The English Version of the Food Disgust Scale: Optimisation and Other Considerations

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Abstract:

The disgust elicited by food plays an important role in food choice and consumption. Recently, Hartmann and Siegrist (Food Quality and Preference, 2018, 63, 38–50) developed and validated in German the food disgust scale (FDS), a 32-item instrument designed to measure visceral disgust elicited by food. In Study 1, we tested the English language translation of the FDS and its shortened version (FDS-SHORT) in England (*n* = 85) and Canada (*n* = 70). The internal reliability (Cronbach's alpha and mean interitem correlation [MCI]) was acceptable for both the FDS (α = .90, MIC = .22) and the FDS-SHORT (α = .73, MIC = .25). Exploratory factor analysis revealed that the English and German versions of the FDS had similar underlying structure and good discriminant validity. In Study 2, female participants (*n* = 159) who completed the FDS where the anchor term *disgusted* was used had higher FDS-SHORT scores than either their male counterparts or females for whom the anchor term *grossed out* was used ($F[2, 266] = 11.1$, $p < .001$). As *grossed out* captures only visceral rather than moral disgust, we recommend its adoption in English versions of these scales. These studies confirm that, as modified, the English FDS and FDS-SHORT are reliable and can be used with confidence in future research.

Key words:
disgust sensitivity, scale validation, visceral disgust, grossed out, cross-cultural research, food neophobia

Practical application:

This study has further assessed and optimized an English translation of the food disgust scale, which will allow for its use by food researchers and practitioners in English-speaking countries. The finding that food disgust scores vary with sex and culture provides guidance to producers and marketers of novel food products and flavors.

Abbreviations:

FDS – Food Disgust Scale
FNS – Food Neophobia Scale
MIC – Mean interitem correlation

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Author contributions:

All authors contributed to the conceptualization and design of the study. Margaret Thibodeau contributed to data collection, data analysis and wrote the initial draft of the manuscript. Gary Pickering contributed to the data analysis. Qian Yang, Rebecca Ford, and Gary Pickering assisted with drafting the final manuscript. All authors read and approved the final manuscript.

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1. Introduction

Researchers are increasingly capturing consumers' emotional responses to food products in order to gain insights into product acceptance, consumption and market segmentation (reviewed in: Köster and Mojet 2015; Meiselman 2015; Kenney and Adhikari 2016; Lagast et al. 2017; Kaneko et al. 2018). For example, individuals that rated feeling positive emotions more intensely (e.g. "active", "good", "satisfied") when tasting aqueous solutions of basic tastes, also rated their liking of the samples higher (Samant, Chapko, & Seo, 2017). Furthermore, in some studies, emotional responses were better at discriminating between products or consumer segments than traditional hedonic measures (e.g. Ng, Chaya, & Hort, 2013; Spinelli et al., 2019; Yang, Dorado, Chaya, & Hort, 2018). Therefore, the development and validation of tools that can effectively capture the emotional responses of consumers to food products is important.

Disgust is defined by the American Psychological Association "as strong aversion, for example, to the taste, smell or touch of something deemed revolting, or towards a person or behaviour deemed morally repugnant" (VandenBos 2006 pp.288). Understanding the role of disgust in food-related behaviour is of particular interest because it plays an important role in disease prevention (Chapman & Anderson, 2012; Oaten, Stevenson, & Case, 2009) and in the adoption of novel food products (Tuorila & Hartmann, 2019). Disgust has long been linked to the sensory dimensions of food. For instance, it has been argued that the human evolutionary origin of disgust lies in the sensory aversion and consequent rejection response to bad-tasting food (Rozin & Fallon, 1987). More recently in the context of novel foods and technologies, disgust and both actual and anticipated sensory properties interact to influence acceptance and consumption intent (e.g. Martins et al., 1997; Martins & Pliner, 2006; Ruzgys & Pickering, 2020).

Hartmann and Siegrist (2018) developed the Food Disgust Scale (FDS), a 32-item questionnaire, in order to measure the disgust sensitivity of individuals to food and food-related situations. During development of the FDS, factor analysis revealed that food disgust sensitivity was best explained by a combination of eight factors (each represented by 3-5 items); animal flesh (FDS-MEAT), poor hygiene (FDS-HYG), human contamination (FDS-HUCO), mold (FDS-MOLD), decaying fruit (FDS-FRUIT), fish (FDS-FISH), decaying vegetables (FDS-VEGI) and living contaminants (FDS-LCON). A shortened version of the FDS, the 8-item FDS-SHORT, was also developed by selecting the item from each factor of the FDS that had the highest item-total correlation and face validity.

The FDS and FDS-SHORT have had early success in showing the impact of disgust sensitivity on food related behaviour. For example, individuals with low food disgust sensitivity were more likely to consume or report intent to consume insects (Ammann, Hartmann, & Siegrist, 2018b; Lammers, Ullmann, & Fiebelkorn, 2019), meat substitutes (Siegrist & Hartmann, 2019) or cultured meat (Ruzgys & Pickering, 2020), and were more likely to have suffered a food-borne illness (Egolf, Siegrist, & Hartmann, 2018; Hartmann & Siegrist, 2018). Conversely, individuals with high disgust sensitivity were more likely to score high on food neophobia, germ aversion (Egolf et al., 2018; Hartmann & Siegrist, 2018) and food pickiness (Hartmann & Siegrist, 2018), and were more likely to participate in hygienic food preparation techniques (Ammann, Siegrist, & Hartmann, 2019).

The FDS and FDS-SHORT were originally developed and validated in the German language using Swiss subjects. For both scales, participants are asked to indicate how disgusting they perceive each of the items to be on a scale from 1 (“not disgusting at all”) to 6 (“extremely disgusting”). While English language translations of the scales were provided in the paper by

Hartmann and Siegrist (2018), they were not validated. Recently, Egolf et al (2019) showed that translations of the FDS-SHORT were largely valid in six languages (German, Chinese, French, Spanish, English and Swedish) across ten new countries. However, to the best of our knowledge the validity of the English language 32-item FDS has not been investigated. Furthermore, the 8-items selected for the FDS-SHORT are based on the original Swiss subject responses. Therefore, we sought to determine if the FDS-SHORT could be optimized for use in English by using a different combination of items from the FDS.

