

Cross-cultural validation of the short version of the Food Disgust Scale in ten countries

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ABSTRACT

The cross-cultural testing of scales represents an important step in the scale validation process. The present study evaluated whether the eight-item short version of the recently developed Food Disgust Scale (FDS-short) is a reliable and valid tool for measuring food disgust sensitivity in ten countries: Australia, China, England, France, Germany, Mexico, South Africa, Spain, Sweden, and the USA. In an online survey, the participants ($N = 6128$) answered items from the FDS-short and other scales related to (food) disgust sensitivity so as to test the construct and criterion validity of the FDS-short. Confirmatory factor analysis of the one-factor structure of the FDS-short revealed an adequate to good model fit in all the countries except for China. Multiple group analysis to test measurement invariance showed the FDS-short to be metrically invariant in all the tested countries (except for China) relative to Australia. With regard to the construct validity, significant positive correlations were observed in all the countries between the FDS-short and pathogen disgust sensitivity, sexual disgust sensitivity, moral disgust sensitivity, germ aversion, and food neophobia. Criterion validity of the FDS-short in all the tested countries was confirmed by the positive correlations between it and having a sensitive stomach, experiencing gastrointestinal complaints after eating animal-based foods (except for France and Germany), and the perceived infection risk of food-borne diseases in one's country. The direction of the correlations indicated that for each country, those with higher FDS-short scores also scored higher on all the tested constructs than those with lower FDS-short scores. Taken together, the present results indicate that the FDS-short is a reliable and valid tool for assessing food disgust sensitivity across countries.

1. Introduction

For a long time, the scientific community paid little attention to the basic human emotion of disgust. In fact, it is only in the last few decades that disgust has been subject to an appreciable level of interest among researchers, with studies examining its functions as well as its effects on various attitudes and behaviors starting to steadily emerge (Olatunji, Sawchuk, Lohr, & de Jong, 2004; Tybur, Cinar, Karinen, & Perone, 2018). The impact of disgust reaches from simple human avoidance behaviors such as food neophobia (Hartmann & Siegrist, 2018), to complex social norms (e.g., social conservatism; Terrizzi, Shook, & Ventis, 2012), and value systems (e.g., moral absolutism; Scott, Inbar, & Rozin, 2016). Nevertheless, the emotion of disgust and its impact on human behavior, particularly on food-related behavior, remains a

relatively underexamined area (see Olatunji & Sawchuk, 2005). Therefore, the present study aimed to contribute to this now growing field of research by testing the validity of a recently developed scale measuring food disgust sensitivity in ten countries, namely Australia, China, England, France, Germany, Mexico, South Africa, Spain, Sweden, and the USA.

Researchers have suggested that the function of disgust is to prevent people from coming into contact with infectious organisms such as bacteria and viruses (Curtis, de Barra, & Aunger, 2011; Rozin, Haidt, & McCauley, 2008; Tybur, Lieberman, Kurzban, & DeScioli, 2013). Thus, people experience feelings of disgust toward vectors that carry a high pathogen load, including rotten food, blood, and feces (Curtis & Biran, 2001; Haidt, McCauley, & Rozin, 1994). Indeed, vectors such as these have also been found to be universal disgust elicitors, evoking disgust in

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people from various cultures (Curtis & Biran, 2001). However, the feelings evoked by other disgust elicitors have been found to vary from culture to culture (Curtis & Biran, 2001), and from individual to individual (Haidt et al., 1994; Hartmann & Siegrist, 2018). For example, the use of insects as a food source has been common in China for thousands of years, especially in rural areas (X. Chen, Feng, & Chen, 2009). Even though Chinese cuisine has changed over time, today's Chinese consumers seem more familiar with the idea of eating insects, and thus, display less disgust in relation to eating them compared Europeans consumers (Hartmann, Shi, Giusto, & Siegrist, 2015).

Disgust is associated with a diversity of different behaviors and attitudes but some researchers assume that its core function is to prevent humans from eating harmful substances (Angyal, 1941; Darwin, 1872; Rozin & Fallon, 1987). Correspondingly, people have reported stronger feelings of aversion in relation to having offensive objects in their mouth than having the same objects touching the surface of their body (Rozin, Nemeroff, Horowitz, Gordon, & Voet, 1995). The fact that disgust elicitors originate from various different domains led numerous researchers to conceptualise disgust according to specific elicitor domains such as food disgust, sexual disgust or moral disgust (e.g., Haidt et al., 1994; Hartmann & Siegrist, 2018; Tybur, Lieberman, & Griskevicius, 2009). Hence, people's level of disgust sensitivity can be to a certain degree domain-specific. This means that people may experience comparatively stronger feelings of disgust toward elicitors from one domain than from another domain (Fessler & Navarrete, 2003; Haidt et al., 1994; Tybur et al., 2009). The present research focused on disgust sensitivity in the food domain.

1.1. Food Disgust Scale

Hartmann and Siegrist (2018) developed an eight-factor Food Disgust Scale (FDS) that assesses how disgusting different foods and eating situations are perceived to be across eight food-related domains: animal flesh, poor hygiene, human contamination, decaying fruits, mold, decaying vegetables, fish, and living contaminants. All the items in the scale were developed to reflect universal food-related disgust elicitors, and to include cues of potential food-related disgust. For example, the items related to animal flesh include situations/food products that serve as a reminders of the animal nature of the food, e.g. "To put meat gristle into my mouth." Compared to a fine cut filet without any other bodily structures than meat, meat gristle rather points to the animal nature of the food, and thus, is considered a potential disgust elicitor (Hartmann & Siegrist, 2018; Martins & Pliner, 2005; Rozin et al., 2008). Additionally, compared to plant-based foods, animal-based foods present a higher risk of infection because they carry potentially more pathogens, and spoil faster (Erkmen & Bozoglu, 2016; Sockett, 1995), factors which likely influence people's experience of disgust.

