thirty-nine adults (17 male, 22 female) were recruited from the School of Psychology within the university and ranged in age from 18 to 25 years ( $M = 19.92$ ,  $SD = 1.64$ ).

### *Materials*

Images of facial expressions were selected from the Extended Cohn-Kanade Database (Kanade, Cohn, & Tian, 2000). Differences in performance on emotion recognition tasks across age groups have been most pronounced in studies using images displaying emotions of low intensities (e.g., Thomas et al., 2007) and the inclusion of images displaying low intensities of emotions in emotion recognition studies is now standard (e.g., Oberman et al., 2007; Niedenthal et al., 2001). By intensity we refer to the relative degree of displacement of a pattern of muscle movements involved in an emotional expression away from a neutral expression (Hess, Blairy, & Kleck, 1997). Only images

displaying high intensities of emotions were coded according to the Facial Action Coding System (FACS; Ekman & Friesen, 1978) by the image database available to the authors. Thus, only the emotions displaying high intensities were guaranteed to reliably display the target emotions. As such, a pilot test was undertaken to identify images displaying emotions at lower intensities that reliably portrayed the target emotion.

#### *Pilot study*

Seven undergraduate students (4 females) were recruited through the School of Psychology within the university and ranged in age from 20 to 22 years ( $M = 21.43$ ,  $SD = 0.79$ ). A within-subjects design was implemented and responses to the presentation of images displaying one of three emotions (happiness, sadness or fear) on a three-alternative-forced-choice emotion recognition task were recorded. In the task 72 images of faces which were selected from the image database were presented. The images consisted of both male and female Caucasian faces. The 72 images chosen were made up of 18 sets of 4 images. Each set contained the image of one individual expressing varying degrees of happiness, sadness or fear. The images were cropped with an ovoid mask to exclude extraneous features such as hair, ears, neckline or accessories. Levels of brightness and contrast were normalised to achieve uniformity among the images. The image of the lowest intensity in each set to be recognised at an above-chance level was accepted to be included in the main study (i.e., at least three of the four participants had to recognise it as portraying the correct emotion). None of the images in 6 of the 18 sets were recognised at an above chance level and were excluded from the main study. Twelve FACS coded images were added to the 12 images selected from the pilot study. Thus, the main study included 24 images of faces displaying emotions at both high and low intensities.

#### *Procedure*

Within each developmental group, participants were randomly assigned to one of two groups, the control (non-interference) condition and the facial mimicry interference condition. Craft sticks (wooden lollipop/popsicle sticks) were used in the facial interference condition. In other similar experiments (e.g., Oberman et al., 2007; Niedenthal et al., 2001) pens were used to manipulate facial mimicry. As this study involved child and adolescent participants, craft sticks provided a safer alternative to pens. Before beginning the experiment, participants in the facial interference condition were given instructions on how to use the craft stick. They were told to place the craft stick into their mouths horizontally and to bite down on the stick. They were asked to hold their lips back from the stick such that their lips were not touching the stick. The experimenter then modelled the interference condition and asked the participants to replicate it. If participants pulled their lips back into a smile they were asked to make a neutral expression, not a smile. This was done to minimise mood induction by producing a smile, a technique used by Strack, Martin, and Stepper (1988). Participants in the facial interference condition were asked to ensure that they continued to bite down on the stick for the duration of the experiment. As such, this interference condition replicated the bite manipulation of Oberman et al. (2007) in which there was constant muscular action and not the interference condition of Niedenthal et al. (2001) in which little muscular activity was required.



Participants in all groups were then told that instructions would be given on-screen before the task began. The on-screen instructions told participants that they would be presented with images of faces displaying emotions. They then directed participants to 'press the happy button if you see a happy face', to 'press the sad button if you see a sad face' and to 'press the scared button if you see a scared face'. At this point, they were shown the response buttons which consisted of keyboard keys (the ',', '.' and '/' keys), covered with adhesives displaying the three emotions in pictographic form, and were told to take a few moments to familiarise themselves with them. Note that the keys were not counterbalanced across participants. They were asked to keep the fingers over the response buttons during the task and to answer as quickly and as accurately as possible. Participants were free to use whichever hand they chose to perform the task. Participants then began the experiment. Note that the adolescent and adult participants read the on-screen instructions while the on-screen instructions were read to the child participants.

The task was presented on a laptop with a 13-inch monitor. The task was preceded by a practice trial consisting of eight FACS coded images of facial expressions that were not used in the main task. An image was presented at the beginning of each trial and stayed on-screen until one of three available responses was made. After the practice trial, the experimenter reminded all participants of the response buttons and reminded participants in the facial mimicry interference condition to ensure that they were biting on the craft stick at all times. Following this, on-screen instructions were presented before the main task, consisting of 24 images, began. On-screen debriefing was presented following the main trial.

