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Age-related differences in self-reported disgust toward core disgust, sex-related, and food stimuli

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Abstract

Introduction: While disgust is functional in preventing contagion from pathogens, it also plays a role in various psychopathologies. Disgust responses toward dirt, bodily secretions, certain types of food, and sexual stimuli typically emerge during (early) childhood. However, there is a lack of research on how disgust develops. This cross-sectional study investigated whether there are age-related differences in subjective, self-reported disgust between early and late adolescence and whether there are differences for distinctive types of disgust (core-disgust, sex-related, food-related).

Methods: Using an online survey, 240 Dutch children (116 female, 124 male) aged 9 through 16 years rated the extent to which they found the different types of stimuli disgusting or not on a VAS scale.

Results and Conclusions: The results showed that only the disgust responses to sex-related stimuli decreased with age, whereas disgust toward the other categories did not show any age-related differences. Overall girls reported somewhat higher disgust ratings than boys for sex-related stimuli, but not for the other categories. The present study offers important new angles for future research, which might further disentangle the mechanisms through which the changes occur.

KEYWORDS
core disgust, development, disgust, food, puberty, sex-related disgust

1 INTRODUCTION

Disgust is thought to have developed in humans to prevent contagion from pathogens (Curtis et al., 2011; Oaten et al., 2009; Rozin et al., 2008). As such, disgust helps us refrain from eating a moldy piece of bread and/or to avoid people who show signs of a contagious disease. Similarly, it also inhibits us from engaging in sexual activities with people who are unfit as sexual partners, for example, people who are family members, and/or appear diseased (Antfolk et al., 2018; Curtis et al., 2011; Tybur et al., 2009). However, while disgust is functional in these circumstances, it has also been found to play an active role in various psychopathologies (Olatunji & McKay, 2007). Among others, disgust is thought to be involved in the etiology of several disorders such as contamination-based obsessive-compulsive disorder (Mancini et al., 2001; Olatunji & McKay, 2007; Olatunji et al., 2008), anxiety disorders (Olatunji & McKay, 2007; Olatunji et al., 2008; van Overveld et al., 2008) and specific sexual dysfunctions (Borg et al., 2010; de Jong et al., 2009).

Disgust is also closely tied to distaste in function, that is, preventing contact or ingestion of dangerous substances (Chapman et al., 2017) as well as in expression, that is, upper lip nose, frowning (Chapman et al., 2017; Rozin et al., 1994; Vrana, 1993), and quite possibly phylogeny (Rozin et al., 2008). However, disgust toward foods also can develop excessively, causing dysfunctional eating behavior (Aharoni & Hertz, 2011; Egolf et al., 2018; Hildebrandt et al., 2015). Yet, there currently is still a lack of research on how various types of disgust develop over time and relate to later functioning. This is particularly the case for disgust toward sexual stimuli since this type of disgust has scarcely been studied in children or young adolescents.
It is also relevant to understand when and how disgust develops from childhood into adulthood, especially as this emotion seems to work quite differently in children of different ages, and as compared to adults (Rozin et al., 2008). For example, young children may happily play with feces and eat mud, whereas a disgust response would be expected toward these stimuli in older children or adults. Interestingly, the reverse seems to be true for stimuli relating to sex. Eight-year-olds may screw their faces in disgust as they witness people kissing in a film, whereas pubescent children may happily engage in such behavior themselves. With these changes of disgust experienced in childhood and the role disgust plays in the etiology of various psychological disorders in mind, it becomes prudent to shed more light on its developmental pathways. Although currently there are no clear-cut data to explain how disgust develops from birth into adulthood (Rozin et al., 2008; Stevenson et al., 2011), several studies have been adding data to this developmental puzzle (e.g., Borg, Hinzmann, et al., 2019; Legare et al., 2009; Oaten et al., 2014).

Already within a few hours after birth, children are able to distinguish between different tastes, and experience distaste as evidenced by their facial expression (Forestell & Mennella, 2014; Rosenstein & Oster, 1988). It is generally accepted however that disgust is not present at this age yet (Rozin & Fallon, 1987; Rozin et al., 1986 in Oaten et al., 2014). Social referencing might be one learning mechanism that builds on distaste as a precursor to disgust (Carver & Vaccaro, 2007; Hertenstein & Campos, 2004; Rozin et al., 2008). The use of emotional expressions of adults as a guide for how to behave in new or ambiguous situations seems to guide infants’ behavior from relatively early in age (e.g., Carver & Vaccaro, 2007; Hertenstein & Campos, 2004). Vicarious learning remains an important factor by which even somewhat older children learn about threats and disgust (e.g., Askew et al., 2014).

