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Parent-Child Transmission of Disgust and Hand Hygiene: The Role of Vocalizations, Gestures and Other Parental Responses

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Abstract Recent findings indicate that parents, in the presence of disgust elicitors, exhibit exaggerated behavioral avoidance and direct expressions of disgust toward younger children. Here we examine whether other communication channels—vocalizations and gestures—are also used to entrain disgust. We also explore whether parents transmit hand hygiene practices in a similar manner. Children's disgust responses factored into two discrete components—expressive and felt disgust. Variance in child expressive disgust, when tested alone, was explained by a combination of parental facial and vocal disgust, moderated by child age. Children's felt disgust, when tested alone, was weakly related to parental self-reports of disgust. Hand hygiene transmission (HHT) was observed and directed toward younger children (2–3 years). Parents who demonstrated HHT also directed more disgust-related behaviors towards their child. The age-moderated effects here suggest parents selectively direct facial and vocal expression of disgust toward young children and this has detectable consequences on their disgust behavior.

Keywords Hand hygiene · Disgust · Contamination · Development

There is only a small body of empirical work examining how objects first come to elicit disgust in children (e.g., Fallon et al. 1984; Rozin et al. 1984; Sawchuk 2008; Stevenson and Repacholi 2003; Stevenson et al. 2010). Rozin and Fallon (1987) suggest that disgust is not present at birth and that children generally appear tolerant of disgust objects until the age of 2 years (Rozin et al. 1986). Basic disgust responses—as measured by behavioral avoidance, facial expression and self-report—appear to develop at around 2–3 years for core disgust elicitors (e.g., body products such as feces, vomit, urine, blood and decaying matter). Rozin et al. (2000) have suggested that this class of elicitors possesses potential for pathogen transmission and therefore rejection serves to protect the body from disease. Next to emerge are the animal–nature elicitors pertaining to reminders of our animal origins and our own mortality. This class of elicitors includes death, poor hygiene, inappropriate sexual behavior, and violations of the body envelope (e.g., gore, deformity, obesity). These are followed by the interpersonal or sexual disgusts, such as revulsion at direct or indirect contact with strangers or other undesirables. Last to emerge are the sociomoral disgusts, our apparent reaction to elicitors such as racism, child molestation, and murder. These latter three domains—animal–nature, sexual and sociomoral—are considered by Rozin et al. (2000) to reflect progressively greater levels of abstraction and ideational content (Rozin et al. 2000; Oaten et al. 2010; Stevenson et al. 2010; Tomkins 1963).

It has been assumed that the child acquires disgust responses towards particular objects via some form of parent–child transmission (Rozin and Fallon 1987; Tomkins 1963). In adults, observing a facial expression of disgust results in a pattern of neural activity, which is similar to that produced by contact with a disgust object (Wicker et al. 2003). The transmission of disgust from parent to child may rely on a similar process, in which observing the parental expression in response to a cue may elicit the emotion in the child. For example, observing the facial expression of disgust may cause a mimetic facial response of disgust, which itself induces a feeling of disgust (Rozin and Fallon 1987; Tomkins 1963). Alternatively, observing the parent's disgust expression may not directly elicit emotion; rather, the child may interpret the expression and use this information to form a response. There

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is some evidence for the role of social cues in acquisition. The observation of an actor consuming a distinct colored (flavored or glass shaped) beverage and facially expressing either like or dislike toward the beverage, while the subject was drinking an identical beverage, caused an appropriate hedonic shift in subsequent responses to that color, flavor, or glass (Baeyens et al. 1996a, b).

We recently observed facial disgust transmission in the laboratory, providing the first evidence that facial expression may provide one method for entraining disgust (Stevenson et al. 2010). This work established that there is a developmental sequence in disgust acquisition and that parents are instrumental in this process. For example, Australian children aged from 2 to 16 years were exposed alone and with their parents to a range of disgust evoking elicitors. Self-reports, behavioral avoidance and facial expression data were obtained. Evidence for parent–child transmission was observed, with parents of younger children in the presence of a disgust elicitor emoting more disgust to their offspring, and these children showing the greatest behavioral avoidance of the potential contaminants.

