COVID-19, national culture, and privacy calculus: factors predicting the cross-cultural acceptance and uptake of contact-tracing technologies

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Funding and acknowledgements

Data collection in Australia was supported by anonymous philanthropic funding to the Peter Doherty Institute for Infection and Immunity to S.Dennis.

Data collection in Germany was funded by the planning grant of the Volkswagen Foundation to R.Hertwig, S.Lewandowsky, and S.Herzog (Initiative "Artificial Intelligence and the Society of the Future"). S.Lewandowsky was supported by a Research Award from the Humboldt Foundation in Germany while this research was conducted. S.Lewandowsky also received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 964728 (JITSUVAX).

Data collection in Taiwan was supported by the National Science and Technology Council (NSTC), Taiwan, the Republic of China, grant number no. 110-2321-B-006-004 and 111-2321-B-006-008 awarded to C-T.Yang., & S.Hsieh.

Data collection in the United Kingdom was supported by the Elizabeth Blackwell Institute, University of Bristol, with funding from the University's alumni and friends.

Data collection in Spain was supported by funding from Leeds University Business School, University of Leeds to Y.Okan, who was in part supported, by a Population Research Fellowship awarded by Cancer Research UK (C57775/A22182).

Data collection in Italy and Japan was supported by funding from the School of Psychological Sciences, the University of Melbourne, and provided to Y.Kashima.

Data collection in the United States of America was funded through discretionary funding provided to R.Goldstone.

Data Availability Statement

Data, code, and materials for this study are available through the Open Science Framework (OSF) at osf.io/ejkmz.

Abstract

The use of information technologies for the public interest, such as COVID-19 tracking apps that aim to reduce the spread of COVID-19 during the pandemic, involve a dilemma between public interest benefits and privacy concerns. Critical in resolving this conflict of interest are citizens' trust in the government and the risks posed by COVID-19. How much can the government be trusted to access private information? Furthermore, to what extend do the health benefits posed by the technology outweigh the personal risks to one's privacy? We hypothesise that citizens' acceptance of the technology can be conceptualized as a calculus of privacy concerns, government trust, and the public benefit of adopting a potentially privacy-encroaching technology. The importance that citizens place on their privacy and the extent to which they trust their governments vary though out the world. The present study examined the public's privacy calculus across nine countries (Australia, Germany, Italy, Japan, Spain, Switzerland, Taiwan, the United Kingdom, and the United States) focusing on social acceptance of contact-tracing technologies during the COVID-19 pandemic. We found that across countries, privacy concerns were negatively associated with citizens' acceptance of the technology, while government trust, perceived effectiveness of the technology, and the health threats of COVID-19 were positively associated. National cultural orientations moderate the effects of the basic factors of privacy calculus. In particular, individualism (value of the individual) amplified the effect of privacy concerns, whereas general trust (trust in the wider public) amplified the effect of government trust. National culture therefore requires careful attention in resolving public policy dilemmas of privacy, trust, and public interest.

Keywords: COVID-19; contact tracking technologies; public health; privacy

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Killing over 6 million, infecting more than 464 million people (World Health Organization, 2022), and adversely affecting the lives and livelihoods of countless others, the novel coronavirus (SARS-CoV-2) and the disease it causes (COVID-19) are a global health and societal threat (Kashima et al., 2021). Although vaccines have proven effective at reducing the health impacts of recent COVID-19 variants (Andrews et al., 2022), as new infectious variants emerge, citizens and governments need to adopt innovative and technologically-supported public health measures to cope with the speed of viral spread (e.g., Bedford et al., 2020; Gelfand et al., 2021; Hale et al., 2021; Ribeiro-Navarrete et al., 2021). Widely discussed and adopted are measures relying on mobile contact-tracing technologies (CTTs; Ahmed et al., 2020; Du et al., 2020; Elkhodr et al., 2021).

CTTs complement manual contact-tracing conducted by health authorities, allowing for rapid infectious modelling and the potential for notifying users through phone applications or a centralized health authority when a user has been in close physical proximity to an infected individual (Elkhodr et al., 2021). Although CTT distributors claimed their potential to reduce the spread of SARS-CoV-2, and improve economic recoveries and public health (Ahmed et al., 2020; Elkhodr et al., 2021; Garrett, White, et al., 2021), serious concerns have been raised about their potential privacy risks, specifically the monitoring of one's locations, contacts, and activities (Ahmed et al., 2020; Elkhodr et al., 2021; Fahey & Hino, 2020; Ribeiro-Navarrete et al., 2021; Zastrow, 2020).

The public acceptance of privacy-encroaching CTTs are, in part, thought to be determined by a 'privacy calculus' (Culnan & Armstrong, 1999; Dienlin & Metzger, 2016; Dinev & Hart, 2006; Kehr et al., 2015), where the perceived privacy risks of CTTs are weighed against the perceived health and societal benefits of reducing the spread and incidence of COVID-19 (Garrett, White, et al., 2021; Garrett, Wang, et al., 2021; White et al., 2021; Kozyreva et al., 2021; Lewandowsky et al., 2021; Garrett et al.,

2022). The degree of privacy risk arising from the use of CTTs stems not only from *privacy concerns* inherent in the technology, but also from *trust* in the government to effectively operate and/or regulate the use of CTTs without violating people's privacy (Culnan & Armstrong, 1999; Dienlin & Metzger, 2016; Dinev & Hart, 2006; Kehr et al., 2015). Indeed, government trust has previously been shown to enhance citizen acceptance of surveillance technologies in general (Davis & Silver, 2004; Thompson et al., 2020; Trüdinger & Steckermeier, 2017; Zarouali et al., 2022) and CTT uptake in particular (von Wyl et al., 2021).

As outlined by the Health Belief Model (Abraham & Sheeran, 2015; Becker & Maiman, 1975; Becker et al., 1977; Hochbaum, 1958), the benefits of preventive measures such as CTTs, depends on their perceived *technological effectiveness* to reduce the spread of COVID-19, and the public's perception of the threat and harm that emanates from COVID-19 itself — the *perceived COVID threat* (see Figure 1). In reducing the perceived threat of the COVID-19 pandemic, these benefits have traded off privacy concerns and become associated with higher CTT acceptance in European, Asian, and North American countries (Chan & Saqib, 2021; Fox et al., 2021; Garrett et al., 2022; Trang et al., 2020; Velicia-Martin et al., 2021; Walrave et al., 2021; Zarouali et al., 2022). However, privacy concerns are not necessarily comparable across cultures.