A person's overall food disgust sensitivity can be assessed by using the FDS-short, which is based on a mean score across eight items from the eight different food domains (see Hartmann & Siegrist, 2018). Hartmann and Siegrist (2018) define food disgust sensitivity as an individual's emotional disposition to experience disgust toward food-related disgust cues. In this sense, food disgust sensitivity is a personality trait, and as such, it remains rather stable over time. Nevertheless, people can habituate to a specific disgust stimulus by means of repeated exposure, although the level of disgust felt toward other stimuli seemingly remains the same (Rozin, 2008).

In contrast to other disgust scales, the FDS-short covers a broad spectrum of food-disgust cue combinations, including textural and olfactory cues, as well as cues related to the potential presence of pathogens. Other scales, such as the 5-Factor Disgust Scale, for example, only contain items related to the animal-based nature of food. Moreover, somewhat unusual food items (e.g., "eating monkey meat") are included in the food subscale of the well-known Disgust Scale (DS) constructed by Haidt et al. (1994) and low reliabilities have been observed for this four-item food subscale in prior research (e.g., the

Cronbach's α of the food subscale is < 0.40) (Haidt et al., 1994; Olatunji et al., 2007). Furthermore, in the revised DS (DS-R) suggested by Olatunji et al. (2007), the food-related items are loaded on a newly defined factor (i.e., core disgust) together with other items that are unrelated to either food or oral rejection (e.g., "Discovering that a friend only changes his/her underwear once a week"). Thus, this new factor is not specific to food disgust. Consequently, the prior research has lacked food disgust specificity.

The FDS-short has not only repeatedly showed good reliability (Ammann, Hartmann, & Siegrist, 2018b; Egolf, Hartmann, & Siegrist, 2019; Egolf, Siegrist, & Hartmann, 2018; Hartmann & Siegrist, 2018); it has also proved predictive of various disgust-related eating behaviors (Al-Shawaf, Lewis, Alley, & Buss, 2015; Kauer, Pelchat, Rozin, & Zickgraf, 2015; Scott et al., 2016), including picky eating among adults (Egolf et al., 2018; Hartmann & Siegrist, 2018), tendencies toward food neophobia (Hartmann & Siegrist, 2018), lower acceptance of new food technologies (Egolf et al., 2019), less willingness to try unfamiliar foods (Ammann et al., 2018b), reduced food hygiene behavior (Ammann, Siegrist, & Hartmann, 2019), and higher generation of food waste (Egolf et al., 2018; Hartmann & Siegrist, 2018).

However, the FDS-short has largely been tested among Swiss consumers, which means that its suitability for use in other cultures is currently unknown. An increasing number of countries worldwide are facing an increasing number of food-related problems (e.g., food waste, obesity, the need for new food sources) in which people's overall disgust sensitivity (Houben & Havermans, 2012), or their food disgust sensitivity in particular (Egolf et al., 2018, 2019), may play an important role. To facilitate future research into such matters in other countries around the world, a cross-culturally reliable and valid measurement tool for assessing food disgust sensitivity is a prerequisite.

1.2. The present study

The overall aim of the present study was to determine whether the FDS-short is a reliable and valid measurement tool for food disgust sensitivity across ten countries: Australia, China, England, France, Germany, Mexico, South Africa (English questionnaire), Spain, Sweden, and the USA. The internal consistency (i.e., Cronbach's α) of the FDS-short was calculated so as to confirm its reliability. Using confirmatory factor analysis, the one-factor structure of the FDS-short was tested to determine whether it fits equally well for all the included countries, thereby confirming its structural validity. Further, measurement invariance of the FDS-short was tested to investigate whether the scale measures food disgust sensitivity in the same way across countries.

Similar to the approach of Hartmann and Siegrist (2018), we also tested the scale's convergent and discriminant validity. The FDS-short's convergent validity was tested using the pathogen disgust scale proposed by Tybur et al. (2009). Its discriminant validity was tested using the food neophobia scale, which assesses an individual's level of aversion to unfamiliar foods (Pliner & Hobden, 1992). We expected to observe higher correlations between people's FDS-short score and their pathogen disgust sensitivity than between their FDS-short score and their food neophobia in all the investigated countries. This expectation is due to the fact that, theoretically speaking, the construct of food disgust sensitivity is more strongly related to pathogen disgust sensitivity than to food neophobia. The FDS-short and the pathogen disgust scale are both measures of disgust and they are both directed toward pathogen risk, whereas the food neophobia scale is more broadly directed toward the avoidance of unfamiliar foods. To further strengthen the construct validity of the FDS-short in different countries, we also examined its associations with sexual and moral disgust sensitivity (Tybur et al., 2009), as well as with germ aversion (Duncan, Schaller, & Park, 2009). The scale's criterion (i.e., concurrent) validity was examined by testing the correlations between the FDS-short and having a sensitive stomach, experiencing gastrointestinal complaints after eating animal-based foods (Egolf et al., 2018), and the perceived infection risk

associated with food-borne diseases in one's country. Based on previous research (Egolf et al., 2018; Hartmann & Siegrist, 2018), we expected to find positive correlations between the FDS-short score and these variables.

Given that gender differences in (food) disgust have been observed repeatedly (e.g., Ammann, Hartmann, & Siegrist, 2018a, 2019; Al-Shawaf & Lewis, 2013; Curtis, Aunger, & Rabie, 2004; Egolf et al., 2018; Haidt et al., 1994; Hartmann & Siegrist, 2018; Olatunji et al., 2009; Tybur et al., 2009), we also tested for gender differences. In accordance with previous findings, we hypothesized that women exhibit higher food disgust sensitivity than men.

2. Method

2.1. Participants

An online survey was conducted in each of the ten countries of interest. The survey participants were recruited by commercial providers of sampling services. Quota samples were used in all the samples with the variables age (five age groups, with participants aged 20–69 years), and gender (females comprised 50% of each age group). Participants who did not complete the survey or whose total survey duration was less than half of the median duration were excluded. The final sample comprised 6128 participants. Table 1 presents the demographic characteristics of the participants from each country. The present study was approved by the Ethics Committee of ETH Zurich (EK 2018-N-104).

