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Prosocial Paradise Lost: Individual Perspectives as Driver behind the Acceptance of Digital Contact Tracing

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Abstract

Digital contact-tracing applications (DCTAs) can control the spread of epidemics, like the COVID-19 pandemic. But people in Western societies fail to accept DCTAs. Understanding the low acceptance is key to policymakers who support DCTAs to avoid harsh nationwide lock-downs. In a preregistered study in a representative Swiss sample (N=757), we compare the role of individual risk perception, risk preferences, social preferences, and social values in the acceptance of and compliance with DCTA. The results show a low acceptance of DCTAs but high compliance with the measures recommended by DCTAs. Risk preferences and perceptions, but not social preferences, influenced accepting DCTAs; a high health risk perception and a low data-security risk perception increased acceptance. Additionally, supporting political measures, technical abilities, and understanding the DCTA functionality had large effects on accepting DCTAs. Therefore, we recommend highlighting personal health risks and clearly explaining DCTAs, focusing on data security, to enhance DCTA acceptance.

Statement of Relevance

Many people do not use and accept contact tracing applications during the 2020 COVID-19 pandemic, although contact tracing can be a very effective mitigation mean against epidemics Ferretti et al., 2020. Understanding this low acceptance matters to policymakers advocating digital contact tracing as a mild yet effective behavioral intervention preferred to full lock-downs. The present work answers recent calls for more vigorous evidence-based investigations into the management of compliance with digital contact tracing applications Blasimme and Vayena, 2020. The results from our preregistered study in a representative Swiss sample (N=757) provide comprehensive new insights into the psychological factors affecting the acceptance of digital contact tracing: We report the novel finding that social values and social preferences were mostly unrelated to the acceptance of contact tracing applications but that people's individual health-risk perceptions and data-security risk-perceptions matter for the acceptance of digital contact tracing. These results should have important policy implications.

Prosocial Paradise Lost: Individual Perspectives as Driver behind the Acceptance of Digital Contact Tracing

A powerful intervention against a pandemic such as the 2020 COVID-19 pandemic is digital contact tracing through mobile applications (hereafter, DCTAs). As long as vaccines and medical treatments for a disease are under development or not widely available, non-pharmaceutical, behavioral interventions are the main means to contain the spread of a pandemic. In the case of COVID-19 such interventions include DCTAs, isolation of symptomatic people, quarantine of contact persons, the closure of schools and universities, and full lock-downs—some of these measures have dramatic negative economic and psychological costs for society and individuals (Alvarez et al., 2020; Brooks et al., 2020). Moderate interventions can therefore be beneficial for maintaining ordinary daily life. Moreover, findings have shown that DCTAs have the potential to contain the spread of a pandemic (Ferretti et al., 2020; Salathé et al., 2020) and to forecast future pandemic hot spots (Menni et al., 2020). Beyond the 2020 COVID-19 outbreak, DCTAs provides a powerful yet mild tool to mitigate the spread of future pandemics at an early stage. But importantly, for DCTAs to work effectively, a large proportion of the population must use them (Xia & Lee, 2020). Still, people in Western countries remain sceptical about DCTAs for reasons including privacy concerns (Akinbi et al., 2020; Blasimme & Vayena, 2020; Jansen-Kosterink et al., 2020; Park et al., 2020). In Switzerland, for instance, only around 22% of the population was actively using the Swiss federal DCTA as of November 2020 (Federal Statistical Office, 2020) and only 26% of the German population had the respective DCTA installed (Robert Koch Institut, 2020). Therefore research is needed to understand the factors affecting DCTAs' acceptance and to inform policy makers fostering the use of DCTAs (Blasimme & Vayena, 2020).

In a recent commentary on good governance of digital contact tracing (Blasimme & Vayena, 2020), policymakers have been advised to use a reflexive adaptation strategy; this strategy involves the gathering of data to evaluate when, how, and why people actually use

DCTAs. For this strategy, data is needed on how people respond to DCTA alerts and perceive the associated risks. Therefore, in the present research, we present new data on the psychological factors that shape people's willingness to accept DCTAs and on their compliance with the recommendations by the DCTA.

Individual and social factors affecting the acceptance of behavioral interventions

From an *individual perspective*, engaging in risky health behavior such as meetings with large groups inside should depend on people's risk perception and risk preferences (Van der Pligt, 1996; Weber & Milliman, 1997) and their general risk knowledge (Weinstein & Lyon, 1999). Regarding the COVID-19 pandemic, risk mitigation behaviors have been linked to knowledge about SARS-CoV-2, the virus causing the disease (Kwok et al., 2020; Zhong et al., 2020), and the perception of associated risks (Abdelrahman, 2020; Betsch et al., 2020; Dryhurst et al., 2020; Glöckner et al., 2020; Plohl & Musil, 2020; Wise et al., 2020; Xie et al., 2020). Individual differences in risk preferences (Frey et al., 2017) may explain why people with similar risk perception and understanding respond differently, with risk-averse people being less likely to take risks than risk-tolerant people. The pandemic also represents an economic risk to the individual, because behavioral interventions in general can have severe negative economic consequences (Alvarez et al., 2020). The use of DCTAs could also be associated with risks for the individual; in various countries the development of DCTAs has been accompanied by a debate about the data-security threat to individuals (Ienca & Vayena, 2020). This debate has led to major changes in the development of DCTAs (Beskorovajnov et al., 2020) in order to reduce the data-security concerns. People perceiving DCTAs as a high threat to their personal data are unlikely to use them. In sum, from the perspective of the individual, the acceptance of specific behavioral interventions might depend on people's risk preferences and the perceptions of the risks they perceive different behavioral interventions to involve.

