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Disgust, sushi consumption, and other predictors of acceptance of insects as food by Americans and Indians

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ABSTRACT

Insects are an important human food source, especially in developing countries, because of their efficiency at converting plant foods into animal protein, and their relatively low environment impact. The present study builds on some prior research on eating insects by surveying Indian and American adults. A composite measure of insect acceptance is developed. The results confirm prior findings that Americans are more accepting of insects as a potential food than Indians, and that men are more accepting than women. Substantially more Indians than Americans consider insect ingestion a violation of a protected/sacred value, suggesting a moral objection. Attitudes to and beliefs about insects and insect consumption are decomposed through factor analysis into the same five factors in both countries: Benefits, Risks, Disgust, Religion, and Suffering. Multiple regression indicates that for Americans, Disgust is the major predictor, followed by Benefits. For Indians, the best predictor is Benefits, followed by Disgust and Religion. In both countries, frequency of sushi consumption (a food commonly met with disgust when it was first introduced) is also a significant and substantial predictor of insect acceptance.

1. Introduction

Humans eat a great variety of insects, with estimates of over 2000 edible species throughout the world (e.g., Deroy, Reade, & Spence, 2015; Jongema, 2017; Ramos-Elorduy, 2009). This is not an uncommon practice, with the FAO estimating that at least a billion people willingly consume insects on a regular basis (Van Huis et al., 2013). In the past several years, partly to address the growing problem of global food security, there has been a great increase of both attention to insects as food and research on this subject (see especially Evans, Flore, & Frøst, 2017; Halloran, Flore, Vantomme, & Roos, 2018; Hartmann & Siegrist, 2017; Looy, Dunkel, & Wood, 2014; Ruby, Rozin, & Chan, 2015; Van Huis et al., 2013).

1.1. Why would people consider adding insects to their diet?

Many species of insects are non-toxic, and can serve as a source of high-quality protein and micronutrients (Belluco et al., 2013; Van Huis et al., 2013). Furthermore, raising them for food is typically much more sustainable than more commonly consumed animals (e.g., cows, pigs, and chickens), in terms of feed efficiency, water use, required space, and greenhouse gas emissions (see Oonincx & de Boer, 2012; Testa et al., 2017). The great majority of insect consumers in the world today are in the developing world, and they consume foraged insects (Halloran et al., 2018; Van Huis et al., 2013). The environmental friendliness of insects in comparison to mammal and bird foods can range from minimal to very large, depending on the species, food fed to the insects, and economies of scale (among other factors; e.g., Halloran et al., 2018; Van Huis et al., 2013).

On the other hand, there are several reasons to be cautious when promoting insect consumption. Very little is known about the nutritive value and toxicity of the great majority of the approximately one million insect species (see Halloran et al., 2018; Van Huis et al., 2013). Among the commonly eaten species, there have been issues of allergy in a small percentage of consumers (related to allergies to crustaceans), and there is some evidence for the possibility of accumulation of heavy metals in some species (Finke, Rojo, Roos, van Huis, & Yen, 2015). Furthermore, the sort of diet fed to insects can critically impact both their survival and nutritional value– Lundy and Parella (2015), for example, found that 99% of crickets fed municipal-scale food waste and diets largely consisting of straw died before reaching a 'harvestable' size. Finally, although most people find the moral issues of killing insects for food less compelling than the issues raised about most commonly consumed animals, if insects raised for food were to suffer in the process, there is the possibility that eating them instead of larger animals could actually cause more suffering, given the far greater number

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of insects that would be required to obtain a kilogram of protein.

1.2. What predicts acceptance?

Past research suggests that the primary reasons people reject insects as food are that they find the prospect disgusting or culturally inappropriate (e.g., Baker, Shin, & Kim, 2018; Hartmann, Shi, Giusto, & Siegrist, 2015; Ruby et al., 2015; Tan, Fischer, van Trijp, & Stieger, 2016). Additionally, acceptance of insects as food has been shown to be related to food neophobia and core disgust sensitivity, sensation seeking, and familiarity with the practice (Hamerman, 2016; Hartmann et al., 2015; Ruby et al., 2015; Verbeke, 2015; Wilkinson et al., 2018). Men tend to be more willing than women to eat insects (e.g., Hartmann et al., 2015; Menozzi, Sogari, Veneziani, Simoni, & Mora, 2017; Ruby et al., 2015; Schösler, de Boer, & Boersma, 2012), and some research has uncovered national differences in attitudes toward eating insects, such that Americans were more willing to eat insects than Indians (Ruby et al., 2015), and Chinese more willing to eat insects than Germans (Hartmann et al., 2015). For some vegetarians, e.g., those that are primary motivated by concerns about environmental sustainability, insects may possibly offer an acceptable animal protein source. Thus far, this remains to be explored.