Understanding the concept of contamination is an important aspect intrinsic to disgust. This is defined as the dismissal of an object once it has been in contact with something that is considered disgusting (Rozin et al., 2008). In the study of Brown and Harris (2012), contamination was found to be present in children as young as 1.5–2 years. However, DeJesus et al. (2015) did not find that children under 4 have a sense of contamination, which may be caused by the fact that the stimuli used in their study were relatively mild (e.g., a used spoon). This suggests that while some notion of contamination is present at a rather young age, the stimuli that are perceived as contaminants may be different in different age groups (DeJesus et al., 2015). In fact, avoiding eating contaminated food, as evident by contextual cues, is also present from at least the age of 5 years (Brown & Harris, 2012; DeJesus et al., 2015; Legare et al., 2009).

Some food items are more easily rejected in this way than others. Rotting food (Calder et al., 2007) and animal-based food (Egolf et al., 2019) are some universal disgust-eliciting elements. This latter category is suspected to elicit disgust responses more easily because it carries a greater infection risk and generally decays faster than plant-based food (Erkmen & Bozoglu, 2016). Particularly meat gristle is shown to be disgust eliciting (Egolf et al., 2019). These types of universally accepted disgust eliciting elements of food also suggest that food texture plays an important role because a lumpy texture may indicate food decay and may thus carry more harmful pathogens.

With regard to the development of disgust toward food, individual differences have been reported to have a large degree of stability over time. For instance, the study of Egolf et al. (2019) showed that food disgust sensitivity was positively correlated with age but this effect was small, suggesting a relatively stable presentation during adulthood. Since disgust toward food is also related to feeding problems in childhood, it is also relevant to consider the developmental pathway of feeding behavior. Derks et al. (2019) studied these pathways in middle childhood and identified several distinctive patterns in the domains of “food responsiveness” (which is the child’s sensitivity to external food cues), “enjoyment of food,” and “emotional overeating.” The results showed that around 85% of the participants belonged to either the “stable low” group or the “moderately increasing” group for each of these domains. In addition, Marchi and Cohen (1990) demonstrated that the variables “meals unpleasant,” “struggle over-eating,” “amount eaten,” “picky eating,” “speed of eating,” and “interest in food” were also relatively stable between the ages of 1 and 10 years. Combined, these studies point toward the existence of stable responses to food and food-related disgust over time.

For various reasons including ethical ones, sex-related disgust, is the type of disgust that has probably been studied the least in children. For instance, in the study referenced earlier by Stevenson et al. (2011), the one item that was qualified as “sex-related” involves mating dogs, rather than a stimulus that relates to human sexuality. As a result, there is little knowledge of how children respond to sex-related disgust (i.e., disgust toward sex-related stimuli such as kissing, saliva, the ejaculate). Borg, Hinzmann et al. (2019) conducted a first study aimed at describing the age-related differences of disgust toward sex versus nonsexual stimuli in three different age groups. They hypothesized that sex stimuli would evoke more disgust before the onset of puberty, as sexual cues in prepubertal children would still be irrelevant. With the onset of puberty however, sexual cues would become more salient, thereby decreasing, or overriding disgust responses to sexual stimuli relative to other disgust elicitors. Additionally, such a decrease in disgust responding would only be beneficial in the case of a suitable sex partner (i.e., someone familiar who is not a family member) (Tybur et al., 2009). The results showed that sex-related disgust in the context of strangers and best friends dropped throughout adolescence, with the strongest decline in sex-related disgust between early and middle adolescence (from 12–14 to 15–17 years of age). A reverse pattern was found for when parents were the source of sex-related disgust, meaning that children aged 12 and up were increasingly more disgusted by sexual cues from relatives (e.g., kissing your mother on the lips) compared with preadolescent children (aged 9–11).
In contrast to sexual cues, disgust unrelated to sex was strongest around age 12–14 and somewhat lower in younger and older teens. Girls generally experienced more intense disgust than boys as is consistent with studies in adults (e.g., Curtis et al., 2011; Oaten et al., 2009).