From a *societal perspective*, a pandemic such as the COVID-19 pandemic represents a threat to the health system, because with exponential growth in the number of infected cases, the number of people requiring treatment in intensive care units will eventually exceed capacity. From a societal perspective, the health system, and specifically intensive care unit capacity, can be viewed as a common-pool resource (Ostrom, 1990) that has to be managed sustainably to prevent overuse. DCTAs present one way to manage this common pool resource, and acceptance of DCTAs can be viewed as act of cooperation and investment into the common pool. Past work has shown that the over-harvesting of common pools is especially prevalent in social groups that contain a substantial number of "free riders," that is, people who take benefits without paying any costs (Camerer, 2003). Whether a common-pool resource can be managed sustainably depends on people's social preferences (Falk & Fischbacher, 2006; Fehr & Schmidt, 1999), and in line with the associated work (Campos-Mercade et al., 2020) results on COVID-19 have demonstrated that prosocial preferences affect the engagement in preventive behaviors like maintaining physical distance and self-isolation (Dryhurst et al., 2020; Zettler et al., 2020). Furthermore, Bavel et al. (2020) have distinguished different societal collectives in the pandemic such as families, communities, nations, and international regions, and people might give different priorities to these collectives (Chen & Li, 2009) when following behavioral interventions. It is known that investment into common resources tends to decreases in more heterogeneous groups with trust as a psychological mediator (e.g., van Klingeren, 2020). Taken together, from this societal perspective on DCTA use as act of cooperation in a common-pool dilemma, people's social preferences, identification with communities, and trust in the governmental management of the COVID-19 crisis should affect the acceptance and compliance with DCTAs.

Critically, the societal and the individual perspectives on pandemics such as the COVID-19 pandemic need not be aligned. Particularly, younger people may perceive COVID-19 as less risky for their own health and consequently might not follow severe

behavioral interventions to fight the pandemic which are necessary from the societal perspective. A person's decision to reject behavioral interventions, which can be reasonable from the individual perspective regarding the risks of COVID-19 to the self, could foster the transmission of the virus and therefore hamper the public health.

Method

The empirical investigation tested the psychological factors that affect (i) the acceptance of DCTAs as a means to manage the COVID-19 pandemic and (ii) the compliance with the recommended behavior from a DCTA such as self-isolation. In particular, we focused on the role of the psychological constructs social preferences (how much do I care about others?), risk perception (how high does a risk seem to me?), and risk preferences (how much risk do I tolerate?). The methods (design and hypotheses, sample size and analysis strategy) have been preregistered (see https://osf.io/b3ud5); they are available online together with the data and the materials (https://osf.io/u6ngf/).

Preregistered hypothesis

A summary of the hypothesis is presented in Figure 1. Regarding the aforementioned *societal perspective*, we hypothesized that the higher the general other-regarding social preferences are, the higher the acceptance of and compliance with DCTAs will be. The higher a person scores on the personality trait honesty-humility, the higher their acceptance of and compliance with DCTAs will be. The higher the social preference for local versus the global community is, the higher the acceptance and compliance with tracing apps. Regarding *individual perspective*, we hypothesized a domain-specific effect of risk preferences in the form that health risk perception will increase the acceptance of and compliance with DCTAs, but data-security risk perception will decreases the acceptance of and compliance with DCTAs. Economic risk perception should increase the acceptance of and compliance with DCTAs. Regarding risk preferences, we hypothesized a general and domain effects, namely that a higher general risk tolerance

in will decrease the acceptance of and compliance with DCTAs, and that health risk tolerance will decrease the acceptance of and compliance with DCTAs, but data-security risk tolerance will increases the acceptance of and compliance with DCTAs. Economic risk tolerance was hypothesized to decreases the acceptance of and compliance with DCTAs.

