The Journal of General Psychology, 2014, *141*(4), 326–347

Is Disgust Prepared? A Preliminary Examination in Young Children

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ABSTRACT. Children may be prepared to associate adult disgust reactions with adult disgust elicitors. To test this, three-year olds (and adults) were presented with two images and an emotive vocalization. The images and vocalizations included stimuli adults found disgusting, fear-provoking, and sad. On one set of trials, the main dependent variable (DV) was time spent looking at each image and on a second set of repeat trials the DV was knowledge of image-sound matches. Fear and disgust vocalizations were both more effective at orienting a child's attention to adult fear and disgust images, than sad vocalizations. Parental disgust sensitivity was associated with this effect, moderated by explicit matching knowledge. Matching knowledge was poor in children and good in adults. These data suggest that in children, fear and disgust vocalizations may both promote attention to stimuli that adults find disgusting and/or fear-provoking, suggesting that "preparedness" may not be wholly emotion-specific.

Keywords: adaptive behavior, emotion, evolutionary psychology

A NUMBER OF AUTHORS HAVE ARGUED that it may be beneficial for an organism to selectively associate specific stimuli and emotions (e.g., Seligman, 1970). Two examples of this seem to stand out. First, there is a predisposition to learn associations between particular animals, especially snakes, and the emotion of fear (Cook & Mineka, 1989; Ohman & Mineka, 2001). Second, humans and many animal species seem prepared to selectively associate the consequences of

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gastrointestinal illness (nausea etc) with recently ingested food, such that this food becomes avoided and can elicit a disgust-like response (Garcia & Koelling, 1966; Logue, Ophir & Strauss, 1981). While preparedness to learn about specific fear-related stimuli has attracted much attention (e.g., Leppanen & Nelson, 2009; Ohman & Mineka, 2001), the other emotion that seemingly provides some evidence of preparedness, disgust, which is also a basic universal emotion (Ekman, 1971), has not. In this manuscript, we make a preliminary examination of whether children are in some way prepared to learn about disgust.

Rozin, Haidt, and McCauley (2008) have presented the only account of disgust development. They suggest that people are born with an innate reactivity to bitter tastes, which generates a particular facial expression designed to assist voiding of the mouth's content, and a feeling of nausea presumably to deter further ingestion (Steiner, 1979). They term this response *distaste*. This distaste response then becomes associated with particular stimuli during the early years of childhood. The first category of disgust elicitor to emerge from this process has been termed by Rozin and colleagues (2008) "the core disgusts." These are typically disease-bearing objects, such as feces, vomit, and rotting food (Curtis & Biran, 2001). Recent research has suggested that these core disgust responses are acquired early in development (Stevenson, Oaten, Case, Repacholi, & Wagland, 2010). In the only study examining this issue, primary caregivers reported that core disgusts were emergent in their child at around 3 to 4 years of age, and in a further laboratory study, children of this age showed some evidence of disgust-like responding to core elicitors (Stevenson et al., 2010).

How then do children of around 3 to 4 years of age come to learn that certain cues (e.g., core elicitors) evoke disgust-like responses? We suggest that it basically involves some form of social learning, as classically demonstrated by observational conditioning of snake fear in monkeys (Mineka, Davidson, Cook, & Keir, 1984). For disgust in humans, the evidence available (Oaten, Stevenson, Wagland, Case, & Repacholi, in press; Stevenson et al., 2010) suggests that parents of young children exaggerate their vocal (e.g., yuck, blah, urgh) and facial expressions of disgust, when they encounter, together with their child an adult disgust elicitor (Oaten et al., in press; Stevenson et al., 2010). These data also suggest that vocal disgust may be especially important in driving learning, because the child can view the disgust elicitor *at the same time* as hearing the vocalization (Oaten et al., in press). Moreover, there is a growing body of evidence that facial disgust recognition in young children can be quite poor (Widen & Russell, 2013), although even infants may recognize that a disgust expression is negatively valenced (Repacholi & Gopnik, 1997). However, vocal representation of emotion may represent a more accurate means of transmitting such information to children (Sauter, Panattoni, & Happe, 2013), and so this form of transmission was our focus here.

We suggest that there are at least three plausible forms of preparedness that could aid children learning adult-like disgust reactions. The first possibility is that adult disgust-related vocalizations selectively prepare children to attend to a specific type of stimulus (e.g., things with a slimy glistening hue—rotting matter;

Oaten, Stevenson, & Case, 2009). This would presumably parallel the way that fear-related sounds may prepare a child to attend to another specific type of stimulus (e.g., things that scuttle or slither—spiders or snakes; Ohman & Mineka, 2001). This would imply a relatively *specific* form of preparedness for both vocalization and object, termed here the emotion *specific* account.

A second possibility also assumes an interaction between a prepared set of vocalizations and a prepared set of stimuli. However, in this case, the stimulus categories are more *generic*. That is disgust or fear vocalizations (and there may be others too) would both be able to focus a child's attention on a broader class of stimuli that includes core adult disgust and fear-related elicitors (e.g., glistening, slimy, scuttling or slithering things). We term this the emotion *generic* account.

A third possibility is that *any* negatively valenced emotional vocalization from parents—be it crying, fear or disgust sounds—is prepared, namely it can act to focus the child's attention on any environmental cue that might pose a threat be it novel, prepared or previously learned as negative. Notably, this places most emphasis on the preparedness of negative vocalizations to mobilize attention towards potential environmental threat stimuli. We term this the *valence* account.