1.1 | The present study

It is important to further explore changes in different types of disgust from childhood into adulthood. Relevant is not only how disgust develops, but also whether it develops differently in the various categories of disgusting stimuli that are associated with a more stable disgust responding versus those that employ a differential disgust response throughout development (e.g., Borg, Hinzmann, et al., 2019). The current study aimed to explore age-related differences in subjective disgust in three domains: (1) core disgust toward stimuli that involve items such as vomit, feces, and many other items that pose a risk of contamination or have similar characteristics (Rozin et al., 2008; Stevenson et al., 2011), (2) disgust toward (textured, animal-based) food stimuli, and (3) disgust in response to sex-related stimuli. This latter domain is expected to develop differently from the other domains and is likely influenced by changes related to the onset of puberty. It may also be due to more experience in handling disgusting stimuli or due to a greater salience of the sexual nature (rather than the disgusting nature) of sex-related stimuli.

Our first hypothesis is (1) that for sex-related stimuli older children will experience less disgust than younger children. In addition, we hypothesize (2) that stimuli in the category of core disgust will be experienced as more disgusting by older children. Unlike sex-related and core disgust stimuli we hypothesize, (3) that disgust toward food items will remain stable across age groups. Lastly, we hypothesize that for all of these categories girls will experience more disgust than boys, which corresponds to the literature on disgust in adults (Curtis et al., 2011; Tybur et al., 2009), and that this difference becomes larger as age increases.

2 | METHOD

2.1 | Participants

Children (aged 9 through 16 years old) were recruited through their parents, who were invited to participate by a survey company Panel Inzicht. During recruitment, our aim was to include the same number of children (i.e., \(n = 30\)) in each age group, with a 1:1 female-to-male ratio. This would allow us to obtain an a priori power of 0.85 per analysis (sensitivity for detecting effect sizes of 0.228 and more). Before analyses of the data, data were screened for unusual/unreliable response patterns. That is, children who, on average, rated neutral stimuli as higher in disgust than stimuli belonging to the core disgust category were excluded (\(n = 8\)). After this, there were still around 30 participants in each age group, only deviating into two age groups (see Table 1) with a total of 240 participants (female, \(n = 116\); male, \(n = 124\); see Table 1). The study design was approved by the Ethical Committee of Psychology for the University of Groningen (ECP Code: ppo_17022_O), and all procedures were conducted accordingly.

<table>
<thead>
<tr>
<th>Age group</th>
<th>(n)</th>
<th>Male, (n)</th>
<th>Puberty (broken voice) in %</th>
<th>Female, (n)</th>
<th>Puberty (menstruation) in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>30</td>
<td>12</td>
<td>0 [8]</td>
<td>18</td>
<td>0 [0]</td>
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<td>30</td>
<td>17</td>
<td>0 [6]</td>
<td>13</td>
<td>0 [0]</td>
</tr>
<tr>
<td>11</td>
<td>28</td>
<td>14</td>
<td>14 [7]</td>
<td>14</td>
<td>29 [0]</td>
</tr>
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<td>30</td>
<td>18</td>
<td>17 [22]</td>
<td>12</td>
<td>58 [8]</td>
</tr>
<tr>
<td>13</td>
<td>30</td>
<td>15</td>
<td>7 [33]</td>
<td>15</td>
<td>80 [0]</td>
</tr>
<tr>
<td>14</td>
<td>30</td>
<td>17</td>
<td>29 [53]</td>
<td>13</td>
<td>77 [15]</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
<td>16</td>
<td>75 [19]</td>
<td>14</td>
<td>100 [0]</td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>15</td>
<td>80 [20]</td>
<td>17</td>
<td>94 [0]</td>
</tr>
<tr>
<td>Total</td>
<td>240</td>
<td>125</td>
<td>28 [22]</td>
<td>115</td>
<td>55 [3]</td>
</tr>
</tbody>
</table>

Note: Numbers in between [–] indicate participants who answered their voice had broken/they had started menstruating “slightly” or “a bit.”
2.2 | Materials and measures