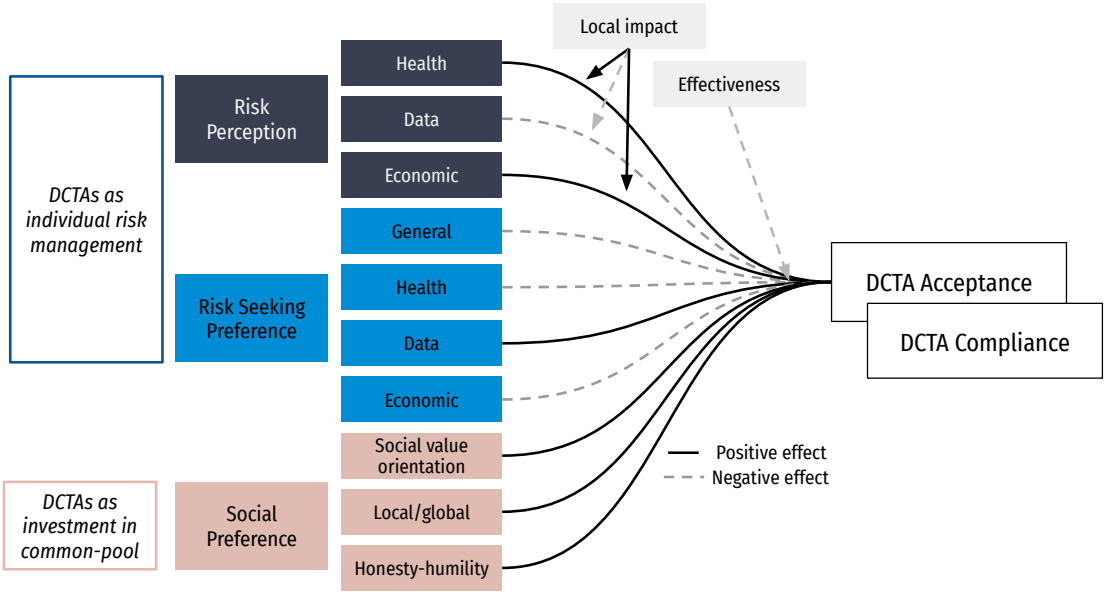

Figure 1

Predictions based on the individual and the societal perspective regarding the role of risk preferences, risk perceptions, and social preferences on DCTA use.

Participants

The data came from a large nationally representative sample of the Swiss population, recruited through a panel provider (LINK Institute, Lucerne, Switzerland), drawing a age- and gender-representative sample from adults residing in the German-speaking part of Switzerland. Participants responded to an online questionnaire assessing the acceptance of and compliance with the Swiss federal contact-tracing application ("SwissCovid"); the data were collected in June 2020 (after the first wave of

SARS-CoV-2 infections in Switzerland and one week after the Swiss DCTA became available). The design was approved by the ethics committee of the Faculty of Psychology at the University of Basel. In total, 848 participants completed the questionnaire; 91 had to be excluded (as preregistered) because of low data quality,[1] leaving a final sample of N = 757 (388 men, 366 women, 3 did not report gender; 51.3%, 48.3%, and 0.4%, respectively); the mean age was 45 years (Mdn = 44 years, SD = 16, range 18–79 years), and 65% had at least a high school diploma (please see Supplement S1 for further demographic information).

Participants received a remuneration of 3.00 Swiss Francs (ca. 3.25 USD at the time of the study) for completing the survey; and ten percent of participants were randomly selected to receive a bonus payment that depended on their response to the social value game-theoretic question (see below) in which participants had to divide 1–1.7 Swiss Francs between themselves and an unknown person. This served to incentivize the social preference measure.[2]

Materials and Methods

Materials

The survey was implemented using the online survey software Qualtrics (Qualtrics, Provo, UT). The dependent variables—acceptance of and compliance with the Swiss DCTA ("SwissCovid App")—were assessed by four items each: The acceptance scale measured the inclination to use, to recommend, the perceived effectiveness and data security of the DCTA on a 5-point Likert-type scale (*1*=disagree completely, *3*=neutral, 5=agree completely). The compliance scale included the willingness to self-isolate, report a positive

[1] Incorrect answers to several explicit attention-check items or self-reported lack of data quality.

[2] Ten percent of the participants were randomly selected together with a counterpart and received the payoff distribution determined by one of their decisions (randomly selected) or the amount assigned to the counterpart.

diagnosis, call the national hotline, and get tested following a critical contact alert by the DCTA. Supplement B presents the wording. The scale responses were averaged by participant into their acceptance and compliance score.

Social preferences were measured using the following standardized measures of trait and state social preferences: the social value orientation was measured by Murphy et al.'s (2011) six mini dictator games, in which participants divide money between themselves and another person; other-regarding personality facets were measured by the honesty-humility subscale of the brief HEXACO personality inventory (de Vries, 2013); participants' identification with the world versus the local community was assessed by the identification with all humanity scale (IWAH, McFarland et al., 2012).

Risk preferences were measured by items from the largest German household panel (SOEP, see Frey et al., 2017; TNS Infratest Sozialforschung, 2009) on a ten point Likert-type scale (*0* = not willing to take risks at all to *10* = very willing to take risks). One additional item was added to measure data-security risks, since this domain is not part of the german socio-economic panel survey.

The risk perception regarding the health risks of COVID-19 were assessed by 3 items (following Weinstein & Lyon, 1999): The number of people out of 100'000 people in Switzerland that have been infected during the last 7 days, that will get infected during the next 7 days, and the number of people out of 100 infected people in Switzerland that will develop a severe course of disease.

The main covariates of interest included demographic variables such as gender, age, income, wealth, as well as the willingness to adopt new technologies (technology affinity, measured on a four-item scale) and the support for the political measures against the 2020 COVID pandemic in general (policy support, measured on a four-item scale).

