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The impact of pathogen-disgust sensitivity on vaccine and GM food risk perceptions: Some evidence for skepticism

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Abstract

Recently scholars and popular commentators have suggested that *disgust* plays an important role in generating conflict over the risks of both GM foods and universal-childhood vaccinations. This paper presents evidence that calls that conclusion into doubt. Results from a large, diverse sample of U.S. adults corroborate that that anxiety over GM foods and over vaccines correlates with the standard pathogen disgust scale (PDS). But so do a multitude of perceived risks that are not plausibly related to disgust—including fear of flying in commercial airliners, worry about elevator crashes in high-rise buildings, and distress over children drowning in swimming pools. Indeed, these correlations tend to be larger than the ones between PDS and vaccine-risk perceptions and at least as large as the ones between PDS and GM-food-risk perceptions. Because what PDS tells us about disgust-driven fears is confounded with the scale's sensitivity to a generalized fear of all manner of risks, it is difficult to draw any confident inferences about what drives the modest correlations between PDS and GM-food and vaccine risk perceptions.

1. Introduction

Does *disgust* play an important role in attitudes toward childhood vaccines and genetically modified foods? That it does is a perfectly plausible conjecture. As an intentional state, disgust is characterized by apprehension of bodily contamination and a resulting disposition to distance oneself from the offending agent (Miller 1997). Both vaccines and GM foods present the prospect of physical invasion by unnatural objects: skin-piercing needles containing pathogens suspended in chemical delivery agents in the one case, and in the other biologically altered matter to be placed in the mouth and swallowed. It seems reasonable, then, to suppose that measures of pathogen disgust sensitivity will explain variance in attitudes toward these putative risk sources. Indeed, a number of researchers have presented evidence to this effect (Clifford & Wendell 2016; Scott, Inbar, & Rozin 2016).

Yet the aim of this paper (one that promiscuously combines exploratory conjectures and *a priori* hypotheses) is to report a bite-size increment of doubt about such a relationship. The analyses replicate in part previous researchers' findings of a correlation between GM food risks and vaccine risks, respectively, with pathogen disgust sensitivity. These correlations, however, were no more substantial than those between pathogen disgust sensitivity and other activities (airline crashes and elevator malfunctions) that are not plausibly related to disgust. By suppling context essential to apprising the inferential significance of correlations between pathogen disgust sensitivity and putative hazards, the analyses reported in this

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paper imply that such sensitivity is probably *not* a meaningful source of variance in GM-food or vaccine risk perceptions.

2. A helping of background

The *affect heuristic* (Slovic et al. 2004) is arguably the most significant finding in the study of human risk perceptions. It might seem natural to attribute affective arousal (in the form of fear, say, or anger, sadness, equanimity, or even pride) to individuals' assessments of information on a putative risk source. But the affect heuristic stands this view on its head: affect is prior to information processing in the sense that most individuals selectively credit or discredit evidence based on its conformity to their immediate and often unconscious feelings toward a putative risk source (Loewenstein et al. 2001). Accordingly, one can infer from individuals' affective reaction not only *who* is likely to respond positively or negatively to a putative risk source but also *how* they are likely to respond to evidence about the source's likely risks and benefits.

Item	Wording
POOP	Stepping on dog poop
SORES	Sitting next to someone who has red sores on their arm
SWEATY	Shaking hands with a stranger who has sweaty palms
MOLDY	Seeing some mold on old leftovers in your refrigerator
SMELLY	Standing close to a person who has body odor
ROACH	Seeing a cockroach run across the floor
CUT	Accidentally touching a person's bloody cut

Table 1. Pathogen disgust scale. Subjects rate disgust with respect to each putative source on 0 ("not disgusting at all") to 6 ("extremely disgusting")**.**

A small but growing body of thoughtful work identifies *pathogen disgust* as the most consequential affective influence on GM-food and childhood-vaccine risk perceptions. Part of a disgust-related ensemble that includes *moral* and *sexual* disgust, pathogen disgust sensitivity has been defended as the more discerning measure, particularly for reactions to bodily contaminants ingested in one form or another (Tybur et al. 2013; Olatunji et al. 2012; Inbar & Pizzaro 2014). In an important paper, Clifford and Wendell (2016) report correlations between PDS and GM-food and vaccine risk perceptions among M Turk and student samples. In another important study, Scott et al. (2016) likewise found such a relationship between trait-disgust measures, including PDS, and various reactions to GM foods in a U.S. general population sample.

Definitely, these results furnish reason to believe that disgust plays a role in GM-food and vaccine risk perceptions. But there are two grounds for qualifying the degree of support they supply.

First, the *size* of the effects reported seems remarkably small. C&W report, for example, standardized beta weights—ones in which a one-standard deviation in the predictor (PDS) is associated with some fraction of a one-standard-deviation change in the outcome variable—of 0.13 and 0.17, in the case of GM food risk perceptions. Likewise, for vaccination risk perceptions: C&W reported standardized beta weights of 0.11 (*ns*) and 0.22. In other words, one-standard deviation in PDS is associated with outcome-variable changes of a much smaller magnitude. The results reported in Scott et al. were comparable for their examination of GM food risk perceptions

Second and relatedly, neither team of researchers supplied particularly robust evidence of discriminant validity. As used here, discriminant validity refers to the uniqueness of the correlation between

PDS and GM food and vaccine risk perceptions, respectively. Such a test would involve showing that the relationship between observed PDS/risk-perception correlations were higher for GM foods and vaccines than were the PDS/risk-perception correlations for putative risk sources *not* plausibly animated by pathogen disgust sensitivity.

C&W reported disgust-sensitivity/risk-perception ratings only for other sources that one might well expect to arouse pathogen disgust sensitivity to some degree (obesity, anti-smoking, and drug use). The size of the effects appears to be smaller than the ones they observed for GM-food risk perceptions. But the critical question is the relative size of the respective correlations between PSD and GM-food and vaccinations, respectively, and the correlations between PSD and activities or states of affairs that *don't* plausibly reflect disgust *at all*.

For their part, SIR compare the effects of *state* disgust on GM foods and dolphin killing. Although dolphin killing is presumably not a disgust-related practice, SIR's results suggest that it actually aroused more disgust than did GM-food consumption.

In sum, because neither of these groups of researchers systematically investigated the relationship between PDS and putative risk sources *not* plausibly related to disgust, it is difficult to determine how much weight to assign their findings. Performing a systematic evaluation of that sort was the principal goal of the current study.

3. Study

2.1. Inference strategy

This paper rests on a simple theoretical premise: that rejection of a "null hypothesis" with respect to the correlation between pathogen disgust sensitivity, on the one hand, and GM-food and vaccine risk perceptions, on the other, is not sufficient to support the conclusion that disgust sensitivity meaningfully explains these risk perceptions (Rozeboom 1960; Ziliak & McCloskey 2008). Like all valid latent variable instruments, any scale used to measure pathogen disgust sensitivity will be imperfect. Such a scale should be highly correlated with, and thus reliably measure, a particular form of disgust sensitivity. But such a scale can still be expected to correlate weakly or even modestly with additional negative affective dispositions (Chapman & Anderson 2013). As a result, there can be modest yet practically meaningless correlations between the pathogen disgust sensitivity scale and all manner of risk perceptions that excite negative affective reactions unrelated to disgust.

A comparative analysis is thus appropriate. If disgust genuinely explains perceived risks of vaccines and GM foods, the degree of the correlation between such concerns and a valid measure of pathogen disgust should be comparable to the relatively large correlation between PDS and attitudes already understood to be grounded in disgust. By the same token, one can infer that PD is not a particularly important source of variance in GM-food and vaccine risk perceptions if the correlation between PDS and these putative risk sources is comparable to correlations between pathogen disgust sensitivity and risk sources that do *not* plausibly excite disgust.

This was the inference strategy that informed design of this study.