2.2. Questionnaire/measures

Food disgust sensitivity. The eight-item short version of the Food Disgust Scale covers eight different food disgust domains: animal flesh, poor hygiene, human contamination, mold, decaying fruits, fish, decaying vegetables, and living contaminants (see Hartmann & Siegrist, 2018). The FDS-short assesses how disgusting people perceive different situations, including foodstuffs (e.g., “To eat with dirty silverware in a restaurant” or “To eat hard cheese from which mold was cut off”), to be on a 6-point rating scale ranging from 1 (not disgusting at all) to 6 (extremely disgusting). The average scores were calculated across the eight items. It is important to note here that the FDS-short was originally developed and tested in German (Hartmann & Siegrist, 2018). We adapted some of the English items published by Hartmann and Siegrist (2018) in order to increase comprehensibility across cultures and to maintain consistency with the German version. The following changes were made: “To put animal cartilage into my mouth” was changed to “To put gristle into my mouth,” while “There is a little snail in the salad that I wanted to eat” was changed to “There is a little snail in the salad that I'm eating.” The English translation was used as a template for the translations into other languages (see Table S1 in the

supplementary materials). The translation process for the FDS-short and the other scales included in the present study is comprehensively described in the supplementary materials.

Pathogen, sexual, and moral disgust sensitivity. These three domains were measured using the Three Domain Disgust Scale (TDDS) by Tybur et al. (2009). In that scale, each disgust domain is measured using seven items. The pathogen disgust subscale includes items such as “Sitting next to someone who has red sores on their arm” or “Standing close to a person who has body odor.” Sexual disgust is measured using items such as “A stranger of the opposite sex intentionally rubbing your thigh in an elevator,” while moral disgust is measured using items such as “Deceiving a friend.” The items are all rated according to the level of disgust experienced on a rating scale ranging from 0 (not disgusting at all) to 6 (extremely disgusting).

Germ aversion. This was measured using the germ aversion subscale of the Perceived Vulnerability to Disease scale by Duncan et al. (2009). The subscale includes eight items (e.g., “It really bothers me when people sneeze without covering their mouths”) that are rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). However, the item “I avoid using public telephones because of the risk that I may catch something from the previous user” was not included in the present study because public telephones are less common nowadays due to the prevalence of mobile phones.

Food neophobia. The food neophobia scale by Pliner and Hobden (1992) includes ten items, for example, “If I don't know what is in a food, I won't try it.” The items are rated according to the participant's level of agreement on a scale ranging from –3 (strongly disagree) to 3 (strongly agree). The average scores were calculated with the items coded from 1 (strongly disagree) to 7 (strongly agree).

Digestive complaints and infection risk. The participants were also asked how high they estimated the risk of infection associated with food-borne diseases to be in their country, as well as whether they have a sensitive stomach. Both questions were rated on a slider scale ranging from 0 (very low/not sensitive at all) to 100 (very high/very sensitive). The participants were further asked how often they experience gastrointestinal symptoms after consuming meat, fish, and milk, as suggested in the study by Egolf et al. (2018). They were instructed to disregard any food intolerances (e.g., lactose intolerance), food allergies (e.g., peanut allergy), or stress-induced gastrointestinal complaints when giving their responses. The response options included never (coded as 1), rarely (coded as 2), sometimes (coded as 3), often (coded as 4), always (coded as 5), and do not know (coded as a missing). A mean score was calculated across the answers for meat, fish, and milk.

Table 1
Descriptive statistics and Cronbach's α s for the FDS-short.

	N	Mean age years (SD)	% Female (N)	FDS-short				
				α	Female M(SD)	Male M(SD)	t(df)	d
Australia	600	46 (14)	51.5 (309)	.75	3.99 (0.93)	3.80 (0.94)	–2.53 (598)	0.21**
China	572	46 (13)	47.9 (271)	.76	3.82 (0.86)	3.71 (0.91)	–1.45 (570)	0.12
England	612	46 (14)	50.8 (311)	.70	4.07 (0.90)	3.76 (0.87)	–4.28 (610)	0.35***
France	618	45 (14)	51.5 (318)	.73	3.66 (0.87)	3.47 (0.92)	–2.69 (616)	0.22**
Germany	617	45 (14)	51.1 (315)	.74	3.84 (0.91)	3.58 (0.94)	–3.45 (615)	0.28***
Mexico	629	44 (14)	50.6 (318)	.76	3.98 (0.96)	3.64 (0.89)	–4.59 (627)	0.37***
South Africa	620	45 (14)	49.8 (309)	.73	4.01 (0.91)	3.88 (0.90)	–1.81 (618)	0.15
Spain	611	45 (14)	51.1 (312)	.73	4.02 (0.83)	3.79 (0.87)	–3.27 (609)	0.26***
Sweden	619	46 (14)	51.4 (318)	.76	3.66 (0.88)	3.38 (1.00)	–3.56 (617)	0.29***
USA	630	45 (14)	50.5 (318)	.69	4.09 (0.84)	3.94 (0.81)	–2.36 (628)	0.19*

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

2.3. Statistical analysis

2.3.1. Country-wise (psychometric) testing with confirmatory factor analysis

The one-factor structure of the FDS-short was tested using confirmatory factor analysis (CFA), with maximum-likelihood estimation being performed for each country individually. The first indicator for each latent variable was constrained to 1 so as to serve as the reference variable. To test the model's fit, the root mean square error of approximation (RMSEA) and the comparative fit index (CFI) were used. RMSEA values ≤ 0.08 indicate an acceptable fit (McDonald & Ho, 2002), while values ≤ 0.05 indicate a good fit (Hu & Bentler, 1999; McDonald & Ho, 2002). A CFI ≥ 0.90 indicates an acceptable fit, while a CFI ≥ 0.95 indicates a good fit (Hu & Bentler, 1999; McDonald & Ho, 2002). The χ^2 statistic was not considered because it is strongly influenced by the sample size, which in the present study was relatively high for each country (around 600 participants). Thus, it was likely that the χ^2 would be significant. The CFI and RMSEA are much less affected by the sample size (Hooper, Coughlan, & Mullen, 2008).