While facial expressions are important in communicating emotion, there are also other channels, notably vocalizations, which may be direct (words—yuck, gross) or indirect (sounds—argh, phew; and laughter), and gestures (e.g., brushing an object away, leaning away from an object, etc). Indeed, Hejmadi et al. (2000) demonstrated that emotion can be communicated through bodily signals, and that such signals are recognized (equally) by both American and Indian participants. As vocalizations are crucial in human communication, it would be surprising if this channel were not used in conjunction with facial expression, to instruct children in the meaning of a particular cue. While the combination of these two cues might be especially potent, there are also likely to be situations where vocalization alone may be more effective, such as when the parent is not in the child's line of sight or when the child is at a distance (e.g., Sauter et al. 2010). Indeed, Mumme et al. (1996) found that in infants, fearful vocal signals when presented without facial cues were sufficient to produce appropriate behavior regulation, whereas fearful facial signals alone were not.

Here, we revisited video data collected in our earlier work (Stevenson et al. 2010) that contained parent and child responses to various disgust elicitors. The behaviors of interest here—vocalizations and gestures—have *not been previously coded or tested* in our earlier work. The aim here was to extract these variables and use them to address two outstanding questions concerning disgust transmission. First, as our original experiment involved presenting disgust elicitors to children when alone, and then later with their parent present, it would allow us to establish whether the child's behavior when alone could be predicted by *later* parental behavior, including vocalizations and gestures. Such concordance between parent and child behavior would be consistent with transmission having occurred in the past, especially if moderated by child age, with stronger concordance for younger children (Davey et al. 1993). Second, when the parent was present during testing, the child was re-presented with the disgust elicitor, providing an opportunity for the parent to influence the child's response there and then. This situation allows us to directly observe parent–child transmission, including the role of vocalizations and gestures. It also allows us to relate this parental behavior back to the child's disgust response when alone (i.e., did parents who tended to be more 'instructive' have children who were more disgust reactive when tested alone?). As we would now have multiple measures of disgust behavior for the child, including the new measures coded here, plus the original variables reported in the previous study, we also needed to determine whether the child's disgust response was a unitary construct (i.e., were facial expressions, vocalizations, gestures, self-reports of disgust and degree of contact with the disgust cue all aspects of the same underlying variable?). Practically, this was important because both of the questions above required us to predict the child's *disgust* behavior.

Finally, a further issue was explored. During the video coding, it became apparent that there were several instances in which parents directed their child to clean their hands with hand wipes made available during testing. Coding these instances would provide the first opportunity to study whether, as suspected, the parent–child transmission of disgust is also used as a vehicle for training hygiene-related practices early in development. Many strands of evidence suggest that this may be so. In children, toilet training, which typically occurs around 2 years of age (Schum et al. 2002), may be instrumental in generating disgust toward feces (Rozin and Fallon 1987). Relatedly, it has been suggested that feeling disgust may be an especially effective motivator for adult hand hygiene (Curtis et al. 2007, 2009). For example, Curtis et al. (2007) included disgust components in a national hand hygiene campaign conducted in Ghana. The campaign made contamination visible following toileting. The contaminant was "visibly" transferred from a mother to her child's meal during food preparation. Reported hand washing after toileting increased by 13 %, and before eating by 41 %. More recent empirical work also supports the view of disgust as a motivator for adult hand hygiene (Porzig-Drummond et al. 2009; Stevenson et al. 2009). Disgust's effectiveness as a cue to hand hygiene in adults *may* parallel events in childhood, where acquisition of disgust-related behavior may be closely tied to that of hand hygiene. This is because many of the cues that are arguably most effective in prompting hand hygiene in adults (e.g., contact with feces, bodily secretions, dirt and visible disease vectors; Curtis and Biran 2001; Oaten et al. 2009) are also cues for disgust *and* disease. Thus, we examined the videos for evidence of parent–child transmission of hand hygiene, whether this was age-related, and the latter's relationship to parent–child transmission of disgust.

Method

Participants

We recruited 101 Australian parent–child pairs. Five parent–child pairs were excluded because the children (all of whom were preschoolers) were either unable to demonstrate an understanding of the self-report measure or did not complete the entire testing session, which left a remaining 96 parent–child pairs for analysis. Parents (and older children) received a small cash payment for participation.

Children were assigned to one of five mean age groups: 2.5 years [2 years to 3 years and 11 months]; 4.5 years [4 years to 5 years and 11 months]; 6.8 years [6 years to 8 years and 11 months]; 10.1 years [9 years to 12 years and 11 months]; and 14.3 years [13 years to 16 years and 11 months]. These age groups provided approximately equal cells (n=19, 21, 21, 17, and 18, respectively). There was no significant difference in the relative frequency of gender within each age group. The child's primary caregiver was generally the mother (94/ 96 parent-child parents). Parental age increased across the child age groups from a mean of 34.8 years (SD= 4.9 years) for the youngest to 43.5 years (SD= 8.6 years) for the oldest. Most of the mothers had more than one child (M= 2.20, SD= 1.10), and reported being the primary care giver during the first 2 years of the target child's life and during the past month. The mothers reported a median family income of $80,000–$100,000 (AUD), and 65 % were university graduates. Fifty-four percent were born locally, with the largest remainder coming from other English-speaking nations (24 %).[1]