Statistical Analyses

Because the questionnaire allowed for non-responses regarding income and wealth (see Table S1), missing values were imputed by the median sample income and wealth (respectively). This imputation was not preregistered. Following our preregistered analysis strategy, we tested the hypotheses using Bayesian linear regressions by modeling the acceptance of and compliance with DCTAs as a function of the theoretically relevant predictors (risk perception variables, risk preference variables, social preference variables) and selected covariates, where the covariates were selected to yield the most parsimonious predictive model (see covariate selection).

Covariate selection

The covariates in the regression model were selected using a Bayesian projective predictive model selection method (Vehtari & Ojanen, 2012). This model selection method has been shown to outperform other methods in selecting the variables that balance model sparsity and predictive accuracy (Pavone et al., 2020; Piironen et al., 2020). This variable selection method constructs a reference model (we used the full model including all possible covariates) and searches for a reduced model with minimal loss of performance compared to the reference model. The simpler model is constructed by projecting the model parameters from the full model, because exhausting all possible combinations of predictor variables is infeasible. The predictive projection was used to select the covariates to be included in the regression; the variables related to risk perception, risk preferences, and social preferences were defined as the last to be excluded in the variable selection (using a penalty).

Results

In addition to presenting the first rigorous comparison of individual and societal psychological factors relevant to DCTAs, our data also go beyond previous descriptions of subjective risk perceptions related to the COVID-19 pandemic (e.g., Karlsson et al., 2020;

Plohl & Musil, 2020) in that the results can provide a detailed account of the factual knowledge about the risks associated with COVID-19 in Switzerland as of June 2020, including incidence rates, symptoms, and risk factors (Weinstein & Lyon, 1999).

The perception of COVID-19

The majority of the sample viewed the COVID-19 pandemic as a problem for the entire world (92%), but less than half (42%) regarded it as a problem for the immediate vicinity or themselves, and many viewed it as no problem in the vicinity (36%; the remaining 22% were undecided). At the time of the survey (June 2020), 1.7% of respondents reported a positive diagnosis of COVID-19, and 11% reported that they or a close contact had received a positive diagnosis in the past. Among the people that reported neither a current infection nor past contact with an infected person, 26% reported at least one COVID-19-related symptom.[3] The majority of respondents (93%) indicated that they were working from home either fully or part-time, and 15% reported a reduction in their income due to the COVID-19 pandemic. Figure 2 shows age and gender differences regarding the respondents' mental well-being and their support of the ongoing political measures against COVID-19. Women supported the political measures slightly more (M = 4.09, SD = 0.84) than men (M = 3.86, SD = 1.00); also the older cohorts above 69 years supported the policies slightly more (M = 4.30, SD = 0.87) than the youngest cohort, up to 28 years (M = 3.86, SD = 0.90).

Risk knowledge regarding COVID-19

Around half of the respondents (M = 49% correct) knew the absolute number of COVID-19-related deaths and one third (38%) knew the absolute number of infections at the time of the survey. They were well-informed about the preexisting conditions associated with a severe illness caused by COVID-19: Nearly everybody (97%) correctly

[3] Fever, sore throat, dry cough, shortness of breath, muscle pain, or sudden loss of sense of smell or taste.

identified chronic respiratory diseases and 68% identified cancer as a risk factor, which was the least-identified risk factor; kidney disease was the most frequently misidentified risk factor (29%); the risk factors were defined according to the Swiss Federal Office of Public Health (Federal Office of Public Health (FOPH), 2020). A third of the participants (31%) correctly stated the past-7-day incidence rate, but many participants (44%) overestimated it (the past-7-day incidence is defined as the cumulative number of new infections relative to 100,000 inhabitants in the 7 days prior to the survey). A quarter (27%) correctly predicted the future-7-day incidence rate, which was overestimated by half the sample (51%). Half of the participants (50%) believed that the incidence rate would remain unchanged from the past to the next 7 days. Only a minority reported the highest possible incidence rate of 45 per 100,000 inhabitants (12% past-7-day, 12% future-7-day incidence).

Acceptance of and compliance with DCTAs

On a scale of 1 to 5, the acceptance of digital contact tracing in the form of the Swiss DCTA averaged 3.75 ($SD = 1.1$, computed based on 4 items). The mean compliance score of 4.34 (range 1 to 5, $SD = 0.82$) shows that participants were highly willing to comply with the DCTA recommendation if they were to use the contact tracing application. The acceptance of DCTAs was lowest for 18- to 28-year-olds ($M = 3.41$, $SD = 1.05$) and highest for age 68 years and older ($M = 3.83$, $SD = 0.93$, Figure 2). Slightly more than half (58%) of the sample agreed that the Swiss DCTA was technically well-designed, but most respondents (89%) did not believe that a sufficient number of people would actually use it. Figure 2 shows age and gender differences regarding respondents' acceptance, compliance, and comprehension of the functionality of DCTAs.