PASW Statistics 18 (SPSS) was used to analyse the data. Both accuracy scores and response times were analysed as it was expected that the facial interference condition would affect the speed but not the accuracy of emotion recognition (Stel & van Knippenberg 2008). The mean response times for the three emotions were calculated using the response times for correct responses and the scores were log transformed (Whelan, 2008).

## Results

Two mixed between-within subjects analyses of variance were carried out with age and facial condition as the between-subject factors and emotion as a within-subject factor. In the first analysis, facial expression recognition accuracy was analysed using the number of correct responses across the three emotions. Table 1 illustrates the mean (*SD*) number of correct responses for images of happiness, sadness and fear across age groups and facial conditions.

In the second analysis, the speed of facial expression recognition was analysed using the mean speed of recognition of correct responses across the three emotions. Table 2 illustrates the mean (*SD*) reaction times (in milliseconds) for images of happiness, sadness and fear across the age groups and facial conditions.

### Accuracy of facial expression recognition

The assumption of sphericity was not met ( $p < .05$ ), thus the Huynh-Feldt corrections were used in interpreting within-subject effects. Tests of within-subject effects revealed a significant main effect of emotion,  $F(1.92, 212.86) = 69.93, p < .001, d = 1.50$ , and a significant emotion and age interaction,  $F(3.84, 212.86) = 3.37, p < .05, d = 0.41$ . Neither the emotion by facial condition interaction,  $F(1.92, 212.86) = 2.13, p > .05, d = 0.20$ , nor the emotion by age by facial condition interaction,  $F(3.84, 212.86) = 1.19, p > .05$ ,



Table 1. Mean (SD) number of correct responses for images of happiness, sadness, and fear across age groups and facial conditions.

Age Group	Condition	Emotion		
		Happiness	Sadness	Fear
Children	Control	7.77 (0.43)	7.09 (1.02)	5.64 (1.62)
	Interference	7.71 (0.46)	7.33 (1.02)	5.71 (1.49)
	Total	7.74 (0.44)	7.21 (1.01)	5.67 (1.54)
Adolescents	Control	7.56 (1.09)	6.63 (1.86)	5.06 (1.48)
	Interference	7.26 (0.99)	7.11 (1.20)	6.21 (1.44)
	Total	7.40 (1.03)	6.89 (1.53)	5.69 (1.55)
Adults	Control	7.67 (0.69)	7.72 (0.75)	6.72 (1.13)
	Interference	7.26 (0.99)	7.52 (0.60)	6.38 (1.53)
	Total	7.44 (1.12)	7.62 (0.67)	6.54 (1.35)
Total	Control	7.68 (0.74)	7.16 (1.30)	5.82 (1.56)
	Interference	7.41 (1.12)	7.33 (0.96)	6.10 (1.49)
	Total	7.54 (0.96)	7.25 (1.14)	5.97 (1.53)

$d = 0.32$ , were significant. Tests of between-subject effects revealed a significant effect of age,  $F(2, 111) = 4.65, p < .05, d = 0.55$ . Tests of between-subject effects revealed no significant effect of facial condition,  $F(1, 111) = 0.21, p > .05, d = 0.09$ . This suggests that the interference condition did not affect emotion recognition accuracy.

Follow-up  $t$ -tests were conducted using the False Discovery Rate (FDR) method (Benjamini & Hochberg, 1995) in order to minimise issues of multiplicity. In this procedure, the comparisons are ranked according to their  $p$ -values and a new alpha level is calculated for each  $t$ -test that is being evaluated using:  $\alpha_i = \frac{(i)}{c} \alpha_{FW}$ , where  $i$  is the rank number of the comparison,  $FW = .05$ , and  $c$  is the number of total comparisons. Note that the alpha levels determined from the FDR method are reported below in determining significance and that the reported degrees of freedom depend on the significance of the associated Levene's test for equality of variances.

No significant differences in the accuracy rates for recognising happiness were detected between children and adults,  $t(46.52) = 1.46, p > .04, d = 0.36$ , children and

Table 2. Mean (SD) reaction times (in milliseconds) for images of happiness, sadness, and fear across the age groups and facial conditions.