Apparatus and Procedure

Testing took place in a single experimental session composed of three consecutive phases. The first involved an instruction and pretest phase to ensure that child understood the procedure and the response process. Preschoolers (i.e., those not yet attending school) received a simplified version of the self-report scale. They were told that they would be asked whether certain things were "good" or "bad." If they did not know, they were instructed to say, "I don't know." To determine whether the preschoolers understood this procedure, the experimenter asked them three pretest questions: (a) "Do you think getting into trouble is good or bad?" (b) "Do you think getting presents at Christmas is good or bad?" (c) "Do you think feeling sick is good or bad?" For children who were attending school, a different self-report scale and pretest procedure was adopted. Children were asked to identify their favorite food. They were then asked what food they "hated." If they could not generate a food, they were asked about TV shows instead. They were then shown a 5-point bipolar scale, with the following anchors: really like, like a bit, unsure, dislike a bit, and really dislike. Underneath each anchor were cartoon faces indicating a matching facial expression. Each child was asked, "If I [gave/showed] you [the child's favorite food/favorite TV show], which face would you point to?" This was followed by the same question, but for the food (or TV show) that the child disliked.

The second phase always involved testing the child alone (aged from 2–16 years), with the mother visibly present (the top of her head could be seen), but with her listening to music on the radio behind a screen. The experimenter took the child through a series of modules (in counterbalanced order). Each module consisted of graded exposures to a particular adult disgust elicitor, which the child was asked to contact or interact with (their responses here forming the behavioral avoidance disgust score). In addition, children were asked to report their affective reaction to the stimulus (self-reported affect). The method adopted here—escalating degrees of disgust exposure—is modeled after the technique used in Rozin et al. (1999), which proved effective with adults. All of this testing was video and audio taped, so that responses could later be coded.

The disgust modules included an invitation to evaluate and sample ice cream mixed with tomato sauce, an invitation to evaluate and touch a dirty sock, an invitation to evaluate and sniff two unidentified odors—one of which was organic fertilizer [fecal], and the other fermented shrimp paste [urine], an invitation to evaluate and touch maggots, and an invitation to evaluate and touch a glass eye. An example of a disgust module is as follows: The experimenter took a single scoop of ice cream and placed it in a bowl. After the children rated it, the experimenter took a tomato sauce bottle and covered the ice cream with sauce. The ice cream was again evaluated, and the children were asked whether they would like to try a tiny spoonful. If they did, they were then asked whether they would like to try a larger spoonful.

Participants were also asked to evaluate stimuli depicting sociomoral violations (e.g., a picture and story of someone stealing from a disabled man, a picture of a young man marrying an elderly woman, a picture of a garbage-strewn park, and a picture of a KKK meeting). An example of a sociomoral item is as follows: Participants were shown a photograph of a much older woman marrying a young man. The experimenter said, "This is a photograph of a wedding between a man and a much older woman." They were then asked to evaluate it after which they were asked, "Do you think these two people should get married?" These stimuli were selected so as to provide a broad range of adult disgust elicitors covering all domains of disgust (Disgust Sensitivity Questionnaire [DSQ]; Haidt et al. 1994). After the child had completed these modules, the third phase of testing began.

[1] A more detailed demographic summary for this sample can be found in the Results section of Study 2 in Stevenson et al. (2010).

The parent was invited into the test arena and was administered the same test modules as their child, with the child sitting beside them. While the parent presentations were largely identical to the child ones (i.e., same dependent variables collected), a further element was added to the end of each module, namely the child was offered another chance to interact with the disgust-inducing stimulus.

Coding

Affective and behavioral scores were aggregated across all modules separately for parents and children, with higher scores reflecting greater disgust. Two coders, blind to study aims, were trained to code the following facial expressions: anger, sadness, surprise, disgust, fear, and happiness. Training was conducted using the Ekman faces from the Facial Expressions of Emotion: Stimuli and Tests (Young et al. 2002). Three principal variables were generated: number of times the child displayed the emotion of disgust on their face; number of times the parent generated a disgust facial expression; and the number of times the parent generated a disgust facial expression that was directed towards their child. A more detailed summary of facial expression coding can be found in our previous paper (see Stevenson et al. 2010, p. 170).