Not all insect foods are created equal– a number of studies with American, Belgian, Indian, and Swiss samples suggest that people prefer insects foods with crispy textures and familiar tastes, and that they are more willing to eat processed foods containing insect flour, such as cookies or crackers, than they are to eat whole insects (e.g., Caparros Megido et al., 2014; Gmuer, Guth, Hartmann, & Siegrist, 2016; Hartmann et al., 2015; Hartmann & Siegrist, 2016; Ruby et al., 2015; Wilkinson et al., 2018). Hartmann and Siegrist (2016) have argued that such processed insect foods may lead to people accepting insects into their daily diet, and they have shown that past experience with eating insects increases people's willingness to do so in the future. Similarly, in a sample of Italian students, Menozzi et al. (2017) reported that 23% of online respondents followed through on an invitation to attend an appointment to taste a chocolate chip cookie containing 10% cricket flour, and that eating this cookie led to a significant increase in both intention to eat similar insect foods in the future, and positive attitudes toward the practice. Furthermore, recent work with Kenyan schoolchildren found that biscuits containing 10% cricket flour were well-liked, albeit less than biscuits containing 10% milk powder (Homann, Ayieko, Konyole, & Roos, 2017).

Gmuer et al. (2016) used photographs of chips including insects in different ways and an array of affect-laden words in evaluation of acceptability, and found that positive emotional expectations played a significant role, as did anticipated disgust and dissatisfaction. The specific beliefs that people hold about eating insects also appear to be important, with acceptance positively related to the beliefs that eating insects is good for human health and the environment (Menozzi et al., 2017; Ruby et al., 2015; Sogari, 2015). It appears that these beliefs can be changed without great difficulty. Verneau et al. (2016) found that exposing Danish and Italian participants to videos on the societal and individual benefits of insect consumption significantly increased their intention to incorporate insects into their diet, and increased the likelihood of them eating a chocolate bar containing insect protein. Notably, this effect emerged regardless of gender and level of previous knowledge. Similarly, in a sample of Kenyan adults, 90% of whom were familiar with or had eaten whole insect foods in the past, participants were provided with information about the potential benefits, or drawbacks, of cricket-flour-containing foods. Those participants informed about the benefits expected the sensory attributes of buns containing 10% cricket flour to be more acceptable than did those informed about the drawbacks. However, after tasting the buns, sensory ratings were generally positive, regardless of what information had been previously given (Pambo, Okello, Mbeche, Kinyuru, & Alemu, 2018).

1.3. What were our aims?

Given the potential for insects as a major human food source, it is important to assess acceptance issues in a range of cultures/countries. By far the two most populous countries in the world are China and India. Hartmann et al. (2015) have reported some data from China, and Ruby et al. (2015) from India. To continue this focus on highly populous countries, we included an Indian sample in the present study.

Given the apparent importance of beliefs about the different positive and negative aspects of eating insects, the present study focused on these beliefs, their relationship to one another, and how strongly they were associated with acceptance of insects as food. As such, we posed the following research questions: 1) What is people's level of acceptance of insects as food, both in terms of their own willingness to eat insects, and their belief that insect eating should be promoted? 2) How strongly do people agree with commonly cited risks and benefits of eating insects? 3) Do people's beliefs about eating insects cluster into discrete factors, and does the strength of these beliefs vary by gender and country? 4) What substantial country differences (Americans vs. Indians) are there in beliefs and acceptance? 5) How do these beliefs about eating insects, or prior food experiences, predict overall acceptance of insects as food? 6) What is the relation between acceptance of sushi (like insects, a food that many people initially find disgusting) and acceptance of insects?

2. Material and methods

We recruited a total of 692 participants– 306 from the USA and 386 from India – via Amazon.com's Mechanical Turk testing service, for a study on "attitudes toward food." Participants were paid a modest sum for their time. To ensure accuracy in responses, we excluded any participants who failed more than one of four catch questions, using a standard seven-point agree-disagree scale (173 from India, 31 from the USA). The catch questions were "I would rather eat a piece of fruit than a piece of paper", "I regularly eat rocks", "I enjoy eating plastic in my food", and "The earth is a cube". Disagreeing with the first question, or agreeing with any of the other questions, counted as a failure. To ensure more representative cross-cultural comparisons, we further excluded data from any participants who were not raised in their current country of residence (12 from India, 0 from the USA).

The final sample included 201 participants from India (34% women, $M_{age} = 32.0$, $SD_{age} = 9.72$), and 275 participants from the USA (55% women; $M_{age} = 35.9$, $SD_{age} = 12.95$). Compared to the American sample, the Indian sample was significantly younger, more educated, more likely to have been raised in an urban environment, more religious, more likely to be vegetarian/vegan, and consisted of a higher percentage of men. For a full overview of participant demographics, see Table 1.

The questionnaire included a series of sections, in fixed order. The subjects covered were (* indicates inclusion in the present manuscript, with more details provided later): Free associations to "insects" and "butterfly", measures of willingness to try eating insects*, dietary intake, willingness to eat animals reared on different foods (including insects), food neophobia, core disgust sensitivity, rating of six attributes of, or attitudes toward, six different insects, attitudes to government involvement in promoting insects as food*, beliefs about eating insects*, and demographics*. Other results from this dataset are reported in Rozin and Ruby (in press) with a focus on people's aversion to consuming butterflies, a group of insects that are not, in themselves, disgusting. The University of Pennsylvania Institutional Review Board approved the study protocol, which conformed to the Declaration of Helsinki.

2.1. Past experience eating insects

Participants were asked "Have you ever voluntarily eaten a whole

Table 1
Participant demographics.