The use of the English versions of the FDS and FDS-SHORT is further complicated by the dual meaning of the term "disgust" in English, as noted by Hartmann and Siegrist (2018) and Egolf et al (2019). Indeed, Petrowski et al. (2010) developed a new scale for overall disgust sensitivity after a translated version of the English Language Disgust Scale (Schienle et al., 2002) performed less effectively in German. The first definition of "disgust" (*Merriam-Webster's advanced learner's English dictionary*, 2008) is "a strong feeling of dislike for something that has a very unpleasant appearance, taste, smell, etc." and is typically referred to as visceral disgust (Herz & Hinds, 2013). Visceral disgust is consistent with "Eklig", the word used in the original German language FDS. "Eklig" is defined as something that is "disgusting, revolting, nauseating", and can be used to describe a smell or taste (Duden, 2000). The second definition "annoyance or anger that you feel toward something because it is not good, fair, appropriate, etc" is consistent with moral disgust (Herz & Hinds, 2013). Importantly, moral disgust differs from visceral disgust as the subject's ratings may also be influenced by anger (Herz & Hinds, 2013; Nabi, 2002), an emotion not targeted in the German-language FDS and FDS-SHORT. In particular, for items related to poor hygiene, such as "to eat with dirty silverware in a restaurant", participants may feel they have experienced a transgression and react with anger. The use of the expression “grossed out” rather than “disgust” when administering the FDS and FDS-SHORT has been suggested as it is less likely to be associated with anger (Hartmann & Siegrist, 2018; Nabi, 2002). As such, we sought to determine if/how scores varied based on the choice of anchor terminology used to administer the FDS-SHORT.

Sex and cross-cultural differences may also impact food disgust sensitivity. It is well established that women have higher levels of disgust than men (reviewed in: Al-Shawaf et al. 2018). Consistent with this trend, mean FDS and FDS-SHORT scores are higher for female subjects than male subjects (Ammann, Egolf, Hartmann, & Siegrist, 2020; Ammann, Hartmann, & Siegrist, 2019; Ammann, Siegrist, et al., 2019; Egolf et al., 2019; Hartmann & Siegrist, 2018). While cross-cultural differences are difficult to interpret (Ares, 2018), Chinese and Swiss subjects rated the disgust elicited by 5 of 8 food related disgust-eliciting images differently (Ammann et al., 2020). Therefore, understanding how the English version of the FDS and FDS-SHORT perform across different cultures and genders is of interest.

1.1 Current research

Overall, the aim of the current research is to better understand the English language versions of the FDS and FDS-SHORT using two related studies. In Study 1, participants from England and Canada completed the full version of the FDS, allowing testing for the first time of the full 32-item English language version of the scale. We also sought to determine if the items selected by Hartmann et al (2018) for the FDS-SHORT were suitable for use in English and if a different combination of items would optimize scale performance. In Study 2, a second cohort of Canadian subjects completed the FDS-SHORT with the term “disgusting” used in the instructions instead of “grossed out”. Verbal anchors are critical scale elements and should be unambiguous and reflect the intended construct; here, we were specifically concerned about the potential for “disgusting” to capture both moral and visceral dimensions of disgust, whereas only the latter is the intent. When combined with the data from Study 1, we were able to characterize the impact of this terminology on FDS-SHORT scores. Finally, data from both studies were used to investigate the impact of sex and cross-cultural differences on food disgust sensitivity.

2. Materials, methods & results

2.1 Study 1 – Validation of scale

2.1.1 General methods

A convenience sample of 155 participants completed the Food Disgust Scale (FDS; Hartmann and Siegrist 2018). Participants were recruited from the student populations of two universities, one in England (n=85, 63 female) and one in Canada (n=70, all female). The Canadian cohort was recruited as a component of a larger project on human taste perception. For the Canadian cohort, males and individuals above the age of 40 were excluded as they did not meet the inclusion criteria for the aforementioned human taste perception project. Overall, participants were primarily university aged students with mean ages of 20.0 ± 2.1 years (n = 83, n=2 missing) and 22.0 ± 2.6 years (n = 40, n=45 missing) for the Canadian and English samples, respectively. Compensation was offered as an incentive to participants in the form of entry into a monetary/gift card draw or participation credit towards select courses. Informed consent was obtained for all participants and all procedures were cleared by the Brock Research and Ethics Board (17-031 and 17-168) or the University of Nottingham Ethics Committee (SBREC170117A).

The FDS is a scale that measures the disgust elicited by food products (e.g., “To eat overripe fruits”) and food-related situations (e.g., “To eat with dirty silverware in a restaurant”). All 32 original items in the English language translation provided by Hartmann and Siegrist (2019) were included without modification. The items were presented in a randomized order. In order to more closely reflect the meaning of the German term ‘eklig’, the term ‘grossed out’ was used instead of ‘disgusting’ in the instructions and anchor terms for the scale. Furthermore, participants were also instructed to “use the term ‘grossed out’ to indicate something that is unpleasant or revolting” (Hartmann & Siegrist, 2018). Participants were asked to rate how ‘grossed out’ they are by each item on a scale from 1 (not grossed out at all) to 6 (extremely grossed out). All individual items within the FDS are referred to using the naming conventions adopted by Hartmann et al (2018; Table 1). FDS-LONG (all 32 items), FDS-SHORT (MEAT1, HYG1, HUCO1, MOLD3, FRUIT4, FISH4, VEGI1 and LCON2), and FDS subscale (3 to 5 items each) scores were calculated by taking the mean of all items included within the measure.

In a follow-up session, most participants (n=149) also completed the Food Neophobia Scale (FNS; Pliner and Hobden 1992). The 10-item scale measures an individual’s reluctance to eat and/or their avoidance of novel foods (e.g. “I don’t trust new foods”). Participants rated each item on a 5-point Likert scale (Henriques et al., 2009) from “strongly disagree” (coded as 1) to “strongly agree” (coded as 5). After adjustment of the reverse-coded items, the mean score of all ten items was calculated for each participant. FNS scores were not normally distributed (Shapiro-Wilks, $W(149) = .949$, $p < .0001$) so a log transformation was performed to improve normality (Shapiro-Wilks, $W(149) = .984$ $p = 0.073$).