Age Group	Condition	Emotion		
		Happiness	Sadness	Fear
Children	Control	1447.18 (331.68)	1785.01 (564.36)	2265.55 (774.65)
	Interference	1617.04 (351.63)	1759.25 (384.79)	2366.79 (1000.53)
	Total	1530.13 (348.24)	1772.43 (479.51)	2314.88 (882.81)
Adolescents	Control	1154.10 (255.45)	1257.19 (241.89)	1450.54 (309.57)
	Interference	1362.05 (369.27)	1423.50 (424.82)	1956.25 (749.13)
	Total	1266.98 (334.70)	1347.45 (358.36)	1725.07 (636.17)
Adults	Control	962.90 (219.41)	1158.22 (338.64)	1284.07 (491.38)
	Interference	1118.25 (323.81)	1130.72 (309.71)	1350.98 (529.74)
	Total	1046.55 (287.89)	1143.41 (319.34)	1320.10 (506.81)
Total	Control	1207.78 (343.61)	1432.74 (506.24)	1717.21 (729.55)
	Interference	1365.90 (400.78)	1438.28 (452.44)	1889.21 (882.17)
	Total	1290.22 (381.25)	1435.63 (476.87)	1806.89 (813.84)

adolescents,  $t(44.04) = 1.84, p > .04, d = 0.46$ , or adolescents and adults,  $t(72) = -0.13, p > .05, d = -0.04$ . Children,  $t(80) = -2.69, p < .02, d = -0.60$ , and adolescents,  $t(72) = -2.53, p < .03, d = -0.59$ , were significantly less accurate at identifying fear than adults but there was no difference in accuracy of recognising fear between children and adolescents,  $t(76) = -0.03, p > .05, d = -0.01$ . Adolescents were less accurate than adults at recognising sadness,  $t(45.62) = -2.70, p < .03, d = -0.66$ , while there was no significant difference between rates of accuracy for sad faces between children and adults,  $t(73.58) = -2.16, p > .03, d = -0.49$ , although there was a trend for significance. Children were not significantly more accurate at recognising sad faces than adolescents,  $t(76) = 1.12, p > .04, d = 0.25$ . All ages, children,  $t(42) = 8.68, p < .01, d = 1.55$ , adolescents,  $t(34) = 5.29, p < .01, d = 0.91$ , and adults,  $t(38) = 3.50, p < .02, d = 0.57$ , were significantly more accurate at recognising happiness than fear. Children,  $t(42) = 5.89, p < .003, d = 0.95$ , adolescents,  $t(34) = 3.85, p < .01, d = 0.65$ , and adults,  $t(38) = 5.32, p < .01, d = 0.96$ , were also significantly more accurate at recognising sadness than fear. Children,  $t(42) = 3.02, p < .02, d = 0.48$ , and adolescents,  $t(34) = 2.28, p < .03, d = 0.40$ , were significantly more accurate at recognising happiness relative to sadness, an effect that was not significant among adults,  $t(38) = -0.87, p > .04, d = -0.01$  (Figure 1).

#### Speed of facial expression recognition

The assumption of sphericity was not met ( $p < .05$ ) and so the Huynh-Feldt estimates are reported. Tests of within-subject effects revealed a significant effect of emotion,  $F(1.97, 218.07) = 74.26, p < .001, d = 1.57$ , and a significant emotion by age interaction,  $F(3.93, 218.07) = 2.52, p < .05, d = 0.35$ . The emotion by facial condition interaction was not significant,  $F(1.97, 218.07) = 2.55, p > .05, d = 0.20$ . No significant three-way interaction of emotion by facial condition by age was observed,  $F(3.93, 218.07) = 0.85, p > .05, d = 0.18$ . Tests of between-subjects effects revealed a significant effect of facial condition,  $F(1, 111) = 4.20, p < .05, d = 0.29$ , and a significant effect of age,  $F(2, 111) = 42.47, p < .001, d = 1.70$ .