Preliminary analyses of the eight-item factor structure revealed that in half the tested countries, the FDS-short did not reach the cut-off points for an acceptable model fit (data not shown). An inspection of the modification indices revealed that in almost all the countries, the hygiene item ("To eat with dirty silverware in a restaurant") was problematic. This hygiene item (Item 2) exhibited error covariance with the item concerning living contaminants (Item 8) in most of the countries (Australia, China, England, Germany, South Africa, Spain, and the USA). Based on the content of both items, it seems reasonable to assume that they are linked to each other by more general hygiene-related behavior. The presence of a snail in a salad might be perceived to stem from improper food hygiene practices (similar to the reason why dirty silverware is available in a restaurant). For example, it is fairly common to find a snail in a salad if that salad has not been properly washed. Therefore, we allowed the error terms of these two items to correlate. The error term correlations between Item 1 (animal flesh) and Item 6 (fish), as well as between Item 5 (decaying fruit) and Item 7 (decaying vegetable), were adopted from the work by Hartmann and Siegrist (2018). The final tested model of the FDS-short is depicted in Fig. 1.

2.3.2. Multiple group CFA: Measurement invariance

The model fit for the ten countries was further investigated using multiple group CFA in which the invariance was tested for both the factor loadings (weak metric invariance) and the intercepts (strong metric/scalar invariance) across the ten countries. Weak metric invariance implies that the factorial loadings of individual items are similar across countries, which means that one unit of change on the item scale in one group is equal to one unit of change on the item scale in another group (Büchi, 2016). Invariant factor loadings should be given if the correlations between different constructs are compared among countries. Scalar invariance is established when differences in mean values of the manifest items across cultures are due to true different means of the underlying/latent construct between countries (Steenkamp & Baumgartner, 1998). Thus, scalar invariance is necessary, if mean values of the latent variables are compared among countries.

Similar to the approach of Olatunji et al. (2009), in the present study, each country was compared with one reference sample so as to avoid making 45 comparisons. In our case, the reference country was Australia, which was chosen due to the number of English-speaking countries included in the study being higher than the number of countries in which other languages are spoken. Further, the CFA criteria exhibited a good fit for Australia. To determine whether the one-factor structure of the model is invariant between the nine other tested countries relative to Australia, a multiple group CFA was conducted. The multiple group CFA parameter estimates were calculated using RStudio version 1.0.136 (RStudio, Inc., Boston, MA). First, a test of

configural invariance was conducted in which the factor structure was specified and tested simultaneously in two countries. This baseline one-factor model without any constraints was then compared to the model in which the factor loadings were constrained so as to be equal (nested model) across the groups. A χ^2 difference test (i.e., the likelihood ratio test) was used to test for weak metric invariance between the baseline model and the nested model. A significant χ^2 difference test indicates that the nested model has lost its goodness of fit due to the imposed restrictions. Thus, the factor loadings are not invariant across countries. In contrast, a non-significant χ^2 difference test indicates that the factor loadings are invariant across countries. More importantly, any changes in the CFI and the RMSEA were also considered when testing invariance in the present study because the χ^2 difference test has the same drawbacks as the absolute χ^2 test (Brannick, 1995; F. F.; Chen, 2007), and thus, it is an excessively stringent test for invariance (Cheung & Rensvold, 2002; Cudeck & Browne, 1983; MacCallum, Roznowski, & Lawrence, 1992). Invariance was assumed if the changes in the CFI were ≤ 0.01 (F. F. Chen, 2007; Cheung & Rensvold, 2002) and the changes in the RMSEA were ≤ 0.015 (F. F. Chen, 2007). To test for scalar invariance, in addition to the equal factor loadings, the item intercepts were constrained to be equal across the groups. An χ^2 difference between the weak metric and the scalar model was tested for significance. A non-significant χ^2 difference test indicates scalar invariance. Again, any changes in the CFI and the RMSEA were evaluated.

2.3.3. Correlational analyses

Corrected item-total correlations were assessed to determine whether each item in every country was appropriate for differentiating between people with low food disgust sensitivity and people with high food disgust sensitivity. Values greater than 0.20 were considered acceptable (Kline, 2015). Correlational analyses were also conducted to test the relationships between the FDS-short score and the variables related to the construct validity (i.e., pathogen disgust sensitivity, sexual disgust sensitivity, moral disgust sensitivity, food neophobia, and germ aversion) and criterion validity (i.e., having a sensitive stomach and gastrointestinal complaints, estimated infection risk associated with food-borne diseases) for each country.

3. Results

3.1. Descriptive statistics and reliabilities

The means and standard deviations of the FDS-short for male and female participants for each country are presented in Table 1. The means and standard deviations of the individual FDS-short items are given in Table S2 in the supplementary materials. The Cronbach's α of the FDS-short depicted in Table 1 ranged from 0.69 to 0.76 among the ten countries in the study, which is adequate for a short scale (Nunnally & Bernstein, 1994; Widaman, Little, Preacher, & Sawalani, 2011). Table 2 presents the item-total correlations for the FDS-short items for each country individually. As can be seen from this table, the coefficients varied from 0.20 to 0.60 across all the countries. Thus, all the items are sufficiently able to discriminate between people with high FDS-short scores and those with low FDS-short scores.¹

The mean values, standard deviations, and Cronbach's α s (only for the scales) for pathogen disgust sensitivity, sexual disgust sensitivity,

¹ To rule out the possibility that a vegetarian or vegan diet strongly influenced the responses, and thus, the results concerning the FDS-short, we calculated the Cronbach's α with a sample consisting of only vegans and vegetarians from all the countries ($N = 430$). This yielded a Cronbach's α of 0.73, which is rather similar to the reliabilities observed in the various countries when considering the full samples (see Table 1), as well as the previously reported reliabilities of the FDS-short (e.g., Egolf et al., 2018; Egolf et al., 2019; Hartmann & Siegrist, 2018).