The new data reported here consisted of coding all of the child and parent videotapes for instances of vocal disgust (words—yuck, disgusting, gross, foul, poo; and sounds—pfaw, urgh, ewww, argh, phew), laughter (which we included as this might be used instead of disgust-related vocalizations to mask embarrassment), and avoidant gestures (movement/s away from, hiding from and shooing/brushing away from the stimulus). In addition, for parents, we also coded whether their vocal disgust, laughter and gestural avoidance were directed at their child. Finally, parental hand hygiene acts and parental hand hygiene instructions directed at their child were also coded. We did not code instances of child hand hygiene alone, as these were rare.

All of the coding was conducted by a single rater blind to the purpose of the experiment. Thirty percent of the coding was then repeated by a second naïve rater, and the inter-rater reliability was established using Pearson correlation and absolute-level intraclass correlation (ALIC). For the children, there was moderate agreement between coders for all variables: vocal disgust, $r(28)=0.77$, ALIC=0.63; laughter, $r(28)=0.83$, ALIC=0.79; gestural avoidance, $r(28)=0.69$, ALIC=0.65. A similar level of agreement was also observed for parental responses: vocal disgust, $r(28)=0.77$, ALIC=0.66; laughter, $r(28)=0.75$, ALIC=0.71; gestural avoidance, $r(28)=0.70$, ALIC=0.70; hand hygiene, $r(28)=0.85$, ALIC=0.83. For behaviors directed at the child by the parent, there was moderate to strong agreement between coders: vocal disgust, $r(28)=0.74$, ALIC=0.68; laughter, $r(28)=0.75$, ALIC=0.71; gestural avoidance, $r(28)=0.72$, ALIC=0.70; hand hygiene, $r(28)=0.94$, ALIC=0.94.

Analysis

Consistent with our previous report (Stevenson et al. 2010), we used five child age groupings (Mean ages=2.5, 4.5, 6.8, 10.1 and 14.3 years) in all analyses that required this variable. Child gender, which was used as a variable in preliminary analyses, was not a significant factor, and so is not included here. Parametric tests were employed as the data met the necessary assumptions.

Results[2]

Child Vocalizations and Gestures, and their Relationship with Other Variables

Instances of disgust-related vocalizations, laughter and gestural avoidance, were calculated separately for each child, collapsing across modules (see Fig. 1). There was a significant quadratic association between age group and disgust-related vocalizations, $F(2,93)=7.84$, $p<0.001$, $r^2=14.4$ %, with vocal disgust most apparent in the 6.8 and 10.1 year old age groups. For laughter, there were linear and quadratic associations with age group, $F(1,94)=48.22$, $p<0.001$, $r^2=33.9$ %; $F(2,93)=23.91$, $p<0.001$, $r^2=34.0$ %, with laughter least evident in the youngest groups and most evident in the oldest. For gestural avoidance, there was a quadratic association with age group, $F(2,93)=4.67$, $p<0.02$, $r^2=9.1$ %, similar to that for vocal disgust, with this form of response most evident in the 6.8 and 10.1 year old age groups. So, consistent with our previous report, these further aspects of disgust responding also demonstrate age-related change.

To examine the relationship between children's avoidant gestures and disgust vocalizations, and between these variables and the children's previously published data (i.e., disgust facial expression, test behavior and self-report), we entered all five variables into a principal components analysis (PCA). Correlations between these variables, including laughter, are presented in Table 1. Laughter's relationship to other disgust measures is not well established. For this reason, we first report the PCA excluding this variable. The data set were suitable for PCA, as the Kaiser-Meyer-Olkin (KMO) index was .61 and Bartlett's test of sphericity was significant (Chi-Squared (10)=93.39, $p<0.001$). Two factors emerged; the

[2] While use is made of existing data, there is no duplicate reporting. No analysis (or table, figure etc) conducted or presented in Stevenson et al. (2010) is included in the Results section of this manuscript. All of the analyses here using existing data are novel, because they always use the data in conjunction (i.e. PCA, Regression) with the new data presented in the manuscript.