The importance of one's privacy and the weight it's given in the privacy calculus may vary across cultures (e.g., Capurro, 2005; Moore, 2003; F. D. Schoeman, 1984; Westin, 1968). Privacy can be understood as concern over limiting or controlling access to information about oneself (Capurro, 2005; F. Schoeman, 1984). Individualism – the extent to which cultural emphasis is placed on the individual person independent of collectives to which he or she may belong – is one such cultural factor that can affect perceptions and attitudes towards privacy. The balancing of such concerns against the common good may be a moderating factor in the acceptance and uptake of CTTs. For example, in Western individualist cultures such as Germany and Australia, the value of an individual's inner private self is more salient, and therefore may be weighed as more important in the privacy calculus, than in East Asian cultures like Taiwan, that are

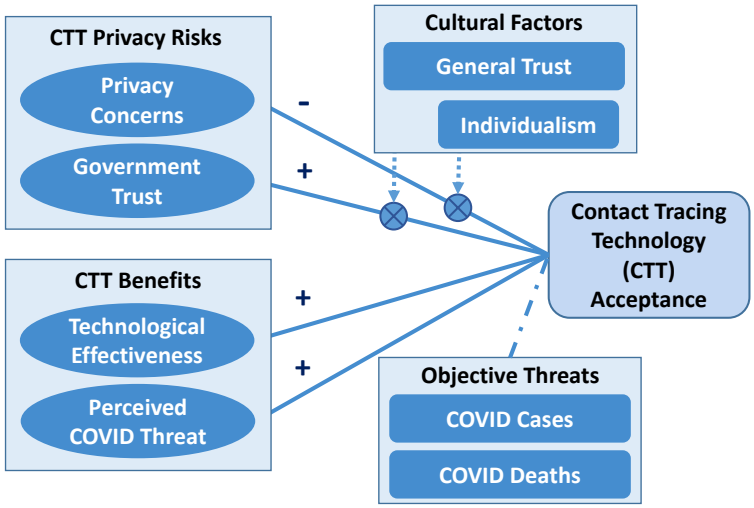

Figure 1. Theoretical model of privacy calculus for the uptake of contract tracing technologies. Solid lines indicate predictive effects on CTT acceptance, with "+" indicating a positive effect for and "-" indicating a negative effect. The cross within the circle, ⊗, indicates the existence of moderating factors (i.e., interaction effects) with the dotted lines with arrows indicating cross-level effect of cultural factors. The dashed/broken line indicates controlled factors (i.e., covariates) that are expected to have a predictive effect on CTT acceptance but that are not the main focus of our analyses.

more collectivistic (e.g., Hofstede, 1984; Kashima et al., 2021; Markus & Kitayama, 1991; Rhee et al., 1995; Triandis, 1989). As such, privacy concerns may have weaker effects on the public acceptance of CTTs in less individualist cultures (see Figure 1).

Consistent with this perspective, Kim & Kwan (2021) found that more individualist American respondents both accepted CTTs less and had greater privacy concerns than their South Korean counterparts. Similarly, Thompson et al. (2020) found Australians weighted privacy concerns more than their less individualist Sri Lankan counterparts in accepting government surveillance. Of course, these two-country comparisons should be extended to multiple countries to test the generalizability of this hypothesis.

Beyond individualism, other aspects of national culture may also influence the extent to which government trust can alleviate privacy concerns. The effectiveness of CTTs depends on citizens' willingness to use the technology and the *general trust* they share in others to do the same (e.g., Yamagishi, 2017; Yamagishi & Yamagishi, 1994). Government surveillance may be tolerated only if governments can be trusted not to

abuse personal information *and* fellow citizens can be trusted to use the CTTs. In this way, general trust and government trust may interact and moderate CTT acceptance. Therefore, in societies where general trust is greater, government trust may carry a greater weight in citizens' acceptance of CTTs (Figure 1). To the best of our knowledge, this general trust hypothesis has not been previously studied with regards to CTTs.

The literature motivates an account of how cultural factors of general trust and individualism may mediate privacy concerns and government trust with regards to CTT uptake for COVID-19. We have detailed how the technological benefits of CTTs and the perceived threat of COVID-19 may influence CTT uptake, beyond the objective threat posed by COVID-19 cases and deaths. To our knowledge, no cross-cultural study has examined how these factors combine and contribute to CTT uptake across cultures. Here, we tested these hypotheses with a sample of more than 30,000 respondents from nine countries in Asia, Europe, North America and Oceania (Australia, Germany, Italy, Japan, Spain, Switzerland, Taiwan, the United Kingdom, and the United States).

Method

Ethics was obtained for data collected in Australia and Japan from the Melbourne School of Psychological Sciences Human Ethics Sub-committee (approval 1955555), in Germany from the Institutional Review Board of the Max Planck Institute for Human Development (approval L2020-4), and in Taiwan from the Ethics Committee of the Department of Psychology at the National Cheng Kung University (approval 108-072). Data collected in Switzerland was carried out in accordance with the ethics regulations of the Faculty of Arts and Social Sciences at the University of Zurich. Data collected in the United Kingdom and Spain received ethics approval from the University of Bristol (approval 103344) and data collected in the United States received ethics approval from the Indiana University institutional review board (approval 2001686712). Participants in the United Kingdom and United States were recruited through Prolific Academic and reimbursed 85 pence and 80 pence, respectively, per 10-minute survey. Remaining participants were reimbursed through gift cards or points programs per their individual

agreements with third-party recruitment services Dynata (Australia), Lucid (Germany, Spain, Switzerland), Gosurvey (Taiwan), and Cross Marketing (Japan).

Table 1 displays participant numbers and demographics collected across countries. One-to-four waves of data were collected in each of nine countries, totalling 31,048 participants (50% women, 49% men, 1% other), of which 26,487 were retained after screening for survey completion. A subset of the national data from Australia (Garrett, White, et al., 2021), Taiwan (Garrett et al., 2022), the United Kingdom (Lewandowsky et al., 2021), and Germany (Kozyreva et al., 2021) have been published, however, these partial analyses did not include any country level statistics.