2.2. Sample

The study was administered to a large (N = 2473) sample of U.S. adults. Subjects were recruited by YouGov, a public research firms that conducts online surveys and experiments on behalf of academic and governmental researchers as well as commercial customers (including political campaigns). Fifty-four percent of the sample members were female; 78% were white, 8% were African-American, and 7% were

Hispanic. The average age was 49. The median educational attainment was "some college," and the median income was $40,000 to $49,000. Thirty-four percent of the sample identified as "Democrats," 25% as Republicans, and 28% as "Independents."

2.3. Measures

a. Pathogen disgust. Subjects' disgust sensitivities were measured with the pathogen disgust scale (Table 1). Standardized responses to each item were summed, and the resulting score also standardized (Smith 2000).

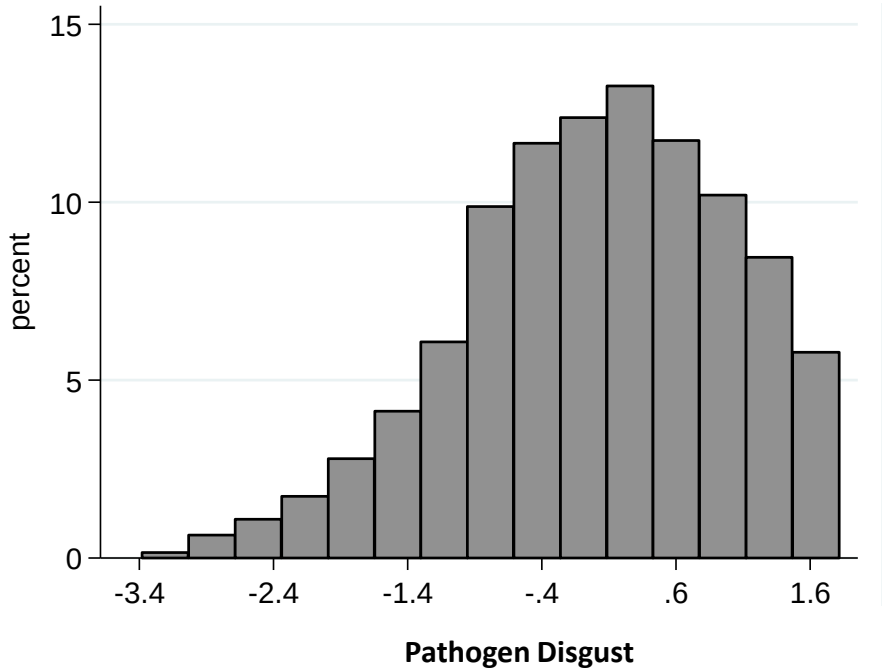

Figure 1. Distribution of pathogen disgust sensibilities. $N = 2471$. Cronbach's $\alpha = 0.83$. The data are left-skewed; after all, most people don't like to step in dog shit.

b. Risk perception attitudes. Subjects' risk attitudes were assessed with two types of measures. For half the subjects, risk perceptions were elicited with the "Industrial Strength Risk Perception Measure" (ISRPM) (Clifford & Wendell 2016; Kahan 2015). The ISRPM directs subjects to rate on an 8-point (or 10-point) scale "how much risk" a putative risk source "poses to human health, safety, or prosperity." Likely because they tap into subjects' global affective assessments of putative risks (Slovic et al. 2004; Loewenstein et al. 2001), ISRPM measures have been shown to be highly correlated with more particular assessments of putative risk sources' benefits and harms as well as with risk-taking behavior (Dohmen et al. 2011; Ganzach, Ellis, Pazy, & Ricci-Siag 2008; Weber, Blais,& Betz 2002).

Item	Item wording
GMFRISK	Genetically modified food
VACRISK	Vaccination of children against childhood diseases (such as mumps, measles and rubella)
PORNRISK	Pornography
WASTE	Disposal of hazardous wastes in landfill sites
MARYJRISK	Legalization of marijuana
PROSTRISK	Legalization of prostitution
IMMIGRISK	Unlawful entry of immigrants into the United States
CIGRISK	Exposure to second-hand cigarette smoke
XRAY	Medical x-rays
FLOURIDE	Fluoridation of drinking water
AIRPOLLUTION	Air pollution
SACHARINE	Use of artificial sweeteners in diet soft drinks
DRONES	Private operation of drones in U.S. airspace
BEEF	Use of synthetic hormones in beef cattle
HPV	Vaccinating adolescents against HPV (the human papillomavirus)
POWER	Residential exposure to magnetic field of high-voltage power lines
CELL	User exposure to radio waves from cell phones
FOODCOLOR	Artificial food colorings
FRACKING	"Fracking" (extraction of natural gas by hydraulic fracturing)
HIGHTAX	Raising taxes for persons in the highest-income tax bracket.
MASSHOOT	Mass shootings in public places
CARJACK	Armed carjacking (theft of occupied vehicle by person brandishing weapon)
ACCIDENTS	Accidents occurring in the workplace
LOOSEREG	Lax regulatory oversight of financial institutions
AIRTRAVEL	Flying on a commercial airliner
SOCSEC	Bankruptcy of the social security system
GWARMING	Global warming
IRAN	The development of a nuclear weapons by Iran
AI	Development of "artificially intelligent" computers capable of reprogramming themselves based on automated information search and experience
ELEVATOR	Elevator crashes in high-rise buildings
TERROR	Terrorist attacks inside the United States
NUKERISK	Nuclear power
KIDPOOL	Accidental drowning of children in swimming pools
GOOGLESPY	Commercial monitoring of private internet activity to collect consumer marketing data

Table 2. ISRPMs. Subjects rated the risk associated with each risk source on a 0 ("no risk at all" to 7 ("very high risk") scale. Item color coding reflects expected "disgust relatedness": *green* for expected relationship; *red* for expected non-relationship; and *yellow* for ambiguous. *Light blue* is used to denote the uncertainty of the relationship between pathogen disgust sensitivity and GM-food- and vaccine-risk perceptions.

The affective associations that are registered in ISRPM also correlate with *policy preferences* (Kahan et al. 2016a), which constitute the second type of measure used in this study to gauge risk atti-

tudes. The half of the sample not administered the ISRPM battery were instructed instead to indicate on a six-point scale their level of opposition or support for a variety of different policy measures.

Item	Item wording
policy_VAC	Requiring children who are not exempt for medical reasons to be vaccinated against measles, mumps, and rubella.
policy_pot	Making it legal for licensed businesses to sell marijuana to adults for personal use.
policy_prostitute	Making prostitution legal for adults.
policy_gaymarriage	Gay marriage (allowing couples of the same sex to marry each other).
policy_racemarriage	Prohibiting couples of different races from marrying each other.
policy_establishment	Amending the U.S. Constitution to recognize Christianity as the official religion of the United States.
policy_porn	Prohibiting the sale of videos depicting adults engaged in explicit sexual activity.
policy_cappun	The death penalty for murder.
policy_ERA	Amending the U.S. Constitution to prohibit discrimination on the basis of sex.
policy_nuke	Increased use of nuclear energy to provide electricity for the U.S.
policy_gun	Stricter gun control laws in the United States.
policy_courtstrip	Amending the U.S. Constitution to remove the power of courts to declare laws passed by Congress or by state legislatures unconstitutional.
policy_partypoker	Making it legal for companies to run internet poker sites in which players can bet real money.
policy_sportsbet	Making it legal for companies to run internet sports betting sites in which players can bet on professional sporting events for real money.
policy_notax	Amending the U.S. Constitution to prohibit the federal government from imposing an income tax.
policy_draft	Instituting a draft to raise soldiers for the armed forces.
campaign_finance	Approval of an amendment to the U.S. constitution that would allow Congress and state legislatures to prohibit corporations from contributing money to candidates for elected office.
policy_healthcare	Universal health care.
policy_taxcut	Raising income taxes for persons in the highest-income tax bracket.
policy_affirm	Affirmative action for minorities.