All data analysis was performed using XLSTAT Version 19.3.2 (Addinsoft, NY, USA) and Microsoft® Excel® for Mac 2011 (Microsoft ®**,** ON, Canada).

2.1.2 Data analysis and results

For each participant, mean, median and the standard deviation for the FDS-LONG, FDS-SHORT and the FDS subscales was calculated (Figure 1, Table 1). The Shapiro-Wilks test was used to access the normality of the FDS-LONG, FDS-SHORT and the FDS subscales. Shapiro-Wilks revealed that only the scores for the FDS-LONG ($W(155) = .994$, $p = .820$), FDS-SHORT ($W(155) = .990$, $p = .307$) and FDS-VEGI ($W(155) = .989$, $p = .237$) were normally distributed; thus non-parametric statistics were used for the other FDS measures (individual items and subscales). Four subscales (FDS-MEAT, FDS-HUCO, FDS-FISH and FDS-FRUIT) had right-skewed distributions while the remaining three scales were left-skewed (FDS-HYG, FDS-MOLD, FDS-LCON). For most of the individual items, the distribution of scores was consistent with that of the corresponding subscale indicating that the skew was not driven by a single item.

In order to measure reliability, Cronbach's alpha was calculated for the FDS ($\alpha = .90$), FDS-SHORT ($\alpha = .73$) and each of the subscales ($\alpha = .72 - .83$, Table 1). Mean interitem correlations (MIC) were also calculated for the FDS-LONG (MIC = .22), the FDS-SHORT (MIC = .25) and each of the subscales (MIC = .38 - .57). Both MIC (.15 - .50) and Cronbach's alpha ($\alpha < .70$) indicate that the long, short and subscales of the FDS demonstrate acceptable internal reliability (Tavakol & Dennick, 2011; Widaman, Little, Preacher, & Sawalani, 2011).

The Food Neophobia Scale (FNS) can be used to test the discriminant validity of the FDS because increased visceral disgust is one factor that contributes to increased food neophobia (Al-Shawaf, Lewis, Alley, & Buss, 2015). Individuals who score highly on the FNS are also more likely to score high on the FDS (Ammann et al., 2020; Ammann, Hartmann, & Siegrist, 2018a; Egolf et al., 2019; Hartmann & Siegrist, 2018). Cronbach's alpha ($\alpha = .89$) indicated that the FNS performed reliably. Pearson's correlation showed a positive correlation between FDS-

LONG scores and log FNS for the individuals who completed both scales ($r(147) = .341$, $p < .001$). Similarly, the FDS-SHORT and log FNS scores were positively correlated (n=149, $r(147) = 0.274$, $p = 0.001$.) As the FDS subscales were mostly non-normally distributed, Spearman's rank correlation was used to test the association between each FDS subscale and the FNS. Significant positive correlations were found between the FNS and FDS-MEAT ($r_s(147) = .300$, $p = .0002$), FDS-MOLD ($r_s(147) = .205$, $p = .012$), FDS-FRUIT($r_s(147) = .309$, $p < .001$), FDS-FISH ($r_s(147) = 0.365$, $p < .001$), and FDS-VEGI ($r_s(147) = 0.185$, $p = 0.024$). The FNS was not correlated with the FDS-HYG ($r_s(147) = .023$, $p = .779$), FDS-HUCO ($r_s(147) = .133$, $p = .107$) or FDS-LCON ($r_s(147) = 0.092$, $p = 0.264$).

2.1.2.1 Factor analysis

Confirmatory factor analysis of the English version of the FDS-LONG was not possible to assess model fit due to low sample size and the lack of normality of most items. Hoetler's Critical N (114) was below the recommended value of 200 used to indicate sampling adequacy (Byrne, 2016), and the strong univariate non-normality of several items indicated the data did not meet the assumption of multivariate normality for maximum likelihood estimation (Byrne, 2016). Alternatively, exploratory factor analysis (EFA) was performed to assess the dimensionality of the 32-items from the FDS-LONG using principal components (Spearman's correlation) with varimax rotation (Kaiser normalization). The Kaiser-Meyer-Olkin measure was 0.825 which indicates that the sample size was adequate (Field, 2013; Kaiser, 1974). Bartlett's test for sphericity showed that the items were sufficiently intercorrelated to continue ($\chi^2(496) = 2112.42$, $p < .001$). Initially, eight dimension had eigenvalues above 1.0 and were retained for the varimax rotation. However, the eighth factor had low face validity as MEAT1, VEGI1 and VEGI4 were most highly loaded on to it after varimax rotation. As a result, the procedure was repeated using only 7 factors in the varimax rotation (Table 2). Together, the seven explained 61.2% of the variability within the data set.

Consistent with Hartmann and Siegrist (2018), most items within an FDS subscale were highly loaded onto the same factor after varimax rotation with two exceptions. MEAT1 and HUCO1 were more highly loaded onto the factor associated with the FISH and HYG items, respectively. Items from the same subscale were most highly loaded onto different factors with the exception of VEGI and FRUIT which loaded together onto Factor 3. When the VEGI and FRUIT items were combined, their internal reliability (α = .82) suggested that both are measuring similar underlying dimensions. Overall, the exploratory factor analysis yielded very similar results to those from the German-language version of the FDS.

2.1.2.2 Investigation of the FDS-SHORT

The short version of the FDS was developed by Hartmann and Siegrist (2018) with a German cohort. While the English translation of the FDS-SHORT has been validated in four countries (Egolf et al. 2019; α = .69 - .75), we sought to determine if a more reliable short version of the FDS could be developed. Three strategies were used to develop alternative short versions of the FDS (Table 3). The FDS-SHORT-A1 was created by including the item most strongly loaded onto each factor from the exploratory factor analysis. The FDS-SHORT-A2 and FDS-SHORT-A3 were generated by selecting the item from each FDS subscale most strongly correlated the FDS-LONG score and the corresponding FDS subscale, respectively (Widaman et al., 2011). For each of the alternative versions, the mean of all items included within the scale was used. Scores for each of the alternative versions were normally distributed (Shapiro-Wilks, $p > 0.05$). Mean, standard deviation, range, Cronbach's and Pearson's correlation between the FDS-LONG and each for the shorten version of the FDS were calculated (Table 3). On balance, the FDS-SHORT-A3 ($r(153) = .912$, $p < .001$) outperformed the alternatives as it had the highest internal reliability ($\alpha = .76$), the widest range of scores and was more strongly correlated to the FDS-LONG than the original FDS-SHORT. However, it only marginally outperformed the original FDS-SHORT ($\alpha = .73$, $r(153) = .918$, $p < .001$); adopting this modified version of the FDS-SHORT in the field for English speakers would likely yield little if any advantage over the original.