Variable	USA	India	F or χ2	p
Age	M = 35.9; SD = 12.95	M = 32.0; SD = 9.72	12.91	< .001
Gender	55% women, 45% men	34% women, 66% men	19.40	< .001
Education	2% less than high school, 9% high school, 36% some college, 41% Bachelor's degree, 12% higher degree	1% less than high school, 2% high school, 8% some college, 69% Bachelor's degree, 19% higher degree	72.58	< .001
Ethnicity	85% White, 6% Black, 9% other	95% South Asian, 5% other	–	–
Religion	39% Atheist/Agnostic, 25% Protestant, 19% Catholic, 17% other	74% Hindu, 10% Catholic, 10% Muslim, 6% other	–	–
Religiosity	M = 2.48; SD = 1.70	M = 4.27; SD = 1.37	150.14	< .001
Neighborhood Where Raised	21% rural, 66% suburban, 13% urban	15% rural, 34% suburban, 51% urban	83.05	< .001
Diet	88% omnivore, 6% partial vegetarian, 4% vegetarian, 2% vegan	57% omnivore, 16% partial vegetarian, 21% vegetarian, 5% vegan	167.88	< .001
Indian Language Fluency		60% Hindi, 49% Tamil, 29% Malayalam, 8% Telugu	–	–

Note: Religiosity was assessed on a scale from 1 (not at all) to 5 (extremely).

insect as food or as an ingredient in food" and "Have you ever voluntarily eaten ground insects as food or as an ingredient in food?" with yes/no response options for both questions.

2.2. Willingness to eat insects

Participants were then asked about their willingness to eat insects in different dishes, incorporated either as insect flour, or whole. Given the cross-cultural nature of this study, we selected the same set of foods used in Ruby et al. (2015), which was designed to be appropriate for use in both India and the USA. For all items, participants were told "assume there is no risk of toxicity or infection from consuming insects, as they have been heat-sterilized and certified safe to eat."

First, participants were asked "Which of the following statements best describes your willingness to try insects as food?" The possible answers were on a five-point scale: "1: I would never eat it under any conditions; 2: I would eat it only if my survival depended on it; 3: I am unsure if I would ever consume it; 4: I could be persuaded to consume it; 5: I would be glad to consume it."

Participants were shown photographs of: 1) tacos with grasshoppers clearly displayed inside; 2) a dosa (an Indian crepe made of rice and lentil flour), rolled up with a (non-visible, but verbally described) filling of potatoes and grasshoppers; and 3) six transparent lollipops, half containing a mealworm and half containing a grasshopper. For each food, participants were asked, "How willing would you be to taste ___?" using the same 5-point scale as above.

Willingness to eat the three foods containing whole insects (taco, dosa, lollipop) displayed high internal consistency (USA α = .94; India α = .78), and was averaged into a composite measure.

2.3. Acceptance of insect flour in food

Participants were shown a picture of a mealworm and told that "Mealworm flour is a powder made from roasted (heat sterilized and non-toxic) mealworms. The flour has a mild taste." They were shown a photograph of a chocolate chip cookie, and asked to indicate the highest level of mealworm flour they would be comfortable eating in the cookie. The choices were 0%, 0.1%, 1%, 5%, 10% and ≥25%. They were then presented with a picture of a paratha (an Indian flatbread), and asked the same question.

Next, participants were told that "ant flour is a powder made from roasted (heat sterilized and non-toxic) ants. The flour has a mild taste." The same questions with respect to ant flour were repeated for the cookie and paratha scenario. Finally, using the same scale as above, participants were asked to indicate the highest level of mealworm flour they would be comfortable eating in a favorite dish, with the same question also posed for ant flour.

Scores on acceptable level of insect flour to eat the dishes containing insect flour (ant & mealworm flour × cookie & paratha) had high internal consistency (α > .90 for both countries) and were thus averaged into a composite measure.

2.4. Promoting insect eating

As one might support insect eating in principle, but not as a personal practice, participants indicated their agreement/disagreement with a series of statements about promotion of insect eating by various groups, on a scale ranging from −100 Disagree Strongly, to 0 Neither Agree nor Disagree, to 100 Agree Strongly. The statements were (reverse-coded items denoted with 'R'): "1) The government should promote insect eating. 2) The United Nations should issue a statement discouraging insect consumption (R). 3) Universities should research ways to promote insect eating. 4) Doctors should endorse the safety of insect eating. 5) Nutritionists should discourage insect eating (R). 6) Businesses should sell insect foods."

Scores on the six items about promoting insect eating displayed high internal consistency (USA α = 0.90; India α = 0.81), and they were averaged into a composite measure.

2.5. Insect eating as violating a protected value

Participants responded to four statements in random order on a standard 7-point agree/disagree scale, to gauge whether or not eating insects violated a protected value for them (see Baron & Spranca, 1997; Scott, Inbar, & Rozin, 2016). The items were: 1) "I do not oppose insect eating (R). 2) It is equally wrong to allow some insect eating to happen as to allow twice as much to happen. The amount doesn't matter. 3) Insect eating should be prohibited no matter how great the benefits and minor the risks from allowing it. 4) Insect eating would be wrong even in a country where everyone thought it was not wrong." If a participant disagreed with the first item, and agreed with all three of the remaining items, they were coded as treating insect eating as violating a protected value. In the demographics section, participants rated their religiosity, on a scale ranging from 1 (not at all) to 6 (extremely).