The aim of the preliminary experiment reported here is to test these three possibilities in children who were of an age to be first starting to learn about disgust-related stimuli (i.e., around 3–4 years old). In addition, children of this age may be more sensitive to disgust than children of a younger age as they are post-weaning and are beginning to eat new foods placing them at heightened risk of ingesting pathogens. The design of the experiment is illustrated in Figure 1. The basic approach is to use a preferential looking paradigm, with two visual

Sound type

Image type	Disgust	Fear	Crying	Laughter
Disgust (Rotten food)	1	2	9	12
Fear (Snakes)	3	4	8	11
Sad (Faces)	5	6	7	10

FIGURE 1. Diagrammatic illustration of the experimental design, showing each of the 12 cells, which were repeated once to form the 24 trials of each phase of the experiment (i.e., passive viewing and matching judgments).

images presented together, alongside an emotive sound. This type of procedure has been used successfully with this age group before (e.g., Scott, He, Baillargeon, & Cummins, 2012) and, in comparisons of children and adults (e.g., Lange-Kuttner, 2010). The underlying idea is that looking time reflects the disposition of attention. Thus preferentially looking at one stimulus over another suggests greater attentional resources being directed towards that stimulus. Looking time can thus serve as a proxy measure of "preparedness," because a prelude to learning will likely involve attending to the object in the presence of the accompanying emotional information. The 12 cells of the design illustrated in Figure 1, allow us to test the three accounts outlined above. Below, we detail how, noting that when we use the terms fear, disgust, and negative images/sounds etc, this refers to an adults judgment of these stimuli as being fear-, negative-, or disgust-related.

To test the *specific* account, requires cells 1–4 of the design (see Figure 1). If the *specific* preparedness account holds true, then we would expect children to look longer at disgusting images with disgust-related vocalizations, and fearful images with fear-related vocalization, than for disgusting images with fear-related vocalizations and fearful images with disgust-related vocalizations (i.e., comparison of cells 1 & 4 vs. cells 2 & 3).

We selected rotten food for the disgusting images in this experiment. This was because rotten food is a core disgust elicitor, and it is conceptually and physically similar to the type of stimuli that might generate distaste. A further advantage is that it is easy to provide a matching control image of fresh food. For adult disgust vocalizations we selected terms (e.g., yuck, blah, urgh), which we knew that adults used with children of this age (Oaten et al., in press). For fear-related stimuli, we selected pictures of snakes, with wild animals as the control stimuli, as children and adults may more readily associate snakes with fear (Ohman & Mineka, 2001). For fear-related vocalizations, we used vocal intonation to deliver the fear sound in a language other than English, so as to broadly match the emotion-arousing ability of the fear and disgust vocalizations.

To test the *generic* account requires comparisons across a broader set of cells (1–9 in Figure 1). If disgust and fear vocalizations are equally effective at directing attention to disgust and fear-related images, children should spend more time looking at such images (i.e., cells 1–4 in Figure 1), than they should when fear and disgust images are paired with another negative vocalization, crying (i.e., cells 8 & 9 in Figure 1). Crying was selected as it would be negatively valenced for children but not (presumably) prepared to direct attention to fear or disgust stimuli. A further control comparison is required here to test the *generic* account, namely one that demonstrate that fear and disgust vocalizations only engage attention to disgust and fear-related images. For this reason we presented a non-disgust and non-fear related negative image, a sad face (vs. a happy face), with disgust and fear-related vocalizations (i.e., cells 5 & 6 in Figure 1), and with crying (i.e., cell 7 in Figure 1). A sad face (vs. a happy face) was selected as it would be negatively valenced for children, but not a stimulus (presumably) prepared to be associated with fear or disgust vocalizations. In sum, these comparisons test whether adult disgust and fear vocalizations compel more attention to disgust- and fear-related images, relative to negative control stimuli.

To test the *valence* account, namely that children are prepared to attend more to novel, unpleasant or prepared stimuli (hereafter negative stimuli/images) when accompanied by negative vocalizations, requires a comparison with positive sounds, hence the inclusion of the final three cells of the design, 10–12, illustrated in Figure 1. Based on the *valence* account, we would expect longer looking at a broad set of negative images when accompanied by negative sounds relative to positive sounds. This can be tested in a number of ways in our design: (1) by comparing sad faces when paired with crying and then with laughter (i.e. cells 7 vs 10); (2) by comparing all of the sad face trials accompanied by a negative vocalization (i.e., cells 5–7), against a sad face with laughter (i.e., cell 10); (3) by comparing all three laughter paired cells (i.e., cells 10–12) against the three sad face trials with negative vocalizations (i.e., cells 5–7); and (4) by comparing all of the negative sound trials (i.e., cells 1–9) against the laughter trials (i.e., cells 10–12). All of these comparisons establish whether children look longer at a broad set of negative images if they are accompanied by negative sounds, relative to a positive sound.

A number of other measures were also collected here. Differences in stimulus familiarity may be important (i.e., longer looking times at novel stimuli), and for this reason we had parents judge the images used in the experiment to indicate whether their child had ever encountered any of them before. In addition, we also collected parent's reaction to the images, and how they thought their child might react, to ascertain whether parents judged the stimuli to be fear-related and disgust-related as we expected. We also assessed parental disgust sensitivity, using the disgust sensitivity scale (Haidt, McCauley, & Rozin, 1994), to see if parental score, alongside other variables (e.g., stimulus familiarity), was related to their child's behavior during the experiment, as found in earlier studies (Oaten et al., in press; Stevenson et al., 2010). Adult participants also completed the disgust sensitivity scale, primarily to ensure that they were not an unusually disgust sensitive or insensitive group, relative to the parents.

As our principal interest was in passive viewing, that is how children would distribute their visual attention to each image on a trial, all of the picture-sound combinations were presented in the first phase of the experiment. We also included a second phase, where we tested whether children had any explicit knowledge of the relationships between the pictures and the sounds displayed in Figure 1. This was important, so that we could establish whether explicit knowledge (i.e., verbalisable) was driving the children's viewing behavior. To confirm that these picture-sound combinations were as we designed them to be, we also had a group of adult participants take part in both phases of the experiment. Not only would this allow us to see whether adult preferential looking behavior was driven by the same or different factors (e.g., by explicit knowledge) to those of the children, it also enabled us to check that the pairings we believed existed in the data, between the various sounds and picture, would be readily detected by other adults.

Method

Participants

All of the children's parents were briefly questioned on the telephone prior to attending the experimental session so as to ensure that their child had no developmental delay or other condition that might affect participation. Twenty-seven developmentally normal children (13 male, 14 female; M age = 38.5 months, SD = 4.4, range = 34–46) commenced the experiment, but only 20 successfully completed its two phases (10 male, 10 female; M age = 39.3 months, SD = 4.4, range = 34–46). Six children were excluded because they were unable to answer the two test questions at the start of the judgment phase and a seventh child was unable to complete the second phase of the study. All but three of the children included in the analysis were accompanied by their mother.