2.2.1 | Stimuli

Stimuli in this online study consisted of 20 pictures (see https://unishare.nl/index.php/s/CZGcBybRW5Stj6Q for all stimuli). The pictures (1024 by 768 pixels) consisted of four conditions. In the first condition, we presented five pictures of neutral stimuli (e.g., flowers, a bath toy). In the second condition, we included five pictures of inherently disgusting stimuli (core disgust stimuli such as feces and vomit). In the third, we presented five images of food-related stimuli that have “disgust-like” features because of their texture and animal-based ingredients (vegetables with meat gristle, beans with lumpy meat, pea soup with meat, mushroom meat stew with meat gristle, pudding with white “egg-like” lumps) as described by Egolf et al. (2018) and Kauer et al. (2015). In the final condition, we presented five images of sex-related stimuli (pictures of couples engaging in French kissing). All disgust scales were shown to have good internal consistency (core disgust stimuli Cronbach’s $\alpha = .76$; food stimuli Cronbach’s $\alpha = .78$). The pictures in the sex-related category were especially high in this aspect, showing a Cronbach’s $\alpha$ of .94. Pictures were from a public domain and selected from an Internet search based on their relevance to each category. There are various classifications for disgust elicitors, our stimuli selection relied on previous work (i.e., Borg, Hinzmann, et al., 2019) that utilized scenarios based on the six pathways of contamination as categorized by Curtis (2013).

For each picture a fixed order of events took place. First, a fixation cross was presented for 1 s, after which the stimulus picture was presented for 5 s. Below the stimulus picture, a visual analog scale (VAS; $0 = \text{Not at all}$ to $100 = \text{A lot}$) appeared in order for participants to subjectively report on how much they liked the image. Finally, a similar VAS ($0 = \text{Not at all}$ to $100 = \text{A lot}$) was presented questioning how disgusting they thought the picture was. To control for order effects, the four categories of pictures were presented in a random order, as were the pictures presented within each category.

2.2.2 | Self-report

Children were asked to rate each picture and scenario on a VAS ($0 = \text{Not at all}$ to $100 = \text{A lot}$). This rated how much they liked each item and to what extent they found it disgusting. In addition, in the latter part of the study, some background information was gathered. Pubertal status was estimated by self-report of the main indicators of puberty: whether their voice had broken for boys or whether they had started menstruating for girls (Brix et al., 2019). This question could be answered either by indicating yes, no, or slightly/a bit. These measurements were found to be the most proximal to an objective division representing the developmental labels.

The other questions were answered using a VAS with $0 = \text{Not at all}$ to $100 = \text{Very}$, unless otherwise specified. To assess “disgust propensity”, the children were asked whether they thought they were easily disgusted, “disgust sensitivity” was assessed by asking them how troublesome they felt it was to be disgusted, “picky eating” and “willingness to try new foods” were assessed by asking whether they classified more as an easy or a difficult eater (VAS; $0 = \text{Not at all easy}$ to $100 = \text{Very easy}$) and whether they liked trying out new foods (VAS; $0 = \text{Not fun at all}$ to $100 = \text{A lot of fun}$). Finally, we asked children how experienced they are with regard to kissing (VAS; $0 = \text{Not at all}$ to $100 = \text{Very much}$), and also how disgusting they feel this activity to be (VAS; $0 = \text{Not at all}$ to $100 = \text{Very much}$).

2.3 | Procedure

The survey was implemented in software provided by the web-based software Qualtrics. Panel Inzicht distributed the survey to people who were registered as having children within the age range of 9 and 16 years. Prospective participants were then invited to participate. Quotas were set to obtain approximately 30 participants in each age group.

The first step was that the parent was presented with information about the study. This information included our aim to find out more about the developmental trajectory of disgust in children and adolescents and a description of what to expect from the study, including example pictures (i.e., one for each category).

When the parent gave permission for their child to participate, the child was provided with the same information but without examples of the pictures from the task and was asked whether they agreed with participating in the study. When both parent and child consented to participation, the study started with a trial of two pictures (i.e., a neutral and a disgusting picture) to let the child get used to the format. After this, the stimuli from the four image categories were presented in a randomized order that is the four category blocks were randomized as well as the five pictures within these blocks. After the stimulus pictures, the children were asked to respond in the same manner to the six scenarios of disgusting situations. However, these scenarios were not used in the current investigation. The final part of the study contained several background questions. Responses were filled with multiple choice answers and VAS.
2.4 Analytical plan

This study was not pre-registered. Assumptions for univariate ANOVAs were reviewed before analysis. The distributions of disgust for sexuality and disgust for ambiguous food, conformed to assumptions reasonably well, showing normally distributed residuals and no outliers. As such, no actions were taken for these variables. While some outliers (i.e., scores removed more than three standard deviations from the mean) were found in the dependent variable disgust, we considered the data to be robust enough for analysis as planned.