2.6. Beliefs about eating insects

Participants were given a set of statements about eating insects, in random order and on the same scale as above (based on Ruby et al., 2015; see Table 3). These items measured the extent to which participants believed eating insects is beneficial, dangerous, disgusting, immoral, and causes suffering. They were included to predict acceptance.

2.7. Sushi intake

Finally, given that sushi is a food many Americans found disgusting when it was first introduced to the USA, but has become a very popular food, with almost 4000 sushi restaurants in the USA as of 2017 (Statistic

Brain, 2017), participants indicated how often they have eaten sushi (containing raw fish) on a scale of 0 (Never), 1 (Once), 2 (A Few Times), 3 (Many Times). This item was included alongside the beliefs to predict insect acceptance.

3. Results

Due to our large number of analyses and large sample size, for all inferential tests, we set a *p* level of 0.01 (2-tailed) as the threshold for statistical significance.

3.1. Acceptability of insects as food

Significantly more American (16%) than Indian (4%) participants reported having voluntarily eaten foods containing whole insects, $\chi 2$ (1, 476) = 16.31, $p < .001$, but there was no significant difference in the percentage of participants who reported having voluntarily eaten foods containing ground insects (USA 8%, India 6%), $\chi 2$ (1, 476) = 0.72, $p = .72$.

For current willingness to eat insects, a consistent pattern emerged for country, such that Americans scored significantly higher than Indians on all four measures. A similarly consistent pattern emerged for gender, such that men scored significantly higher than women on all four measures. In no case was the interaction of gender and country significant. For an overview of means, standard deviations, and ANOVA statistics, see Table 2.

Overall, 82% of the Americans participants said they would at least consider eating insects in general, with comparable numbers for eating foods containing whole insects (80%). Fewer people were in favor of promoting insect eating (50% above neutral).

A smaller percentage of Indian participants held favorable views of insect eating, for willingness to eat insects in general (34%), willingness to eat foods containing whole insects (48%), and promoting insect eating (19% above neutral). For a broad overview of frequency counts of acceptance of eating insects by country, see Table 3.

In both countries, a higher percentage of men than women were willing to eat insects in general (USA 90% vs. 75%; India 37% vs 26%; rating 2 or higher), to eat foods containing whole insects (USA 80% vs. 64%; India 34% vs. 22%; rating 2 or higher), to eat foods containing a higher percentage of insect flour (USA 5.8 vs. 0.03; India 0.18 vs 0.00; median flour %), and were in favor of promoting insect eating (USA 56 vs. 46%; India 24% vs. 10%; above neutral).

3.2. Insect eating as violating a protected value

Significantly fewer Americans (4.0%) than Indians (25.9%) felt that eating insects violated a protected value, $\chi 2$ (2, $N = 475$) = 36.3, $p < .001$. In India, those participants that felt that eating insects violated a protected value were significantly more religious ($N = 52$, $M = 4.75$, $SD = 0.97$) than those who did not ($N = 149$, $M = 4.11$, $SD = 1.45$), $F(1\,9\,9) = 8.80$, $p < .01$, $d = 0.48$). In the USA, those that felt that eating insects violated a protected value ($N = 11$, $M = 3.64$, $SD = 1.75$) were not significantly more religious than those who did not ($N = 264$, $M = 2.44$, $SD = 1.69$; $F(273) = 5.30$, $p = .02$, $d = 0.78$).

3.3. Beliefs about risks and benefits of eating insects

We then examined beliefs about potential benefits and risks of eating insects within each country. The questions for these and subsequent items are listed in Table 4. Regarding benefits, in both countries, agreement was highest for the belief that rearing insects for food takes less space than conventional livestock, and lowest for the belief that insects have a rather mild and pleasant taste. Regarding risks, in the USA and India, agreement was highest for the belief that some people would have allergic reactions to eating insects, and lowest for the belief that eating insects would increase the risk of infectious disease. For an overview of means, standard deviations, and significant differences, see Table 5.

3.4. Beliefs about eating insects

With the pool of items measuring beliefs about insect eating (see Table 4), we conducted an exploratory factor analysis using principal axis factoring and promax rotation, suppressing factor loadings below 0.5 (Chatterji, 2003). Because the initial pool involved disproportionately many items about the perceived benefits of eating insects (12, vs. 4–6 for the other domains), we dropped six items (i.e., insects are high in fiber, cheap to produce, easy to mill into flour, have interesting textures, have medicinal properties, and are low in sugar). Five factors emerged with an eigenvalue above 1, collectively explaining 63% of the variance of responses, and clustering according to the themes of eating insects being 1. beneficial, 2. disgusting, 3. risky, 4. causing insects to suffer, and 5. violating religious principles. Internal reliability was good for all five factors, and we calculated factor scores by averaging together the items that loaded onto each factor (see Table 4 for items, loadings, Cronbach's alphas, and corrected item total correlations).