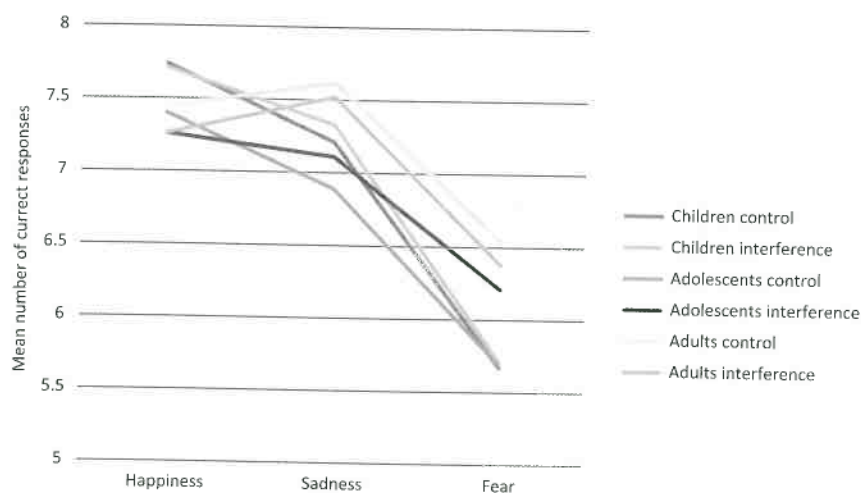


Figure 1. Mean number of correct responses for images of happiness, sadness, and fear across age groups and facial conditions.



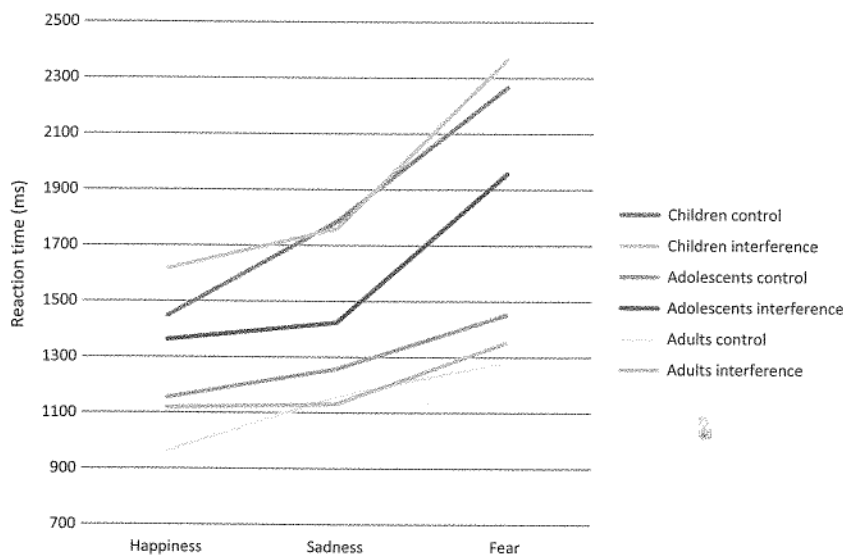


Figure 2. Mean reaction time (in milliseconds) for images of happiness, sadness, and fear across the age groups and facial conditions.

The FDR method was used during post hoc testing to correct for multiple comparisons. Note that the alpha levels determined from the FDR method are reported below in determining significance. Children performed significantly slower than adults on happy,  $t(80) = 7.64, p < .01, d = 1.52$ , sad,  $t(80) = 7.71, p < .01, d = 1.58$ , and fear,  $t(80) = 7.80, p < .02, d = 1.43$ , trials. Adolescents performed significantly slower than adults on happy,  $t(72) = 3.37, p < .03, d = 0.71$ , sad,  $t(72) = 2.81, p < .04, d = 0.60$ , and fear,  $t(72) = 3.44, p < .04, d = 0.71$ , trials. Children performed significantly slower than adolescents on happy,  $t(76) = 3.80, p < .003, d = 0.77$ , sad,  $t(76) = 4.71, p < .01, d = 1.01$ , and fear,  $t(76) = 3.89, p < .01, d = 0.78$ , trials. In terms of the age by emotion interaction, the speed of recognition was significantly different for happy and fear in children,  $t(42) = -8.11, p < .03, d = -1.11$ , adolescents,  $t(34) = -5.67, p < .03, d = -0.94$ , and adults,  $t(38) = -2.93, p < .03, d = -0.77$ . Reaction times to sad faces were also significantly faster than fear in children,  $t(42) = -5.13, p < .02, d = -0.74$ , adolescents,  $t(34) = -5.27, p < .02, d = -1.07$ , and adults,  $t(38) = -3.55, p < .04, d = -0.61$ . Happiness was more quickly identified than sadness in children,  $t(42) = -3.46, p < .04, d = -0.50$ , and adults,  $t(38) = -2.93, p < .05, d = -0.45$ , but not in adolescents,  $t(34) = -1.54, p > .05, d = -0.25$  (Figure 2).

### Discussion

The current study aimed to replicate previous studies on emotion recognition in children, adolescents and adults which have shown performance differences among the different age groups. It was hypothesised that children and adolescents would perform as well as adults on tasks involving images of happiness and that they would perform significantly worse than adults on tasks involving images of negative emotions. The study also examined whether or not children and adolescents employ embodied simulation strategies when recognising facial expressions. It was hypothesised that children and adolescents would not employ these strategies and that this could partially account for the differences

in emotion recognition performance between children, adolescents and adults observed in past studies.