Table 1
Participant samples, demographics, and online recruitment platforms by country.

Country		Italy	Taiwan	Australia	United Kingdom	Spain	Germany	Switzerland	Japan	USA
N.Participants		505	6000	4089	4246	2954	6924	1665	1227	2046
N.Retained		501	5999	3662	4220	2277	5688	1126	1082	1932
N.Waves		1	4	4	3	2	4	1	1	1
Age (SD)		27 (8)	41 (12)	46 (17)	46 (15)	47 (16)	46 (17)	48 (17)	45 (17)	46 (16)
Gender (%)	Man	56	50	50	49	50	50	46	48	48
	Woman	43	50	49	51	50	50	54	52	51
	Other	0.4	0.1	0.1	0.1	0.2	0.5	0.3	0	0.7
	Prefer not to say	0.4	<0.1	0.3	<0.1	0.3	0	0	0	0.2
Education (%)	<H.School	3.4	1.1	9.7	16	13	18	14	2.5	0.7
	≥ H.School	52	14	38	18	42	60	57	38	41
	University	44	85	52	65	45	22	29	54	59
Recruitment		Prolific	Gosurvey	Dynata	Prolific	Lucid	Lucid	Lucid	Cross-Marketing	Prolific

Figure 2 illustrates the survey design used across countries; items denoted by an asterisk were used in the current analysis. The survey asked gender (male, female, do not wish say, other), age (years), and education (not completing high school, completing high school, or above high school), before querying participants' perception of 'COVID threats' and their experience with COVID-19 (Table 2). Participants were then presented a description of a contact-tracing technology. When surveys were conducted before a technology had been introduced in each country, a hypothetical scenario was described: telecommunication tracking with no possibility to opt-out, a voluntary government App, or a voluntary Bluetooth App developed by Apple and Google (see Supplementary Materials for full descriptions). When a technology had been introduced in a country, only a description of the actual in-use technology was queried (e.g., Australia's COVIDSafe or Germany's Corona-Warn-App; see Supplementary Materials). Each participant viewed only one hypothetical or one real-world scenario description.

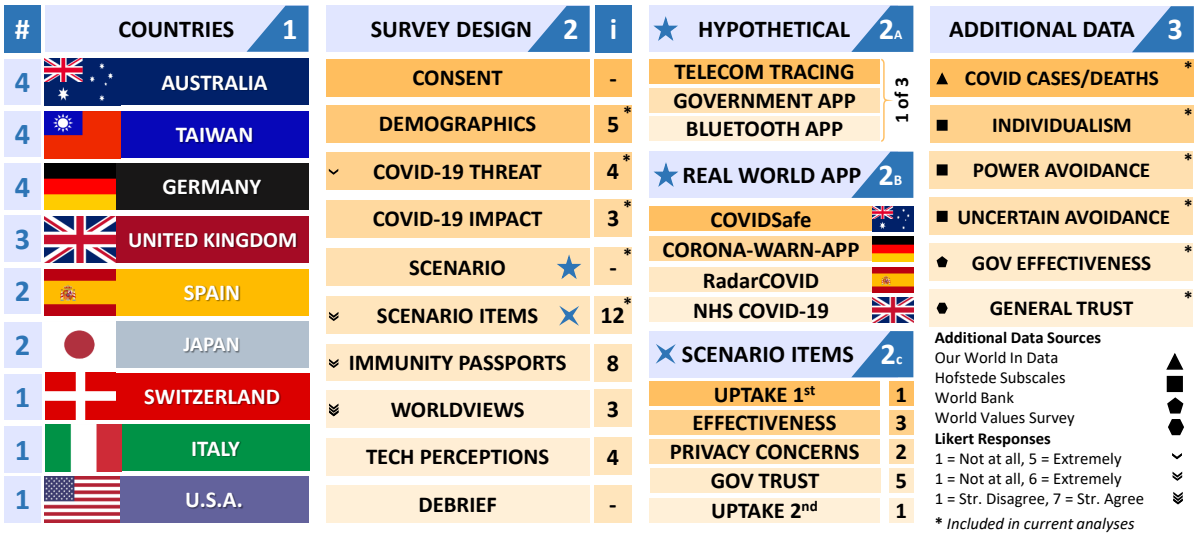

Figure 2. From left to right: Sampled waves (#), sampled countries (1), survey design (2), number of items (i), scenario description and primary measures (2a – 2c), and additional data added to the end of each survey (3). * Items included in the current analysis.

Table 2

Survey item categories (displayed in Figure 1) and item descriptions for items used in the current analyses. Where appropriate, acceptance items were updated to assess real-world app uptake instead of hypothetical acceptance.

Survey Item	Survey Item Description
COVID threat 1	How harmful would it be for your health if you were to become infected COVID-19?
COVID threat 2	How severe do you think novel coronavirus (COVID-19) will be for the general population?
COVID threat 3	How concerned are you that you might become infected with COVID-19?
COVID threat 4	How concerned are you that somebody you know might become infected with COVID-19?
COVID impact 1	Did you become unemployed because of the COVID-19 pandemic?
COVID impact 2	Have you tested positive to COVID-19?
COVID impact 3	Do you know someone who has tested positive to COVID-19?
Scenario Acceptance 1	If the Government developed the described tracking app, would you download and use it?
Scenario item 1: Effectiveness	How confident are you that the described scenario would reduce your likelihood of contracting COVID-19?
Scenario item 2: Effectiveness	How confident are you that the described scenario would help you resume your normal activities more rapidly?
Scenario item 3: Effectiveness	How confident are you that the described scenario would reduce the spread of COVID-19?
Scenario item 4: Privacy	How sensitive is the data being collected?
Scenario item 5: Privacy	How serious is the risk of harm from the proposed scenario?
Scenario item 6: Trust	To what extent is only data necessary to achieve the purposes of the policy being collected?
Scenario item 7: Trust	How much do you trust that the tracking data will only be used to deal with the COVID-19 pandemic?
Scenario item 8: Trust	How much do you trust the privacy of each individual will be ensured?
Scenario item 9: Trust	How secure is the data that would be collected?
Scenario item 10: Trust	To what extent do people have ongoing control of their data?
Scenario Acceptance 2	If the Government developed the described tracking app, would you download and use it?