Twenty-three adult participants (11 male, 12 female; M age = 20.3 years, SD = 2.6, range = 17–27) successfully completed the experiment, with all answering correctly the two test questions at the start of the judgment phase. The adult participants did not significantly differ in disgust sensitivity score ($M = 19.2$, SD = 4.9) from the children's parents ($M = 18.6$, SD = 4.9). Informed consent was obtained from the adult participants and the children's parents. The task was explained to the children and their verbal agreement was sought before the study commenced. The University IRB approved the protocol.

Stimuli

The experimental test area was dimly lit so as to enhance the salience of the test images. The test images were displayed on two TV monitors, always one image per monitor, with the monitors placed 0.2m apart and 1.2m in front of the participant. Each image occupied the central portion of its respective monitor, being presented in landscape A4 size, and in color. The audio component was played from speakers concealed between the two TV monitors at approximately 60 dB. The video camera was also placed between the TV monitors so that it could record the direction in which participants were looking. The output from the video camera was also visible in real-time to the experimenter. This ensured that participants were looking towards the TV monitors when the experimenter commenced each trial.

The images were obtained from a variety of sources, including from the experimenters, the Internet and the International Affective Picture System (Lang, Bradley, & Cuthbert, 2001) and these are described in Table 1.

The sounds were produced by the experimenters or obtained from the International Affective Digitized Sounds (Bradley & Lang, 2007). Eight different sounds, all matched for loudness, were used: two disgust, two fear, two laughing, and two

TABLE 1. Description of the Images Used in the Experiment

Image category	Item descriptions
Rotten food	Moldy bread, moldy cheese, moldy grated cheese, rotten oranges, rotten strawberries, moldy pizza, moldy take-away food, and rotten tomato
Fresh food	Fresh versions of each of the rotten foods
Snakes	Eight different snakes
Wild animals	Camel, rhino, gorilla, elephant, polar bear, zebra, hippo, and giant tortoise
Happy female faces	Eight different young adults
Sad female faces	Eight different young adults

crying sounds, with each one lasting six secs. Each sound was used three times in each phase of the experiment. All sounds were adult vocalizations, one male and one female in each case. The disgust sounds were of someone reacting to a disgust-evoking scene with yuck, blah and urgh type noises. The fear sounds were of someone talking in Japanese, with a fearful intonation and tremor in their voice. Both the fear and disgust sounds were piloted on 14 adults before the experiment to ensure that they evoked the requisite emotion. The fearful voices evoked more fear (M = 4.5/7) than disgust (M = 2.9/7), $t(13) = 3.46$, $p = .004$, d = 0.93, 95% CI [0.60, 2.55], and the disgusting vocalizations evoked more disgust (M = 5.3/7) than fear (M = 2.8/7), $t(13) = 5.08$, $p < .001$, d = 1.35, 95% CI [1.35, 3.40]. The laughing sounds were of an adult laughing in amusement, and the crying sounds of an adult crying and sobbing.

Procedure

Overview

The experiment had two phases that were administered in a fixed order. The first phase involved a passive viewing task with two practice and 24 experimental trials (i.e., each of the cells in Figure 1 repeated once). On each trial, participants were shown two images along with an accompanying sound for a fixed time period, and the dependent variable (DV) was the time spent looking at each image. The second phase involved two test trials, followed by the same set of 24 experimental trials, but this time with participants judging which picture best matched the accompanying sound. The DV for the second phase was the explicit matching judgment.

For child participants, their parent was partially visible throughout testing. Children could see their parents' lower limbs (and vice versa) under the screen separating the viewing area from the experimenter's control desk and the parent waiting area. Parents listened to music on headphones for the duration of the study and could not see or hear the stimuli being presented to their child. During this period, parents completed various ratings about the images, as well judging their own degree of disgust sensitivity on the Disgust Sensitivity Questionnaire (DSQ; Haidt et al., 1994). The DSQ was also completed by adult participants at the end of the experiment. In total the experiment took around 30mins, with both the viewing and judging tasks taking around 10mins each.

The Passive Viewing Phase

At the start of this phase, participants were told "What's going to happen is that there's going to be a picture on that TV screen (pointing) and a picture on that TV screen (pointing) and there is going to be a sound as well. You can look at whatever picture you want to." This was followed by the two familiarization trials, which consisted of images of a train vs. a swimming pool, with laughter, followed by an untidy room vs. flowers, with the sound of sawing. These two trials served just to accustom participants to the procedure, using non-threatening stimuli.

The 24 test trials then followed, with content as detailed in Figure 1 (each image pair type [rotten vs. fresh food, snake vs. wild animal, happy face vs. sad face] by each of the four sounds, repeated once). The assignment of images to the left or right TV monitor was counterbalanced across accompanying sound type, by participant. The assignment of different images from within a picture class to each trial was randomized, with the caveat that each image could only be used once during each phase of the experiment. Trial order was random.

Each trial followed the same procedure. When the experimenter could see that the participant was looking in the direction of the monitors, the auditory stimulus was started and played through the centrally located speakers for one second prior to the visual stimuli being displayed. Two different pictures were then presented simultaneously, one on each TV monitor. The auditory stimulus continued for a further 5 seconds and the visual stimuli were displayed for ten seconds in total. Thus, once the audio stopped, the pictures remained on the screen for a further five seconds with no accompanying sound. A trial concluded when the images simultaneously disappeared from the screen.

The Judgment Viewing Phase

The second task commenced with two practice trials, followed by viewing the same set of experimental trials again, but this time judging the best picture-to-sound match (using a different random order and with different counterbalancing and image-to-trial allocations). Participants were told "What we are going to do now is look at the pictures and listen to the sounds again. What I would like you to do, when I ask you, is to tell me which picture goes best with the sound. You can tell me this by pointing and, if you want to, telling me in words which picture goes best. Does that sound OK to you?"

Two test trials followed. The purpose of these trials was to establish, using stimuli very familiar to the children, whether they could appropriately perform the matching task. The first practice trial involved two images, a car and a clock, accompanied by car sounds. The second practice trial was composed of a picture of Santa Claus and a picture of a police car, accompanied by the sound of “Ho, Ho, Ho.” To be eligible for study inclusion, children (and adults) had to successfully pass both test trials. Following each trial, participants were requested to point to the screen on which the best matching picture had been displayed. Participants were thanked for their response but no other feedback was provided. This same procedure was used on each trial.