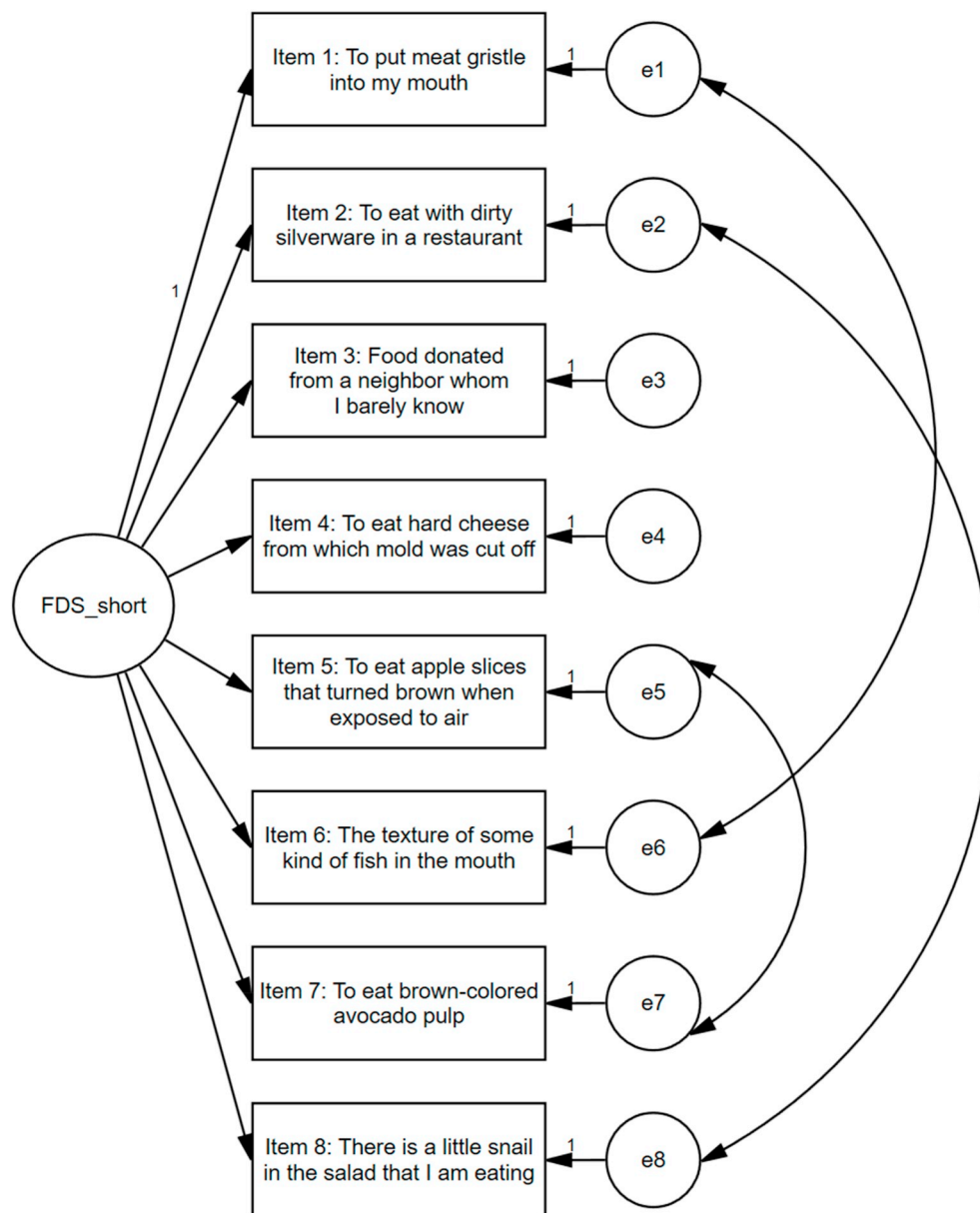


Fig. 1. One-factor model of the FDS-short. The correlations of the error terms between e1 and e6, as well as between e5 and e7, were adopted from the work by Hartmann and Siegrist (2018). The correlations between e2 and e8 were introduced in the present study.

moral disgust sensitivity, food neophobia, germ aversion, having a sensitive stomach, experiencing gastrointestinal complaints, and the perceived infection risk are provided in the supplementary materials

(Table S3). Cronbach's α s for most scales ranged between 0.68 and 0.92; i.e. acceptable to good. Cronbach's α s for the germ aversion scale were comparatively lower (0.49 and 0.63) with the lowest value (0.49)

Table 2

Corrected item-total correlations for the FDS-short items.

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
Australia	.38	.28	.44	.55	.54	.41	.55	.47
China	.44	.25	.49	.46	.59	.54	.60	.33
England	.25	.32	.36	.48	.49	.35	.50	.43
France	.32	.24	.37	.53	.48	.48	.50	.50
Germany	.41	.27	.41	.45	.45	.44	.54	.53
Mexico	.38	.31	.45	.51	.57	.48	.54	.46
South Africa	.27	.20	.44	.49	.59	.48	.49	.39
Spain	.34	.20	.45	.46	.58	.43	.56	.33
Sweden	.42	.31	.50	.53	.47	.41	.50	.48
USA	.30	.20	.38	.46	.48	.45	.46	.29

Note. For all correlations $p \leq .001$.

observed in the Mexican data set.²

3.2. CFA of the one-factor model of the FDS-short

The results of the CFA can be found in the supplementary materials (Table S4). The one-factor model of the FDS-short showed an acceptable to good model fit for almost all the countries (Australia, England, France, Germany, Mexico, South Africa, Spain, and the USA) based on both evaluation criteria (i.e., the RMSEA and CFI). In the case of Sweden, the CFI indicated an acceptable fit (CFI = 0.90) as well. Only in the case of China did the model not fit very well based on both evaluation criteria (RMSEA = 0.12 and CFI = 0.88).³

3.3. Multiple group CFA: Measurement invariance

The results of the measurement invariance analysis (Table S5 in the supplementary materials) in which the factor loadings (weak metric invariance) were constrained to be equal across the countries yielded non-significant χ^2 differences between the baseline model and the nested model for England, Mexico, and Spain, relative to Australia. An inspection of the changes in the CFI and the RMSEA revealed that in the cases of South Africa and Sweden, the CFI changes between the baseline model and the nested model were ≤ 0.01 , while the RMSEA changes were ≤ 0.015 . For France, Germany, and the USA, the changes in the CFI were slightly above the cut-off criterion of ≤ 0.01 , ranging from 0.013 to 0.019, while the changes in the RMSEA were ≤ 0.015 for all three countries, indicating metric invariance. Taken together, the presented results support the suggestion of metric invariance in all eight countries relative to Australia. The tests of scalar invariance showed significant χ^2 differences, while the CFI and the RMSEA were above the cut-off values, for all the tested countries relative to Australia. Thus, for none of the eight countries was scalar invariance confirmed relative to Australia.