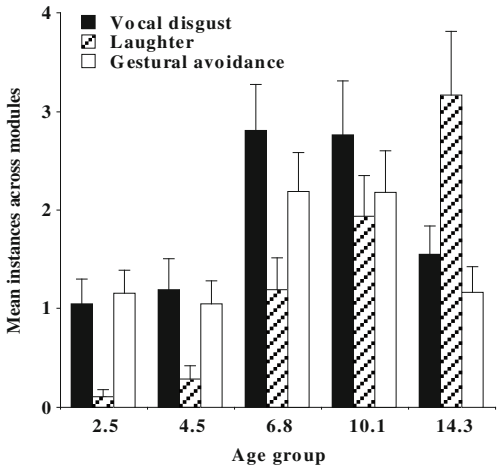

Fig. 1 Mean (and standard error) instances of vocal disgust, laughter and gestural avoidance (collapsed across all modules) generated by the child, by child age group

first, accounting for 39.3 % of the variance following rotation, included three variables—vocal disgust, facial disgust expression and gestural avoidance—which we term child *Expressive disgust*. The second factor, accounting for 28.9 % of the variance following rotation, included the remaining two variables—test behavior and self-report, which we term child *Felt disgust*. We then repeated the PCA (KMO [0.62] and Bartlett's tests [Chi-Squared=102.1] indicated its suitability for this analysis) including laughter. A two-factor solution emerged again, with *Expressive disgust*, as above, but with laughter now included in the *Felt disgust* factor. As we noted above, because of uncertainty over laughter's status in relation to disgust, all further analyses using the *Expressive* and *Felt* factor scores, use those derived from the laughter-free PCA.

Finally, we tested whether each component score from the first PCA was associated with age group. For *Expressive disgust*, there were significant linear and quadratic associations with age group, $F(1,94)=5.72$, $p<0.02$, $r^2=5.7$ %; $F(2,93)=11.83$, $p<0.001$, $r^2=20.3$ %, with expressive disgust increasing with child age, but with a peak in the 6.8 and 10.1 year age groups. For *Felt disgust*, only the quadratic association was significant, $F(1,94)=3.24$ $p=0.075$, $r^2=3.3$ %; $F(2,93)=4.54$, $p<0.02$, $r^2=8.9$ %, with a marginal linear association ($p=0.075$). The age-related changes here were as for *Expressive disgust*, with a peak in the 6.8 and 10.1 year age groups.

Table 1 Correlation between child disgust response measures

Variable	VD	L	SRA	FD	Task behavior
Gestural avoidance (GA)	0.45*	0.07	0.31*	0.35*	0.17
Vocal disgust (VD)		0.01	0.18	0.56*	0.01
Laughter (L)			0.29*	0.16	0.11
Self-report affect (SRA)				0.35*	0.40*
Facial disgust (FD)					0.01

* $p<0.05$

Transmission—Predicting Children's Responses from Parental Responses

Using linear regression, we examined whether parental disgust responses could predict their child's *earlier* disgust responses when tested alone. In particular, we included parental facial, vocal and gestural disgust, self-report ratings, and test behavior scores as predictors. In addition, we also included all of these variables moderated by child age group, to determine whether any particular form of response was exaggerated for younger children, as well as including child age group alone and parental disgust sensitivity (from the DSQ) to account for variation in the parents own reactivity to disgust stimuli. Finally, we included a further predictor, child age by parent facial and parent vocal disgust, as we thought this combination might be used with especial force in younger children.

The first regression used child *Expressive disgust* as the dependent variable, with all of the predictors entered simultaneously, followed by backwards elimination. The final model was significant, accounting for 25.5 % of the variance, $F(5,90)=7.49$, *MSRE* (mean square residual error)=0.75, $p<0.001$ in child *Expressive disgust*. Five variables remained in the model: (1) parental vocal and facial disgust moderated by child age, $Sr^2=15.6$ %, $p<0.001$; (2) parent test behavior moderated by child age, $Sr^2=7.5$ %, $p<0.005$; (3) parent test behavior alone, $Sr^2=5.8$ %, $p=0.01$; (4) parent gestural avoidance moderated by child age, $Sr^2=4.5$ %, $p=0.02$; and (5) parent gestural avoidance alone, $Sr^2=3.5$ %, $p=0.05$. Two findings emerge from this analysis. First, a moderately strong relationship is evident between the child's expressive disgust behavior when tested alone, and their parent's *later* responses with the child present—consistent with a transmission account of disgust. Second, as expected, the combination of parental vocal and facial disgust, especially in younger children, is found to be the single most powerful predictor of the child's expressive disgust behavior when tested alone.

The second regression used the child's *Felt disgust* score, with the same predictors and technique. The final model was significant, $F(1,94)=5.90$, $MSRE=0.95$, $p<0.02$, accounting for 4.9 % of the variance. Only one predictor variable remained in the model, parental self-report disgust moderated by child age, $Sr^2=5.9$ %, $p<0.02$. This finding suggests that parents of younger children reported *feeling* more disgust, and this was reflected in the child's *Felt disgust* responses when tested alone.