Parental and Adult Participant Ratings

The accompanying parent was asked to complete two questionnaires. The first presented them with the images used in the experiment, and asked them to rate both their own reactions and how they thought their child would react. For parental reactions, we asked them to rate how fear provoking and disgusting they found each image (all seven point scales from 1 = Not at all to 7 = Very). For their child’s expected reaction, they were also asked to rate fear and disgust, alongside whether their child had ever seen anything like this before (Yes, Unsure, No). Only the ratings relevant to food and animals are reported (any item in a particular class [e.g., rotten food] identified as familiar led to the child being classified as ‘familiar’), as all children were judged to be familiar with sad and happy faces, and these were not rated as fear or disgust provoking. This was followed by their completion of the Disgust Sensitivity Questionnaire (DSQ). Adult participants completed the DSQ after they had finished the second phase of the experiment.

Coding and Reliability

Video coding was undertaken blind to trial type. On each trial, the primary coder could see a signal indicating that the images were being displayed. From this signal until the images disappeared, the video was coded to quantify the amount of time spent looking at each image. Video data from 7/23 adults and 8/20 children were recoded by a different coder to assess reliability. In each case, we obtained the intraclass correlation coefficient between the two coders’ looking time measures for the right-side and for the left (which are both included in the medians reported below), during each phase of the experiment. The intraclass correlation coefficient was used so as to assess for both differences in magnitude and association between coders time measures. Adults’ data had a median intraclass correlation coefficient of .97 (range .74 to .99), and children, a median intraclass correlation coefficient of .94 (range .73 to .99). Together, this indicates that the coding procedure was reliable.

TABLE 2. Mean Proportion of Time (%) Spent Viewing the Negative Image (and SD)

	Sound type			
	Disgust	Fear	Crying	Laughter
Age group				
Image type				
Children				
Disgust (Rotten food)	53.2 (15.6)	49.9 (16.5)	42.4 (14.0)	46.2 (21.1)
Fear (Snakes)	48.5 (18.0)	48.5 (23.8)	41.8 (10.7)	49.3 (18.7)
Sad (Sad faces)	51.0 (9.4)	52.0 (14.2)	52.1 (19.1)	49.4 (15.7)
Adults				
Disgust (Rotten food)	41.5 (18.0)	44.9 (18.4)	41.5 (15.0)	48.5 (18.3)
Fear (Snakes)	51.1 (18.7)	49.7 (21.8)	55.8 (18.7)	53.8 (22.3)
Sad (Sad faces)	45.7 (18.7)	46.3 (17.5)	39.1 (17.9)	59.8 (16.5)

Analysis

Looking times for all trials on the passive viewing phase were converted into the proportion of time spent looking at the more negatively valenced picture—the rotting food, snakes, and sad faces (i.e., viewing time for more negatively valenced picture/total time looking at both pictures). These data, along with parental ratings, were analyzed using mixed design and repeated measures ANOVA. For the matching of pictures to sound data, and parental familiarity ratings, where the data were not suitable for parametric analysis, Wilcoxon tests were used for within group comparisons. Finally, as there was no indication of any sex differences on the various analyses (all *p's* involving Gender $>.26$), we do not report this variable.

Results

Passive Viewing Phase

Testing the Specific Account

The first analysis addressed whether disgust sounds bias looking towards pictures of rotten food, and fear sounds bias looking towards pictures of snakes, in children and/or adults. Table 2 present the mean proportion of time spent viewing these negative images. We used a three-way mixed design ANOVA, with Age (adult vs. child) as the between factor, and Sound type (disgust vs. fear) and Image type (rotten food vs. snakes) as within factors. There were no significant effects, indicating that looking times were not systematically altered by Age, Sound or Image type here (all p's $> .10$). These data do not support the specific preparedness hypothesis.

Testing the Generic Account

The second analysis examined whether adults and children spent longer looking at rotten food and snakes when disgust or fear sounds were present, relative to another negative emotion (crying) and image type (sad faces). To address this question we used a three-way mixed design ANOVA, with Age (adult vs. child) as the between factor, and Sound type (disgust and fear combined vs. crying) and Image type (rotten food and snakes combined vs. sad faces) as the within factors. This ANOVA revealed one significant effect, a three-way interaction between Age, Sound type and Image type, $F(1, 41) = 9.18$, $p = .004$, $\eta^2 = .18$, which is illustrated in Figure 2a and b.

To unpack this interaction, we repeated the ANOVA, separately for children and adults. For children, as illustrated in Figure 2a, there was a significant interaction of Sound type by Image type, $F(1, 19) = 5.23$, $p = .034$, ${\eta^2}_p = .22$. Children had significantly longer looking times for rotten food and snake images when accompanied by disgust and fear sounds relative to crying, $t(19) = 3.37$, $p = .003$, $d = 0.75$, 95% CI [3.00, 12.85], but with no significant difference in looking times at sad faces by Sound type ($p = .90$).

For adults, the ANOVA revealed a significant Sound type by Image type interaction, $F(1, 22) = 4.32$, $p < .05$, ${\eta^2}_p = .16$, which is illustrated in Figure 2b. In this case, adults watched the sad face for longer when it was accompanied by fear or disgust sounds than when accompanied by crying sounds, $t(22) = 2.26$, $p = .034$, $d = 0.46$, 95% CI [0.58, 13.19], but there was no difference in looking times by Sound type when the image was rotten food or snakes ($p = .57$).

These findings suggest two things. First, children look more at rotten food and snake pictures when they are accompanied by disgust and fear sounds, relative to crying, while for sad faces, the type of accompanying sound has no impact. This is consistent with the generic preparedness hypothesis, that threat-related emotions bias attention to threat-related environmental cues. Second, for adults, fear and disgust sounds result in longer looking times at sad faces relative to crying, but these negative sounds have no impact on looking times for rotten food or snakes.