A consistent pattern emerged for country, such that, relative to the Americans, the Indians scored significantly lower in the Benefits factor, and higher in the Disgust, Risks, Suffering, and Religion factors. The effects of gender were less consistent, such that relative to the men, the women scored significantly higher only on the Disgust and Suffering factors. In no case was the interaction of country and gender significant. For an overview of means, standard deviations, and ANOVA statistics, see Table 6.

Table 2
Measures of acceptance of eating insects by country and gender (USA n = 275; India n = 201).

Measure	Mean (SD)		Mean (SD)		Gender		Country		Gender × Country
	USA Women	USA Men	India Women	India Men	*F* *p*	*d*	*F* *p*	*d*	*F* *p*
General Willingness to Eat Insects	2.46 (1.23)	2.96 (1.22)	1.38 (0.75)	1.58 (0.90)	11.51 < .01	0.31	139.62 < .001	1.10	2.07 (0.15)
Willingness to Eat Whole Insect Foods	2.38 (1.23)	2.75 (1.19)	1.38 (0.73)	1.59 (0.79)	8.39 < .01	0.27	113.76 < .001	0.99	0.64 (0.42)
Acceptable Insect Flour Percent	5.12 (8.16)	9.38 (10.26)	2.12 (5.84)	3.51 (5.84)	13.76 < .001	0.34	174.69 < .001	0.54	3.56 (0.06)
Promoting Insect Eating	−6.30 (52.88)	11.15 (47.61)	−44.00 (40.32)	−35.46 (47.39)	7.85 < .01	0.26	82.61 < .001	0.85	0.92 (0.34)

Note: Response scales were as follows– General Willingness & Willingness to Eat Whole Insect Foods: 1 (I would never eat it under any conditions), 2 (I would eat it only if my survival depended on it), 3 (I am unsure if I would ever consume it), 4 (I could be persuaded to consume it), 5 (I would be glad to consume it); Acceptable Insect Flour Percent: 0%, 0.1%, 1%, 5%, 10% and ≥25%; Promoting Insect Eating: −100 (Disagree Strongly), to 0 (Neither Agree nor Disagree), to 100 (Agree Strongly).

Table 3
Frequency counts for levels of acceptance of eating insects by country (USA n = 275; India n = 201).

General Willingness to Eat Insects

	Never	Survival	Unsure	Persuadable	Gladly
USA	49 (18%)	100 (36%)	39 (14%)	63 (23%)	24 (9%)
India	133 (66%)	44 (22%)	15 (7%)	7 (3%)	2 (1%)

Willingness to Eat Whole Insect Foods (3-item composite)

	Never	> Never < Survival	≥ Survival < Unsure	≥ Unsure < Persuadable	≥ Persuadable < Gladly	Gladly
USA	54 (20%)	25 (9%)	93 (34%)	44 (16%)	45 (16%)	14 (5%)
India	116 (58%)	24 (12%)	44 (22%)	15 (7%)	2 (1%)	0 (0%)

Acceptable Insect Flour Percent (3-item composite)

	0%	> 0% < 1%	≥1% < 5%	≥5% < 10%	≥10% < 25%	≥25%
USA	107 (39%)	32 (12%)	22 (9%)	34 (12%)	37 (13%)	43 (16%)
India	100 (50%)	29 (14%)	29 (14%)	23 (11%)	14 (7%)	6 (3%)

Promoting Insect Eating (6-item composite)

	−100	> −100 < −50	≥ −50 < 0	0	> 0 < 50	≥50 < 100	100
USA	9 (3%)	37 (13%)	82 (30%)	7 (3%)	87 (32%)	48 (17%)	5 (2%)
India	21 (10%)	62 (31%)	74 (37%)	5 (2%)	32 (16%)	6 (3%)	1 (< 1%)

Note: For response scales, see Table 2.

Table 4
Exploratory factor analysis of beliefs about eating insects (USA n = 275; India n = 201).

	Factor and Loadings					Item-Total Correlation
	Benefits	Disgust	Risks	Suffering	Religion	
	α = .88	α = .87	α = .79	α = .81	α = .80	
Rearing insects for food generates less pollution and greenhouse gas than rearing conventional livestock.	.86					.76
Rearing insects as food is more efficient and requires fewer resources than rearing conventional livestock.	.85					.73
Rearing insects for food requires much less space than rearing conventional livestock.	.82					.65
Insects contain high levels of high-quality animal protein.	.79					.71
Insects are highly nutritious.	.73					.73
Insects have a mild and rather pleasant taste.	.63					.55
The idea of eating insects makes me nauseous.		.87				.73
The idea of eating insects makes me ill.		.87				.75
Eating insects is disgusting.		.84				.76
I am offended by the idea of eating insects.		.72				.62
It is unacceptable to eat insects in public.		.56				.60
I would rather not to be friends with someone who eats insects regularly.		.54				.57
Insects carry harmful microbes.			.77			.53
Insects contain harmful toxins.			.74			.60
Eating insects will increase risk of infectious disease.			.74			.60
Eating insects would expose me to harmful chemicals and insecticides.			.70			.65
Some people would have allergic reactions to eating insects.			.66			.46
Insects are capable of feeling pain.				.87		.68
Insects are capable of suffering.				.85		.63
Insects have consciousness.				.66		.62
Insects have rights.				.58		.60
It is against my religion to eat insects.					.81	.70
Spiritual leaders would not approve of me eating insects.					.72	.64
Killing insects is immoral.					.68	.55
Most world religions prohibit insect consumption.					.53	.59