3.4. Validity variables

As shown in Table 3, the FDS-short was found to be significantly correlated with all the measures of construct validity in almost all the countries. Only in France and Germany was the gastrointestinal complaints score not significantly correlated with the FDS-short. Across the countries, Pearson correlation coefficients with the FDS-short ranged from 0.50 to 0.63 in the case of pathogen disgust sensitivity, 0.25 to 0.43 for sexual disgust sensitivity, 0.14 to 0.31 for moral disgust sensitivity, 0.20 to 0.38 for food neophobia, 0.27 to 0.39 for germ aversion, 0.15 to 0.28 for having a sensitive stomach, 0.10 to 0.41 for perceived infection risk, and from 0.08 to 0.28 for experiencing gastrointestinal complaints after eating animal-based food. The directions of the

² Low reliabilities in relation to the germ aversion scale have also been observed in other studies (e.g., Gilles et al., 2013; Hartmann & Siegrist, 2018). This scale consists of negatively and positively worded items, which often leads to lower reliabilities and/or item loadings on two factors despite the recoding of the negatively worded items (Weijters, Baumgartner, & Schillewaert, 2013). This was also the case for the germ aversion scale for some countries in the present study. Even though the reliabilities were found to be low, we observed the expected significant correlations between the germ aversion scale and food disgust sensitivity. However, it is likely that the effect sizes were underestimated because of the weaker internal consistency of that construct.

³ Error term correlations indicated for the FDS-short items in China two factors. However, the CFI value concerning the one-factor model in China (CFI = 0.88) was only slightly below the criterion of 0.90, which confirms an acceptable fit. More importantly, the reliability of the FDS-short in China was found to be acceptable, and the correlations with all the validity measures were comparable to those of the other countries (see Table 3). Therefore, it would have been quite the overreaction to change the one-factor model of the FDS-short for China simply because it did not quite achieve structural validity.

coefficients indicated that across the countries, people who exhibited higher levels of food disgust sensitivity also exhibited higher levels of pathogen, sexual, and moral disgust sensitivity, scored higher on the food neophobia and germ aversion scales, perceived greater risk of food-borne diseases in their country, and were more likely to have a sensitive stomach and to experience gastrointestinal complaints (except in France and Germany).

3.5. Gender differences

As can be seen in Table 1, the mean values of the FDS-short between the male and female participants differed significantly for Australia, England, France, Germany, Mexico, Spain, Sweden, and the USA. In all these countries, the female participants achieved higher FDS-short scores than the male participants. There were, however, no significant gender differences found in the cases of China and South Africa.

4. Discussion

Food disgust sensitivity is a characteristic describing a person's tendency to experience disgust toward pathogen-related food risks. Previous studies have demonstrated that the FDS-short (Hartmann & Siegrist, 2018) is a reliable and valid measurement tool for assessing people's level of food disgust sensitivity (Ammann et al., 2018b; Egolf et al., 2018; Hartmann & Siegrist, 2018). However, to date, the majority of studies that have assessed the FDS-short were conducted in Swiss samples. Therefore, the present study aimed to fill this gap in disgust research by performing the cross-cultural validation of the FDS-short in ten countries, namely Australia, China, England, France, Germany, Mexico, South Africa, Spain, Sweden, and the USA. This represents an important next step in facilitating research concerning the various food-related problems that human societies worldwide are currently facing (e.g., food waste, consumers' aversion to sustainable new food sources), which food disgust has been shown to contribute to (Egolf et al., 2018, 2019).

The observed reliabilities across all the tested countries for the FDS-short were found to be comparable to previous findings from Switzerland (Ammann et al., 2018a; Egolf et al., 2018; Hartmann & Siegrist, 2018), as well as to be acceptable for a short scale (Cattel & Tsujioka, 1964; John & Soto, 2007). The corrected item-total correlations of the FDS-short for all the countries were sufficiently high. The CFA of the FDS-short revealed that the one-factor model fitted all the tested countries, except for China. Hence, in almost all the countries, the FDS-short appears to measure food disgust sensitivity as a unidimensional construct; and in each individual country, all the FDS-short items are seemingly appropriate for differentiating between people who exhibit high disgust sensitivity and people who exhibit low disgust sensitivity. The measurement invariance analyses of the scale indicated that the FDS-short is weakly metrically invariant in all the countries (except for China) relative to Australia, which suggests that the factor and the items have similar meanings in all the countries. In contrast, scalar invariance could not be confirmed in any of the countries relative to Australia. Thus, factors unrelated to food disgust sensitivity likely led to upward or downward biases of the scores of one or more items (see Gregorich, 2006) of the FDS-short. The typical sources of unequal scalar invariance include culture, race, norms, and age. As food choices, food attitudes, and food behavior are all to a large degree determined by culture (e.g., Frewer & van Trijp, 2007; Rozin, 2005), and because the items of the FDS-short include different food products and different food situations, this result is not particularly surprising. However, many earlier scales also failed to achieve scalar invariance (for a review, see Cieciuch, Davidov, Schmidt, & Algesheimer, 2019), including the DS-R (Olatunji et al., 2009), which suggests that scalar invariance might actually be an unachievable ideal (Cieciuch et al., 2019; Marsh et al., 2018; Rutkowski & Svetina, 2013).