Testing the Valence Account

To test the valence account, we started by comparing the proportion of time spent viewing the sad face when accompanied by crying versus when accompanied by laughter. The means for this comparison are presented in Table 3. Using a two-way repeated measures ANOVA, with Age (children vs. adults) and Sound type (crying vs. laughter), revealed a main effect of Sound type, $F(1, 41) = 5.61$, $p = .023$, ${\eta^2}_p = .12$, which was qualified by an interaction of Sound type and Age, $F(1, 41) = 9.45$, $p = .004$, ${\eta^2}_p = .19$. For children, there was no difference in looking time at the sad face vs. the happy face by Sound type ($p = .49$), while adults looked significantly longer at the sad face when it was accompanied by laughter, $t(22) = 3.32$, $p = .003$, $d = 0.69$, 95% CI [7.76, 33.56].

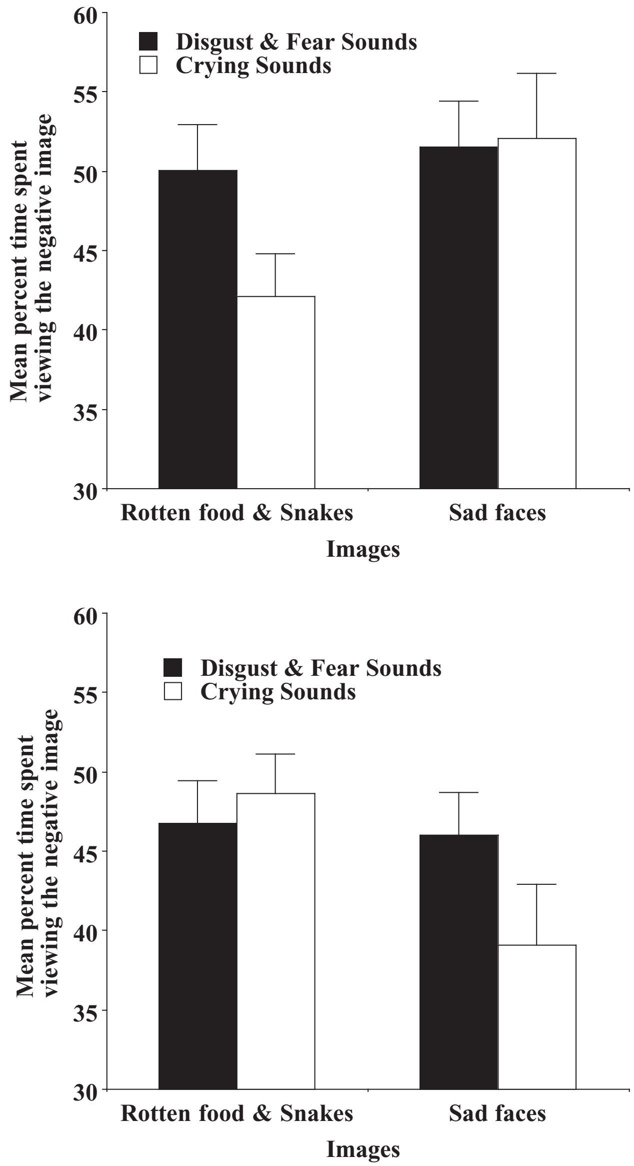

FIGURE 2a and 2b. (a): Upper panel: mean percent (and SEM) of time spent viewing the negative image for child participants by image and accompanying sound type. (b): Lower panel: mean percent (and SEM) of time spent viewing the negative image for adult participants by image and accompanying sound type.

TABLE 3. Mean Proportion of Time (%) Spent Viewing the Negative Image (and SD) for the Four Valence Account Comparisons

	Children		Adults	
Comparison	Negative sound	Positive sound	Negative sound	Positive sound
Sad faces with crying vs. Sad faces with laughter[1]				
	52.1 (19.1)	49.4 (15.7)	39.1 (17.9)	59.8 (16.5)
Sad faces with disgust, fear and crying sounds vs. Sad faces with laughter[2]				
	51.7 (9.3)	49.4 (15.7)	43.7 (14.7)	59.8 (16.5)
Sad faces with disgust, fear and crying sounds vs. All images (sad, fear, disgust) with laughter[3]				
	51.7 (9.3)	48.3 (10.9)	43.7 (14.7)	54.0 (14.1)
All images (sad, fear, disgust) with disgust, fear and crying sounds vs. All images with laughter[4]				
	48.8 (6.0)	48.3 (10.9)	46.2 (9.1)	54.0 (14.1)

[1]In Figure 1 this corresponds to cell 7 vs. 10.
[2]In Figure 1 this corresponds to cells 5, 6 and 7 combined vs. 10.
[3]In Figure 1 this corresponds to cells 5, 6 and 7 combined vs. 10, 11 and 12 combined.
[4]In Figure 1 this corresponds to cells 1 through to 9 combined vs. 10, 11 and 12 combined.

We then repeated this type of analysis, first, by comparing all of the sad face trials accompanied by a negative sound (i.e., cells 5–7 in Figure 1) against the sad face accompanied by laughter. The means for this comparison (and the subsequent valence account comparisons) are presented in Table 3. ANOVA revealed a significant interaction of Sound type and Age, $F(1, 41) = 7.09$, $p = .011$, $\eta^2_p = .15$, but no other effects. For children, there was no difference in looking times ($p = .54$), but adults spent longer at the sad face when it was accompanied by laughter, $t(22) = 2.89$, $p = .008$, $d = 0.60$, 95% CI [4.55, 27.59]. Next, we compared the sad face trials accompanied by a negative sound (i.e., cells 5–7 in Figure 1), with all of the trials in which a negative image was accompanied by laughter (i.e., cells 10–12 in Figure 1). ANOVA revealed a significant interaction of Sound type and Age, $F(1, 41) = 4.17$, $p = .048$, $\eta^2_p = .09$, but no other effects. For children, there was no difference in looking time ($p = .38$), but adults tended to spend longer looking at the negative images when they were accompanied by laughter ($p = .066$). Finally, we compared all of the trials in which a negative sound accompanied the image (i.e., cells 1–9, in Figure 1) against all of the trials in which a negative image was accompanied by laughter (i.e., cells 10–12 in Figure 1). This time the ANOVA revealed no significant main effects, but the interaction approached significance ($p = .074$). Examination of the means in Table 3 again suggested that adults tended