3.5. Correlations between measures

In the USA, the four measures of acceptance of insects as food were significantly and highly correlated with one another (*r*s ranging from .58 to .84). In India, these measures were also significantly correlated (*r*s ranging from .39 to .68). Although these outcomes were strongly related, they were measured using very different metrics (e.g., how much one agrees that insect eating should be promoted is quite different from the highest percentage of insect flour one would be willing to eat in various foods). Thus, we converted each measure into Z scores

Table 5
Perceived risks and benefits of eating insects (USA n = 275; India n = 201).

Benefit	Agreement (M and SD)	
	USA	India
Less Space	1.47 (1.46) a	0.44 (1.68) a
Less Pollution	1.23 (1.47) ab	0.00 (1.67) b
More Efficient	1.13 (1.49) bc	−0.11 (1.79) b
Nutritious	0.93 (1.46) c	−0.64 (1.87) c
High Protein	0.83 (1.47) c	−0.20 (1.77) b
Pleasant Taste	−0.11 (1.38) d	−0.74 (1.67) c
Risk	**USA**	**India**
Allergic Reaction	1.10 (1.36) a	1.86 (1.37) a
Microbes	0.41 (1.39) b	1.05 (1.54) b
Toxins	−0.11 (1.54) c	1.01 (1.63) bc
Chemicals	−0.12 (1.62) c	0.60 (1.71) cd
Disease	−0.53 (1.50) d	0.50 (1.78) d

Note: Means that do not share subscripts differ at $p < .01$, with Bonferroni correction for multiple comparisons. Response scale ranged from −3 (Strongly Disagree), to 0 (Neither Agree nor Disagree), to 3 (Strongly Agree).

(standardized within each of the two countries) and averaged the Z scores to create a composite measure of acceptance of eating insects. This composite measure was significantly correlated with all five insect belief factors in both countries.

In the USA, the five insect belief factors were significantly correlated with one another (absolute value of *r*s ranging from .17 to .54, all in the predicted direction), with the exception of benefits-suffering. In India, these measures were also significantly correlated (*r*s ranging from .19 to .54, all in the predicted direction), with the exception of benefits-disgust, benefits-risk, and benefits-religion. In both countries, frequency of sushi intake was significantly associated with the composite willingness to eat insects score (USA: $r = .48$; India $r = .24$). For an overall view of all correlations, see Table 7. The disgust factor is by far the strongest predictor of composite willingness to eat for Americans ($r = .84$); for Indians, this correlation is the highest of any other variables with the composite willingness score, but is much smaller ($r = .46$).

3.6. Predicting acceptance of eating insects

Finally, we ran a stepwise regression, using composite insect eating acceptance as the dependent variable, entering the five insect belief factors and sushi intake frequency as predictors.

In the USA, the Disgust factor emerged as by far the largest and most significant predictor ($\beta = -0.70$, $p < .001$), with sushi intake frequency ($\beta = 0.20$, $p < .001$) and Benefits ($\beta = 0.16$, $p < .001$) also emerging as significant predictors (adjusted $R^2 = .76$).

Table 7
Correlations between insect acceptance measures, insect belief factors, and sushi intake frequency (USA n = 275; India n = 201).

	1	2	3	4	5	6	7
1. Composite Willingness to Eat Insects	–	**.43**	**−.46**	**−.22**	−.16	**−.35**	**.24**
2. Benefits Factor	**.53**	–	−.03	−.02	**.19**	.06	.04
3. Disgust Factor	**−.84**	**−.47**	–	**.51**	**.43**	**.54**	−.12
4. Risk Factor	**−.45**	**−.31**	**.54**	–	**.44**	**.41**	−.06
5. Suffering Factor	**−.20**	−.05	**.17**	.06	–	**.46**	−.10
6. Religion Factor	**−.43**	**-.32**	**.47**	**.36**	**.42**	–	−.04
7. Sushi Intake Frequency	**.48**	**.22**	**−.36**	−.11	−.17	**−.18**	–

Note: Values for the USA are below the diagonal, and values for India above. Bolded correlations are significant at $p < .01$ or less.

In India, a somewhat different pattern of results emerged. Benefits ($\beta = 0.43$, $p < .001$) was the strongest predictor, followed by Disgust ($\beta = -0.33$, $p < .001$), Religion ($\beta = -0.19$, $p < .01$), and sushi intake frequency ($\beta = 0.17$, $p < .01$; $F = 38.94$, $p < .001$, adjusted $R^2 = .43$).

Neither Risk nor Suffering emerged as significant predictors of overall willingness to eat insects in either country. It is notable that Benefits were a predictor but Risks were not, even for the Indians, for whom the risks were rated as higher than the benefits.