Three separate univariate (factorial) ANOVAs were performed using age and sex as independent predictors with the three possibly disgusting categories (i.e., core disgust, textured food, sexuality) as dependent variables. In all cases the univariate ANOVAs were subjected to a Bonferroni-correction to allow for multiple testing (leading to $\alpha = .0167$). When significant differences were detected, we explored the data further via post hoc testing (paired comparisons across age groups and puberty status groups).

Finally, Pearson correlations were computed between: (1) average disgust toward sex-related stimuli and self-reported “experience with kissing” and “disgust toward kissing in general,” (2) average disgust toward core stimuli and self-reported general “disgust propensity” and “disgust sensitivity,” and (3) average disgust toward food stimuli and self-reported “picky eating” and “willingness to try new foods.”

3 RESULTS

The three different categories of disgust-stimuli resulted in different disgust responses across the explored age-span (see Figure 1 and Table 2). It appears that stimuli in the core-disgust category are experienced as generally the most disgusting, whereas disgust toward food items is a category that is experienced less intensely. Disgust toward sex-related stimuli is the only type of disgust that seems to decrease with increasing age.

3.1 Age-related differences in response to sex-related stimuli

The first univariate ANOVA (with disgust for sex-related stimuli as the dependent variable, and age and sex as independent variables) showed a significant difference in the experienced disgust in different age groups; $F(7) = 4.01, p < .001$. The average disgust rating for each age-group declines from an average disgust rating of $M = 79.00$ ($SD = 21.44$) at age 9, to an average disgust rating of $M = 52.68$ ($SD = 28.22$) at age 16. This is in line with our first hypothesis, which stated that older children are generally less disgusted by sex-related stimuli.

![Figure 1](image-url) Average disgust responses (incl. 95% CI) to different stimuli in children aged 9–16 years
In addition, a significant difference in the appraisal of the sex-related stimuli was also found between boys and girls; $F(1) = 13.83$, $p < .001$, with boys generally scoring lower in experienced disgust ($M_{\text{boys}} = 53.78$, $SD_{\text{boys}} = 26.87$) than girls ($M_{\text{girls}} = 67.44$, $SD_{\text{girls}} = 28.04$) (see Figure 2). Lastly, we found no evidence for an interaction-effect between age and sex; $F(7) = 0.79$, $p = .598$.

Differences between age groups were further examined using paired comparisons. The results indicate that differences in disgust between age groups are predominantly present between 9-year olds and children from 12 years and older (see Table 3). In addition, 10- and 11-year olds also differ significantly from 15- to 16-year olds.

To also explore whether differences in pubertal status also relate to disgust for sex-related stimuli, an additional univariate ANOVA (with sex and pubertal status as independent variables) was conducted. The results showed that children with different pubertal statuses had different disgust responses; $F(3) = 5.91$, $p < .001$, and that sex was only marginally significant; $F(1) = 5.76$, 

### Table 2

<table>
<thead>
<tr>
<th>Age group</th>
<th>Sex-related, M (SD)</th>
<th>Core disgust, M (SD)</th>
<th>Food, M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>79.00 (21.45)</td>
<td>91.51 (11.95)</td>
<td>50.04 (23.05)</td>
</tr>
<tr>
<td>10</td>
<td>67.23 (24.71)</td>
<td>92.84 (9.22)</td>
<td>47.98 (23.62)</td>
</tr>
<tr>
<td>11</td>
<td>67.18 (25.68)</td>
<td>91.85 (7.36)</td>
<td>56.80 (18.25)</td>
</tr>
<tr>
<td>12</td>
<td>56.92 (30.16)</td>
<td>80.88 (24.25)</td>
<td>42.51 (24.01)</td>
</tr>
<tr>
<td>13</td>
<td>54.05 (29.13)</td>
<td>90.74 (7.95)</td>
<td>47.76 (24.34)</td>
</tr>
<tr>
<td>14</td>
<td>59.71 (25.97)</td>
<td>91.93 (9.35)</td>
<td>45.91 (26.59)</td>
</tr>
<tr>
<td>15</td>
<td>47.25 (28.23)</td>
<td>88.10 (11.52)</td>
<td>42.49 (20.27)</td>
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<tr>
<td>16</td>
<td>52.68 (28.22)</td>
<td>91.93 (9.34)</td>
<td>48.52 (21.53)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sex</th>
<th>Sex-related, M (SD)</th>
<th>Core disgust, M (SD)</th>
<th>Food, M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>53.78 (26.87)</td>
<td>87.93 (13.70)</td>
<td>44.73 (21.72)</td>
</tr>
<tr>
<td>Girls</td>
<td>67.44 (28.04)</td>
<td>91.93 (11.54)</td>
<td>50.84 (23.82)</td>
</tr>
</tbody>
</table>