2.1.2.3 Other considerations

Data for the current study was collected in both England (n = 85) and Canada (n = 70). Cronbach's alpha was calculated for participants from Canada ($\alpha = .90$) and England ($\alpha = .89$), indicating that the FDS-LONG performed equitably across both countries. Similarly, the FDS-SHORT also performed similarly in Canada ($\alpha = .74$) and England ($\alpha = .67$).

In order to determine if cross-cultural differences in food disgust existed, we compared the FDS scores for the female participants from England (n = 63) and Canada (n = 70) using t-tests. As males score lower than females on the FDS (Egolf et al., 2019; Hartmann & Siegrist, 2018) and none were recruited in Canada, the male participants from England (n = 22) were excluded. Mean FDS-LONG scores were significantly higher in Canada than in England ($t(131) = 1.98$, $p = .049$) but no difference was found in FDS-SHORT scores ($t(131) = 1.48$, $p = .142$). Canadian females also rated the FDS-MOLD ($U_{standardized} = 2.76$, $p = .006$), FDS-FRUIT ($U_{standardized} = 2.72$, $p = .007$) and FDS-FISH ($U_{standardized} = 2.76$, $p = .006$) significantly higher than did English females (see Table 4 for full statistics; Mann-Whitney U). Mean scores for all the items in the FDS-MOLD, FDS-FRUIT and FDS-FISH were higher for the Canadian cohort, suggesting that the difference is robust. No significant difference was found for the other five subscales.

The impact of sex on the FDS-LONG and the FDS subscales was not investigated due to the low number of male participants recruited to Study 1 (n=22).

2.2 Study 2 – Influence of sex and scale anchor terms

2.2.1 General methods

In order to more closely investigate the effect of sex and scale anchor terms, a second cohort of Canadians (n =199, 40 males, age = 20.6 ± 2.7 years) completed the 8-item FDS-SHORT. The FDS-SHORT was administered using the same criteria as in Study 1, with one exception: participants were instructed to rate how "disgusting" each item was for them in Study 2 (as opposed to "grossed out" in Study 1). This is consistent with the original translation of the FDS-SHORT provided by Hartmann and Siegrist (2018). All participants provided informed consent and the procedures were approved by the Brock Research and Ethics Board (18-036).

Data from this second Canadian cohort was combined with the responses to the FDS-SHORT items of Canadian participants from Study 1 (n = 70). As in Study 1, FDS-SHORT scores were calculated for each participant by taking the mean of all eight items included in the scale.

2.2.2 Data analysis and results

Cronbach's alpha indicated that FDS-SHORT had good overall reliability (α = .74). Participants were divided into three subgroups based on sex and scale terminology; females using the anchor term "grossed out" (n = 70, α = .74), females using the anchor term "disgusted" (n = 159, α = .74) and males using the anchor term "disgusted" (n = 40, α = .67). FDS-SHORT scores were normally distributed within each subgroup ($p > 0.05$, Shapiro-Wilks). However, the distribution of scores for individual items was not normally distributed. No males completed the FDS-SHORT using the anchor term "grossed out" leaving a missing cell which violates the assumptions of Type I-III Sum of Squares; thus a two-way ANOVA was not possible. Instead, the FDS-SHORT scores were compared across the three groups using a 1-way ANOVA and Tukey's HSD as the means separation test. Female participants using the "disgusted" anchor terms had significantly higher FDS-SHORT scores than the other two groups ($F(2, 266) = 11.0$) $p, < .001$, Figure 2). Males using the anchor term "disgusted" and females using the anchor term "grossed out" did not differ significantly.

As anger may be more readily elicited by some items in the FDS-SHORT, Mann-Whitney U was used to determine if the scores of Canadian females differed for each item. The analysis was limited to Canadian females in order to eliminate country/culture and sex as possible confounding effects. Females using the "disgusted" anchor terms rated MEAT1 ($U_{standardized} = 3.40$, $p < .001$), HYG1 ($U_{standardized} = 2.71$, $p = .007$), HUCO1 ($U_{standardized} = 3.50$, $p < .001$), MOLD3 ($U_{standardized} = 2.68$, $p = .007$) and FISH4 ($U_{standardized} = 3.45$, $p < .001$) significantly higher than those using the "grossed out" terminology (Figure 3). No differences were found for FRUIT4, VEGI1 or LCON2 ($U_{standardized} < 1.96$, $p > 0.20$), although mean values trended in the same direction as for the other subscale groups.

3. Discussion

3.1 Performance of the scale

When tested in Canada and England, the English language version of the FDS-LONG performed well as the internal reliability ($\alpha = .90$) was within an acceptable range ($\alpha = .70 - .95$; Tavakol & Dennick, 2011). In addition, it largely had the same factor structure as the original German version. In addition, the FDS-LONG demonstrated discriminant validity as scores were positively correlated to food neophobia, consistent with the German language version (Hartmann

& Siegrist, 2018). The reliability of each of the FDS subscales was lower than when initially developed in German, however each subscale can still be regarded as was reliable as Cronbach's alphas were within the acceptable range (Tavakol and Dennick 2011). Together, this provides good support for the use of the FDS-LONG in English.

The English language FDS-SHORT also performed well in the current study. Cronbach's alpha ($\alpha = .73$) fell within the range reported by Egolf et al (2019) when a slightly different English language translation was validated in four countries (England, United States, Australia and South Africa). Marginal improvements in the scale's performance were obtained when alternative versions of the FDS-SHORT were tested here. However, the modest gains do not outweigh the benefits of using the same items as in the original German version across languages in cross-cultural research. Therefore, we recommended using the same eight-items in English as proposed by Hartmann and Siegrist (2018) when developed in German.