Psychological factors that impact the acceptance of and compliance with DCTAs

The effects on the acceptance of DCTAs were estimated with Bayesian regression models using standardized variable scales (effect in units of standard deviations). The

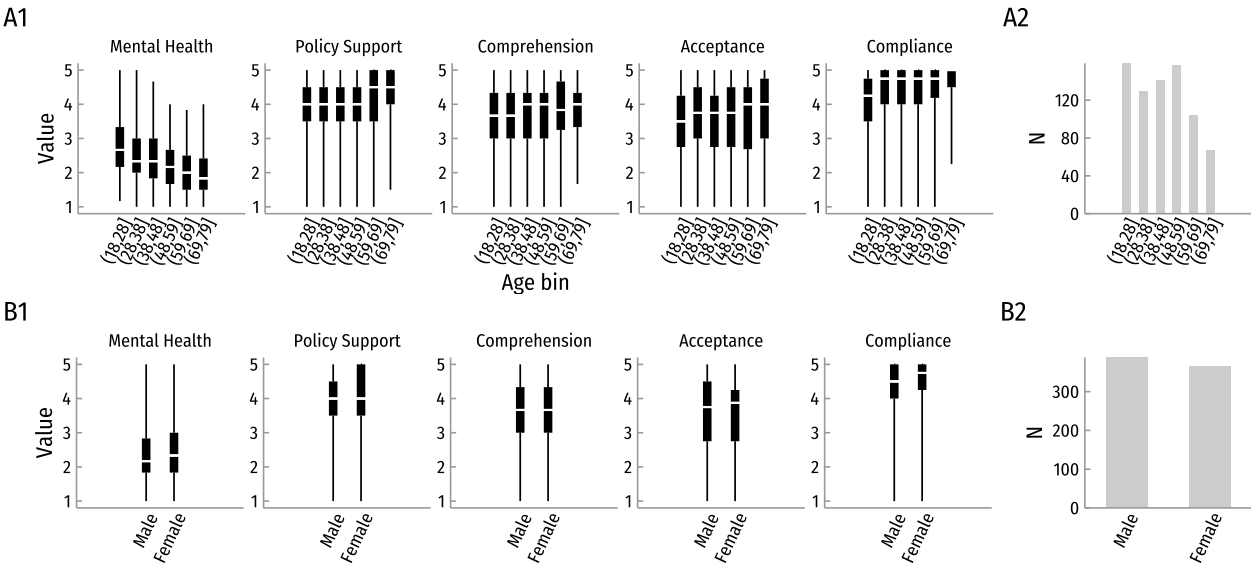

Figure 2

Descriptive Information. *Mental health in the last month before the study, support for political measures against COVID-19, comprehension of the functionality of digital contact-tracing applications (DCTAs), acceptance of DCTAs, and compliance with DCTAs. (**A1**) Age differences. (**B1**) Gender differences. (**A2**, **B2**) Frequency distribution of age groups and gender in the sample (n = 3 gender nonresponses were excluded in B1 and B2).*

resulting regression coefficients (shown in Table 1) seem to indicate that risk perception variables and risk preference variables had an overall larger effect than the social preference variables (risk perception βs from -0.08 to 0.06; risk preference βs from -0.06 to 0.11 and social variable βs from -0.01 to 0.04). Therefore we tested if excluding the social variables improved the model using a model comparison, which revealed that exclusion of the social preference variables greatly improved the model fit [Bayes factor (BF) = 20,271,851 for a model without the social predictor group compared to the full model; the former also outperformed a model excluding risk perceptions, BF = 2,236, and one excluding risk preferences, BF = 12]. Also, we found no evidence of moderation effects.[4] We can conclude

[4] The effects on DCTA acceptance were not moderated by the perceived effectiveness of contact tracing, defined as the mean belief in the technical functioning and sufficient adoption (model comparison, BF =

that the social preference variables did not have a substantial effect on the acceptance of DCTAs compared to people's risk perception and risk preferences and therefore, in the following we will present the results based on a Bayesian regression model without the social preference variables.

Figure 3 shows the median standardized Bayesian regression coefficients (βs), that is, the effect that a change of a predictor by one standard deviation has on one standard deviation of the acceptance of DCTAs. The acceptance of DCTAs was strongly associated with a better understanding of the mode of operation of a DCTA ($\beta = 0.52$) and with higher support for the general political measures against COVID-19 ($\beta = 0.20$), as shown in Figure 3A [for the predictor comprehension of DCTAs, the median $\beta = 0.52$, 95% highest density interval (HDI) 0.46 to 0.60, evidence in favor of a positive effect $BF_{(+)} > 100$ based on a normal prior with $M = 0$ and $SD = 10$; policy support $\beta = 0.20$, 95% HDI 0.14 to 0.26, $BF_{(+)} > 100$].

7.94 for a model without effectiveness as moderator[5]). Nor were the effects on DCTA acceptance moderated by the perceived threat level of COVID-19 in Switzerland (BF= 4.67 for a model without local threat as moderator). Therefore, the results do not include moderator variables (Table 1).