Transmission—Evidence During the Experiment

The number of occasions on which a parent directed a vocal disgust response or laughter at their child were analyzed in a

two-way mixed design ANOVA, with child Age group as the between factor and Vocal response (directed vocal disgust vs. directed laughter) as the within-participant variable. The ANOVA revealed a main effect of Vocal response, $F(1,91)=16.71$, $MSE=2.04$, $p<0.001$, partial eta-squared=0.16, with greater number of laughter responses directed at the child (M=1.5) relative to disgust responses (M=0.7). There was also a significant interaction between child Age group and Vocal response, $F(4,91)=5.72$, $MSE=2.04$, $p<0.001$, partial eta-squared=0.20, with instances of directed laughter increasing with child age and with instances of directed vocal disgust decreasing with child age (see Fig. 2). We then tested polynomial contrasts for each type of directed Vocal response by child Age group. In each case there were just significant linear contrasts by child Age group (p's<0.001). For vocal disgust, parents directed more instances of vocal disgust to their child if they were younger, while for laughter, the reverse relationship was apparent (see Fig. 2).

Directed gestural avoidance responses were analyzed using a one-way ANOVA. There were no significant effects of child Age group.

Correlations were tested between directed facial disgust responses (which were associated with child age group, see Stevenson et al. 2010) and parent directed vocal disgust, laughter and avoidance gestures. Both directed vocal disgust and avoidance gestures (which intercorrelated; $r(95)=0.50$, $p<0.001$) were positively associated with directed facial disgust, respectively; $r(95)=0.46$, $p<0.001$; $r(95)=0.43$, $p<0.001$, but directed laughter was not associated with any of these variables. We then examined the partial correlation between vocal disgust and child age group, controlling for parental disgust sensitivity, to establish whether greater parental disgust sensitivity might account for this relationship. This relationship was still significant, $r(93)=-0.27$, $p<0.01$, suggesting that the presence of a younger child was probably responsible for greater parental disgust vocalizations.

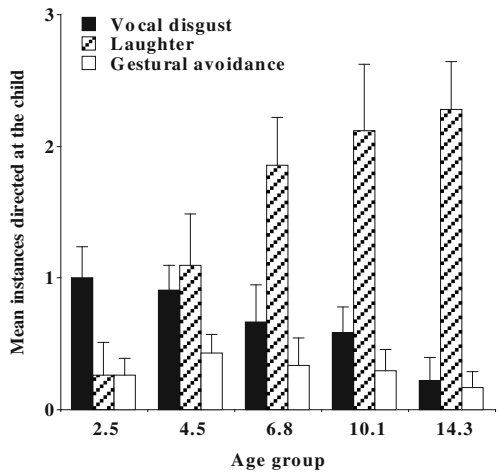

Fig. 2 Mean (and standard error) instances of vocal disgust, laughter and gestural avoidance by parent directed at the child (collapsed across all modules), by child age group

A regression analysis was then conducted to examine whether parental *directed* expressions, gestures and vocalizations could predict *Expressive* and *Felt* disgust of the child when tested alone. For this regression (again with simultaneous entry and backward elimination), we entered the latter three variables, parental disgust sensitivity and child age group, along with all potential interactions between the three parental directed behaviors, with and without moderation by child age group. The interactions were included, as we suspected that combinations of directed behaviors might be more effective than individual predictors alone—as suggested by the earlier analyses above. The final model was significant, $F(3,92)=8.35$, $MSRE=0.81$, $p<0.001$, accounting for 18.8 % of the variance in child expressive disgust. There were three predictors: directed facial expression and vocalization moderated by child age, $Sr^2=10.8$ %, $p<0.001$; directed facial expression and vocalization alone, $Sr^2=4.9$ %, $p<0.02$; and child age, $Sr^2=3.6$ %, $p<0.05$). These findings suggest that parental disgust responding that is focused on the child can predict the child's expressive disgust responding when tested alone. Moreover, it suggests that the combination of directed parental disgust facial expression and vocalization, especially in young children, is the most powerful predictor of the child's expressive disgust behavior when tested alone.

We then repeated this analysis for child *Felt disgust*. The final model was significant, $F(3,92)=7.28$, $MSRE=0.84$, $p<0.001$, accounting for 16.5 % of the variance. There were three predictors in this model, avoidant gestures directed at the child, $Sr^2=13.1$ %, $p<0.001$; parental disgust sensitivity, $Sr^2=4.4$ %, $p<0.05$, and child age, $Sr^2=5.4$ %, $p<0.02$. In this case, parental avoidant gestures directed at the child, were most predictive of the child's felt disgust when tested alone.