Immediately after reading a scenario, contact-tracing technology acceptability (or uptake in the case of real-world apps) was assessed (Yes vs No), followed by items assessing the technologies' perceived effectiveness, privacy concerns, and government trust, ending with a second query on the technology's acceptability to determine if attitudes changed following these questions (Table 2). The survey concluded with items querying neoliberal worldviews and technology perceptions (not analysed in this paper) and a participant debrief. Surveys were developed in English (available from

osf.io/sw7rq; Garrett, White, et al., 2021), translated by each research team to the country's dominant language, and back-translated to English to check equivalence.

Table 3 summarizes nation-level measures that were augmented to each national survey after data collection. They include national COVID-19 cases and deaths (Our World in Data, 2022), perceived Government effectiveness (The World Bank, 2021), general trust (method from Yamagishi, 2017, scores reflect the proportion of people from each country who responded "Trust completely" or "Trust somewhat" people you meet for the first time from the World Values Survey Wave 7 2017-2020), and national levels of individualism and uncertainty avoidance (Hofstede, 2001). Uncertainty avoidance was included as a robustness check on individualism; Krasnova et al. (2012) suggests uncertainty avoidance, rather than individualism, may explain differences in privacy concerns regarding the acceptance of social networking sites. This point is further addressed in the results.

Table 3
Additional data augmented to national surveys

Measure	Australia	Germany	Italy	Japan	Spain	Switzerland	Taiwan	UK	USA
Individualism	90	67	76	46	51	68	17	89	91
Power distance	38	35	50	54	57	34	58	35	40
Uncertainty avoidance	51	65	75	92	86	58	69	35	46
Government effectiveness	1.57	1.59	0.46	1.59	1.00	1.95	1.44	1.44	1.49
General trust	47.5	28.1	26.8	10.4	43.8	51.3	25.3	55	39.4

Results

Our data analysis strategy was as follows. First, we examined cross-cultural equivalence of the measures of the psychological constructs such as privacy concern (Van de Vijver & Leung, 1997, 2011) to ensure that comparisons between countries would be theoretically meaningful. If construct measures did not have comparable meanings across cultures, comparisons between country means and correlations would not be theoretically meaningful. Second, we conducted a series of preliminary analyses to select variables that capture objective levels of COVID-19 threats (e.g., case numbers and mortality), which we use to set the baseline of CTT acceptance. We included both COVID-19 cases and mortality. Citizens appear to be sensitive to COVID-19 mortality

in evaluating their governments' performance (Devlin et al., 2021). Third, we finalized a model of individual-level predictors of CTT acceptance (privacy concern, government trust, COVID threat, CTT effectiveness) while removing control variables that did not contribute to the prediction of CTT acceptance. Fourth, we added cultural-level variables such as individualism and general trust, and tested for their cross-level interaction effects on CTT acceptance.

Cross-Cultural Equivalence

We examined cross-cultural comparability of the measures of privacy concerns, government trust, COVID threat, and perceived CTT effectiveness. Cross-cultural equivalence is often conceptualized and tested within the framework of multigroup confirmatory factor analysis (Boer et al., 2018; Rutkowski & Svetina, 2014). At minimum, a theoretical construct of interest needs to have similar factor structures (configural equivalence). At the level of metric equivalence, the items have sufficiently similar factor loadings. At the scalar equivalence level, item intercepts need to be equivalent for the scale across cultures. In order to compare mean levels directly across cultures, scalar equivalence needs to be established; to compare correlations between variables across cultures, at least metric equivalence needs to be feasibly defended (Boer et al., 2018; Rutkowski & Svetina, 2014). Our analyses showed that we could not assume scalar equivalence; however, metric equivalence can be assumed. In other words, the means of these measures cannot be meaningfully compared across countries, but their correlations with the outcome variable (CTT acceptance) is interpretable and therefore our hypotheses can be tested. See Supplementary Material for further details.

Do Objective Levels of COVID-threats Predict CTT Acceptance?

We fit a generalized linear mixed model (logit) for CTT acceptance with maximum likelihood method. We included a random intercept for each wave of data collection nested under each country. Recall that CTT acceptance was assessed twice before and after responding to a battery of questions about respondents' perceptions about CTT technologies and privacy concerns. Because we were interested in their

considered responses about CTT acceptability, we report the results of the analyses for CTT acceptance assessed after the privacy questions were asked. We also report in Supplementary Materials the analyses for acceptance before those questions were asked.

Figure 3 reports the coefficients for the final model. CTTs are likely to be accepted if the respondent had a personal experience of contracting COVID-19 (COVID Positive Self), the respondent knew someone who contracted COVID-19 (COVID Positive Other), as cumulative deaths increased (Log Cum. Deaths; number of deaths expressed as a natural log of the percentage of the population) and cumulative cases decreased (Log Cum. Cases; number of cases expressed as a natural log of the percentage of the population), and if respondent received higher education (Linear and Quadratic components of the three levels; less than high school, high school, and university or higher)[1]. The same pattern of results was observed for both CTT acceptance measures (see Supplementary Material).

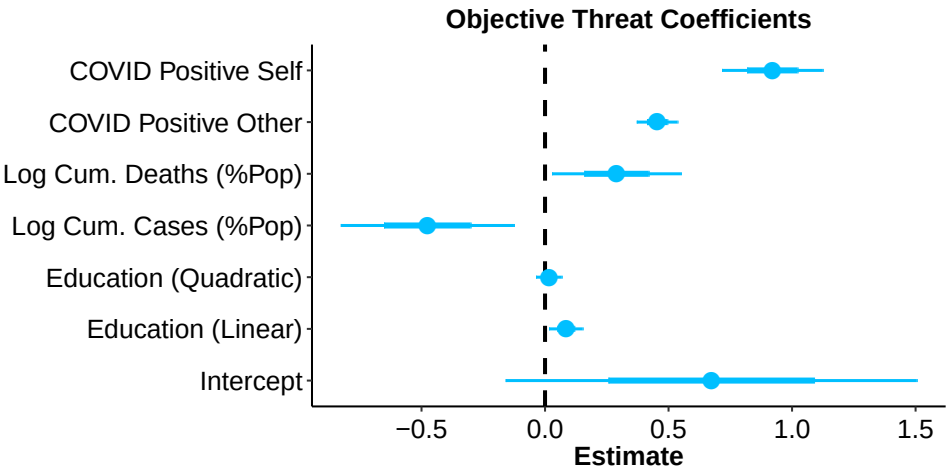

Figure 3. Coefficients for objective COVID-19 threats. Dependent variable: CTT Acceptance. %Pop: percentage of the national population.