TABLE 4. Mean Proportion of Correctly Identified Matches of Sound and Image (and SD) Based Upon the Experimenters Criteria (i.e., Principally Valence)

	Sound type			
	Disgust	Fear	Crying	Laughter
Age group				
Image type				
Children				
Disgust (Rotten food)	43.8 (38.0)	36.3 (33.9)	45.0 (42.5)	72.5 (30.0)
Fear (Snakes)	40.0 (41.5)	37.5 (42.5)	35.0 (40.0)	72.5 (34.3)
Sad (Sad faces)	48.8 (41.5)	62.5 (39.0)	55.0 (39.5)	60.0 (41.5)
Adults				
Disgust (Rotten food)	100.0 (0.0)	84.8 (27.5)	95.7 (14.4)	95.7 (20.9)
Fear (Snakes)	63.0 (45.5)	82.6 (35.5)	78.3 (36.4)	73.9 (39.5)
Sad (Sad faces)	86.9 (22.3)	86.9 (22.3)	95.7 (14.4)	100.0 (0.0)

to spend relatively longer viewing the negative images when they were accompanied by laughter than when accompanied by negative sounds, and this difference was significant, $t(22) = 2.07$, $p = .05$, $d = 0.43$, 95% CI [−.04, 15.73]. There was no difference for the child means ($p = .30$). In sum, children appeared insensitive to valence, while adults generally looked longer at negative images when they were accompanied by a positive sound—laughter.

Explicit Matching of the Pictures and Sounds

Each participant could score between 0 and 2 for each *cell* of the design (recall there are two trials for each cell). A score of 2 indicated correct matching of image and sound for both trials for a given cell (e.g., snake vs. wild animal, with fear sound - the correct response would be snake-fear on both occasions), with a score of 1 indicating correct matching on one of the two trials for a given cell, and a score of 0 indication incorrect matches on both trials for a given cell. These scores were then converted to percent correct and are presented in Table 4.

Testing Knowledge About the Specific Hypothesis

For children, disgust sounds and disgust images (vs. fresh food), and fear sounds and fear images (vs. wild animals) were correctly matched on $M = 40.7\%$ (SD = 29.5) of trials. For fear sounds with disgust images (vs. fresh food) and disgust sounds with fear images (vs. wild animals), children made correct matches on $M = 38.2\%$ (SD = 38.1) of trials. There was no significant difference between these two scores (Wilcoxon test; $p = .87$), suggesting that children had no explicit knowledge of the specific hypothesis. We then tested whether these scores were significantly greater than chance (i.e., 50%; Wilcoxon test; p's $> .83$), but they were not.

For adults, disgust and fear congruent sounds and images, were more likely to be judged as matching ($M = 91.3\%$, SD $= 17.9$), relative to, fear sounds with disgust images (vs. fresh food), and disgust sounds with fear images (vs. wild animals) (M $= 73.9\%$; SD $= 25.5$), Wilcoxon test, $Z = 2.66$, $p = .008$. We then tested whether these scores were significantly above chance (i.e., 50%; Wilcoxon test) and both were, with Z's of 3.24 and 3.62 respectively, with both p's $< .005$, indicating that adults knew about these pairings.

Knowledge About the Generic Hypothesis

For children, we tested their explicit matching knowledge for the same four combinations tested in the passive viewing analysis of the generic hypothesis (i.e., mirroring the ANOVA used in the passive viewing data; and from Figure 1, cells 1-4 minus cells 8 & 9, vs. cells 5 & 6 minus cell 7). There was no significant difference (Wilcoxon test) between these two scores (p $= .92$), indicating that children did not have more knowledge about the disgust/fear images with disgust and fear sounds - relative to crying (i.e., cells 1-4 minus cells 8 & 9; M difference $= -0.6\%$, SD $= 24.0$), than they did about sad images with disgust and fear sounds - relative to crying (M difference $= 0.6\%$, SD $= 44.5$). Thus while the passive viewing data indicated that children looked longer at disgust and fear images when accompanied by disgust and fear sounds (relative to these other control conditions), this was not accompanied by differential explicit knowledge of these matches. We then tested whether the four cell combinations used here were significantly above chance, but they were not (p's $> .82$).

Adults also showed no difference on this comparison of knowledge relating to the generic hypothesis (disgust/fear images with disgust and fear sounds - relative to crying, M difference $= -4.0\%$, SD $= 17.5$; versus, sad images with disgust and fear sounds - relative to crying, M difference $= -8.5\%$, SD $= 22.0$; $p = .47$). Not surprisingly, the four cell combinations here for adults were all significantly above chance (Wilcoxon test's, all Z's < 4.17, all p's $< .001$), indicating that they could readily identify all of these matches.

Knowledge About Valenced Pairings

We started by establishing whether children were better than chance (Wilcoxon test) at selecting the appropriate image (sad vs. happy face) when these were accompanied by crying and by laughter. Children did no better than chance at matching a sad face to crying, or a happy face to laughter (p's $> .30$), with mean scores presented in Table 4. Next we tested if children were better than chance, when all of the negative sad trials were combined (i.e., in Figure 1, cells 5–7) and here too they were no better than chance ($M = 55.4\%$, SD $= 28.5$; $p =$ .18). We then tested whether they were better than chance at detecting the three positive pairings (i.e., in Figure 1, cells, 10-12; $M = 68.3\%$, SD = 21.5), and in this case they were significantly better than chance, Wilcoxon test, $Z = 2.96$, $p = .003$. Finally, we tested whether children were more likely to pick a positive image if it was accompanied by a positive sound (i.e., laughter), than if the positive image was accompanied by a negative sound (note this comparison requires subtracting the negative trials [i.e., cells 1-9 in Figure 1] from 100, so that all values reflect selection of the positive image). Children were significantly more likely to match laughter to a positive image ($M = 68.3\%$, SD = 21.5) than they were to match a negative sound to a positive image ($M = 55.1\%$, SD = 19.0), Wilcoxon test, $Z = 2.40$, $p = .016$. This suggests that children display some limited knowledge on this task indicating some sensitivity to valence congruency.