In line with past research (e.g., Thomas et al., 2007), the emotion recognition task revealed performance differences among children, adolescents and adults with performance, as indicated by accuracy of facial expression recognition, increasing with age on trials involving fear. Within each age group, children and adolescents were significantly more accurate at identifying happiness than both sadness and fear. Accuracy ratings for recognition of happiness and sadness did not differ significantly in adults. These findings are consistent with past research which has shown children as young as five years old to be as accurate as adults at recognising happiness but less accurate than adults at recognising negative emotions (Gao & Maurer, 2009). The finding that all three groups, including adults, were significantly less accurate at recognising fear than both happiness and sadness is in line with previous research which has shown fear to be recognised with lower levels of accuracy than other emotions (e.g., Calvo & Lundqvist, 2008).

Adolescents were significantly less accurate at recognising sadness than adults, a finding that was not observed in children. This is a surprising finding, although there is some evidence for non-linear developments in facial expression recognition from childhood to adulthood with decrements emerging at the onset of puberty (McGivern, Andersen, Byrd, Mutter, & Reilly, 2002). Other research has failed to replicate this finding (Merz, 2008). Taking measures of pubertal status when conducting developmental studies examining facial expression recognition will be crucial in future research to gain insight into the developmental trajectory of this process during puberty.

Performance differences in emotion recognition were also revealed in the speed of facial expression recognition. The speed of recognition across all emotions increased with age, demonstrating that gains in emotion recognition ability continue to be accrued even after the age at which the ability to accurately identify emotions is established. Within children and adults, the speed of recognition across all three emotions was significantly different, with happiness recognised quickest and fear recognised slowest. In adolescents, no significant differences were observed between reaction times to sadness and happiness. Such a finding is surprising and once more suggests non-linear development in aspects of facial expression recognition during the adolescent period. Addressing this question appropriately will require replication and the use of larger adolescent samples.

Interfering with facial mimicry did not significantly affect the accuracy of facial expression recognition. While individuals with impaired facial mimicry were not significantly less accurate at recognising facial expressions than those in the control group, the speed of recognition was significantly affected with individuals with impaired facial mimicry displaying slower recognition times than participants in the control group. This is in line with the distinction Stel and van Knippenberg (2008) made between a faster route of emotion recognition involving simulation and a slower route involving other strategies.

The finding that the speed of emotion recognition of children, adolescents and adults were all significantly affected by the facial mimicry interference condition is a novel finding suggesting that embodied simulation strategies of facial expression recognition are being used by children and adolescents, as well as adults. This suggests that the differences in emotion recognition across ages reported in past research and in the current study may not solely be accounted for by the lack of embodied simulation strategies in children and adolescents. This finding which runs contrary to our hypothesis, indicates the need for more detailed examination of other neural (Herba & Phillips, 2004), perceptual (Durand et al., 2007) and experiential (Elfenbein & Ambady, 2003)



mechanisms involved in the development of emotion recognition but also the need for more detailed examination of embodied simulation in younger populations.

Although the current study suggests that the differences in emotion recognition across ages cannot be partially accounted for by the lack of embodied simulation strategies in younger participants, there may be differences in the extent to which embodied simulation strategies are employed across age groups. In order to approach this question, studies such as that by Hennenlotter et al. (2009) in which the extent to which facial mimicry interference modulates activity of central emotion circuits is examined are recommended. This recommendation is based on findings that brain areas involved in facial expression processing do not fully develop until late adolescence (Aylward et al., 2005; Casey, Tottenham, Liston, & Durston, 2005; Schumann et al., 2004) and that exposure to images of faces displaying different emotions produce different neuronal activation patterns in children, adolescents and adults (Batty & Taylor, 2006; Monk et al., 2003). Thus, although simulation may occur in children and adolescents as well as in adults, it is suggested, following the aforementioned studies, that the quality of the internal simulation may differ across age groups and that this may lead to differences in emotion recognition abilities. Developmental differences in peripheral mechanisms (such as muscular or hormonal responses) that also underpin embodied simulation (Niedenthal, 2007) may play a role here and are worth of further investigation.