**Figure 2** Disgust response (incl. 95% CI) to sex-related stimuli in children aged 9–16 years
The current study aimed to add to the knowledge of the possible developmental changes in disgust during childhood by exploring age-related differences in self-reported core disgust and disgust toward sex-related and food items. The first hypothesis, which stated that older children in our sample would be less disgusted than younger children by sex-related stimuli; experience in kissing. Experience was negatively associated with the amount of disgust experienced toward the sex stimuli; r = −.53, p < .001. Likewise, general self-reported disgust for kissing was also negatively correlated with responses to sex-related stimuli; r(240) = −.57, p < .001.

### 3.2 Age-related differences in response to core disgust stimuli

The univariate ANOVA with core disgust as the dependent variable, and age and sex as independent variables, showed that children of different ages report different levels of disgust for core disgust stimuli; (7) = 2.87, p < .007 (also see Figure 3). No differences were found between children of different sexes; (1) = 4.83, p = .029, nor was there an interaction-effect between age and sex; (7) = 1.05, p = .395.

Post hoc comparison between age groups revealed that only the appraisals of the 12-year olds were different than (most of) the other age groups (see Table 4). On average, this group reported somewhat lower levels of disgust toward core disgust stimuli. However, close inspection of the scores in this subsample of 12-year olds showed that there were three participants who scored more than 2 standard deviations below the average core disgust appraisal. Further analyses showed that the core disgust variable has a moderate positive correlation with disgust propensity; r(240) = .32, p < .001 and a weak positive correlation with disgust sensitivity; r(240) = .19, p < .001.

### 3.3 Age-related differences in response to food stimuli

No evidence was found for age-related differences with regard to disgust toward food stimuli; (1) = 1.05, p = .397, nor was there for sex differences; (1) = 3.52, p = .062 (also see Figure 4). Also no interaction-effect between age and sex was found for the appraisal of the food items; (7) = 0.55, p = .798.

Individual differences in children’s willingness to try new foods were negatively correlated to the experienced disgust toward the stimuli in the food category; r(240) = −.38, p < .001. Being a picky eater was positively correlated with experienced disgust; r(240) = .36, p < .001.

### 4 DISCUSSION

The current study aimed to add to the knowledge of the possible developmental changes in disgust during childhood by exploring age-related differences in self-reported core disgust and disgust toward sex-related and food items. The first hypothesis, which stated that older children in our sample would be less disgusted than younger children by sex-related stimuli; experience in kissing. Experience was negatively associated with the amount of disgust experienced toward the sex stimuli; r = −.53, p < .001. Likewise, general self-reported disgust for kissing was also negatively correlated with responses to sex-related stimuli; r(240) = −.57, p < .001.
stimuli, was supported. In our sample, older children experienced less disgust for sex-related stimuli than younger children, which is also in line with the earlier study by Borg, Hinzmann, et al. (2019). In addition, girls, on average, were more disgusted by these sexual cues than boys; a pattern which is also in line with our expectations and has also been reported previously (e.g., Tybur et al., 2009). Besides, there was an indication that this discrepancy between boys and girls grew larger with increasing age, but this pattern did not reach significance.

A possible explanation for this age-related difference in disgust toward sex-related stimuli might be found in the hormonal changes that occur in puberty, as higher levels of testosterone increase sexual arousal and willingness to approach in both girls and boys, which can impact levels of disgust (Halpern et al., 1997; Lee et al., 2014). A growing body of evidence specifically indicates that sexual excitation may temporarily reduce the experience of sex-related disgust in both men (Ariely & Loewenstein, 2006; Stevenson et al., 2011) and women (Borg & de Jong, 2012) and thus in the short term promotes approach behavior toward disgusting stimuli (Borg & de Jong, 2012). As prolonged contact with disgusting stimuli has been shown to weaken disgust (Bosman et al., 2016), repeated sexual behavior might attenuate the disgust response toward