4. Discussion

In the past few years, a veritable swarm of studies have investigated the practice and acceptance of eating insects, largely to address the growing problems of global food security and environmental sustainability. We have replicated and extended some important prior findings about acceptance of insects as food, with a focus on beliefs and attitudes about eating insects, in both the USA and India. We demonstrated for the first time that acceptance of sushi (measured as frequency of consumption) is a significant and substantial predictor of insect acceptance.

In contrast to Ruby et al. (2015), we created composite measure of acceptance of insects as food, which included a general statement about willingness to eat insects, willingness to eat common Indian and American food made with whole insects, the highest level of insect flour that people would find acceptable in common Indian and American foods, and a composite measure of support for promotion of insects as food via various institutions. Using a broader array of measures, we replicated Ruby et al. (2015) previous findings that there is a surprisingly high level of acceptance of insects among Americans, and a much lower level among Indians. This contrasts with an even higher level of acceptance (based on different measures) for an online Chinese sample (Hartmann et al., 2015).

Table 6
Factor scores for beliefs about eating insects (USA n = 275; India n = 201).

Factor	Mean (SD)		Mean (SD)		Gender		Country		Gender × Country
	USA Women	USA Men	India Women	India Men	*F* (*p*)	*d*	*F* (*p*)	*d*	*F* (*p*)
Benefits	0.85 (1.17)	1.00 (1.06)	−0.43 (1.22)	−0.10 (1.35)	4.24 (.04)	0.19	106.88 (< .001)	0.96	0.76 (.38)
Disgust	0.49 (1.72)	−0.38 (1.53)	1.23 (1.17)	0.97 (1.30)	15.56 (< .001)	0.36	53.00 (< .001)	0.68	4.58 (.03)
Risks	0.17 (1.22)	0.08 (0.92)	1.08 (1.04)	0.96 (1.14)	0.97 (.32)	0.09	71.60 (< .001)	0.79	0.02 (.89)
Suffering	−0.06 (1.47)	−0.68 (1.41)	0.88 (1.19)	0.71 (1.39)	8.56 (< .01)	0.27	76.45 (< .001)	0.81	2.81 (.09)
Religion	−1.44 (1.12)	−1.57 (1.00)	0.82 (1.39)	0.60 (1.39)	2.32 (.12)	0.14	362.76 (< .001)	1.77	0.14 (.71)

Note: Response scale ranged from −3 (Strongly Disagree), to 0 (Neither Agree nor Disagree), to 3 (Strongly Agree).

Also, in support of past findings, we found substantially greater acceptance of insects by men than women, in both India and the USA (Ruby et al., 2015; a difference also reported by Hartmann et al., (2015), Menozzi et al., 2017, and Schösler et al., 2015).

We introduced measures of protected or sacred values (Baron & Spranca, 1997; Tetlock, 2003) as an indication of an absolute, potentially moral opposition to consuming insects. There was a major cultural difference, with 4% of Americans and 26% of Indians indicating that insect consumption violated a protected value. Insect consumption appears to touch on moral issues much more for Indians than Americans, as suggested by the fact that religiosity predicted insect acceptance in India and not in the USA. Many Hindus are vegetarian for religious reasons, and insects may be considered in the domain of animals that are prohibited as food.

Our list of beliefs and attitudes about insects separated very cleanly into the same five factors in India and the USA: Benefits, Risks, Disgust, Suffering, and Religion. In keeping with their lower insect acceptance, Indians scored lower on Benefits and higher on Risks, Disgust, Suffering, and Religion. Women scored higher on Disgust and Religion. It is particularly striking that disgust and danger (risks) emerged as separate factors. This was also observed using a different technique (rating of a large set of affectively-laden attributes) by Gmuer et al. (2016).

Sushi is a food which, as it usually includes raw fish, is found to be disgusting by many Americans. Since that is also true of insects, we thought that acceptance of sushi, which seems to involve overcoming initial disgust, might predict insect acceptance. Our data supported this, with a 0.48 correlation between frequency of consumption of sushi and insect acceptance for Americans, and 0.24 for Indians. This also could result from the possibility that disgust sensitivity is related to both sushi and insect acceptance.

In the American sample, Disgust, sushi intake, and Benefits were the strongest predictors of acceptance of insects as food, whereas in India, the strongest predictors were Disgust, Religion, and sushi intake. This contrasts with recent work by Gmuer et al. (2016), who had a sample of German-speaking Swiss respondents indicate how strongly they felt they would experience a range of 39 emotions or feelings (in German) when eating chips containing varying amounts of crickets. Ratings were on a 6-point scale, from (1) “not at all” to (6) “extremely strongly”. These 39 emotions/feelings were condensed into three factors, which all predicted acceptance of the insect-based foods. In decreasing order of predictive power, these were positive emotional evaluations, disgust/uneasiness, and inertia/dissatisfaction.

This disparity in the principal predictor might result from 1) the fact that 22 of the 39 adjectives in the Gmuer et al. analysis were positive, and all fell in one factor, giving it a much larger range than the six adjectives in the disgust factor; 2) our “positive” was based on specific benefits, in contrast with expected feelings such as good and happy; and 3) in many languages, including German and English, the denial (“not at all”) of a positive amounts to a negative. For example, responding “not at all” to happy” would mean “unhappy”, a negative as opposed to a neutral word (Rozin, Berman, & Royzman, 2010). In contrast, negation of negative words connotes neutrality, not positivity, so “not sad” does not mean “happy”.