#### *Limitations*

It was observed that interfering with facial mimicry significantly affected the speed of all emotions. Past studies in which similar facial interference conditions were used affected the recognition of happiness more than any other emotion (Oberman et al., 2007). It is possible that the facial mimicry interference condition employed in the current study affected the muscles involved in the expression of all three emotions equally. While the interference condition in the current study was similar to facial mimicry interference techniques in past studies which have found differences in the extent to which the interference affected recognition of different emotions (Niedenthal et al., 2001; Oberman et al., 2007), it differed in its use of a craft stick instead of a pen. As a craft stick was used, participants were able to bite harder and this may have created a stronger muscular interference than that produced in past studies which may have had a stronger effect on the muscles involved in the expression of negative emotions. In order to explore this possibility, the degree to which the interference of the current study activated facial muscles could be examined using electromyography (Tassinari & Cacioppo, 2000).

Alternatively, the facial mimicry interference condition may have affected emotion recognition reaction times through distraction and increased cognitive load, a common critique of the facial manipulations employed in past studies (Bogart & Matsumoto, 2010). While this is a possibility, a study by Stel and van Knippenberg (2008), which included a control condition in which cognitive load was increased, found the effects of facial mimicry interference were still significant suggesting that this interpretation is unlikely. This study did not contain a condition to control for this possibility due to the potential for participant fatigue, especially with the younger sample of children, and due to the difficulties in recruiting sufficiently large samples to allow adequate power for a third condition. Due to these difficulties, it is important for future studies in this area to consider ways in which the disruption of facial mimicry can be improved. The use of BOTOX in studies of adults has proven effective (Havas, Glenberg, Gutowski, Lucarelli, & Davidson, 2010; Hennenlotter et al., 2009) and ensures interference of facial mimicry

in other parts of the face involved in facial expressions (i.e., eyebrows). This technique, however, is not appropriate for children and adolescents. Improvement in methods will lead to clearer and more credible results.

In conclusion, the results of the current study are in line with findings from the developmental literature highlighting differences in the facial expression recognition abilities of children, adolescents and adults. Also, the results of the study are in line with research highlighting the role of embodied simulation strategies in emotion recognition. Furthermore, the results of the current study suggest that children and adolescents use embodied simulation strategies in recognising facial expressions. This is a novel finding which highlights the need for future exploration of the differences and similarities in embodied simulation among children, adolescents and adults.

### References

- Aylward, E. H., Park, J. E., Field, K. M., Parsons, A. C., Richards, T. L., Cramer, S. C., & Meltzoff, A. N. (2005). Brain activation during face perception: Evidence of a developmental change. *Journal of Cognitive Neuroscience*, *17*, 308–319. doi:10.1037/h0027474
- Batty, M., & Taylor, M. J. (2006). The development of emotional face processing during childhood. *Developmental Science*, *9*, 207–220. doi:10.1111/j.1467-7687.2006.00480.x
- Beall, P. M., Moody, E. J., McIntosh, D. N., Hepburn, S. L., & Reed, C. L. (2008). Rapid facial reactions to emotional facial expressions in typically developing children and children with autism spectrum disorder. *Journal of Experimental Child Psychology*, *101*, 206–223. doi:10.1016/j.jecp.2008.04.004
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society. Series B (Methodological)*, *57*, 289–300.
- Bogart, K. R., & Matsumoto, D. (2010). Facial mimicry is not necessary to recognize emotion: Facial expression recognition by people with Moebius syndrome. *Social Neuroscience*, *5*, 241–251. doi:10.1080/17470910903395692
- Calvo, M. G., & Lundqvist, D. (2008). Facial expressions of emotion (KDEF): Identification under different display-duration conditions. *Behavior Research Methods*, *40*(1), 109–115. doi:10.3758/BRM.40.1.109
- Campbell, R., Walker, J., & Baron-Cohen, S. (1995). The development of differential use of inner and outer face features in familiar face identification. *Journal of Experimental Child Psychology*, *59*, 196–210. doi:10.1006/jecp.1995.1009
- Camras, L. A., & Allison, K. (1985). Children's understanding of emotional facial expressions and verbal labels. *Journal of Nonverbal Behavior*, *9*(2), 84–94. doi:10.1007/BF00987140
- Caron, A. J., Caron, R. F., & MacLean, D. J. (1988). Infant discrimination of naturalistic emotional expressions: The role of face and voice. *Child Development*, *59*, 604–616. doi:10.2307/1130560
- Carton, J. S., Kessler, E. A., & Pape, C. L. (1999). Nonverbal decoding skills and relationship well-being in adults. *Journal of Nonverbal Behavior*, *23*(1), 91–100. doi:10.1023/A:1021339410262
- Casey, B., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: What have we learned about cognitive development? *Trends in Cognitive Sciences*, *9*(3), 104–110. doi:10.1016/j.tics.2005.01.011
- Dimberg, U. (1982). Facial reactions to facial expressions. *Psychophysiology*, *19*, 643–647. doi:10.1111/j.1469-8986.1982.tb02516.x
- Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, *11*(1), 86–89. doi:10.1111/1467-9280.00221
- Durand, K., Gallay, M., Seigneure, A., Robichon, F., & Baudouin, J.-Y. (2007). The development of facial emotion recognition: The role of configural information. *Journal of Experimental Child Psychology*, *97*(1), 14–27. doi:10.1016/j.jecp.2006.12.001
- Ekman, P., & Friesen, W. V. (1978). *Facial action coding system*. Palo Alto, CA: Consulting Psychologists Press.