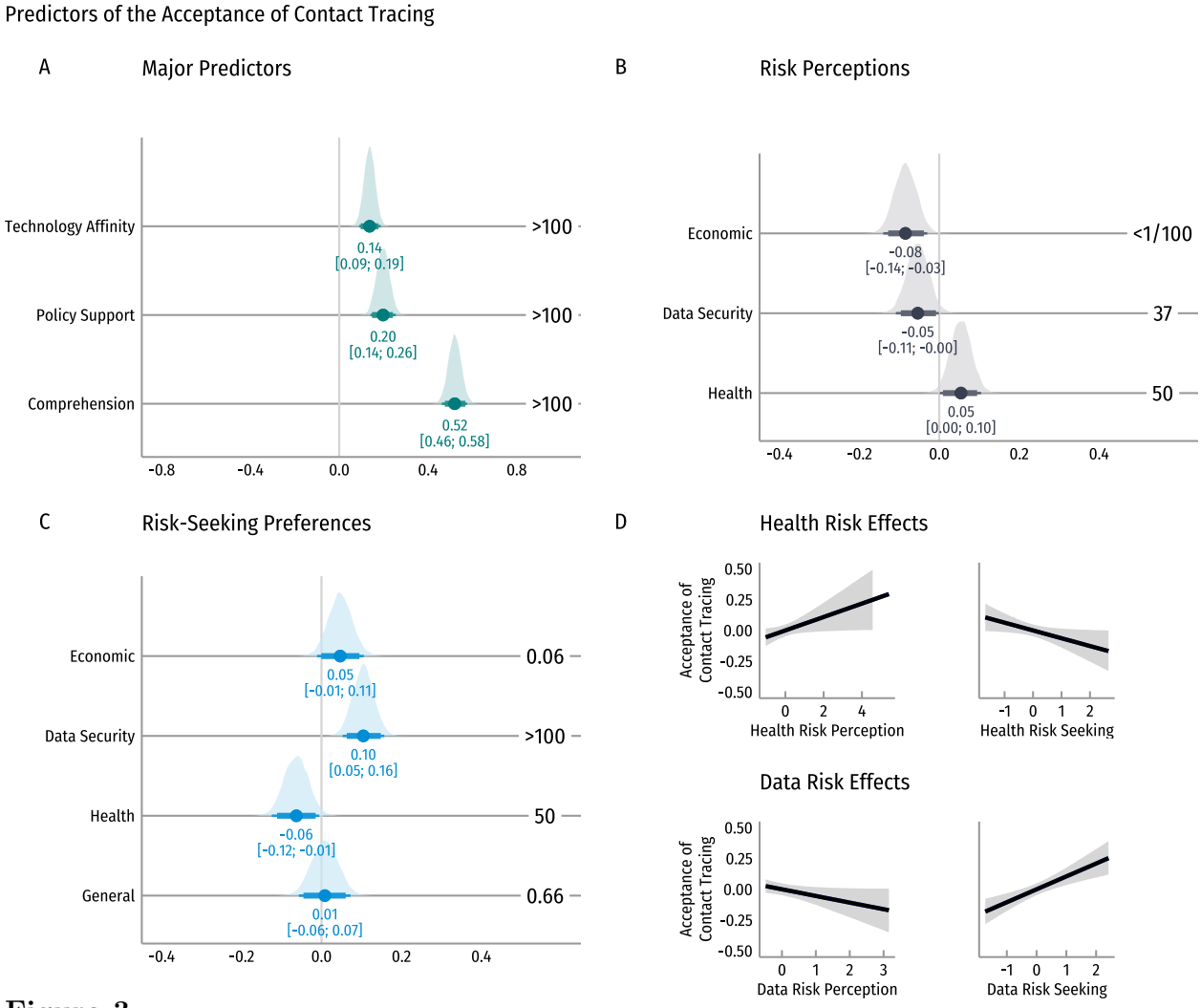

Figure 3

Factors that influence the acceptance of digital contact-tracing applications. *(**A**–**C**) Effects on acceptance of contact tracing (the posterior estimates of regression coefficients). Points = median posterior estimate, interval = 95% highest density intervals, bold numbers in the lines = Bayes factors in favor of the hypotheses. (**D**) Fitted effects of increasing health risk perception compared to increasing health risk tolerance.*

In terms of psychological factors, accepting DCTAs was positively related to perceiving COVID-19 as a severe health risk ($\beta = 0.05$) and negatively related to perceiving DCTAs as a data-security risk ($\beta = -0.05$), which was in line with the preregistered hypothesis (see Materials and Methods); contrary to the hypothesis, DCTA

acceptance was negatively correlated with perceiving COVID-19 as an economic risk ($\beta = -0.08$); see Figure 3B (health risk perception, $\beta = 0.05$, HDI 0.00 to 0.10, $BF_{(+)} = 50$; data-security risk perception, $\beta = -0.05$, 95% HDI −0.11 to 0.00, $BF_{(-)} = 37$; economic risk perception $\beta = -0.08$, 95% HDI −0.14 to −0.03, $BF_{(+)} < 1/100$). The negative association of DCTA acceptance with data-security concerns is in line with previous results (Jansen-Kosterink et al., 2020; Zhang et al., 2020).