Privacy Calculus for CTT Acceptance

After ascertaining that relatively objective levels of COVID-19 threats influence CTT acceptance, we added the predictors that capture the presumed privacy calculus: privacy concerns and government trust as well as perceived COVID health concerns and

[1] A linear but not quadratic increase in acceptance would indicate a continuous improvement with education that lacks clear educational thresholds.

perceptions of CTTs' effectiveness. We also included the factor that distinguishes different scenarios presented to the respondents in the surveys. Recall that in the waves before a CTT was deployed, different scenarios were presented to the participants, which described different types of CTTs that may be hypothetically deployed in the country (telecom tracing, government app, Bluetooth app), whereas the actually deployed technology was described in Australia, Germany, Spain, and the UK in later waves of data collection when one CTT (similar to Bluetooth scenario) was actually deployed. These different scenarios were dummy coded with the reference category of the telecom tracing technology — the scenario with the highest privacy risk. The final model including significant predictors is reported in Figure 4.

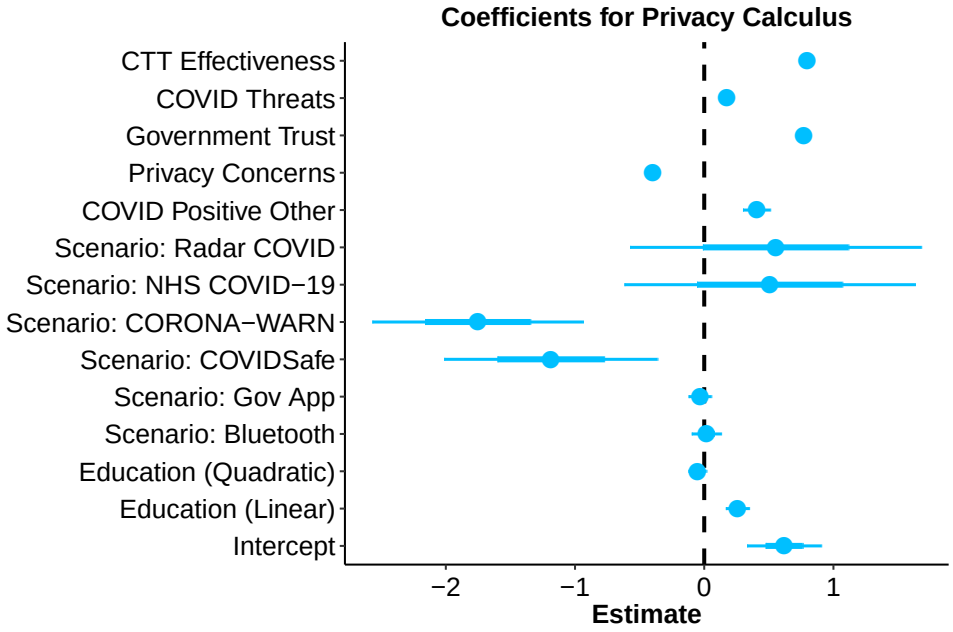

Figure 4. Coefficients for individual-level privacy calculus (Scenario: Radar COVID = Spanish; Scenario: NHS COVID-19 = UK; Scenario: CORONA-WARN = German; Scenario: COVIDSafe = Australia). Dependent variable: CTT acceptance. Note that some error bars are hidden by their markers.

In the final model with significant individual-level predictors, many of the objective indicators of COVID-19 threats were non-significant (i.e., cumulative cases, cumulative deaths, one's own COVID-19 infection status), suggesting that *perceptions* of COVID threats (COVID Impact) and CTT effectiveness (Effectiveness) are likely to capture these contextual variations. Only respondents' education and whether they

knew someone who was infected remained significant. It is also noteworthy that different types of hypothetical scenarios (government app or Bluetooth technology as opposed to the most privacy encroaching telecommunications technology) made no difference to CTT acceptance, implying a perceived equivalence between these technologies in terms of privacy. For CTTs actually deployed (and therefore measured by uptake), the Australian (COVIDSafe) and German (Corona-Warn) were downloaded less than the reference category was accepted, but Spanish (RadarCOVID) and UK (NHS COVID-19) uptake didn't differ. Notably, a privacy calculus was clearly at play: individual-level psychological variables — Perceived COVID threats and CTT effectiveness, as well as privacy concerns and government trust — predicted CTT acceptance beyond the control variables.

Cultural Shaping of the Privacy Calculus

Finally, we examined the role of cultural individualism and general trust in the privacy calculus. A cross-level interaction of individualism with privacy concern was first added to the individual-level baseline model in Figure 4. This addition improved the model fit relative to the baseline (Supplementary Material). We then added a cross-level interaction of general trust with government trust, which also improved the fit of the model (Supplementary Material). Table 4 reports the individual-level predictors and the cross-level interaction effects included in this model and the parameter estimates.

The results support the notion that privacy calculus for CTTs involves the consideration of privacy threats against health threats. On the one hand, people are more likely to accept CTTs when they feel greater COVID threats, but think the CTTs are more effective in combating the health risk. On the other hand, people are less likely to accept CTTs when they feel greater privacy concerns but more likely to accept them when they trust their governments more.