Table 3. Policy preferences. Subjects indicated their level of disagreement or agreement with each policy a 6-point "strongly oppose" to "strongly support" scale. Item color coding reflects expected "disgust relatedness": *green* for expected relationship; *red* for expected non-relationship; and *yellow* for ambiguous. *Light blue* is used to denote the uncertainty of the relationship between pathogen disgust sensitivities and vaccine-risk perceptions.

The advantages of assessing risk attitudes with two discrete measures are two-fold. First, the coherence of the measures vouches for their common status as indicators of the latent affective variable that generates the relevant risk perceptions. Second, results that support the same inference regardless of the attitudinal variable being used to measure subjects' reactions help to establish the robustness of the testing strategy.

To determine the commensurability of the ISRPM and risk-preference battery as indicators of common affective responses to various risk sources, pairs of items from each that referred to the same risk source were evaluated in relation to subjects' political dispositions. Left-right outlooks, measured here

with a scale that comprises responses to a 5-point "liberal-conservative" ideology scale and a 7-point political party identification one (e.g., Kahan 2013), are often posited to be the source of individual differences in the affective disposition that accounts for both perceptions of risk and preferences for policies relating to those risks (Kahan 2016b).

That test corroborated that items from the ISRPM battery and policy-preference ones are essentially interchangeable ways to capture ideologically informed differences in positions. For paired items (e.g., "risk of global warming" and support for "stricter carbon emission standards to reduce global warming"; "risk of pornography" and "prohibiting the sale of videos depicting adults engaged in explicit sexual activity") the covariance with a right-left political orientation measure is near-identical (Figure 2).

The selection of items for both the ISRPM and the policy-preference modules reflected the inference strategy for this study. That is, items were selected to enable the relationship between disgust and opposition to childhood vaccination and to GM foods, respectively, to be compared to the relationship of disgust to a host of disgust-related and disgust-unrelated risk sources (Table 2 &Table 3). Disgust-related policies included "making prostitution legal for adults," "prohibiting the sale of videos depicting adults engaged in explicit sexual activity," "gay marriage," "prohibiting couples of different races from marrying each other, and "the death penalty for murder." Disgust-unrelated policies included "raising income taxes for persons in the highest-income tax bracket," "approval of an amendment to the U.S. constitution that would allow Congress and state legislatures to prohibit corporations from contributing money to candidates for elected office," "flying in a commercial airliner," and "elevator crashes in high-rise buildings." Accordingly, this paper will treat both sets of indicators as evincing subjects' risk orientations.

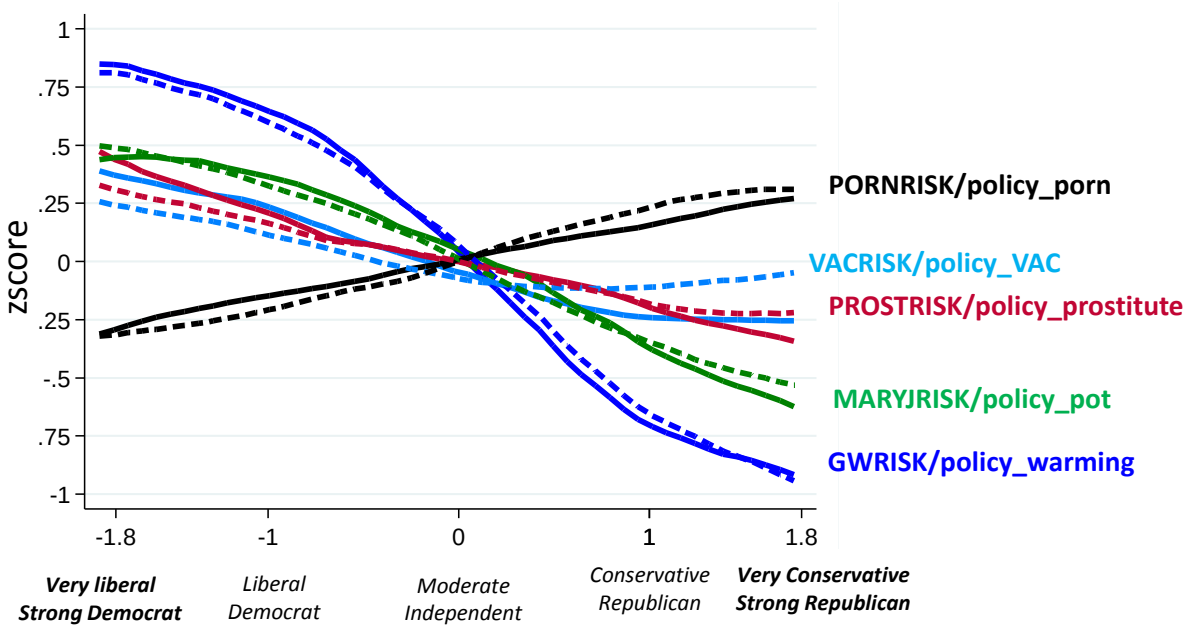

Figure 2 Psychometric equivalence of policy-preference and ISRPMs. ISRPM and policy preferences measured in two different samples (*n's* ≈ 1250 for each). *Y*-axis is based on standardized scores for both types of measures. Plotted lines derived by locally weighted regression. Dashed lines reflect responses to ISRPMs, solid to corresponding policy preference. GWRISK, PROSTRISK, VACRISK & MARYJRISK reverse coded. Suggested nickname for Figure: "The Psycho-tarantula."

3. Results

3.1. Preliminary findings

a. PDS and political outlooks. Commentators often report that disgust sensitives, including the type measured by PDS, are correlated with left-right political orientations (Terrizzi et al., 2013; but see Tybur et al. 2010). In this data set, there was such a correlation (Figure 3) but it was trivially small (0.09, $p < 0.01$).

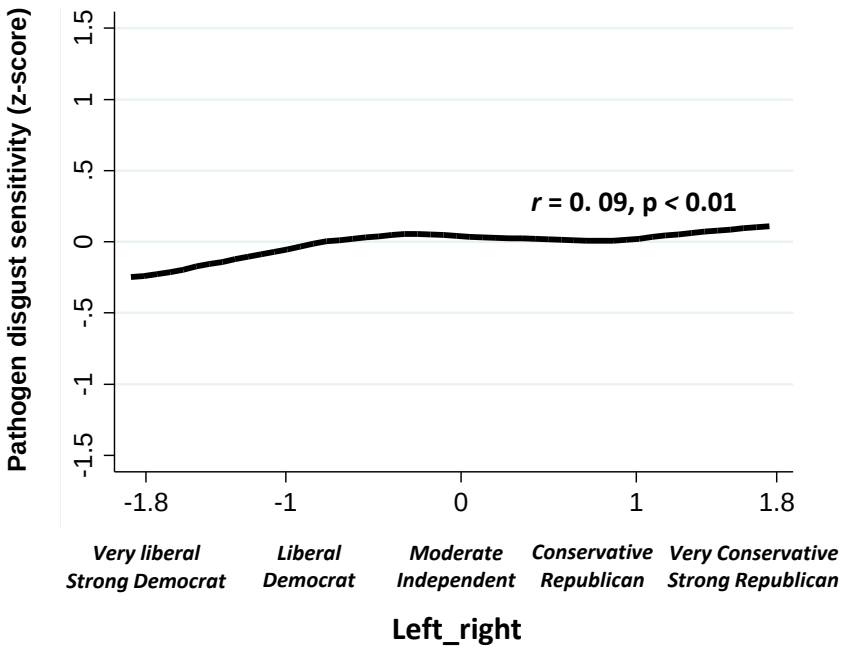

Figure 3. Relationship between PDS and right-left political outlooks. N = 2414. Locally weighted regression.