**Figure 3** Disgust responses (incl. 95% CI) to core disgust in children aged 9–16 years

**Table 4** Post hoc tests for age differences in experienced disgust toward core stimuli: mean differences and p-values

<table>
<thead>
<tr>
<th>Age</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>10</td>
<td>−1.33 (.678)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>11</td>
<td>−0.34 (.918)</td>
<td>0.99 (.761)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td>10.63 (.001)</td>
<td>11.96 (.000)</td>
<td>10.97 (.001)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>13</td>
<td>0.77 (.809)</td>
<td>2.10 (.512)</td>
<td>1.11 (.733)</td>
<td>−9.86 (.002)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14</td>
<td>0.46 (.886)</td>
<td>1.79 (.577)</td>
<td>0.80 (.817)</td>
<td>−10.17 (.002)</td>
<td>−0.31 (.922)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15</td>
<td>3.41 (.287)</td>
<td>4.74 (.139)</td>
<td>3.75 (.250)</td>
<td>−7.22 (.025)</td>
<td>2.64 (.410)</td>
<td>2.95 (.356)</td>
<td>—</td>
</tr>
<tr>
<td>16</td>
<td>−0.42 (.894)</td>
<td>0.91 (.773)</td>
<td>−0.81 (.980)**</td>
<td>−11.05 (.001)</td>
<td>1.19 (.75)</td>
<td>−0.88 (.780)</td>
<td>−2.95 (.224)</td>
</tr>
</tbody>
</table>

*Significant differences (at $p \leq .01$).

**Significant differences (at $p < .05$) between age groups in their disgust responses to core disgust stimuli.
sex-related stimuli. Therefore, this initial sexual contact could be driven by the surge of sex hormones, which is also strongly linked to the generation of sexual arousal (Borg, Hinzmann, et al., 2019). This finding is also partly corroborated by the finding that in our own sample, children who indicated to have one marker of puberty (voice broke/had their period “a little/slightly” or “yes”) reported the lower disgust toward sex-related stimuli than those who indicated not to have this marker.

Vicarious learning, which is already very influential in the development of disgust throughout childhood and in infancy (e.g., Askew et al., 2014; Hertenstein & Campos, 2004; Oaten et al., 2014) could also be a factor through which children learn to evaluate sexual cues differently as they get older and have more proximity to these stimuli. Evidence that this mechanism exerts some effect on the evaluation of stimuli related to sex can be gathered from the notion that people with more sexually repressive (i.e., conservative) ideologies and less liberal views tend to be more disgusted by diverse sexual topics (e.g., Borg et al., 2011; Brenner & Inbar, 2015; Haidt & Hersh, 2001).

A third factor that likely weighs in on this developmental pattern is the mere effect of experience with sexual behavior. Directly in line with the process we just discussed above on the hypothesized hormonal-triggered sexual approach, exposure to sexual stimuli (e.g., French kissing another person) may habituate children/youngsters with sexual stimuli so that the stimuli become less disgusting and more likeable and rewarding (e.g., Knowles et al., 2018) thus creating more space for sexual arousal and less capacity for disgust. This last rationale is tentatively supported by the post hoc analyses showing a clear negative relation between the reported experience with kissing and the amount of disgust experienced.

Of course, the rationales described above are not mutually exclusive and could all weigh in to cause the decline in disgust. In fact, the processes could possibly reinforce each other and/or have a bidirectional relationship with disgust in which a further decline in disgust makes sex-related stimuli more prone to approach and this approach in turn causes a further decline in disgust (Borg, Oosterwijk, et al., 2019; de Jong et al., 2013).

The second hypothesis, that older children would be more disgusted than younger children by core disgust stimuli, was not confirmed as there were no systematic age differences between the ratings toward core disgust stimuli. One of the age groups (the 12-year olds) scored generally lower than the other groups, but this is probably due to the existence of three outliers (participants whose scores were more than two standard deviations from the mean) in this group. These results may imply that disgust toward stimuli in the core disgust domain has already reached maturity by the age of 9 years in most children, though further studies are necessary to arrive at more concrete answers. Previous research has clearly shown developmental changes in this regard during infancy (e.g., Brown & Harris, 2012; Hertenstein & Campos, 2004) and also with regard to contamination in early childhood (Legare et al., 2009). Our results are compatible with the idea that core disgust
may have reached a mature level at age 9 (i.e., the entry age of our study), though it is possible that some development still occurs toward stimuli that are less extreme or that reasoning surrounding core disgust stimuli is still in development.

For the third hypothesis, that disgust toward food items would be similar across age groups, the results do not support the existence of any age-related differences in disgust toward (textured, animal-based) food stimuli. This corresponds to studies that show a relatively stable development in food responsiveness across age, both in children and in adults (Derks et al., 2019; Egolf et al., 2019). These findings support the idea that disgust toward food items is also stable throughout puberty.