In support of the individualism hypothesis, the cross-level interaction effect of individualism with privacy concerns was negative and significant. In other words, when

Table 4
Generalized Linear Model of CTT Acceptance

	Coefficient	SE	z-value	p.
Intercept	.49	.23	2.08	.038
Education (Linear)	.27	.05	5.91	<.0001
Education (Quadratic)	-.06	.04	-1.71	.087
Bluetooth	-.01	.06	0.10	.919
Government App	-.04	.04	-0.98	.326
COVIDSafe (Australia)	-1.59	.16	-9.76	<.0001
CORONA-WARN (Germany)	-1.61	.15	-10.84	<.0001
RadarCOVID (Spain)	.47	.22	2.18	.029
NHS COVID-19 (UK)	.28	.19	1.45	.148
OtherCOVID	.42	.05	7.88	<.0001
Privacy Concerns	-.38	.02	-20.87	<.0001
Government Trust	.77	.02	38.53	<.0001
COVID Threat	.17	.02	7.94	<.0001
Effectiveness	.80	.02	41.95	<.0001
Individualism	-.12	.12	-1.00	.316
Individualism × Privacy Concerns	-.04	.01	-5.61	<.0001
General Trust	.24	.20	1.17	.242
General Trust × Government Trust	.05	.01	3.41	.001

individualism is higher, the coefficient for privacy concerns is even more negative. Therefore, privacy concerns have a greater dampening effect on the public acceptance of CTTs in more individualist cultures.

General trust moderates the effect of government trust. The slope of government trust was more positive in those cultures with higher levels of general trust. As hypothesized, the combination of trust in government and trust in fellow citizens enhances the public acceptance of CTTs.

It is also noteworthy that a country's general trust was highly correlated with its national experience with a totalitarian goverment at some point during the 20th century (in our sample, Germany, Italy, Japan, Spain; r = -.72, totalitarianism is associated with lower general trust; see Supplementary Material). We therefore explored the possibility that national experience of totalitarian governance may weaken the effect of government trust on CTT acceptance. When a totalitarian × government trust interaction was added to the above model, it did not improve the model fit significantly. However, when the totalitarian × government trust interaction *replaced* the general trust × government trust interaction, the totalitarian's interaction effect was significant. The effect of government trust was weaker in those countries with a

national experience of totalitarianism (Supplementary Material).

Additional Robustness Checks

In examining cross-cultural variations, it is important to explore other variables that may be able to explain the results. First, we examined whether Uncertainty Avoidance (Hofstede, 1984) — cultural differences in the extent to which people are concerned about uncertainties — may explain individualism's effect on the privacy calculus. As suggested by Krasnova et al. (2012), uncertainty avoidance rather than individualism, may explain the lower weight given to privacy concerns in the acceptance of social networking sites. This was researched in the context of a private-sector privacy issue and may not be relevant in the current context. Indeed, the addition of an uncertainty avoidance × privacy concern interaction did not improve the model fit.

Second, a cross-cultural study of public acceptance of government surveillance (Thompson et al., 2020) suggested that when a culture has a high level of power distance (i.e., tolerant of greater power differences; Hofstede, 1984), people are more likely to tolerate government surveillance and the potential of governments to control their lives. We tested for a power distance × privacy concern interaction effect; however, this again did not improve the model fit.

Third, as a final check, we used individual items instead of the scale for COVID threats because our test of its cross-cultural equivalence raised a potential issue. This did not change the results appreciably. These additional results are reported in greater detail in Supplementary Material.

Discussion

The COVID-19 pandemic is a threat to the lives and livelihoods of people around the world, and CTTs are a means to alleviate this public health risk. However, to be effective, people must be willing to use them. We found that acceptance of COVID-19 CTTs was determined by a form of privacy calculus, with national culture moderating how people weigh issues of trust and privacy. In a first, we show that general trust amplifies the impact of government trust and CTT acceptance, and that cultural

individualism amplifies the importance of privacy concerns, diminishing CTT acceptance. We further observed that acceptance increased with cumulative national COVID-19 deaths, and decreased with cumulative cases, implying that people weigh such risks in terms of *national deaths proportionate to national cases*. Acceptance also increased with personal experiences of COVID-19 infections — having been or having known someone who was infected.

As expected, privacy concerns and government trust are critical for the public acceptance of CTTs across cultures. Across the nine countries and regions around the world, citizens' concerns about their privacy tend to reduce the public acceptance of CTTs. However, citizens' trust in their government can substantially moderate these concerns. Although citizens are concerned about potential risks to their privacy, they are willing to accept CTT use when they trust their governments. Even if the CTTs are seen to be effective and the health threats of COVID-19 large, the dynamic interplay between privacy and trust are significant policy issues that require close attention.

Nevertheless, national culture needs to be taken into consideration in calibrating the importance of privacy and trust in governments' use of information and communication technologies for the public interest. Different aspects of national culture — individualism and general trust in particular — can influence the role of privacy concerns and government trust in the privacy calculus for the public interest. As hypothesized, individualism — cultural importance of the private self — amplified the effect of privacy concerns and concerns about controlling governments' access to one's personal information.

Independently of individualism, general trust and Government trust appear to interact when influencing public acceptance of CTTs. Presumably, government trust alone may not be able to counter people's privacy concerns entirely, unless fellow citizens can also be trusted to use CTTs appropriately. This implies that general trust may play a particularly important role when the effectiveness of public health measures is contingent on the general public's behaviors. For example, even if people trust their government to provide effective vaccines for a pandemic, if they do not trust their fellow

citizens to vaccinate, their acceptance of the vaccines may be undermined. This is because a majority of the public needs to be vaccinated before vaccines can effectively curtail the spread of the virus.

After controlling for the psychological determinants of CTT acceptance and cultural effects, acceptance of deployed CTTs varied across Australia, Germany, Spain, and the UK. Both Australians and Germans accepted and downloaded their governments' CTT less than the reference category (Telecom tracking, the most privacy encroaching scenario), whereas acceptance and uptake in the United Kingdom was similar to the reference category. By contrast, Spaniards were somewhat more accepting of their government's app than the Telecom tracing technology. This may be due to the Spanish App's description, which included clear details about its privacy protections. In alleviating privacy concerns about an information technology for the public interest, a clear communication of privacy protections measures may be useful.

Supplementary analysis on the role of totalitarian governance experience provided intriguing insights. As noted, the national experience of totalitarian governance during WWII appears to be highly correlated with general trust in the current sample of countries. Totalitarian governance may erode general trust within a country, which in turn may weaken the effect of government trust on citizens' acceptance of national public health initiatives such as CTTs. It is also possible that a totalitarian government may be elected in those countries with lower levels of general trust. Either way, a potential relationship between totalitarianism and general trust is an issue worthy of future investigation.

Although the present study provided insights into the public policy issues surrounding privacy concerns about governments' use of information technologies, it can be improved further. We included only nine countries and regions in Western Europe, North America, Oceania, and East Asia. A broader set of samples for investigation would be ideal. For example, our samples are from medium to low levels of power distance, and exclude those regions with high power distance such as South East Asia, South America, the Middle East, and Central and Eastern Europe (Hofstede, 2001).