Food neophobia scores were significantly correlated to the FDS-LONG, FDS-SHORT and five of the FDS-subscales. For these items, correlations were in the same direction and of similar strength to those reported when tested in German (Hartmann & Siegrist, 2018). In contrast, the FDS-HUCO, FDS-LCON and FDS-HYG were not correlated with food neophobia, despite the fact that the FDS-HUCO and FDS-LCON were significantly correlated with food neophobia in the German language version (Hartmann & Siegrist, 2018). Ceiling and floor effects may have reduced the discriminating power of these FDS subscales (Figure 1). For example, to obtain an FDS-LCON score of 5.67, the median in our sample, a participant must have rated two of the three items at the maximum (6 of 6) and the other item just below the maximum (5 of 6). As a result, when the FDS-LCON scores are summed rather than averaged, over 50% of our sample differed by a single point or less for this subscale despite a wide range of possible scores (3 to 18). Furthermore, the mean score of 5.13 and the fact that 78% of individuals did not use the lower half of the scale for any FDS-LCON item supports the hypothesis that ceiling effects exist for the FDS-LCON. Similarly, the FDS-HYG (median = 5.00) and the FDS-HUCO (median = 1.75), are likely impacted by ceiling and floor effects, respectively. The appropriate choice of anchor terms to increase the range of scores (see Section 3.2) could increase the discriminating power of these subscales, ultimately increasing the range of scores for the FDS overall. Studies have shown that when the number of points is increased from 6 to 11 for Likert scales, the skew is reduced and normality is improved without affecting the underlying structure of the results (Leung, 2011; Wu & Leung, 2017). If the current scores for the FDS-LCON, FDS-HUCO and FDS-HYG do not represent the true extreme responses for food-related disgust, increasing the number of scale point may also improve the performance of these subscales. However, the low number of males in our sample (22 of 155) may have inflated the ceiling effects, as on average females are more sensitive to disgust than are males (Ammann et al., 2020; Ammann, Hartmann, et al., 2019; Ammann, Siegrist, et al., 2019; Egolf et al., 2019; Hartmann & Siegrist, 2018).

Another advantage of reducing ceiling and floor effects is that this could reduce the non-normality of the data and ultimately allowing for the use of parametric statistics on the subscales (Leung, 2011; Wu & Leung, 2017). A limitation of our study was the inability to complete confirmatory factor analysis due to the non-normality of most items within the FDS-LONG and our small sample size. Nevertheless, exploratory factor analysis showed that the English and German 32-item versions of the FDS had similar underlying structures (Table 2). The primary difference between the structure of both scales is the number of factors. The final version of the German language FDS-LONG was composed of eight dimensions, while the English version is best explained by seven. In the English language version, the items from the VEGI and FRUIT subscales are loaded onto a single factor. This grouping is logical as all items relate to the decay of fresh produce. Interestingly, during the early stages of the development of the German FDS-LONG, items associated with decaying vegetables were not included (Hartmann & Siegrist, 2018), consistent with our findings. Thus, decaying fruit and decaying vegetables may represent a single dimension of food disgust sensitivity for English speakers. However, a larger sample size is required to test this hypothesis using confirmatory factor analysis.

In the Egolf et al (2019) version of the FDS-SHORT, all items were the same as used in the current study except for MEAT1 ("to put animal cartilage into my mouth") which was changed to "to put meat gristle into my mouth". Interestingly, in the exploratory factor analysis, MEAT1 was more highly loaded onto the factor associated with FISH items than the factor associated with other FDS-MEAT items. It could be that English speakers associate the term "cartilage" more closely with fish as it is often served whole while the livestock examples in the other FDS-MEAT items (pig, cow) are typically served after being butchered into small portions. Based on these findings and in the absence of research comparing the two expressions, we favour the use of "meat gristle" over "animal cartilage" in future studies.

In both of our studies, individual items on the disgust scales were presented to participants in randomized order, in contrast with the fixed order used by others (Egolf et al., 2019; Hartmann and Siegrist, 2018). We recommend the continued use of item randomization as sound practise in product-focused studies to balance across the cognitive biases—such as halo effects and proximity errors—that are known to influence participant responses with other scales (Kemp et al., 2009). Finally, we recommend for future work a comprehensive validation study that makes use of a representative sample of sufficient size in order to complement the narrower scope of the current study.

3.2 Influence of sex and scale anchor terms

The adoption of consistent anchor terminology in future studies using the English language FDS will allow for a more robust comparison of findings across studies. FDS-SHORT scores were significantly higher when the anchor term “disgusted” was used compared to “grossed out” (Figure 2). Five of the eight items that comprise the FDS-SHORT also had significantly higher scores when “disgusted” was used (Figure 3). While both anchor terms capture feelings of visceral disgust, only “disgusted” also applies to moral disgust. Notably, situations that elicit moral disgust also commonly elicit anger (Herz & Hinds, 2013; Nabi, 2002). As such, the higher scores associated with “disgusted” compared with “grossed out” may be attributed to anger elicited by the items. As the intent of the original German-language FDS was only to capture visceral disgust, we recommend using the anchor term “grossed out” in order to avoid the possible confounding effects of anger on FDS scores.

Cross-cultural and sex differences in food disgust sensitivity were found in our study. Female Canadian participants had higher mean scores than female English participants on the FDS-LONG and for three FDS subscales (MOLD, FISH and FRUIT). The foods that elicit disgust vary across both individuals (Martins & Pliner, 2005) and cultures (Ammann, Egolf, Hartmann, & Siegrist, 2020); it is possible that the selection of specific items in the FDS rather than ‘true’ differences in food disgust sensitivity may have influenced this finding. FDS-SHORT scores did not differ between Canada and England, suggesting that it may be a better choice than the FDS-LONG for cross-cultural research. Consistent with other literature, we found that males had lower FDS scores than females (Ammann et al, 2020; Ammann, Hartmann, & Siegrist, 2019; Ammann, Siegrist, et al., 2019; Egolf et al., 2019; Hartmann & Siegrist, 2018). As no males were included in the cross-cultural analysis portion of our study, it is currently not known if food disgust in males differs between Canada and England.