With regard to the FDS-short's convergent and discriminant validity,

Table 3
Pearson correlations between the FDS-short and the validity variables.

	Construct validity					Criterion validity		
	Pathogen Disgust	Sexual Disgust	Moral Disgust	Food Neo.	Germ Aversion	Gast. Compl.	Sens. Stom.	Infect. Risk
Australia	.61***	.30***	.26***	.35***	.39***	.18***	.27***	.24***
China	.50***	.39***	.29***	.23***	.32***	.28***	.23***	.16***
England	.59***	.38***	.22***	.35***	.39***	.08*	.24***	.22***
France	.51***	.25***	.18***	.32***	.27***	.04	.15***	.25***
Germany	.54***	.30***	.16***	.38***	.39***	.08	.28***	.41***
Mexico	.63***	.43***	.17***	.33***	.39***	.14***	.24***	.10**
South Africa	.59***	.32***	.14***	.26***	.38***	.13**	.23***	.16***
Spain	.59***	.38***	.29***	.20***	.34***	.12**	.23***	.18***
Sweden	.59***	NA	.31***	.35***	.38***	.21***	.27***	.32***
USA	.53***	.26***	.19***	.33***	.36***	.14***	.22***	.22***

Note. Infect. Risk = perceived infection risk in one's country, Sens. Stom. = sensitive stomach, Gast. Compl. = gastrointestinal complaints, Food Neo. = food neophobia, NA = not available. Pathogen, sexual, and moral disgust are all measures of domain-specific disgust sensitivity. In Sweden the sexual disgust subscale could not be assessed because the Swedish commercial provider of participants refused to conduct the survey with this subscale in it.

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

the data revealed that in each country, the correlations between the FDS-short and pathogen disgust sensitivity were higher than the correlations between the FDS-short and food neophobia (as well as all the other measures). This finding is in accordance with the results concerning the convergent and discriminant validity of the FDS-short in relation to a Swiss sample (Hartmann & Siegrist, 2018). Thus, the FDS-short's convergent (pathogen disgust sensitivity) and discriminant (food neophobia) validity could be confirmed in each country. Moreover, in all the countries, the FDS-short score was found to be significantly correlated with sexual disgust sensitivity, moral disgust sensitivity, and germ aversion, which further strengthens the construct validity of the scale. The coefficients between the FDS-short and these three measures were also found to be relatively similar across the countries in terms of the effect sizes (Cohen, 1988). For all the countries, an inspection of the correlation coefficients between the FDS-short score and the three disgust scales revealed the strongest correlations to exist with pathogen disgust sensitivity, followed by sexual disgust sensitivity. Moreover, the weakest correlations were found to exist with moral disgust sensitivity, which indicates that the kind of food disgust sensitivity measured by the FDS-short has a weaker relationship with violations of moral-social behavior than with physiological threats. The FDS-short's correlation with food neophobia confirmed its relationship with food aversion, which was true for all the tested countries. Taken together, the correlation results support the FDS-short's construct validity in all the tested countries.

In almost all the countries, the FDS-short was found to be positively correlated with having a sensitive stomach and experiencing gastrointestinal complaints after eating animal-based foods (except for France and Germany). The directions of the correlations are in accordance with the findings of previous research conducted among a Swiss sample (Egolf et al., 2018). These results are further supported by physiological evidence showing the existence of an association between disgust and gastrointestinal activity (Meissner, Muth, & Herbert, 2011). For instance, Meissner et al. (2011) found that the intensity of experienced disgust toward disgusting pictures, as well as disgust sensitivity, are predicted by bradygastria (i.e., slow gastric myoelectrical rhythms), which reflects a disruption of normal digestive activity. Such gastric dysrhythmias have previously been found to be associated with both nausea and vomiting (Geldof, van der Schree, van Blankenstein, & Grashuis, 1986; Hasler, 2003; Horn, 2008; Quigley, Hasler, & Parkman, 2001), which represent the strongest defense mechanisms of disgust. Nonetheless, it cannot be determined from the present results whether the experience of disgust leads to gastrointestinal disruptions that may, in turn, lead to vomiting, or whether the opposite is true, or even if both factors work together simultaneously. This would make an interesting topic for future research.

The present study also generated a novel finding, as we observed that compared to individuals that scored lower on the FDS-short, people who with higher scores estimated the risk of catching a food-borne disease in their country to be higher. This result again indicates that food disgust is a pathogen-related mechanism, which is most likely intended to prevent an organism from engaging in risky food-related behavior (Egolf et al., 2018, 2019; Hartmann & Siegrist, 2018). Interestingly, across all countries this effect was found to be the strongest in Germany, and least in Mexico where temperatures are much higher and bacteria can grow faster (Hobbs & Roberts, 1993). Thus, both the actual and perceived risk of catching a food-borne disease would be expected to be higher in Mexico than in Germany. However, in pathogen-rich ecologies, exposure to food-related pathogens is likely to be unavoidable because too many foods would have to be avoided in order to prevent contact with all pathogens (see Tybur et al., 2018); investment in the biological immune system, rather than avoidance, is a more efficient means of avoiding illness (Curtis, 2014; Tybur et al., 2018). It is, therefore, possible that due to their higher frequency and intensity of exposure to such pathogens, Mexicans' immune systems are better adapted to food-borne pathogens, which may have resulted in a reduction in disgust-related food avoidance, and risk perception. Taken together, the present data support the predictive value of the FDS-short, not only for previously known variables (i.e., having a sensitive stomach or experiencing gastrointestinal complaints), but also for a new variable, which aligns with the theoretical assumptions regarding the function of food disgust sensitivity.