- Elfenbein, H.A., & Ambady, N. (2003). When familiarity breeds accuracy: Cultural exposure and facial emotion recognition. *Journal of Personality & Social Psychology, 85*, 276–290. doi:10.1037/0022-3514.85.2.276
- Feldman, L., & Lindquist, K. A. (2008). The embodiment of emotion. In G. R. Seim & E. R. Smith (Eds.), *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches* (pp. 237–262). New York, NY: Cambridge University Press.
- Gao, X., & Maurer, D. (2009). Influence of intensity on children's sensitivity to happy, sad, and fearful facial expressions. *Journal of Experimental Child Psychology, 102*, 503–521. doi:10.1016/j.jecp.2008.11.002
- Goldman, A. I., & Sripada, C. S. (2005). Simulationist models of face-based emotion recognition. *Cognition, 94*, 193–213. doi:10.1016/j.cognition.2004.01.005
- Harrigan, J. A. (1984). The effects of task order on children's identification of facial expressions. *Motivation and Emotion, 8*, 157–169. doi:10.1007/BF00993071
- Havas, D. A., Glenberg, A. M., Gutowski, K. A., Lucarelli, M. J., & Davidson, R. J. (2010). Cosmetic use of botulinum toxin-A affects processing of emotional language. *Psychological Science, 21*, 895–900. doi:10.1177/0956797610374742
- Hennenlotter, A., Dresel, C., Castrop, F., Ceballos-Baumann, A. O., Wohlschlagler, A. M., & Haslinger, B. (2009). The link between facial feedback and neural activity within central circuitries of emotion—new insights from botulinum toxin-induced denervation of frown muscles. *Cerebral Cortex, 19*, 537–542. doi:10.1093/cercor/bhn104
- Herba, C., & Phillips, M. (2004). Annotation: Development of facial expression recognition from childhood to adolescence: Behavioral and neurological perspectives. *Journal of Child Psychology & Psychiatry, 45*, 1185–1198. doi:10.1111/j.1469-7610.2004.00316.x
- Hess, U., Blairy, S., & Kleck, R. E. (1997). The intensity of emotional facial expressions and decoding accuracy. *Journal of Nonverbal Behavior, 21*, 241–257. doi:10.1023/A:1024952730333
- Huynh, H., & Feldt, L. S. (1976). Estimate of the box correction for degrees of freedom from sample data in randomized block and split-plot designs. *Journal of Educational and Behavioral Statistics, 1*(1), 69–82. doi:10.3102/10769986001001069
- Kanade, T., Cohn, J. F., & Tian, Y. (2000). *Comprehensive database for facial expression analysis*. Proceedings of the Fourth IEEE International Conference on Automatic Face and Gesture Recognition (FG'00), Grenoble. pp. 46–53.
- Kirouac, G., Dore, F. Y., & Gosselin, F. (1985). The recognition of facial expressions of emotions. In R. E. Tremblay, M. A. Porovost, & F. F. Strayer (Eds.), *Ethologie et développement de l'enfant* (pp. 131–147). Paris: Stock.
- Lord, C., & Bailey, A. (2002). Autism spectrum disorders. In M. Rutter & E. Taylor (Eds.), *Child and adolescent psychiatry* (pp. 636–663). Oxford: Blackwell.
- McGivern, R. F., Andersen, J., Byrd, D., Mutter, K. L., & Reilly, J. (2002). Cognitive efficiency on a match to sample task decreases at the onset of puberty in children. *Brain & Cognition, 50*(1), 73–89. doi:10.1016/S0278-2626(02)00012-X
- McIntosh, D. N., Reichmann-Decker, A., Winkielman, P., & Wilbarger, J. L. (2006). When the social mirror breaks: Deficits in automatic, but not voluntary, mimicry of emotional facial expressions in autism. *Developmental Science, 9*, 295–302. doi:10.1111/j.1467-7687.2006.00492.x
- Merz, S. (2008). *Facial emotion recognition in children and adolescents: Effects of puberty and callous unemotional traits in a community sample* (Unpublished doctoral dissertation). University of New South Wales, Sydney.
- Monk, C. S., McClure, E. B., Nelson, E. E., Zarahn, E., Bilder, R. M., Leibenluft, E., ... Pine, D. S. (2003). Adolescent immaturity in attention-related engagement to emotional facial expressions. *Neuroimage, 20*, 420–428. doi:10.1016/S1053-8119(03)00355-0
- Montagne, B., Kessels, R. P. C., De Haan, E. H. F., & Perrett, D. I. (2007). The emotion recognition task: A paradigm to measure the perception of facial emotion expressions at different intensities. *Perceptual and Motor Skills, 104*, 589–598. doi:10.2466/pms.104.2.589-598
- Niedenthal, P. M. (2007). Embodying emotion. *Science, 316*, 1002–1005. doi:10.1126/science.1136930
- Niedenthal, P. M., Brauer, M., Halberstadt, J. B., & Innes-Ker, A. H. (2001). When did her smile drop? Facial mimicry and the influences of emotional state on the detection of change in emotional expression? *Cognition and Emotion, 15*, 853–864. doi:10.1080/02699930143000194

- Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The simulation of smiles (SIMS) model: Embodied simulation and the meaning of facial expression. *Behavioral and Brain Sciences*, 33, 417–433. doi:10.1017/S0140525X10000865
- Oberman, L. M., Winkielman, P., & Ramachandran, V. S. (2007). Face to face: Blocking facial mimicry can selectively impair recognition of emotional expressions. *Social Neuroscience*, 2, 167–178. doi:10.1080/17470910701391943
- Ruffman, T., Henry, J. D., Livingstone, V., & Phillips, L. H. (2008). A meta-analytic review of emotion recognition and aging: Implications for neuropsychological models of aging. *Neuroscience and Biobehavioral Reviews*, 32, 863–881. doi:10.1016/j.neubiorev.2008.01.001
- Schumann, C. M., Hamstra, J., Goodlin-Jones, B. L., Lotspeich, L. J., Kwon, H., Buonocore, M. H., ... Amaral, D. G. (2004). The amygdala is enlarged in children but not adolescents with autism; the hippocampus is enlarged at all ages. *Journal of Neuroscience*, 24, 6392–6401. doi:10.1523/JNEUROSCI.1297-04.2004
- Serrano, J. M., Iglesias, J., & Loeches, A. (1992). Visual discrimination and recognition of facial expressions of anger, fear, and surprise in 4- to 6-month-old infants. *Developmental Psychobiology*, 25, 411–425. doi:10.1002/dev.420250603
- Shimokawa, A., Yatomi, N., Anamizu, S., Torii, S., Isono, H., Sugai, Y., & Kohno, M. (2001). Influence of deteriorating ability of emotional comprehension on interpersonal behaviour in Alzheimer-type dementia. *Brain and Cognition*, 47, 423–433. doi:10.1006/brcg.2001.1318
- Simpson, L. L. (1981). The origin, structure, and pharmacological activity of botulinum toxin. *Pharmacological Review*, 33, 155–188.
- Stel, M., & van Knippenberg, A. (2008). The role of facial mimicry in the recognition of affect. *Psychological Science*, 19, 984–985. doi:10.1111/j.1467-9280.2008.02188.x
- Strack, F., Martin, L. L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology*, 54, 768–777. doi:10.1037/0022-3514.54.5.768
- Tassinary, L. G., & Cacioppo, J. T. (2000). The skeletomotor system: Surface electromyography. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of Psychophysiology* (pp.163–199). New York, NY: Cambridge University Press.
- Thomas, L. A., De Bellis, M. D., Graham, R., & LaBar, K. S. (2007). Developmental of emotional facial recognition in late childhood and adolescence. *Developmental Science*, 10, 547–558. doi:10.1111/j.1467-7687.2007.00614.x
- Walden, T. A., & Field, T. M. (1982). Discrimination of facial expressions by preschool children. *Child Development*, 53, 1312–1319. doi:10.2307/1129021
- Whelan, R. (2008). Effective analysis of reaction time data. *The Psychological Record*, 58, 475–482.
- Wicker, B., Keysers, C., Plailly, J., Royet, J.-P., Gallese, & Rizzolatti, G. (2003). Both of us disgusted in my insula: The common neural basis of seeing and feeling disgust. *Neuron*, 40, 655–664. doi:10.1016/S0896-6273(03)00679-2