Taken together, the results of Study 1 and Study 2 provide new insights into the validity and use of the English language FDS. The English translation of the FDS-LONG has a similar underlying structure to that of the original German language version. Additionally, the FDS-LONG, FDS-SHORT and the FDS subscales had acceptable levels of internal reliability and demonstrated discriminant validity. FDS scores were impacted by sex, cross-cultural differences and anchor terminology, and these variables should be considered and accounted for in future research. Importantly, our findings largely support the use in future research of the English language translation of the FDS provided by Hartmann et al (2018).

4. References

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Tables

Table 1: FDS-LONG, FDS-SHORT, FDS subscales and individual items (Hartmann and Siegrist, 2018) with descriptive statistics and Cronbach's alpha St. dev. = standard deviation, MIC= mean interitem correlation.

Scale, Subscale or Item		Median	Mean	St. Dev
FDS-LONG (α = .902, MCI = .22, normal)		3.41	3.46	0.74
FDS-SHORT (α = .729, MCI = .25, normal)		3.50	3.53	0.88
Animal flesh (α = .720, MIC = .39, right skewed)		2.50	2.83	1.30
MEAT1	To put animal cartilage into my mouth	4	3.7	0.7
MEAT2	To see raw meat	1	2.2	0.8
MEAT3	To eat steak that is still bloody inside	2	2.8	0.8
MEAT4	To see a whole pig en brochette	2	2.7	0.8
Poor hygiene (α = .781, MIC = .43, left skewed)		5.00	4.82	0.89
HYG1	To eat with dirty silverware in a restaurant	5	5.1	0.5
HYG2	A meal prepared by a cook who has greasy hair and dirty fingernails	6	5.1	0.5
HYG3	If the cook in a restaurant has an open cut	5	4.8	0.5
HYG4	If people blow their nose before they serve my meal	5	4.4	0.5
HYG5	Another person's hair in my soup	5	4.7	0.5
Human contamination (α = .771, MIC = .43, right skewed)		1.75	2.20	0.97
HUCO1	Food donated from a neighbor whom I barely know	2	2.6	0.8
HUCO2	If a friend bites into my bread	1	1.9	1.2
HUCO3	To drink from the same glass a friend has already drunk from	2	2	1.2
HUCO4	If friends or acquaintance have touched my food	2	2.3	0.9
Mold (α = .804, MIC = .51, left skewed)		4.00	3.90	1.29
MOLD1	To eat the mold-free part of a moldy tomato	4	4.2	0.7
MOLD2	To eat bread from which mold was cut away	4	3.8	0.4
MOLD3	To eat hard cheese from which the mold was cut off	3	3.3	0.6
MOLD4	To eat marmalade from which the mold was removed from the surface	5	4.4	0.8
Decaying fruit (α = .805, MCI = .49, right skewed)		2.25	2.55	1.12
FRUIT1	To eat overripe fruits	3	3	0.7
FRUIT2	To eat a banana that has black spots	2	2.6	0.8
FRUIT3	To eat fruits (e.g., apple and peach) with pressure marks	2	2.2	0.7
FRUIT4	To eat apple slices that turned brown when exposed to air	2	2.4	0.8
Fish (α = .826, MIC = .52, right skewed)		2.50	2.87	1.45
FISH1	To have a whole fish with its head on the plate	3	3	0.8
FISH2	To eat raw fish like sushi	2	2.6	0.9
FISH3	The smell in a fish shop or in fish sections with fresh fish	3	3.1	0.7
FISH4	The texture of some fish in the mouth	2	2.8	0.8
Decaying vegetables (α = .719, MIC = .38, normal)		3.50	3.42	1.08
VEGI1	To eat brown-colored avocado pulp	4	3.7	0.6
VEGI2	To eat an overripe cucumber that can already be bent	4	3.8	0.6
VEGI3	To eat shrunken radishes	3	3	0.7
VEGI4	To eat salad that is not crispy anymore	3	3.2	0.7
Living contaminants (α = .807, MIC = .57, left skewed)		5.67	5.13	1.05
LCON1	There is a maggot in the cherry that I wanted to eat	6	5.4	0.5
LCON2	There is a little snail in the salad that I wanted to eat	5	4.9	0.5
LCON3	There is a worm in my apple	6	5.2	0.5

Table 2: Factor loadings from the exploratory factor analysis of the 32-item FDS from Study 1 after varimax rotation. Shaded cells indicate the factor on which each item is most highly loaded.

Factor	F1	F2	F3	F4	F5	F6	F7
MEAT1	0.215	0.511	0.188	0.046	0.250	-0.053	0.299
MEAT2	0.140	0.231	-0.012	0.120	0.267	-0.028	0.606
MEAT3	0.122	0.433	-0.117	0.279	0.011	0.065	0.507
MEAT4	0.147	0.271	0.151	-0.007	0.149	0.106	0.717
HYG1	0.606	-0.052	0.092	0.140	0.164	0.221	0.134
HYG2	0.650	0.013	-0.012	0.088	0.219	0.290	-0.065
HYG3	0.485	0.390	0.007	0.165	0.336	0.115	-0.315
HYG4	0.648	0.075	0.064	0.180	0.293	0.069	0.200
HYG5	0.716	0.006	0.057	0.119	0.075	0.177	0.296
HUCO1	0.585	0.094	0.306	0.235	-0.047	-0.107	0.052
HUCO2	0.249	0.024	0.117	0.798	0.105	0.062	-0.004
HUCO3	0.116	0.082	0.021	0.842	-0.011	0.069	0.117
HUCO4	0.415	0.037	0.289	0.579	0.051	-0.058	0.078
MOLD1	0.222	0.003	0.192	-0.061	0.710	-0.018	0.025
MOLD2	0.123	0.050	0.123	0.197	0.735	0.068	0.081
MOLD3	0.018	0.108	0.146	0.073	0.787	0.136	0.079
MOLD4	0.185	-0.016	0.190	-0.098	0.688	0.187	0.285
FRUIT1	0.144	0.098	0.756	0.071	0.134	0.113	0.027
FRUIT2	-0.342	0.016	0.638	0.201	0.106	0.228	-0.013
FRUIT3	-0.062	0.113	0.734	0.208	0.267	0.037	0.210
FRUIT4	-0.011	0.028	0.566	0.301	0.305	0.074	0.165
FISH1	-0.040	0.733	0.074	-0.008	0.040	0.194	0.245
FISH2	-0.076	0.801	0.073	0.170	0.083	0.081	-0.089
FISH3	0.006	0.708	0.187	-0.031	-0.018	0.081	0.199
FISH4	0.130	0.725	0.229	-0.017	-0.006	0.014	0.151
VEGI1	0.222	0.222	0.404	-0.035	0.379	0.171	-0.001
VEGI2	0.417	0.194	0.573	0.015	0.050	0.019	-0.212
VEGI3	0.279	0.229	0.631	-0.104	0.103	0.019	0.002
VEGI4	0.285	0.299	0.439	-0.109	0.042	0.015	-0.050
LCON1	0.189	0.084	0.098	-0.127	0.077	0.837	-0.026
LCON2	0.136	0.352	0.139	0.163	0.121	0.688	-0.032
LCON3	0.139	0.020	0.105	0.118	0.141	0.810	0.161
Variation Explained	10.54%	10.50%	10.77%	7.12%	9.34%	7.08%	5.85%