***b. Vaccine and GM risk perceptions and political outlooks*.** In the popular media, both vaccine and GM risk perceptions are frequently depicted as associated with "liberal" outlooks (e.g., Shermer 2013). Empirical data do not support this view (e.g., Kahan 2015, 2016b). In this study, too, there was no meaningful correlation ($r = 0.00$, $p= 0.96$) between GM-food risk perceptions and political outlooks (Figure 4). For vaccines, there were small to moderate correlations (Figure 4), but the direction was contrary to the popular-commentary position: *right-leaning scores* on the political outlook measure predicted both *more concern* over vaccine risk perceptions (0.09 $p < 0.01$) and *less support* for mandatory vaccination ($r = - 0.24$, $p < 0.01$).

3.2. Principal findings

a. Disgust and vaccine policy preferences. Consistent with the inference strategy for the paper, we measured the correlation between PDS and sets of disgust-unrelated and disgust-related policy positions (Table 4). The results were largely in line with expectations. Thus, as PDS scores increased, so did opposition to gay marriage ($r= - 0.14$, $p < 0.01$) and legalization of prostitution ($r = - 0.21$, $p < 0.01$), forms of behavior that one might expect to conjure anxieties of bodily contamination. Support for the death penalty was also positively correlated with PDS ($r = 0.22$, $p < 0.01$)—consistent with the relationship between high pathogen disgust sensitivity and punitiveness (Olatunji & Puncochar 2014). There was also a correlation between PDS and support for a constitutional amendment recognizing Christianity as the "official religion" of the U.S. ($r = 0.26$, $p < 0.01$). The nexus between Christian faith and dedication to "moral purity" (Koleva et al. 2012; Ritter & Preston 2011) plausibly explains this relationship.

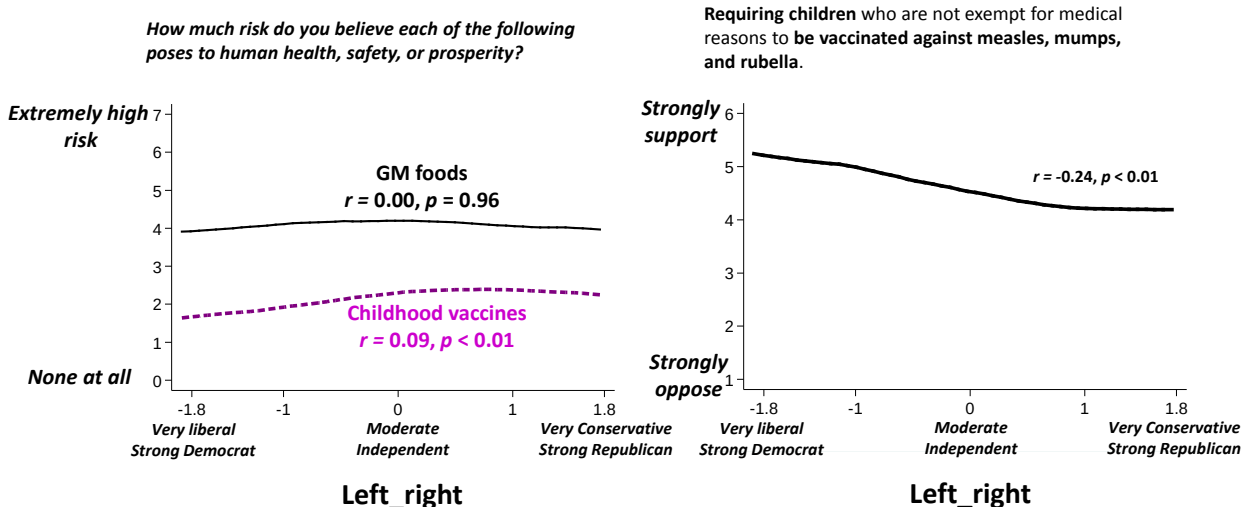

Figure 4. Relationship of left-right outlooks to GM-food & childhood-vaccine risk attitudes. *N*'s 1217 (left panel), 1194 (right panel). Locally weighted regression.

PDS also correlated positively ($r = 0.20$, $p < 0.01$) with "amend[ing] the U.S. Constitution to remove the power of courts to declare laws passed by Congress or by state legislatures unconstitutional." This result was not entirely surprising given the role that courts have played in invalidating laws (restrictions on gay marriage, interracial marriage, abortion etc.) that one might think evince concern with pathogen disgust.

Policy Preferences	*r*	*p*-val
policy_establishment	0.26	< 0.01
policy_cappun	0.22	< 0.01
policy_prostitute	-0.21	< 0.01
policy_porn	0.20	< 0.01
policy_courtstrip	0.20	< 0.01
policy_notax	0.15	< 0.01
policy_racemarriage	0.15	< 0.01
policy_gaymarriage	-0.14	< 0.01
policy_gun	0.08	< 0.01
policy_VAC	0.07	< 0.05
policy_pot	-0.06	< 0.05
policy_warming	0.06	<0.05
policy_taxcut	0.06	0.05
policy_partypoker	-0.05	0.06
policy_affirm	0.05	0.12
policy_ERA	0.04	0.13
policy_healthcare	0.04	0.17
campaign_finance	0.04	0.18
policy_nuke	-0.03	0.32
policy_draft	0.02	0.40
policy_sportsbet	-0.02	0.44

Table 4. Correlations between PDS and policy preferences. $N = 1226$. Colors reflect hypothesized relation of indicated item to disgust sensitivity (Table 3).

By the same token, disgust-*unrelated* policy preferences displayed trivial correlations with PDS. Among these policies was "approval of an amendment to the U.S. constitution that would allow Congress and state legislatures to prohibit corporations from contributing money to candidates for elected office" ($r = 0.04$, $p = 0.18$), and "stricter carbon emission standards to reduce global warming" ($r = 0.06$, $p < 0.05$). Support for "universal health care" ($r = 0.04$, $p = 0.17$) also displayed no meaningful correla-

tion with PDS, and the same was true for "instituting a draft to raise soldiers for the armed forces" ($r = 0.02$, $p = 0.40$).

Judged against these benchmarks, mandatory vaccination cut a profile substantially more in line with the disgust-unrelated class of putative risks (Table 4, Figure 5 & Figure 6). The disgust scale had a statistically significant correlation with "requiring children who are not exempt for medical reasons to be vaccinated against measles, mumps, and rubella." The size of the correlation, however, was trivial ($r = 0.07$, $p < 0.05$)—much like those for members of the disgust-unrelated policies (Table 4).

Even more decisively, the sign of the correlation was in the *wrong direction*. As disgust sensitivity (measured by PDS) increased, so did *support* for mandatory vaccination. In light of this evidence, it is difficult to see how anyone would view disgust sensitivity as a meaningful contributor to divisions over the safety of vaccines.

To discipline and probe this inference, factor analysis was performed on the policy items (Table 5). The analysis identified three factors with eigenvalues greater than 1.0. The vaccine policy item loaded modestly (0.40) on the first. That factor comprised an eclectic selection of risks—global warming, gun control, tax policies, affirmative action—that generally divide people along the conventional left-right ideological continuum. The correlation between scores on this factor and PDS was an anemic 0.08.