There are two primary limitations to our findings. First, there are general limits on the validity of the self-report measures that we utilized. In particular, our measure of frequency of sushi intake was relatively rough and subjective, with response options of never, once, a few times, many times. A more precise and objective measure, such as number of times eaten in the past month or year, would likely provide more predictive power. Similarly, our measure of acceptable level of insect flour would have been better measured on a ratio scale of percentage points, rather than the ordinal scale that we employed. Second, there are major concerns about the representativeness of the Indian MTurk samples. MTurk samples only English-speaking Indians who have computer access and are on the internet. This sample is no doubt biased to individuals of higher socio-economic status and with higher levels of education. Although our sample did include some rural participants (21% of the American and 15% of the Indian sample), people from these regions remain relatively underrepresented. As such, future research is required to more carefully examine regional differences within countries in attitudes toward eating insects.

4.1. Issues for future research

There has been relatively little attention in the newer literature on insect acceptance to the selection of optimal species and life stages for promotion of consumption. Earlier work by Ruby et al. (2015) suggested that ants would be promising, but the majority of research with actual insect foods has employed crickets, which also constitute the base for many insect flours (e.g., Caparros Megido et al., 2014; Homann et al., 2017; Menozzi et al., 2017). Since one of the problems with the spread of insects as food is cost, selection of species should be informed by efficiency of rearing large numbers. This includes environmental conditions, length of lifecycle, arrangement of optimal breeding conditions, and appropriate feed. The larvae of black soldier flies have drawn attention because of their short life cycle, ease in rearing, and the fact that they can grow on human food waste (see Bußler, Rumpold, Jander, Rawel, & Schlüter, 2016). They are used as animal feed, but there is very little research on them as a direct human food. Some of the options and manners of preparation are reviewed in two excellent new books (Evans et al., 2017; Halloran et al., 2018).

Insects are very appealing as food in many cultures. They are typically consumed whole, rather than as flour. Although insects stand, nutritionally, as a promising meat substitute, they do not have the sensory appeal of meat. They generally have a mild, slightly nutty flavor, but there is minimal work on the sensory profile of insects. Adult forms, like crickets, and fried larva, may be crispy, an appealing texture for many humans. Thus, there are arguments both for promoting preparations of whole insects, guided by traditional recipes and modern culinary experimentation (e.g., Roasted, 2014), and for using insect flour as a protein-rich substitute for some standard grain flours in products like crackers, biscuits, and protein bars (e.g., Homann et al., 2017).

Another practical issue is to define the focal populations in which to promote insect consumption. From a nutritional and public health perspective, that the focus would be on the billions of people from developing countries that do not currently consume insects (e.g., Homann et al., 2017; Pambo et al., 2018) From a sustainability perspective, the focus would be on the developed world, where consumption of meat is often very high (see FAOSTAT, 2018). Research studies and commercial snacks containing insect flour are active enterprises in the developed world. This may have a positive effect on sustainability, and it may create a market that would encourage manufacturers to develop breeding and processing systems to make insects and insect flour much cheaper.

In addition to finding ways to make edible insects less expensive, there are a number of psychological factors that could promote acceptance, as indicated in the literature reviewed above, and in the present findings. Since disgust is a major deterrent to insect consumption, two strategies suggest themselves. One is to de-emphasize insect origins of a food, by using mild tasting insect flours. Another is to use insect flour as a first stage in introducing insects, with the aim of increasing its concentration in foods, and gradually shifting to whole insects, prepared in a palatable form. Additional taste test studies similar to the work of Caparros Megido et al. (2014) can help determine the relative utility of each approach. It is important to realize that people adapt to disgust, and in fact, consume and favor many foods around the world that have disgust properties, such as sushi, odorous cheeses, fermented fish sauce, and, of course, insects (e.g., Rozin & Fallon, 1987; Rozin, Guillot, Fincher, Rozin, & Tsukayama, 2013).

5. Conclusions

Research on acceptance of insects as food is currently accelerating. Future directions building on the present and other studies should include more studies of individuals in the developing world, representing the largest countries (e.g., China and India) and countries where a substantial portion of residents consume insects (e.g., Thailand and Mexico). It would also be advisable to include more rurally-located individuals, who are not on the internet, in these samples. There could also be an increase in the use of actual insect stimuli, and the possibility of eating them (e.g., Caparros Megido et al., 2014, 2016; Homann et al., 2017; Pambo et al., 2018); the use of photos in some studies (e.g., Ruby et al., 2015; Gmuer et al., 2017) is a step in this direction. There are major ways in which the psychology of preferences, phobias and disgust can be harnessed to promote insect acceptance, which is important for both nutritional and sustainability reasons. The linkage between insect acceptance and moral vegetarianism also deserves further study, including lay beliefs of whether insects feel pain. Indeed, the general lack of moral objection to raising insects for food is predicated on the belief that they do not suffer in the process; if this is untrue, then raising insects for food rather than larger invertebrates may actually increase overall suffering, given the much larger number of insects required to make one kilogram of food.

Author contributions

Both authors participated in all stages of this research, from conception to write-up.

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