Table 3: Descriptive statistics for the FDS-SHORT and three alternative versions (A1, A2, A3) from Study 1 (n=155).

Scale	FDS-SHORT	FDS-SHORT-A1	FDS-SHORT-A2	FDS-SHORT-A3
Description	Developed by Hartmann and Siegrist (2018) using a German Cohort	Items with the highest factor loading from each factor from the exploratory factor analysis	Items with the highest correlation to FDS-LONG from each subscale	Items with the highest correlation to items in the same subscale
Items	MEAT1	MEAT4	MEAT3	MEAT1
	HYG1	HYG5	HYG4	HYG4
	HUCO1	HUCO3	HUCO2	HUCO4
	MOLD3	MOLD3	MOLD3	MOLD3
	FRUIT4	FRUIT1	FRUIT3	FRUIT3
	FISH4	FISH2	FISH1	FISH4
	VEGI1	*	VEGI2	VEGI1
	LCON2	LCON1	LCON2	LCON2
Mean	3.53	3.37	3.29	3.41
Standard Deviation	0.88	0.80	0.83	0.91
Range	1.50-5.75	1.43-5.86	1.63-5.38	1.38-5.63
Cronbach's alpha	.729	.589	.622	.755
Correlation with FDS-LONG	.912	.906	.939	.918

*VEGI and FRUIT subscale items loaded onto a single factor in the exploratory factor analysis. As a result, only to more strongly loaded item across both subgroups was included in the scale.

Table 4: Summary of the comparison between mean FDS scores) for females from England (n=63) and Canada (n=64) (t_{crit} = 1.98, U(standardized)$_{crit}$ = 1.96).

Scale/Item	Test	Mean Score (Standard Deviation)		Test Statistic	p-value
		England	Canada		
FDS-LONG	t-test	3.37 (0.70)	3.61 (0.72)	t = 1.98, df = 131	.049
FDS-SHORT	t-test	3.46 (0.81)	3.68 (0.90)	t = 1.48, df = 131	.142
FDS-MEAT	Mann-Whitney U	2.87 (1.30)	3.00 (1.33)	U (standardized) = 0.56	.577
FDS-HYG	Mann-Whitney U	4.92 (0.78)	4.87 (0.87)	U (standardized) = 0.04	.966
FDS-HUCO	Mann-Whitney U	2.34 (1.03)	2.07 (0.85)	U (standardized) = 1.52	.127
FDS-MOLD	Mann-Whitney U	3.62 (1.30)	4.20 (1.25)	U (standardized) = 2.76	.006
FDS-FRUIT	Mann-Whitney U	2.30 (1.07)	2.79 (1.14)	U (standardized) = 2.72	.007
FDS-FISH	Mann-Whitney U	2.53 (1.24)	3.19 (1.48)	U (standardized) = 2.76	.006
FDS-VEGI	Mann-Whitney U	3.33 (1.07)	3.54 (1.11)	U (standardized) = 1.29	.198
FDS-LCON	Mann-Whitney U	5.06 (1.10)	5.34 (0.89)	U (standardized) = 1.78	.075