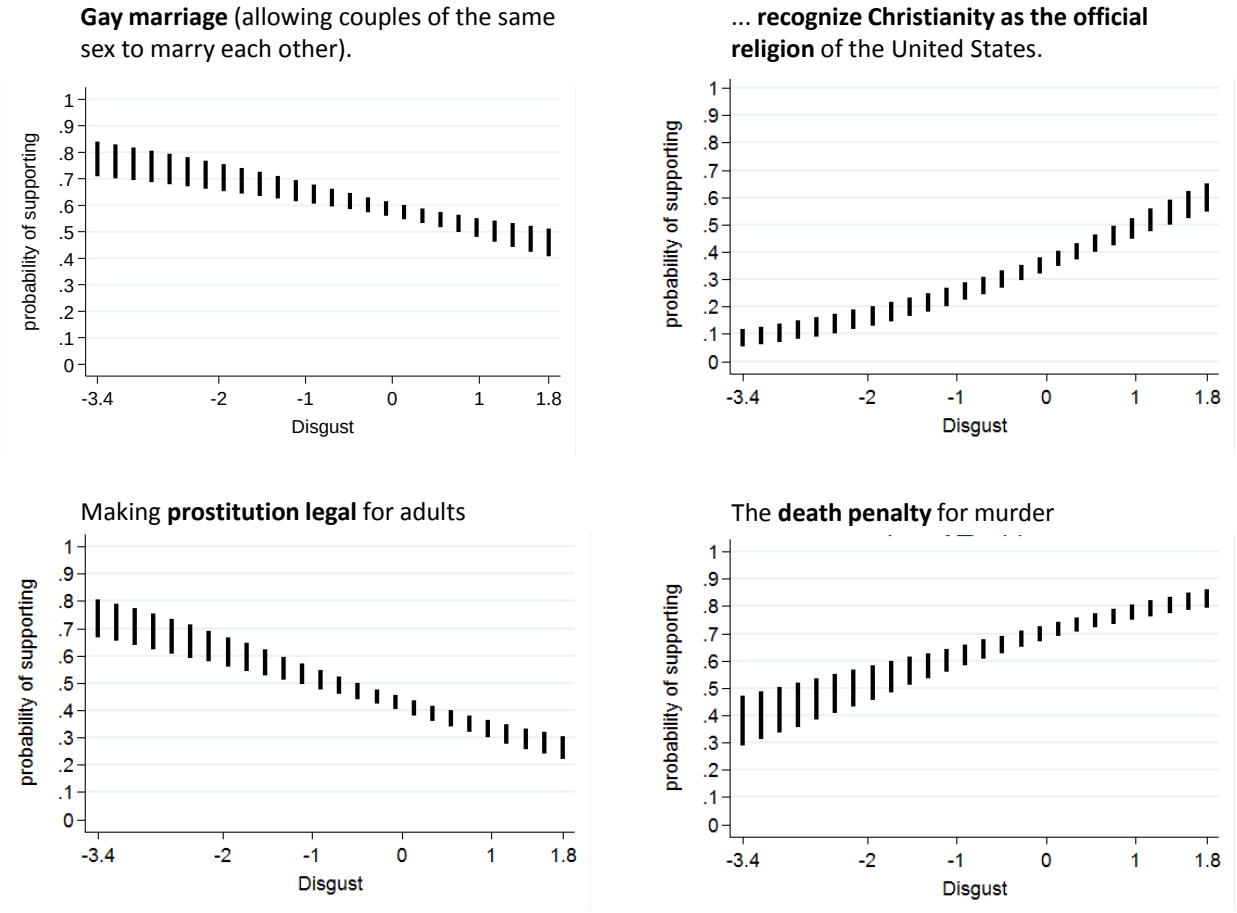

Figure 5. Representative item response profiles for disgust-related issues. *N*'s ≈ 1200. Derived by ordered logistic regression. "Probability of supporting" includes supporting indicated policy either "slightly," "moderately," or "strongly." Bars represent 0.95 levels of confidence.

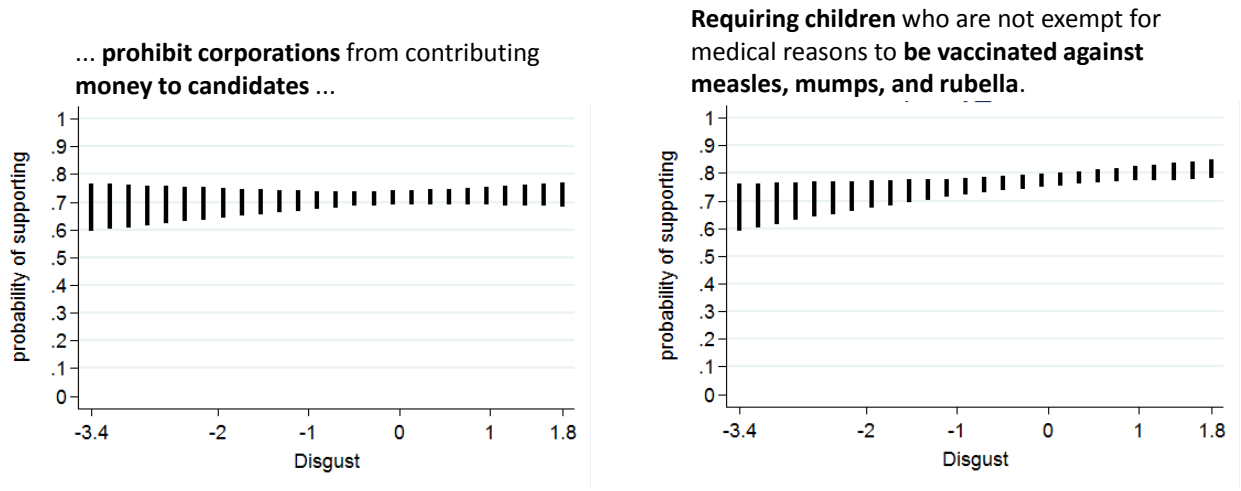

Figure 6. Item response profiles for campaign-financing reform and for universal vaccination. *N*'s ≈ 1200. Derived by ordered logistic regression. "Probability of supporting" proposed policy either "slightly," "moderately," or "strongly." Bars represent 0.95 levels of confidence.

PDS correlated more strongly ($r = 0.37$, $p < 0.01$) with the second factor, which comprised various disgust-related items, such as support for capital punishment, legalization of prostitution and marijuana, support for recognizing Christianity as the national religion, and opposition to both interracial and same-sex marriages. The policy item for universal vaccination, however, did not meaningfully load on this disgust-related policies factor. Its correlation with this factor was an underwhelming - 0.08.

	factor 1	factor 2	factor 3
policy_gun	0.79		
policy_cappun	-0.37	0.37	
policy_pot	0.38	-0.34	0.38
policy_prostitute		-0.41	0.40
policy_healthcare	0.81		
policy_taxcut	0.76		
policy_affirm	0.73		
policy_nuke	-0.33		
policy_warming	0.84		
policy_draft			0.39
policy_gaymarriage	0.56	-0.46	
policy_racemarriage		0.35	
policy_ERA	0.68		
policy_partypoker			0.77
policy_sportsbet			0.77
policy_VAC	**0.40**		
policy_notax	-0.36	0.41	
policy_establishment		0.67	
policy_courtstrip		0.55	
policy_porn		0.54	
campaign_finance	0.50		
Eigenvalue	4.87	2.05	1.70
R^2	0.57	0.23	0.20

Table 5. Policy preference factor analysis. Principal factors, orthogonal rotation. Loadings < 0.30 suppressed.

In sum, when one compares the level of support for universal vaccination to responses to disgust-related and -unrelated policy preferences, there is little reason to view negative reactions to vaccines as evincing disgust.