4.1 Limitations and future research

This study carries some limitations that should be acknowledged here. The first limitation concerns the use of online questionnaires. While stimuli were set to be a specific size, people could have used different tools to access the questionnaire (e.g., smartphones, tablets) resulting in smaller displays of our stimuli. It is possible that such smaller displays of the stimuli on a phone could have resulted in decreased responses from the children. However, as disgust ratings were sufficiently high, this does not seem to have had a large impact on the outcomes of the study. Because the participants filled in the questionnaires at home, there was also no control over the potential aiding of peers, siblings, or parents with the questionnaire.

Secondly, it may be the case that our core-disgust items were rather intense (e.g., a rather large amount of vomit smeared onto some clothes, a toilet stained with feces, a saucepan covered in mold). Perhaps we would have found greater differences in responses if the stimuli comprised a wider range of disgust intensity. For example, differently aged children and children of different sexes might have appreciated these items in more varied ways, while our current items perhaps only elicited more uniform, rather extreme responses. Future work could be focused on investigating the responses of children to less extreme disgust prompts. In addition, it is also reasonable to assume that the stimuli in the other categories are not really representative of the category as a whole. For the food category, all of these consisted of textured (wet, lumpy) food with both animal-based ingredients and vegetables. We did not include possibly disgust-eliciting foods such as raw fish, blue cheese, or pickled eggs. Similarly, the sex-related stimuli only included French kissing, which is relatively "mild" in comparison with other sexual behaviors.

A third limitation is that the results are solely based on self-reported subjective measures of disgust. For future studies, it is also highly relevant to incorporate physical measurements of disgust.

A fourth and final limitation is that for measuring subjective disgust, we decided for a direct and simplistic approach using the VAS rather than the validated scales such as the Child Disgust Scale (Viar-Paxton et al., 2015) and the Disgust Emotion Scale for Children (Muris et al., 2012), that are available. This was done to limit the demand on the participants, for suitability, and because our main category of interest was the sex-related disgust which is not better captured by the available disgust assessment tools (see de Jong & Borg, 2020, for a critical evaluation of the available disgust assessment tools).

This study has shown that there are age-related differences in sex-related disgust between the age of 9 until and including 16 years, in the sense that older children report less disgust toward these stimuli. As most children may undergo hormonal changes between these ages as a result of puberty, future research should also be directed at analyzing how such hormonal changes relate to these alterations in disgust responses. It would be particularly interesting to investigate whether hormonal changes precede changes in disgust sensitivity or not. Since there are large individual differences with regard to the age of onset of puberty it would be important to include objective measures to define participants’ developmental stages. In addition to hormonal measurements, other more specific parent-report scales of pubertal timing may also be used for more accurate information on pubertal status, instead of relying upon a single indicator (see, for instance, Petersen et al., 1988; Tanner & Whitehouse, 1976). Another line of research may be directed at understanding how exposure to sexual topics and sexual behaviors is related to a decrease in disgust. In this regard, cross-cultural research is also needed to understand the contribution of societal norms around sexuality and having access to media with a more or less explicit sexual nature.

4.2 Conclusion

The present study has offered a unique insight into the age-related differences of disgust responses in the ages around puberty. Disgust responses toward sex-related imagery were shown to exhibit rather large differences between 9 through 16 years of age, with disgust responses decreasing in intensity with increasing age. The age effect was similar for boys and girls, but girls were generally somewhat higher in disgust than boys across all age groups. Disgust responses toward stimuli representing core-disgust and food did not show such an age effect and turned out to be rather similar across ages and between boys and girls. To our knowledge this study is one of the first to clearly lay out how disgust responses may change in one of the most turbulent developmental stages in human development, puberty. By providing an overview of age-related changes in a nonclinical population, future studies will be able to gauge at which stages maladaptive adjustment arise. In addition, the present study offers important new angles for future research, which might further disentangle the mechanisms through which the explored changes in disgust responses occur.
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CONFLICT OF INTERESTS
The authors declare that there are no conflict of interests.

ETHICS STATEMENT
The study design was approved by the Ethical Committee of Psychology for the University of Groningen (ppo_17022_O), and all procedures were conducted accordingly.

DATA AVAILABILITY STATEMENT
The data are stored under the HI data storage protocol and is available on request from the authors.

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