Adults were significantly above chance at detecting the appropriate pairings for sad and crying, Wilcoxon test, $Z = 4.58$, $p < .001$, and happy and laughter, Wilcoxon test, $Z = 4.80$, $p < .001$, with the accompanying means presented in Table 4. Next, we tested if adults were better than chance, when all of the negative sad trials were combined (i.e., in Figure 1, cells 5-7), which they were ($M = 89.9\%$, SD = 14.9), Wilcoxon test, $Z = 4.24$, $p < .001$. Then we tested whether the adults were better than chance at detecting the three positive pairings (i.e., in Figure 1, cells, 10-12; $M = 89.9\%$, SD = 13.9), and in this case, as with the children, they were significantly better than chance, Wilcoxon test, $Z = 4.32$, $p < .001$. Finally, and not surprisingly, the adults were significantly more likely to match laughter to a positive image ($M = 89.9\%$, SD = 13.9) than they were to match a negative sound to a positive image ($M = 14.1\%$, SD = 12.4), $Z = 4.20$, $p < .001$. Thus, while children had some limited knowledge of the valence-related pairings, this knowledge was clearly present in adults.

Parental Ratings

Picture Familiarity

Parents indicated that their children had seen rotten food less frequently (30% seen before) than fresh food (100% seen before), Wilcoxon test, $Z = 3.84$, $p < .001$. Parents also reported that snakes were likely to have been seen by their children (75% seen before) less often than wild animals (90% seen before), Wilcoxon test, $Z = 2.33$, $p = .02$.

Parental Disgust and Fear Ratings of the Pictures

Parental disgust and fear ratings are presented in Table 5. Parents rated the rotten food pictures as significantly more disgusting, $t(19) = 16.28$, $p < .001$, $d = 3.64$, 95% CI [3.34, 4.40], and fear provoking, $t(19) = 3.59$, $p = .002$, $d = 0.81$, 95% CI [0.42, 1.58], than the fresh food pictures. The snake pictures were rated by parents as significantly more fear provoking, $t(19) = 6.73$, $p < .001$, $d = 1.51$, 95% CI [0.28, 1.83], and disgusting, $t(19) = 2.87$, $p = .01$, $d = 0.64$, 95% CI [1.56, 2.97], than the wild animal pictures.

TABLE 5. Mean Parental Ratings (and SD) of Their Reaction, and How They Expected Their Child to React, to the Fear and Disgust Related Image Sets

	Disgust image set		Fear image set	
Reaction type	Rotten food	Fresh food	Snakes	Wild animals
Rating type				
Reaction of parent				
Disgust	4.9 (1.1)	1.0 (0.0)	2.4 (1.7)	1.3 (0.4)
Fear	2.0 (1.2)	1.0 (0.0)	3.8 (1.7)	1.5 (0.6)
Expected reaction of their child				
Disgust	3.4 (1.4)	1.0 (0.0)	1.9 (0.2)	1.2 (0.3)
Fear	1.6 (0.7)	1.0 (0.0)	3.8 (1.5)	1.8 (0.7)

Parents expected their child to feel greater disgust, $t(19) = 7.42$, $p < .001$, $d = 1.66$, 95% CI [1.70, 3.04], and fear, $t(19) = 3.74$, $p = .001$, $d = 0.84$, 95% CI [0.26, 0.94], to the rotten food images than to those of fresh food. Parents also expected their child to feel greater fear $t(19) = 8.59$, $p < .001$, $d = 1.94$, 95% CI [1.49, 2.46], and disgust, $t(19) = 3.60$, $p = .002$, $d = 0.81$, 95% CI [1.49, 2.46], to snakes than to wild animals.

Predicting Children's Passive Viewing Behavior

We tested whether the passive viewing score reflecting the generic hypothesis (i.e., from Figure 1, cells 1–4 minus cells 8 & 9, minus, cells 5 & 6 minus cell 7) could be predicted from parental and child variables. As predictors we used parental DS score, the child's matching knowledge score for the generic hypothesis (from the explicit matching test), the centred interaction of these two variables, and parent reports of how familiar their child was with the images. Using regression, all of these variables were entered simultaneously with backward elimination, and the final model was significant and is displayed in Table 6. Two predictors were retained, parental disgust sensitivity and the interaction of parental disgust sensitivity with child's matching knowledge score. In this case higher parental disgust sensitivity was associated with longer looking times at the disgust and fear images when accompanied by disgust and fear sounds, but children with greater generic matching knowledge combined with greater parental disgust sensitivity, looked less at the rotting food and snake images.

Discussion

In the Introduction, we outlined three possible ways in which children could be prepared to learn about disgust. The first proposed a *specific* predisposition

TABLE 6. Predictors of the Generic Passive Viewing Effect in Children

	Generic passive viewing effect	
Variable	*B*	95% CI
Constant	−15.44	[−44.60, 13.73]
Parental disgust sensitivity	1.23	[−.24, 2.71]
Interaction of parental disgust sensitivity and child explicit knowledge	−0.29	[−0.63, 0.04]
Adjusted *R2*	.21	
$F(2, 17)$	3.60*	

* $p < .05$.

to attend to disgust-related stimuli in the presence of disgust-related vocalizations. The second suggested a more *generic* predisposition to attend to disgust or fear-related stimuli in the presence of disgust or fear related vocalizations. The third proposed a *valenced* predisposition to attend to novel, prepared, or negative stimuli in the presence of affectively negative vocalizations. We examined these possibilities by testing how long children, and adults, looked at the relevant images in the presence of the relevant sounds. The children's data were most consistent with the *generic* account. Children looked longer at images that adults judged as disgusting and fear-provoking, when in the presence of disgusting and fear-related vocalizations, than they did in the presence of another negatively valenced sound, crying. Moreover, crying, fear, and disgust vocalizations, did not affect looking times at another negatively valenced image, sad faces. Note that it is the *comparison* of looking times that is important here rather than the absolute values, as the absolute values have little meaning unless they are compared to the relevant control conditions. These findings are consistent with the idea that fear and disgust vocalizations can combine with particular types of environmental object, in this case rotting food and snakes, so as to promote attention to them. This would suggest a generic type of preparedness, in which the child is prepared to attend to a relatively broad class of object (drawn from core adult fear and disgust elicitors) when disgust or fear vocalizations are present.