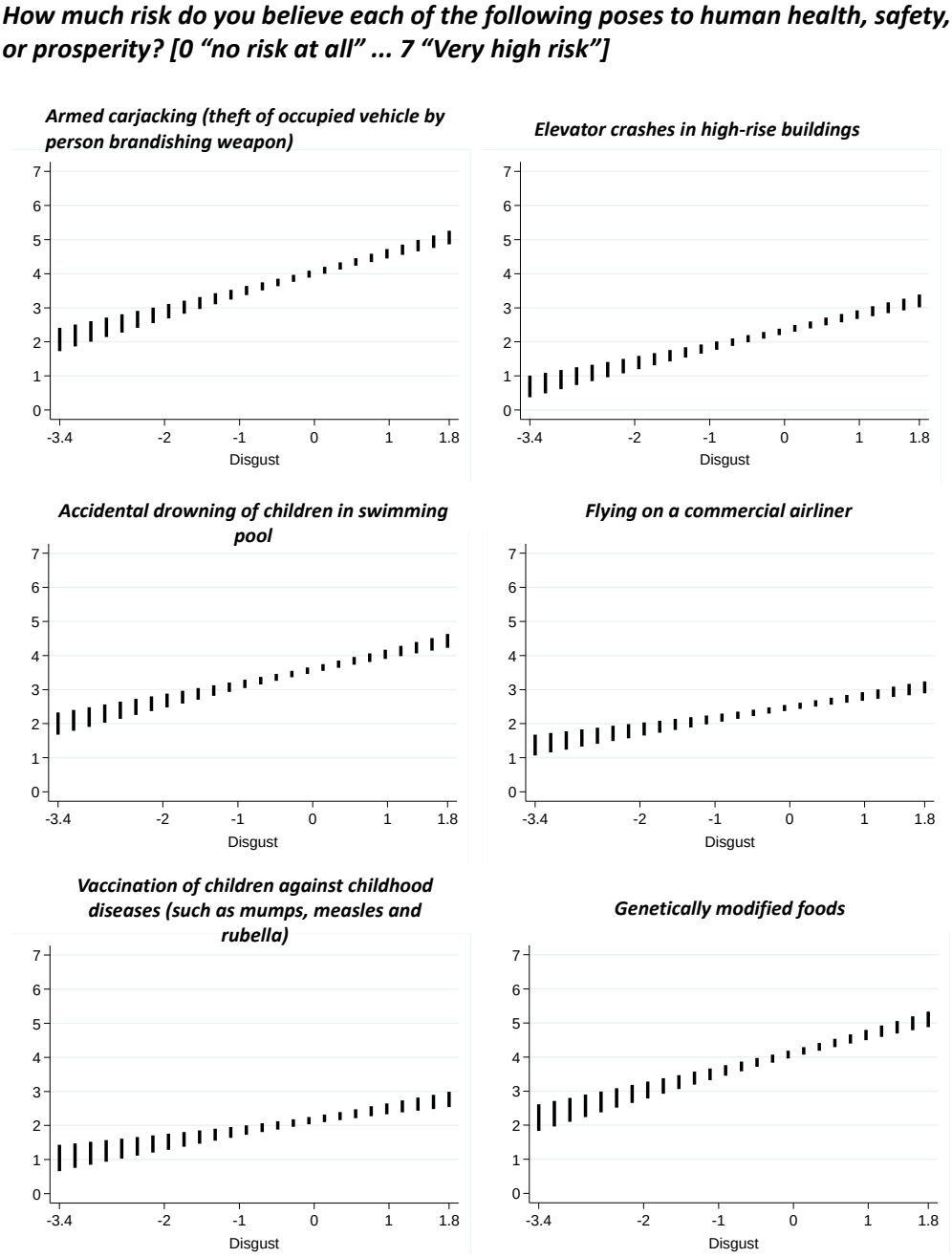

Figure 7. Item response profiles for select disgust-unrelated risks, plus profiles for childhood vaccinations and GM foods. Derived from linear regression. Black bars reflect 0.95 confidence intervals.

b. Vaccine and ISRPMs. The ISRPM battery generated a similar result (Table 6). ISRPMs that were modestly correlated with PDS included the disgust-related ones of "legalization of prostitution" ($r = 0.27$, $p < 0.01$), "pornography" ($r = 0.24$, $p < 0.01$), and "unlawful entry of immigrants into the United States" ($r = 0.24$, $p < 0.01$). Obediently, many disgust-unrelated ISRPMs were less strongly associated with PDS: e.g., "global warming" ($r = 0.03$, $p = 0.10$); "commercial monitoring of private internet activity

to collect consumer marketing data" (r = 0.15, p < 0.01); and "raising taxes for persons in the highest-income tax bracket" (r = 0.05, p = 0.11).

"[V]accination of children against childhood diseases (such as mumps, measles and rubella)"—the vaccination ISRPM item—scored 25th of the 34 items in the battery. The correlation with PDS (r = 0.17, p < 0.01) was weak to moderate.

The most informative element of this comparative approach, however, was the size of the vaccination risk perception/PDS correlation, on the one hand, and the size of the correlations between PDS and myriad activities that no one would plausibly suspect of being disgust-related, on the other. It's not very plausible, for example, to believe that "elevator crashes in high-rise buildings" or the "accidental drowning of children in swimming pools" vary in relation to disgust sensibilities, yet the correlation with PDS (r = 0.28, p < 0.01; r = 0.27, p < 0.01, respectively) was markedly higher than the one between PDS and vaccine risk perceptions. Also comparable but still higher were the risks associated with "accidents occurring in the workplace" (r = 0.18, p < 0.01), and "flying on a commercial airliner" (r = 0.21, p < 0.01). If one takes at face value the proposition that PDS reliably distinguishes disgust-related risk perceptions from disgust-unrelated ones, then these results cast serious doubt on the claim that vaccine risk perceptions is being driven by disgust.

Risk source	*r*	*p*-val
CARJACK	**0.31**	**< 0.01**
TERROR	**0.31**	**< 0.01**
MASSHOOT	**0.30**	**< 0.01**
NUKERISK	**0.29**	**< 0.01**
ELEVATOR	**0.28**	**< 0.01**
POWER	**0.27**	**< 0.01**
PROSTRISK	**0.27**	**< 0.01**
GMFRISK	**0.27**	**< 0.01**
KIDPOOL	**0.27**	**< 0.01**
IRAN	**0.25**	**< 0.01**
PORNRISK	**0.24**	**< 0.01**
IMMIGRISK	**0.24**	**< 0.01**
DRONES	**0.23**	**< 0.01**
CELL	**0.22**	**< 0.01**
WASTE	**0.22**	**< 0.01**
XRAY	**0.22**	**< 0.01**
AIRTRAVEL	**0.21**	**< 0.01**
BEEF	**0.21**	**< 0.01**
CIGRISK	**0.21**	**< 0.01**
FLOURIDE	**0.20**	**< 0.01**
FOODCOLOR	**0.20**	**< 0.01**
HPV	**0.18**	**< 0.01**
ACCIDENTS	**0.18**	**< 0.01**
AI	**0.17**	**< 0.01**
VACRISK	**0.17**	**< 0.01**
SOCSEC	**0.17**	**< 0.01**
AIRPOLLUTION	**0.17**	**< 0.01**
SACHARINE	**0.17**	**< 0.01**
GOOGLESPY	**0.15**	**< 0.01**
MARYJRISK	**0.12**	**< 0.01**
FRACKING	**0.07**	**< 0.05**
HIGHTAX	**0.05**	**0.11**
GWRISK	**0.03**	**0.10**
LOOSEREG	**0.00**	**0.98**

Table 6. Correlations between PDS and ISRPM items. N = 1226. Colors reflect hypothesized relation of indicated item to disgust sensitivity (Table 2).

c. GM-food-risk perceptions and ISRPMs. What complicates this analysis, however, was the uneven responsiveness of PDS to risk perceptions that on theoretical grounds seemed most likely to be disgust-related and disgust-unrelated. The nature of this anomaly is most readily observed in the GM-food risk perception item in the ISRPM battery.

	factor 1	factor 2	factor 3	factor 4
TERROR			0.65	0.31
NUKERISK	0.44	0.33	0.41	
GMFRISK	**0.63**			
HIGHTAX		-0.65		
PORNRISK	0.35		0.43	
MASSHOOT		0.31	0.60	
CARJACK			0.65	
ACCIDENTS		0.33	0.41	
LOOSEREG		0.45		0.32
AIRTRAVEL	0.40		0.43	
SOCSEC				0.38
CIGRISK		0.37	0.33	
XRAY	0.61			
FLOURIDE	0.65			
AIRPOLLUTION		0.71		
WASTE	0.30	0.47		0.35
IRAN			0.53	0.39
POWER	0.56		0.36	
CELL	0.64			
FOODCOLOR	0.66			
FRACKING		0.73		
AI	0.41			0.34
GOOGLESPY	0.31			0.37
SACHARINE	0.61			
MARYJRISK		-0.42	0.36	
DRONES	0.31			0.38
VACRISK	**0.58**			
ELEVATOR			0.61	
BEEF	0.58	0.31		0.37
KIDPOOL			0.53	
PROSTRISK			0.52	
IMMIGRISK		-0.59	0.34	0.35
HPV	0.65			
GWRISK		0.81		
Eigenvalue	5.43	4.31	4.20	1.54
R^2	0.34	0.27	0.27	0.10

Table 7. Factor analysis of ISRPM items. Principal factors, orthogonal rotation. Loadings < 0.30 suppressed.