Besides the association with risk perceptions, the acceptance of DCTAs was also related to risk preferences: The acceptance of DCTAs increased with more aversion towards health risks ($\beta = -0.06$) and more tolerance regarding data-security risks ($\beta = 0.10$). Neither people's general risk preferences nor their economic risk preferences showed a robust association with their acceptance of DCTAs; see Figure 3C (health risk-taking preferences $\beta = -0.06$, HDI −0.12 to −0.01, $BF_{(-)} = 50$; data-security risk-taking preferences, $\beta = -0.10$, 95% HDI −0.05 to 0.16, $BF_{(+)} > 100$; economic risk-taking preferences $\beta = 0.05$, 95% HDI −0.01 to 0.11, $BF_{(-)} = 0.06$; general risk-taking preferences $\beta = 0.01$, 95% HDI −0.06 to 0.07, $BF_{(+)} = 0.66$).

Further results

We further examined the variables related to the support for the political measures in Switzerland and factors influencing the comprehension of DCTAs. People's support for COVID-19-mitigating political measures in Switzerland increased with lower mental health ($\beta = -0.16$) and lower risk perception regarding data-security risks, economic risks, and general risks ($\beta = -0.14$, −0.11, and −0.12, respectively), and higher DCTA comprehension ($\beta = 0.38$), according to an exploratory Bayesian regression (see Supplement Table S1). Better comprehension of DCTAs, which was a main variable linked to their acceptance, was associated with high policy support, high data-security risk tolerance, and high interest in new technologies ($\beta = 0.40$, 0.11, 0.10, respectively), and the DCTA comprehension decreased for people that were not working from home ($\beta = -0.18$) and

with the perception of DCTAs as data-security risk ($\beta = -0.14$; see Supplement Table S2).

Discussion

The present study examined the psychological factors that impact the acceptance of and compliance with digital contact tracing devices (DCTAs) as a measure against the COVID-19 pandemic. DCTAs constitute a mild yet efficient behavioral means to mitigate the spread of a pandemic (Ferretti et al., 2020; Menni et al., 2020; Salathé et al., 2020), but their success depends on widespread use and acceptance of DCTAs in the population. Using a Swiss representative survey conducted after DCTAs were made available in Switzerland, we compared the role of individual and social preferences in DCTA acceptance and compliance. Unlike previous work (Jansen-Kosterink et al., 2020; Zhang et al., 2020), our study focused on individual and social factors and used a representative sample. From a technical standpoint, DCTAs offer direct societal benefits but only indirect individual benefits, because self-quarantine alerts from the application protect others rather than the user of the DCTA who has been in contact with an infected person. Indirect benefit may exist nevertheless; for instance, people may avoid putting unnecessary strain on their immune system after contact alerts or be prepared for getting sick. Interestingly, the results revealed that acceptance of DCTAs was not related to social preferences but rather was associated with individual considerations related to risk perception and risk preferences. More specifically, our results show the need in this global pandemic to trade off different risks against each other, for example, the risks concerning health and data security. Acceptance of DCTAs was high for individuals perceiving COVID-19 as a severe health threat but low for individuals associating DCTA use with high data-security risks (see also Jansen-Kosterink et al., 2020; Zhang et al., 2020).

We further found that acceptance was low for risk-tolerant individuals in the health domain and high for risk-tolerant individuals in the data-security domain. Much to our surprise and against our preregistered hypotheses, acceptance of DCTAs was low for

individuals who perceived COVID-19 as a high economic risk. One reason might be a general societal divide, with people who emphasize the health risks of COVID-19 giving less attention to the economic repercussions and vice versa. Thus, people who are most concerned about the economic risks of COVID-19 might tend to give little support to measures against the COVID-19 pandemic, because they might think they have severe negative economic repercussions. However, this perception appears to be incorrect, as measures to contain the health threat posed by the COVID-19 pandemic ultimately also reduce the long-term economic impact.

In addition to individual and social factors, general policy support for measures to counter the spread of COVID-19, technology affinity, and comprehension of the functionality of the DCTAs were all positively related to their acceptance. First, general policy support seemed to have a general positive effect on the acceptance of any means to slow the pandemic and safety behavior in general, such as wearing masks. It is therefore essential that policy makers ensure that the general policy finds public support, and there are several paths that can be taken to maintain this support. In this respect it is interesting to note that policy support is negatively correlated with the perception of data-security risks of DCTAs. Second, it is less surprising that a general technology affinity is positively correlated with the acceptance of DCTAs. Finally, it is important to ensure that people have good comprehension of the functionality of DCTAs. This might also include a good understanding of DCTAs' data-security precautions, because DCTA comprehension is negatively related to risk perception in the data-security domain.

Compliance with DCTAs was strong: The results show a high willingness to comply with DCTAs in the sense that upon receiving a warning from the application about a potential risk, people indicated they would follow the suggested measures, such as self-quarantine or testing. Risk-averse individuals and more honest individuals were more likely to comply with DCTAs. However, compliance with the assessment of a DCTA is only fully effective if DCTAs are used, so broadly increasing acceptance of DCTAs must have a

high priority.