We also observed a number of additional effects. First, while adults had generally good knowledge of which image went best with which sound on the explicit matching test, children's knowledge on this test was far more limited. Second, we found that parental disgust sensitivity and child knowledge, but not stimulus familiarity, could predict children's passive viewing preferences. Below, we outline the factors that might influence adult and child viewing preferences, and then we examine the broader implications of all of these findings.

An important issue in the design of this experiment concerned stimulus selection. Unlike studies on fear, where the literature is better developed (e.g., Ohman & Mineka, 2001), here we had no directly relevant published work on which to base our decisions. This is potentially problematic because there are a large number of stimulus parameters relating to the images and sounds that *could* have been used here. This extends from considerations such as the class of elicitor selected for disgust (e.g., rotting food for disgust) to the choice of control emotions included in the study. This makes the rationale for our stimulus selections important to consider. For the disgusting stimuli, these were based on both theoretical and practical considerations. Previous data suggested that food-related disgusts are probably acquired at around this age (Oaten et al., in press; Stevenson et al., 2010), and theoretical considerations suggest that these maybe more closely tied to the presumed origin of disgust in distaste than other core elicitors (Rozin et al., 2008). Disgust vocalizations were selected over other disgusting sounds (e.g., gagging, diarrhea), primarily because our developmental data suggested that these were actually used by parents when encountering disgusting stimuli with their children (Oaten et al., in press). In addition, for both disgust images and sounds, ethical parameters and recruitment considerations also had to be taken into account, as parents might reasonably be concerned about exposing their child to disgusting images and sounds. Similar considerations also drove our selection of images and vocalizations for fear. For the control stimuli of sad and happy faces, and crying and laughter, these were selected primarily because they were negatively valenced and were likely to have been encountered before. However, we also note here a further potential limitation, in that sad and happy faces were social stimuli, while the food and animal stimuli were nonsocial. While we cannot gauge the impact this may have had on the experiment's outcome, it would perhaps have been better to use sad- and happy-related objects, rather than social-related stimuli. In sum, when interpreting our results, it is important to bear in mind that they *could* be specific just to the particular set of stimuli used here.

On the passive viewing task of the experiment, adult participants looked longer at different picture-sound combinations than children. In particular, surprising combinations of sounds and pictures (e.g., watching the sad face when it was accompanied by laughter) appeared effective at capturing adults' attention. This pattern might be expected, given that adults could readily identify the appropriate image-sound matches, suggesting that at least some of their passive viewing preferences—and hence the differences from children—result from violated expectancies. Children had different viewing and knowledge patterns to adults, and in particular they did not have the disgust- and fear-related knowledge that adults had. This lack of disgust- and fear-related matching knowledge probably does not reflect poor test sensitivity. First, all of the children could perform the two matches with the highly familiar stimulus combinations used in the test matches (i.e., car picture-car sound, Santa Claus-Santa Claus sound). Second, the children also demonstrated some valence-related knowledge on the matching test (i.e., positive picture with positive sound, and not with a negative sound). As children did not evidence much explicit knowledge about disgust and fear, we suggest that explicit knowledge was not of primary importance in driving their passive viewing behavior. The one exception to this emerged in the regression analysis, which suggested that the presence of explicit knowledge, combined with heightened parental disgust sensitivity was associated with a more adult-like pattern of viewing behavior. This might imply that once the children have learned the match (i.e., at home etc.), they are less interested in that type of pairing when it is presented in the laboratory. For this reason their attention is then better captured by the mismatching (i.e., expectation violating) pairing, just as it appears to be in adults.

A further possible driver of children's passive viewing behavior is image novelty. Just as a violated expectation is surprising and thus attention demanding, so (relatedly) is a novel event. Novelty, could then potentially account for the children's viewing behavior, especially as snakes and rotten food were generally less familiar to the children than wild animals and fresh food (or at least as reported by their parents). However, if this were the case, then we would expect a *consistent looking bias* towards these images irrespective of the accompanying sound, yet this is not what we observed. Instead, longer looking times for disgusting and fearful images were only observed when the disgusting and fear provoking sounds were present.

While explicit knowledge may then have had some influence on children viewing behavior at the individual difference level (as revealed by regression), neither this nor stimulus novelty are able to account for the key observation from the passive viewing phase of the experiment. Children looked longer at disgust- and fear-related images in the presence of disgust and fear related sounds, which we suggested was consistent with the generic preparedness account outlined in the Introduction (i.e., an attentional disposition to look longer at these type of stimuli when accompanied by particular types of sound). We suggest this finding has two implications, both related to child development. The first concerns emotional specificity. It is well established that there is a considerable overlap in the emotions of fear and disgust. Both may be elicited by certain cues (e.g., spiders, blood phobia; or complex disgust, Marzillier & Davey, 2004), and one may come to fear contact with disgust elicitors (e.g., fear of contamination; Rachman, 2004). This overlap is also apparent in the current dataset. Parent ratings of the snake and rotten food images, and the pilot ratings of the fear and disgust vocalizations, both show significant above baseline reports of fear *and* disgust in response to all of these stimuli. While snakes may be the archetypal fear stimulus, it is interesting to note that animals in particular are very good examples of stimuli that can elicit both the emotion of fear and of disgust (e.g., Davey, Forster & Mayhew, 1993; Muris, Hujiding, Mayer, & de Vries, 2012). Our data would suggest that both fear and disgust responses may be important in driving the acquisition of child responses to core disgust elicitors such as rotten food, and equally, that disgust may also play a role in negative emotional responses to snakes. This serves an important goal in motivating avoidance of potentially dangerous things during early childhood, without having to wait for the development of more specific emotional responses.

The second implication of our findings, which we suggest far more tentatively, is that fear and disgust may be much more closely entwined during the acquisition of adult-related fear and disgust elicitors, such that adult fear and disgust reactions might be *equally* effective in driving attention to threatening events in the environment. Preparedness in children then might reflect a more general tendency to attend to threat-related events in the environment, when adults emote regardless of whether they are fear *or* disgust stimuli. This possibility does not seem to have been widely considered in evolutionary accounts of fear acquisition during development.

AUTHOR NOTES

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Original manuscript received January 20, 2014
Final version accepted June 23, 2014