The correlation between the "genetically modified foods" ISRPM and PDS was 0.27. Tied for sixth on the 34-item battery, this degree of association was equivalent to the correlations between PDS and "legalization of prostitution" and higher than the ones observed between PDS and "unlawful entry of immigrants into the United States" and "pornography" (both $r = 0.24$, $p < 0.01$), respectively. The correlation between "genetically modified foods" and PDS was higher than the one observed between PDS and "exposure to second-hand cigarette smoke" ($r = 0.21$, $p < 0.01$), "use of artificial sweeteners in diet soft drinks" ($r = 0.17$, $p < 0.01$), and "artificial food colorings" ($r = 0.20$, $p < 0.01$), not to mention "legalization of marijuana" ($r = 0.12$, $p < 0.01$), all of which are plausibly disgust-related. On this basis, one might reasonably infer that concern over GM-food consumption *is* linked to pathogen disgust sensitivity.

The problem is that if one takes this approach, one must conclude the same about myriad other risk sources that on theoretical grounds do not seem to partake of disgust (Table 6 & Figure 7). The three ISRPM items that had the highest correlation with PDS—"armed carjacking (theft of occupied vehicle by person brandishing weapon)" ($r = .31$, $p < 0.01$), "terrorist attacks inside the United States" ($r = .31$, $p < 0.01$), and "mass shootings in public places" ($r = 0.30$, $p < 0.01$)—are all ones that it is hard to believe reflect disgust sensibilities. The same is true for number five on the list—"elevator crashes in high-rise buildings" ($r = 0.28$, $p < 0.01$). This relationship. of course, is equivalent to the one between PDS and GM foods. The same goes for the relationships between PDS and "accidental drowning of children in swimming pools" ($r = 0.27$, $p < 0.01$) and "flying on a commercial airliner" ($r = 0.21$, $p < 0.01$).

To try to improve the clarity of these results, factor analysis was again performed, this time on the ISRPMs (Table 7). The results were not particularly enlightening.

The ISRPM measures formed four factors with eigenvalues equal to or greater than one. Both "vaccination of children against childhood diseases" (0.58) and "genetically modified foods" (0.63) loaded on the first factor, which included an eclectic set of risk-sources, from "development of 'artificially intelligent' computers capable of reprogramming themselves based on automated information search and experience" (0.41) to "privately owned drones" (0.31), from "fluoridation of drinking water" (0.65) to "flying on a commercial airliner" (0.40). The correlation between this factor and PDS was $r = 0.24$, $p < 0.01$.

PDS correlated most strongly ($r = 0.39$, $p < 0.01$) with the third. That factor comprised moderate to heavy loadings with many of the disgust-related ISRPMs, including "legalization of prostitution" (0.52), "pornography" (0.43), "unlawful entry of immigrants into the United States" (0.34), and "legalization of marijuana" (0.36). The GM food ISRPM, however, did *not* load meaningfully on this factor (0.06). Nor did the vaccine ISRPM (0.14).

One might reasonably infer on the basis of the factor analysis, then, that GM food risk perceptions are *not* an indicator of a latent pathogen-disgust sensitivity.

The reason to refrain from treating the factor analysis as decisive evidence for this conclusion, however, is that *none* of the factors neatly distinguished between disgust-related and disgust-unrelated ISRPMs. Like the first factor, the third promiscuously combined disgust-related and disgust-unrelated risk sources. "Accidental drowning of children in swimming pools" (0.53) loaded on this factor, for example. So did "accidents occurring in the workplace" (0.41) and "elevator crashes in high-rise buildings" (0.61).

The truth of the matter is that *none* of the identified factors neatly distinguished between disgust-related and disgust-unrelated risk sources. Accordingly, nothing particularly edifying can be inferred from which of the factors GM food—or childhood-vaccine risk perceptions, for that matter—loaded on.

3.3. Poking a bit at PDS

The analysis so far has presupposed that PDS is a valid measure of pathogen disgust sensitivity. Nevertheless, the affinity between the scale and so many disgust-unrelated risks—from flying on commercial airliners to riding elevators in high-rise buildings to the drowning of children in swimming pools—furnishes at least some reason to question that assumption. This section considers the possibility that PDS measures risk sensitivity generally, and how this possibility might affect the analyses so far presented.

a. Explaining PDS. For this purpose, the ISRPMs were used to form scales, the validity of which was based on theoretical considerations and face validity:

If PDS is valid, one would presumably expect it to be most strongly correlated with "Pathogenic," the risk-perception scale formed by summing the ISRPMs that relate to ingested substances. PDS should be correlated substantially more with Pathogenic than with "Generic," the scale formed by summing the ISRPMs of a motley collection of risk sources that are disgust-unrelated.

scale	**items**	**Cronbach's α**
"pathogenic"	XRAY, FLOURIDE, BEEF, SACHARINE, FOOD-COLOR CELL, POWER	0.86
"deviancy"	MARYJRISK, PROSTRISK, PORNRISK	0.74
"environmental"	GWRISK, NUKERISK, AIRPOLLUTION, WASTE, FRACKING	0.82
"generic"	ELEVATOR, KIDPOOL, CARJACK, ACCIDENTS, MASSHOOT	0.80

Table 8. Risk-concern scales.

But in fact, PDS had a much tighter connection to Generic than Pathogen. This is illustrated by the analyses reported in Table 9 & Table 10.

	pathogenic	deviancy	environment	generic
	0.30	**0.25**	**0.23**	**0.37**
	(10.45)	(8.65)	(6.79)	(-13.28)
R^2	0.09	0.06	0.04	0.13
BIC	6389.92	6431.82	6123.47	6320.49
BICΔ		+42.10	-266.45	-68.71

Table 9. Model fit determined by BIC differentials. Dependent variable is PDS**. Bolded** denotes that predictor coefficient is significant at $p < 0.05$. Lower value BIC models fit the data better than ones with higher BICs. The BIC differentials for "deviancy," "environment," and "generic" imply that the data is astronomically more consistent with a model that posits that "environment" and "generic" account for variation in the PDS scale than does the "pathogenic" scale (Raftery 1995; Wagenmakers 2007).

Table 9 compares the BIC scores of opposing models that attribute disgust sensitivity only to one scale at a time. The difference in BICs scores implies that a model that posits PDS is explained *only* by Generic is orders of magnitude more consistent with the data than is a model that posits PDS is explained *only* by Pathogenic (Raftery 1995).

	b		sr^2
pathogenic	**0.12**	(3.17)	**0.01**
deviancy	**0.12**	(3.64)	**0.01**
environment	0.00	(-0.05)	0.00
generic	**0.26**	(7.11)	**0.04**
N	1135		
R^2	0.16		

Table 10. Model fit determined by squared semi-partial coefficients. Dependent variable is PDS; "*b*" reflects unstandardized beta coefficient, "sr^2" squared semi-partial coefficients. The latter convey the contribution that indicated predictor makes to overall model R^2 independent of the contribution made by the other predictors (Cohen, Cohen, West & Aiken 2003). **Bolded** denotes that the indicated predictor or squared semi-partial correlation is significant at $p < 0.05$.