Figures

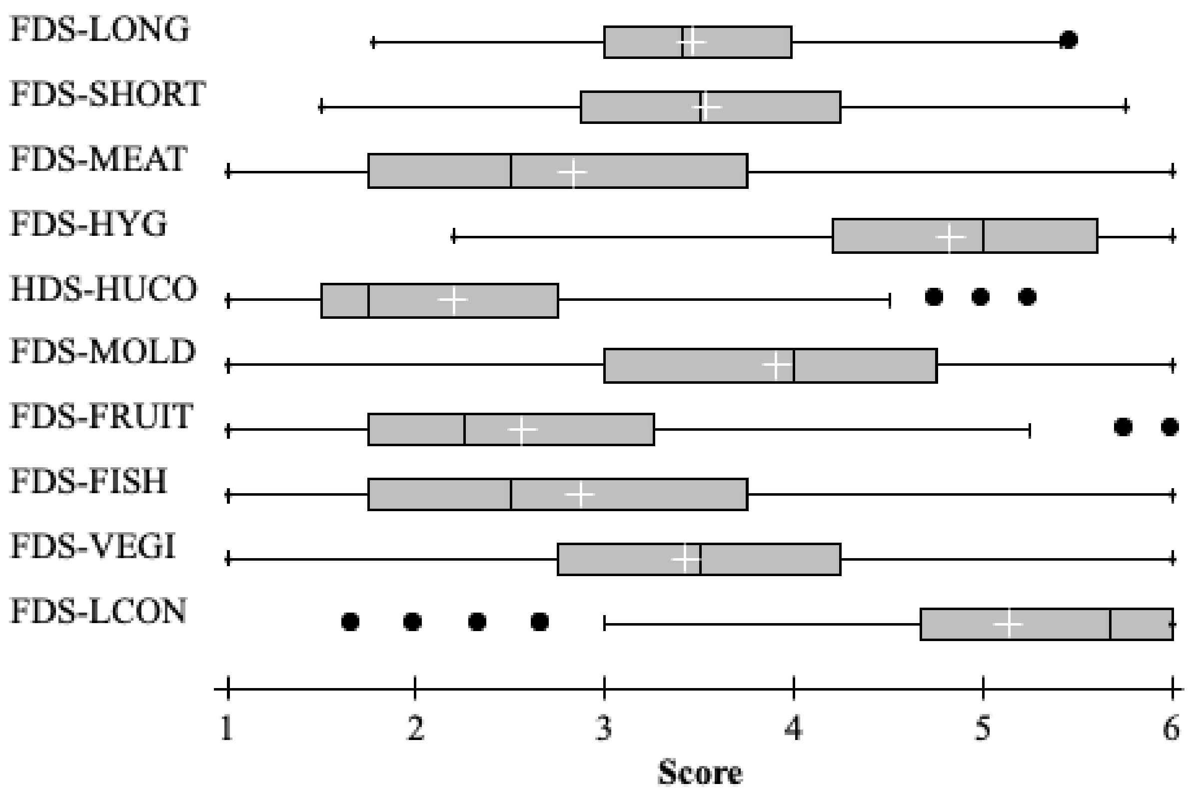

Figure 1: Boxplots of FDS-LONG, FDS-SHORT, and FDS subscales from Study 1. The position of the + indicates the mean while the line in the gray shaded box is the median. Outliers are indicated by solid black dots.

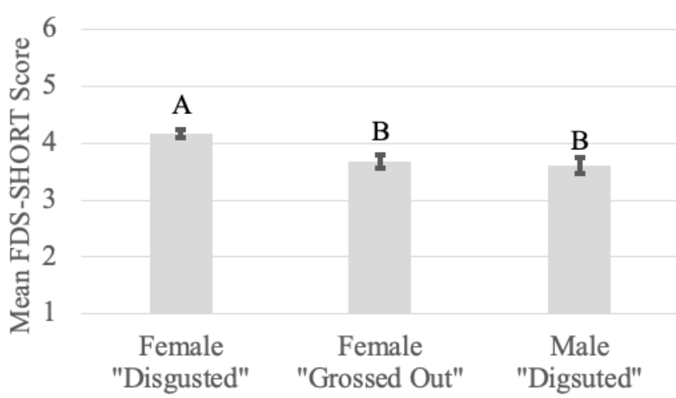

Figure 2: Mean FDS-SHORT scores (±*SE*) from Study 2. Participants were divided into three subgroups; females who used the anchor term "disgusted" (n = 159), females who used the anchor term "grossed out" (n = 70) and males who used the anchor term "disgusted" (n = 40). Significantly different means are indicated by different letters.

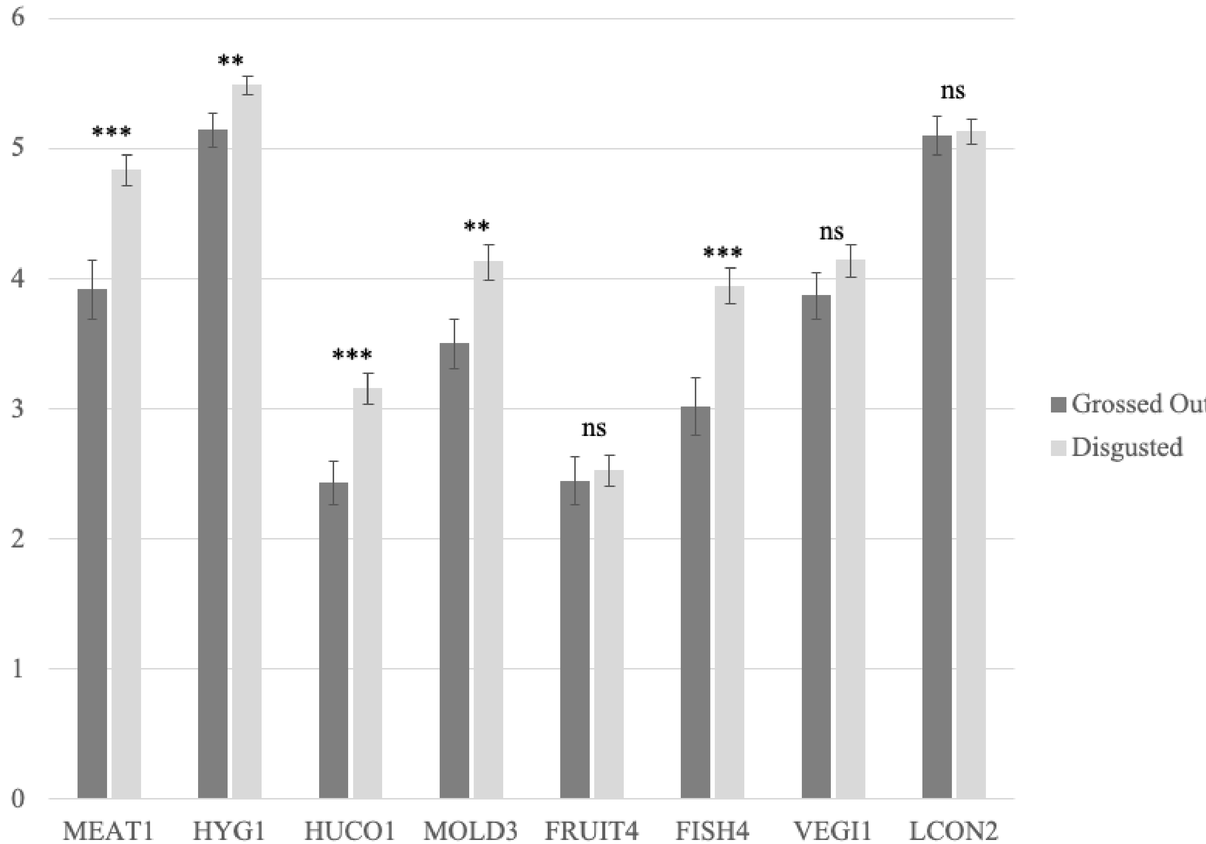

Figure 3: Mean scores ±*SE* from Study 2 for female participants using two different sets of anchor terms (“grossed out” or “disgusted”) for each item in the FDS-SHORT (** = $p < .01$, *** = $p < .001$, ns = not significant).