Finally, there were significant gender differences in food disgust sensitivity in eight of the ten investigated countries. Women in Australia, England, France, Germany, Mexico, Spain, and Sweden and the USA had higher levels of food disgust sensitivity than men. This is in accordance with previous findings concerning food disgust (Ammann et al., 2018a; Ammann, Hartmann, et al., 2019; Egolf et al., 2018; Hartmann & Siegrist, 2018), and other disgust scales (e.g., Al-Shawaf & Lewis, 2013; Curtis et al., 2004; Haidt et al., 1994; Olatunji et al., 2009; Tybur et al., 2009). There are likely to be a variety of reasons behind the selective pressure on women to be more disgust sensitive than men (for a review, see Al-Shawaf, Lewis, & Buss, 2018). For example, women have larger minimum investment costs in relation to producing offspring (i.e., nine months of pregnancy) (Fleischman, 2014), while various infectious diseases (including food-borne diseases) can have detrimental effects on their fertility (Smith, 1999; Tsevat, Wiesenfeld, Parks, & Peipert, 2017). With regard to food-related behavior, women were generally more involved than men in food cleaning, preparation, and cooking in our ancestral past (e.g., Counihan & Kaplan, 2004; Gurven, Winking, Kaplan, von Rueden, & McAllister, 2009), and they seemingly still are (e.g., Counihan & Kaplan, 2004; Hartmann, Dohle, &

Siegrist, 2013; Taillie, 2018). Consequently, the higher disgust sensitivity exhibited by the female participants might have been a favorable trait in ancestral women (when the disgust system was principally formed) due to leading to more hygienic food-related behavior (Al-Shawaf et al., 2018). High hygiene standards would have reduced the food-borne infection risk not only for the woman herself, but also for her offspring and her mate. Thus, the findings of the present study involving the FDS-short provide further evidence that women are more (food) disgust sensitive than men, which seems to be fairly culture-unspecific.

The present study had some limitations. In China, the one-factor model did not seem to fit very well. It is possible that some items of the FDS-short, as well as the term “disgust” (Barger, Nabi, & Hong, 2010), have different meanings in China than in the other investigated countries, as the Chinese language belongs to a completely different language family (Sino-Tibetan) than the other languages (Indo-European) included in the present study. Additionally, in China, the consumption of certain products mentioned in the FDS-short (e.g., cheese) has only just started to become widespread (Zhang, Dagevos, He, van der Lans, & Zhai, 2008). Despite the fact that most of the disgust elicitors included in the FDS-short seem to be independent of culture (e.g., mold on food), the interaction with a specific food product likely results in different experiences of disgust. Nevertheless, the correlations between the FDS-short and the measures of both construct validity and criterion validity were comparable between China and the other countries in the study, as were item-total correlations and reliability. It appears that the FDS-short is not a unidimensional measurement scale in China. Nevertheless, it can be used in cross-cultural research. On the other hand, a tool such as the Food Disgust Picture Scale (FDPS; Ammann et al., 2018a), which seemingly measures the food disgust sensitivity construct quite well in both China and Switzerland (Ammann et al., 2020) could help overcome this challenge. The FDPS could be used to measure food disgust sensitivity in countries with strongly divergent languages, as it largely circumvents text-based misinterpretations.

Finally, it should also be noted that compared to the English language, the meaning of the term “disgust” in the French and German languages may be somewhat different. The French word for disgust (*dégoût*) is closely associated with eating (Wierzbicka, 1986) and revulsion (Russel, 1991), while in English, disgust has several meanings related to revulsion, anger (Haidt, Rozin, McCauley, & Imada, 1997; Nabi, 2002), and feelings concerning moral indignation (Russel, 1991). In German, the word for disgust (*Ekel*) is also more closely tied to feelings of revulsion than to feelings of anger. It might be that some items (e.g., “To eat with dirty silverware in a restaurant”) included in the FDS-short also elicit, at least to a certain degree, feelings of anger. Hence, in the English-speaking countries, the participants' sense of anger may have been included in their disgust rating, thereby leading to a slightly different response when compared to the data from Germany and France. This might explain the somewhat weaker support for the FDS-short's metric invariance found in Germany and France (relative to Australia). To circumvent such differences, future cross-cultural studies should consider further specifying the meaning of disgust in the instructions for the FDS-short provided in English-speaking countries, for example, “How disgusting (in terms of being grossed out) do you perceive these situations/products to be?”

The validity testing scales used in the present study were primarily chosen because they are well established in the literature as well as being linked to food disgust sensitivity from a theoretical point of view. Previously published translations of these scales were used where available. Of course, these scales have not been comprehensively validated in all the countries included in the present study. In an ideal world, measurement scales would always be cross-culturally validated; however, for various reasons, this is not always possible. Yet, to ensure that the scales used in this study worked appropriately in the various cultural contexts, the item-total correlations, internal consistencies, and factor structures were checked for significant deviations from what

would be expected based on the findings of earlier publications. If inconsistencies or noteworthy aspects were identified, they were mentioned in the manuscript (e.g., in relation to the germ aversion subscale). Nevertheless, we cannot completely rule out the possibility that these occurred as a result of interpretations of certain items between countries and cultures on the part of the study participants. However, the correlations that we observed were as expected. Therefore, we concluded that the applied scales were suitable tools for the purposes of the present study.

5. Conclusion

In order to evaluate the validity of the FDS-short in ten different countries, various measures of its construct and criterion validity were considered in the present study. Our data revealed higher correlations between the FDS-short and pathogen disgust sensitivity than between the FDS-short and food neophobia, thereby confirming its construct validity by means of its convergent and discriminant validity. Correlations between the FDS-short and the other disgust scales (sexual and moral disgust sensitivity) further strengthened the idea that the FDS-short is a measure of disgust sensitivity that is more closely related to physiological risk protection than to moral indignation, which is in accordance with the general understanding of the construct of food disgust sensitivity. Additionally, people from different countries who scored higher on the FDS-short were found to be more likely to have a sensitive stomach and to experience gastrointestinal complaints after eating animal-based foods. They were also found to estimate the risk of catching a food-borne disease in their country to be higher than those people who scored lower on the FDS-short. The criterion validity of the FDS-short was thus confirmed. Finally, the data indicate acceptable reliability and item-total correlations of the FDS-short in each country. Based on the overall findings of this study, we believe that the FDS-short can be used to measure food disgust sensitivity in all the investigated countries, despite the fact that the scale might not be unidimensional in China.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2019.104420>.

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