The analysis in Table 10 regresses PDS on all the scales simultaneously. The squared semi-partial coefficients (sr^2) convey how much each of the scales uniquely contributes to overall variance explained (R^2) independently of the other predictors and their covariance with the predictor in question (Cohen, Cohen, West & Aiken 2003). The analysis implies that Generic—the generalized fear scale—explains over 4x as much variance in pathogen disgust sensitivity as does Pathogenic.

These results ought to be a matter of concern for researchers who believe PDS is truly measuring disgust. The factor-analysis result is more consistent with the infernce that PDS is measuring a generalized risk sensitivity—one that would, for example, result in fear of flying or riding in elevators in the new World Trade Center, in addition to submitting to vaccination and consuming GM foods.

b. Interactions between PDS and right-left outlooks. Still another ad hoc test supports this conclusion. It consists in observing the interaction of PDS and political outlooks in relation to controversial risk topics.

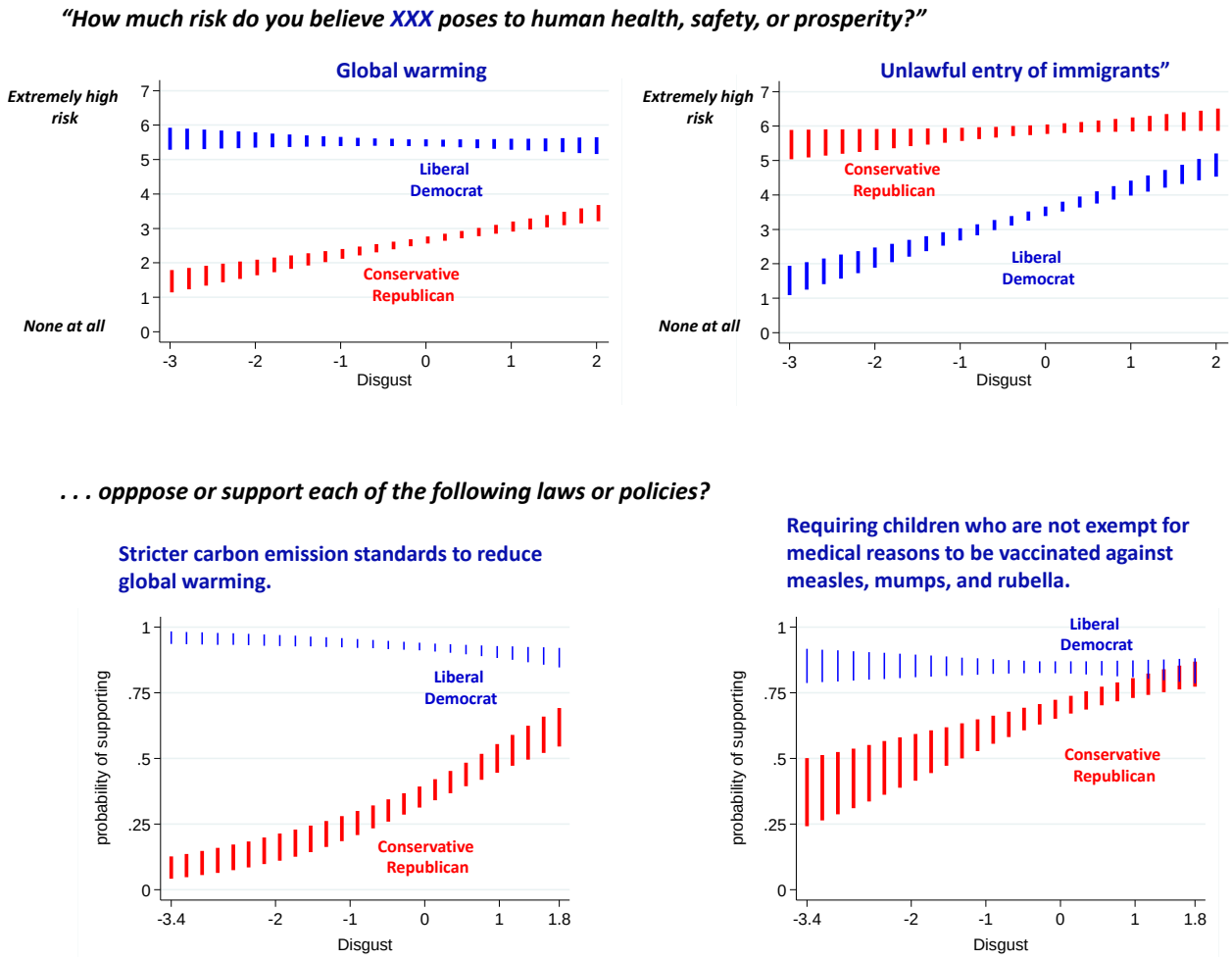

Figure 8. Interaction of PDS and political outlooks in relation to culturally polarized risk sources. Top panels derived by linear regression, bottom by ordered logistic regression, in which predictor values were set to reflect reactions of individuals scoring +1 SD and -1 SD respectively on the composite political-outlook scale. In bottom panels, "probability of supporting" is aggregate probability of "slightly," "moderately," and "strongly" supporting. Colored bars reflect 0.95 level of confidence.

Figure 8 shows how increases in disgust sensibilities influence risk perceptions conditional on subjects' political outlooks. The patterns are genuinely baffling. In each case, high disgust sensitivity predicts that individuals will form risk perceptions more in line with the position held by their partisan rivals than with the one held by their disgust-inured partisan peers.

It is hard to fathom how or why high disgust sensitivity would mitigate risk polarization if PDS were really measuring what it is supposed to. If PDS in truth measures a generic risk sensitivity, howev-

er, the patterns would make perfect sense: regardless of the political resonances of the issue in question, people who are high in disgust sensitivity are more prone to form a risk-concerned posture toward it.

c. So . . .? How does *this* analysis contribute to understanding the asserted link between disgust sensitivity and fear of vaccines and fear of GM foods? The answer is pretty simple. If not lacking completely in the power to identify disgust-sensitive reactions to stimuli, PDS remains *over*-sensitive to a general propensity to see all manner of risks as high. Accordingly, a correlation grounded in PDS is an unstable foundation on which to build the claim that disgust sensitivity explains a particular risk perception. For in such a situation, the data will always be equally if not more consistent with the inference that vulnerability to the risk perception in question (here GM foods or childhood vaccines) is being driven by a generalized fear of hazards that have nothing to do with disgust.

4. Discussion and Conclusion

In assessing risk perceptions, simple correlations can be misleading. Bare null-hypothesis testing doesn't in itself support inferences without benchmarks to help interpret the uniqueness and magnitude of observed "significant" correlations.

This paper supplied benchmarks for appraising the relationship between pathogen disgust sensitivity and perceptions of vaccine and GM food risks. With respect to both, the correlations with an established disgust-sensitivity scale were no greater than the relationships between that scale and myriad risks that were unrelated to disgust, such as the danger of a crash of a commercial airliner or the catastrophic malfunctioning of an elevator in a high-rise building.

In addition, the analyses revealed at least some reason to doubt the discriminant validity of one of the disgust measure that is being used in the study of childhood-vaccine and of GM-food risk perceptions. The conventional PDS scale, it turns out, is even better for predicting who will worry about carjacking and mass shootings than it is for predicting who will worry about the hazards of consuming food additives or being exposed to noxious wastes, not to mention who will be afraid of vaccines and GM foods.

Obviously, this is only one study of many examining the sources of variance in these risk perceptions. A thoughtful reader ought to weigh all of them in forming an opinion, which itself should be open to revision as new evidence arises. We submit, however, that the weight of the evidence presented here ought to be placed on the side of the balance suggesting that disgust is not a meaningful influence on GM-food and vaccine risk perceptions at the general population level.

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