The inclusion of these countries may provide a clearer picture about the role of power distance. Our measure of privacy concern may also be improved by including different facets of privacy issues.

When considering COVID-19 contact-tracing technologies, people balance epistemic access to their private self and the objective risks of COVID-19, against the trust they place in their Governments and fellow citizens. National culture moderates how people weigh issues of trust and privacy within their internal privacy calculus. Cultural individualism amplifies the importance of privacy concerns, and general trust amplifies the impact of government trust. Although focused on the threat of COVID-19, these findings may prove instrumental in rapidly and effectively developing national public health policies and technologies to combat future viral threats.

References

Abraham, C., & Sheeran, P. (2015). The health belief model. *Predicting health behaviour: Research and practice with social cognition models*, *2*, 30–55.

Ahmed, N., Michelin, R. A., Xue, W., Ruj, S., Malaney, R., Kanhere, S. S., ... Jha, S. K. (2020). A survey of covid-19 contact tracing apps. *IEEE access*, *8*, 134577–134601.

Andrews, N., Stowe, J., Kirsebom, F., Toffa, S., Rickeard, T., Gallagher, E., ... others (2022). Covid-19 vaccine effectiveness against the omicron (b. 1.1. 529) variant. *New England Journal of Medicine*.

Becker, M. H., & Maiman, L. A. (1975). Sociobehavioral determinants of compliance with health and medical care recommendations. *Medical Care*, 10–24.

Becker, M. H., Maiman, L. A., Kirscht, J. P., Haefner, D. P., & Drachman, R. H. (1977). The health belief model and prediction of dietary compliance: A field experiment. *Journal of Health and Social behavior*, 348–366.

Bedford, J., Enria, D., Giesecke, J., Heymann, D. L., Ihekweazu, C., Kobinger, G., ... others (2020). Covid-19: towards controlling of a pandemic. *The lancet*, *395*(10229), 1015–1018.

Boer, D., Hanke, K., & He, J. (2018). On detecting systematic measurement error in cross-cultural research: A review and critical reflection on equivalence and invariance tests. *Journal of Cross-Cultural Psychology*, *49*(5), 713–734.

Capurro, R. (2005). Privacy. an intercultural perspective. *Ethics and information technology*, *7*(1), 37–47.

Chan, E. Y., & Saqib, N. U. (2021). Privacy concerns can explain unwillingness to download and use contact tracing apps when covid-19 concerns are high. *Computers in Human Behavior*, *119*, 106718.

Culnan, M. J., & Armstrong, P. K. (1999). Information privacy concerns, procedural fairness, and impersonal trust: An empirical investigation. *Organization science*, *10*(1), 104–115.

Davis, D. W., & Silver, B. D. (2004). Civil liberties vs. security: Public opinion in the context of the terrorist attacks on america. *American journal of political science*, *48*(1), 28–46.

Devlin, K., Fagan, M., & Connaughton, A. (2021). *People in advanced economies say their society is more divided than before pandemic.* Retrieved from `https://www.pewresearch.org/global/2021/06/23/people-in-advanced-economies-say-their-society-is-more-divided-than-before-pandemic/`

Dienlin, T., & Metzger, M. J. (2016). An extended privacy calculus model for snss: Analyzing self-disclosure and self-withdrawal in a representative us sample. *Journal of Computer-Mediated Communication*, *21*(5), 368–383.

Dinev, T., & Hart, P. (2006). An extended privacy calculus model for e-commerce transactions. *Information systems research*, *17*(1), 61–80.

Du, L., Raposo, V. L., & Wang, M. (2020). Covid-19 contact tracing apps: A technologic tower of babel and the gap for international pandemic control. *JMIR mHealth and uHealth*, *8*(11), e23194.

Elkhodr, M., Mubin, O., Iftikhar, Z., Masood, M., Alsinglawi, B., Shahid, S., & Alnajjar, F. (2021). Technology, privacy, and user opinions of covid-19 mobile apps for contact tracing: Systematic search and content analysis. *Journal of Medical Internet Research*, *23*(2), e23467.

Fahey, R. A., & Hino, A. (2020). Covid-19, digital privacy, and the social limits on data-focused public health responses. *International Journal of Information Management*, *55*, 102181.

Fox, G., Clohessy, T., van der Werff, L., Rosati, P., & Lynn, T. (2021). Exploring the competing influences of privacy concerns and positive beliefs on citizen acceptance of contact tracing mobile applications. *Computers in Human Behavior*, *121*, 106806.

Garrett, P. M., Wang, Y., White, J. P., Hsieh, S., Strong, C., Lee, Y.-C., ... Yang, C.-T. (2021). Young adults view smartphone tracking technologies for covid-19 as acceptable: the case of taiwan. *International journal of environmental research and public health*, *18*(3), 1332.

Garrett, P. M., Wang, Y.-W., White, J. P., Kashima, Y., Dennis, S., & Yang, C.-T. (2022). High acceptance of covid-19 tracing technologies in taiwan: A nationally representative survey analysis. *International journal of environmental research and public health*, *19*(6), 3323.

Garrett, P. M., White, J. P., Lewandowsky, S., Kashima, Y., Perfors, A., Little, D. R., ... Dennis, S. (2021). The acceptability and uptake of smartphone tracking for covid-19 in australia. *Plos one*, *16*(1), e0244827.

Gelfand, M. J., Jackson, J. C., Pan, X., Nau, D., Pieper, D., Denison, E., ... Wang, M. (2021). The relationship between cultural tightness–looseness and covid-19 cases and deaths: a global analysis. *The Lancet Planetary Health*, *5*(3), e135–e144.

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., ... others (2021). A global panel database of pandemic policies (oxford covid-19 government response tracker). *Nature Human Behaviour*, *5*(4), 529–538.

Hochbaum, G. M. (1958). *Public participation in medical screening programs: A socio-psychological study* (No. 572). US Department of Health, Education, and Welfare, Public Health Service ....

Hofstede, G. (1984). *Culture's consequences: International differences in work-related values* (Vol. 5). sage.

Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations*. Sage publications.