Recommendations for Increasing DCTA acceptance

Based on our results, the acceptance of DCTAs may be increased by educating people about *specific risks* and emphasizing *personal benefits* from the use of DCTAs. In doing so, the emphasis should be on the magnitude of health risks to the individual and on the clarification of the comparably low data-security risk posed by DCTAs. Individual health risks include an overreaction of the immune system as well as long-term or chronic illness, which have been shown to affect young people. Individual benefits of using DCTAs, such as protecting people with whom one is close, such as family and friends, or avoiding stress to one's own immune system if one receives a contact alert could also be emphasized. Clarification about data-security risks could compare the DCTAs' data collection, data storage, and data use relative to other frequently used smartphone apps and social media platforms. Further, efforts to educate the public about *how and why DCTAs work* and the explanation of the technical details of contact tracing applications in an accessible way should have a substantial positive effect on their acceptance. In sum, efforts may be put into emphasizing individual benefits resulting from DCTAs and on the other hand educating people so they understand the societal policy in general and the specific measure in particular.

Future empirical research into the uptake of digital contact tracing devices is needed to examine the effectiveness of potential types of interventions to facilitate DCTA uptake. Regarding interventions that target risk perception, for instance, it is an open question whether effective interventions in the domain of digital contact tracing consist in choice architectures such as nudges (which are effective for climate action, Nisa et al., 2019), graphical risk and uncertainty communication (Spiegelhalter et al., 2011), social comparisons, or the contextualization of a novel risk in relation to old risks such as the data security of other mobile applications. Which intervention designs works in the context

of digital contact tracing needs to be addressed in future research.

Table 1

Results of the Bayesian regression: Effects on the acceptance of and compliance with digital contact-tracing applications

		Acceptance			Compliance		
			CI			CI	
Group	Predictor	*Mdn*	2.5%	97.5%	*Mdn*	2.5%	97.5%
Risk perceptions	Health	0.06	0.02	0.10	-0.01	-0.07	0.04
	Data security	-0.05	-0.10	-0.01	-0.01	-0.07	0.04
	Economic	-0.08	-0.13	-0.04	-0.03	-0.08	0.03
Risk preferences	General	0.01	-0.04	0.07	0.00	-0.06	0.06
	Health	-0.06	-0.11	-0.01	-0.08	-0.14	-0.02
	Data security	0.11	0.06	0.15	0.00	-0.05	0.05
	Economic	0.05	0.00	0.10	–	–	–
Social preferences	Honesty-humility	0.04	0.00	0.08	0.06	0.01	0.11
	Social value orientation	-0.01	-0.05	0.03	-0.01	-0.06	0.04
	Identification with world over community	-0.01	-0.05	0.04	–	–	–

Note. CIs are Bayesian credibility intervals. Dashes (–) denote variables that the variable selection did not select as predictor (see Materials and Methods)

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Appendix A

Supplementary Materials

Table S1

Demographics of the sample

	Mdn	*Mean*	*SD*	Nonresponse
Female	–	49%	–	3
Age (years)	44	44.93	16	0
At least high school diploma	–	65%	–	0
Household size	2	2.19	1	0
Number of children	0	0.50	–	0
Monthly net income (Swiss Franks)	5,300	8,716	18,543	140
Total *N*	757			

Appendix B

Material

The acceptance scale included the following questions (translated to English, original wording was German): *Do you think that the data the SwissCovid App collects are safe? Will you try to convince other people to use the SwissCovid App? Will you use the SwissCovid App? (If you use it already, please chose "agree completely") Do you think the SwissCovid App will help to slow the spread of the coronavirus?*).

The compliance scale included the following questions (translated to English, original wording was German): *Would you self-isolate if the SwissCovid App alerted you about having been in contact with an infected person? Would you enter your own infection into the SwissCovid App if you were infected with the coronavirus? Would you call the hotline that is recommended if the SwissCovid App alerted you about having been in contact with an infected person? Would you try to get tested for an infection with the coronavirus yourself if the SwissCovid App alerted you about having been in contact with an infected person?*

Table S1

Results of the Bayesian regression: Effects on the acceptance of COVID-19-related political measures in Switzerland

			CI	
Term	Estimate	*SE*	5%	95%
Intercept	-0.09	0.16	-0.41	0.22
Comprehension of DCTAs	0.38	0.03	0.31	0.44
Risk perception: data security	-0.14	0.03	-0.21	-0.08
Risk perception: economic	-0.11	0.03	-0.17	-0.04
Risk preference: general	-0.12	0.04	-0.19	-0.05
Mental health in last 30 days	-0.16	0.03	-0.22	-0.10
Risk preference: health	-0.06	0.04	-0.13	0.01
Gender: female	0.20	0.16	-0.12	0.52
Gender: male	-0.01	0.16	-0.33	0.31

Note. CIs are Bayesian credibility intervals. DCTA = digital contact-tracing application.

Table S2

Results of the Bayesian regression: Effects on the comprehension of the functionality of digital contact-tracing applications in Switzerland

			CI	
Term	Estimate	*SE*	5%	95%
Intercept	0.12	0.05	0.03	0.21
Support for political measures	0.40	0.03	0.33	0.46
Risk perception: data security	-0.14	0.03	-0.21	-0.08
Risk preference: data security	0.11	0.03	0.05	0.17
Interest in new technologies	0.10	0.03	0.03	0.16
Not working from home	-0.18	0.05	-0.28	-0.08
Partially working from home	0.00	0.06	-0.12	0.13

Note. CIs are Bayesian credibility intervals.