Impact of Disgust Typologies

Several authors have suggested that there may be sub-types of disgust and many now draw a basic distinction between 'core' disgusts versus those invoked by sociomoral and sexual-related cues (e.g., Rozin et al. 2000; Stevenson et al. 2010; Tybur et al. 2009). As there were relatively few behavioral responses to sociomoral/sexual items, analysis of this class of elicitor alone was uninformative. Removing these items and repeating the analyses above produced a largely identical pattern of outcomes, suggesting that our data speak most directly about core disgusts.

Transmission of Hand-Hygiene and Disgust

Parents wiped their hands on average 0.1 times/module and instructed their child to wash their hands 0.3 times/module. Instructions to wash were analyzed in a one-way ANOVA

with child Age group as the between factor. The ANOVA revealed an effect of child Age group, $F(4,91)=2.47$, $MSE=0.37$, $p<0.05$, partial eta-squared=0.10. Polynomial contrasts by child age group revealed a significant quadratic component ($p<0.02$), and as is evident in Fig. 3, instances of parental intervention were highest in the youngest children (a contrast of the youngest age group vs. the remainder, confirmed this impression, $t(94)=2.82$, $p<0.01$).

We then examined whether parental *directed* expressions, gestures and vocalizations could predict parental hand hygiene interventions using the same regression strategy described in the preceding analysis. The final model was significant, $F(6,89)=4.63$, $MSRE=0.32$, $p<0.001$, accounting for 18.7 % of the variance in parental hand hygiene interventions. There were six predictors in this model: (1) directed avoidant behavior by facial expression, $Sr^2=19.1$ %, $p<0.001$; (2) directed avoidant behavior by facial expression moderated by child age, $Sr^2=9.3$ %, $p<0.001$; (3) directed avoidant behavior by facial expression by vocalization, $Sr^2=7.5$ %, $p<0.005$; (4) directed facial expression, $Sr^2=6.3$ %, $p<0.01$; (5) directed facial expression by vocalization, $Sr^2=3.6$ %, $p<0.05$; and (6) the interaction between all three directed behaviors and child age, $Sr^2=2.9$ %, $p=0.069$. Two conclusions emerge from this regression: first, that child age is a moderating factor in two cases, suggesting more focused hand-hygiene interventions by parents of younger children; second, that combinations of avoidant behaviors, disgust facial expression and vocalizations, were all predictive of a greater number of parental hand-hygiene interventions.

Discussion

Several findings from the current study contribute to our emerging understanding of parent–child transmission of disgust and hand hygiene development. First, the behavior of the child alone, both for expressive and felt disgust, could be predicted by their parent's later behaviors, and by their parent's later child *directed* behaviors. The most striking finding was the interaction between facial expression and vocalization, which in combination with child age was the best predictor of child expressive disgust, suggesting this combination may be more important than either variable alone in shaping the child's response to disgust elicitors. Second, parents directed more disgust-related vocalizations to younger than older children, and this behavior was associated with both directed expressions of disgust and avoidant gestures, but not laughter. Third, we observed that parents intervened to promote hand hygiene more frequently in younger children, and that the frequency of intervention related to several aspects of parent-to-child directed disgust.

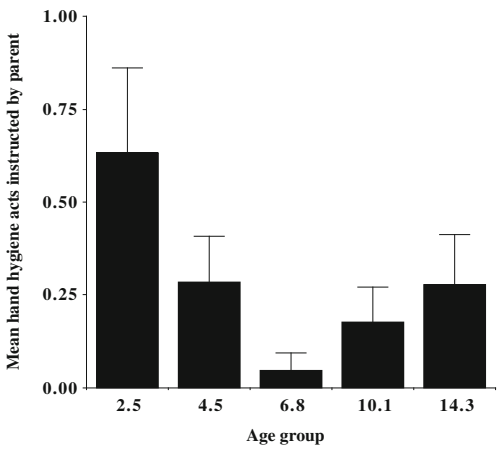

Fig. 3 Mean (and standard error) instances of hand-hygiene instructed by the parent (collapsed across all modules), by child age group

One implication of our findings concerns the additive effect of facial expression and vocalization when predicting expressive disgust. It might be that children "learn" these disgust behaviors by virtue of having complex psychological mechanisms that are *prepared* to take in this information and interpret it in highly specific ways (Seligman 1970)—for example; it might be that very young children are prepared to attend to facial expressions, especially when associated with vocalizations. A more practical implication of this work is that it involves the first empirical test to provide some information about how hand hygiene practices are acquired by children and some of the techniques parents use during entraining such practices. Effective hand hygiene is the most powerful preventative agent in the spread of infectious disease (e.g., Aiello et al. 2008; Luby et al. 2005). Despite this, almost nothing is known about how hand hygiene develops. Understanding how hand hygiene habits are formed allows us to teach parents the most effective means of inculcating good hand hygiene practices in their children, with life-long benefits for the child and the broader community.