Kashima, Y., Dennis, S., Perfors, A., & Laham, S. M. (2021). Culture and global societal threats: Covid-19 as a pathogen threat to humanity. *Group Processes & Intergroup Relations*, *24*(2), 223–230.

Kehr, F., Kowatsch, T., Wentzel, D., & Fleisch, E. (2015). Blissfully ignorant: the effects of general privacy concerns, general institutional trust, and affect in the privacy calculus. *Information Systems Journal*, *25*(6), 607–635.

Kim, J., & Kwan, M.-P. (2021). An examination of people's privacy concerns, perceptions of social benefits, and acceptance of covid-19 mitigation measures that harness location information: A comparative study of the us and south korea. *ISPRS International Journal of Geo-Information*, *10*(1), 25.

Kozyreva, A., Lorenz-Spreen, P., Lewandowsky, S., Garrett, P. M., Herzog, S. M., Pachur, T., & Hertwig, R. (2021). Psychological factors shaping public responses to covid-19 digital contact tracing technologies in germany. *Scientific reports*, *11*(1), 1–19.

Krasnova, H., Veltri, N. F., & Günther, O. (2012). Self-disclosure and privacy calculus on social networking sites: the role of culture. *Business & Information Systems Engineering*, *4*(3), 127–135.

Lewandowsky, S., Dennis, S., Perfors, A., Kashima, Y., White, J. P., Garrett, P., ... Yesilada, M. (2021). Public acceptance of privacy-encroaching policies to address the covid-19 pandemic in the united kingdom. *Plos one*, *16*(1), e0245740.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological review*, *98*(2), 224.

Moore, A. D. (2003). Privacy: its meaning and value. *American Philosophical Quarterly*, *40*(3), 215–227.

Our World in Data. (2022). *Our world in data.* Retrieved from `https://ourworldindata.org/coronavirus`

Rhee, E., Uleman, J. S., Lee, H. K., & Roman, R. J. (1995). Spontaneous self-descriptions and ethnic identities in individualistic and collectivistic cultures. *Journal of personality and social psychology*, *69*(1), 142.

Ribeiro-Navarrete, S., Saura, J. R., & Palacios-Marqués, D. (2021). Towards a new era of mass data collection: Assessing pandemic surveillance technologies to preserve user privacy. *Technological Forecasting and Social Change*, *167*, 120681.

Rutkowski, L., & Svetina, D. (2014). Assessing the hypothesis of measurement invariance in the context of large-scale international surveys. *Educational and psychological measurement*, *74*(1), 31–57.

Schoeman, F. (1984). Philosophical dimensions of the literature. *Philosophical dimensions of privacy: an anthology. Cambridge University Press, Cambridge*, 1–33.

Schoeman, F. D. (1984). *Philosophical dimensions of privacy: An anthology*. Cambridge University Press.

The World Bank. (2021). *Government effectiveness.* Retrieved from `https://govdata360.worldbank.org/indicators/h580f9aa5?country=BRA&indicator=388&viz=line_chart&years=1996,2019#table-link`

Thompson, N., McGill, T., Bunn, A., & Alexander, R. (2020). Cultural factors and the role of privacy concerns in acceptance of government surveillance. *Journal of the Association for Information Science and Technology*, *71*(9), 1129–1142.

Trang, S., Trenz, M., Weiger, W. H., Tarafdar, M., & Cheung, C. M. (2020). One app to trace them all? examining app specifications for mass acceptance of contact-tracing apps. *European Journal of Information Systems*, *29*(4), 415–428.

Triandis, H. C. (1989). The self and social behavior in differing cultural contexts. *Psychological review*, *96*(3), 506.

Trüdinger, E.-M., & Steckermeier, L. C. (2017). Trusting and controlling? political trust, information and acceptance of surveillance policies: The case of germany. *Government Information Quarterly*, *34*(3), 421–433.

Van de Vijver, F. J., & Leung, K. (1997). *Methods and data analysis for cross-cultural research.* Sage.

Van de Vijver, F. J., & Leung, K. (2011). Equivalence and bias: A review of concepts, models, and data analytic procedures. In D. Matsumoto & F. J. R. van de Vijver (Eds.), *Cross-cultural research methods in psychology* (pp. 17–45). New York, NY: Cambridge University Press.

Velicia-Martin, F., Cabrera-Sanchez, J.-P., Gil-Cordero, E., & Palos-Sanchez, P. R. (2021). Researching covid-19 tracing app acceptance: incorporating theory from the technological acceptance model. *PeerJ Computer Science*, *7*, e316.

von Wyl, V., Höglinger, M., Sieber, C., Kaufmann, M., Moser, A., Serra-Burriel, M., ... Puhan, M. A. (2021). Drivers of acceptance of covid-19 proximity tracing apps in switzerland: panel survey analysis. *JMIR public health and surveillance*, *7*(1), e25701.

Walrave, M., Waeterloos, C., & Ponnet, K. (2021). Ready or not for contact tracing? investigating the adoption intention of covid-19 contact-tracing technology using an extended unified theory of acceptance and use of technology model. *Cyberpsychology, Behavior, and Social Networking*, *24*(6), 377–383.

Westin, A. F. (1968). Privacy and freedom. *Washington and Lee Law Review*, *25*(1), 166.

White, J. P., Dennis, S., Tomko, M., Bell, J., & Winter, S. (2021). Paths to social licence for tracking-data analytics in university research and services. *PloS one*, *16*(5), e0251964.

World Health Organization. (2022). *Who coronavirus (covid-19) dashboard.* Retrieved from `https://covid19.who.int/`

590 Yamagishi, T. (2017). *Individualism-collectivism, the rule of law, and general trust.*
591 Oxford University Press.

592 Yamagishi, T., & Yamagishi, M. (1994). Trust and commitment in the united states
593 and japan. *Motivation and emotion*, *18*(2), 129–166.

594 Zarouali, B., Strycharz, J., Helberger, N., & de Vreese, C. (2022). Exploring people's
595 perceptions and support of data-driven technology in times of covid-19: the role of
596 trust, risk, and privacy concerns. *Behaviour & Information Technology*, 1–12.

597 Zastrow, M. (2020). Coronavirus contact-tracing apps: can they slow the spread of
598 covid-19? *Nature (Lond.)*.