It is also important, however, to consider study limitations. A key limitation of the current study is that demonstrating an association between parental and child disgust leaves open a number of alternative causes of this relationship. While we suggest above that these associations reflect the consequences of parental training, they might equally reflect inherited predispositions. However, a number of arguments would favor a training interpretation. First, in the only twin study relating to disgust, there was no evidence of innate similarities in responding (Rozin and Millman 1987). Second, the frequently observed moderating effect of child age, which we observed, suggests that parents make their disgust responses more pronounced as a consequence of a young child's presence and not because of any individual difference in disgust sensitivity. The presence of such moderating effects has been suggested before as a reason to suspect parental training effects over that of inherited dispositions (Davey et al. 1993). Third, if child-directed behavior by parents is a means of transmission, then

the frequency with which this occurs when the child is present, should relate *back* to the child's behavior alone—and this relationship was observed. Fourth, if parent–child transmission is the principal method for acquiring disgust responses, then we would expect that expressive measures of disgust—in other words, those that are most overt—should also be those with the closest correspondence between parent and child. Again, this was observed, in that child expressive disgust consistently shared more variance with overt aspects of their parents' behavior. While we would like to suggest that our results reflect the effects of transmission, it would be premature to rule out innate predispositions entirely.

That children's disgust responding can be factored into two discrete components suggests that what they display and what they feel may not always align. It is well established that adults modulate emotional expression, including disgust, dependent upon the presence of other people (e.g., Gilbert et al. 1987). On this basis, it should not be surprising then that the strongest parent–child relationships emerged for expressive disgust. For felt disgust, while parental behavior and self-reports significantly explained variation in their child's scores, this was consistently less than for expressive disgust. In addition, both regression analyses for child-felt disgust obtained predictors that weakly reflected their parents feelings (self-report ratings and disgust sensitivity, these correlate $r(96)=0.47$), suggesting that expressive transmission may precede similarity in feeling, arguably supporting a social referencing account. In terms of the expressive modality, the most effective channel here was the combination of vocal and facial disgust. This combinatorial effect has not been observed before.

Finally, we also obtained some unique data on the transmission of hand hygiene behavior between parents and children, which has been suspected (e.g., Whitby et al. 2006), but never before observed in a laboratory setting. This was most evident in the youngest age group, exactly the same group that appears to be targeted for disgust entraining by parents. Moreover, as expected, there were significant relationships between a parent's propensity to train their child in hand hygiene and their propensity to do the same for disgust. These findings support the contention that training of hand hygiene behavior does indeed relate to entraining of disgust responding.

As noted earlier, several authors have suggested that there may be sub-types of disgust, and many draw a basic distinction between 'core' disgusts and those invoked by sociomoral and sexual cues (e.g., Rozin et al. 2000; Stevenson et al. 2010; Tybur et al. 2009). It may be that the different domains of disgust also involve different patterns of transmission—a topic worthy of future attention. A second area for further consideration concerns instances of parental instructions to engage in hand hygiene. We reported that parental intervention was highest in the youngest children; however, there was also an unexpected significant quadratic component to this finding. That is, parental hand hygiene intervention appears to taper off at 6.8 years, and then resurfaces again at 10.1 and 14.3 years (see Fig. 3). The pattern of parental intervention is not immediately intuitive to us and therefore warrants further exploration. Finally, another interesting finding was that laughter becomes more common, relative to other expressions, in both children and in adults, directed at children. Participants in studies on disgust often laugh and show signs of amusement (Hemenover and Schimmack 2007; Rozin et al. 1999). There is also some evidence of that disgust sensitivity decreases following early adolescence (Haidt et al. 1994), and of a negative relationship between disgust sensitivity and disgust humor (Oppliger and Zillman 1997), which might explain, at least in part, the increase of laughter with age. Alternatively, it has also been proposed that disgust is enjoyable because it elicits a negative emotion or feeling, but in an environment in which cognitions indicate there is no real threat (Rozin 1990; McCauley 1998). It seems that the relationship between disgust and laughter is deserving of further investigation.

In conclusion, the data here provide further evidence for the similarity between parents and young children in their disgust responding. These correspondences suggest that a combination of facial, vocal and gestural cues are used to entrain disgust, and that similar practices may be used in the development of hand hygiene habits, and that parents selectively focus these on young children.

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