

Understanding Cultural Influence on Perspectives Around Contact Tracing Strategies

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Contact tracing, a major way to curb COVID-19 and other epidemics, has been employed worldwide, with human interviewing and proximity tracing technology as two major approaches. While previous research has contributed some understanding of people's perspectives on contact tracing technology, much of this is based in single countries or regions where technology has been deployed. To understand how culture influences people's perceptions toward human tracing and digital tracing, we replicated a mixed-methods survey study conducted in the U.S. in South Korea and compared participants' perspectives. South Korean participants preferred digital tracing to human tracing, contrasting with the U.S. context where no strong preference was observed. We discuss how observed differences in perspective align and contrast with the country's typical cultural dimensions, such as high power distance, informing the perspective that human tracing will have greater accuracy. We emphasize the need for culturally designing contact tracing technology to highlight personal benefits regardless of cultural dimensions, and leverage technology to support social interaction in human tracing.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**; Empirical studies in HCI.

Additional Key Words and Phrases: Contact tracing; Public health; Personal informatics; Self-tracking; COVID-19

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1 INTRODUCTION

Contact tracing has been an effective and significant way to curb infections, such as tuberculosis, sexually-transmitted diseases, and epidemics in recent years (e.g., SARS in 2003, H1N1 in 2009, Ebola in 2014, and COVID-19 in 2020) [1, 24, 37, 50, 84]. Contact tracing aims to identify, notify, and monitor infected people (positive cases) and the people who have closely interacted with positive cases (close contacts) [45]. The traditional approach is human tracing, which relies on human investigators to interview people [37, 45]. Digital tracing, with a relatively short history beginning

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with Ebola in 2014 [37], has been widely implemented globally for the first time during COVID-19 to augment human tracing. Digital tracing functions by either passively tracking people through proximity, location or requiring manual entry of personal data, such as daily symptoms and close contacts [5, 34]. Digital tracing and human tracing have been both employed in many countries and regions to curb the spread of COVID-19 for these two approaches' respective benefits and drawbacks, though one approach may be prioritized over the other.

During the COVID-19 pandemic, the HCI research community has developed some understanding of people's perceptions around digital contact tracing. For example, people's desires for privacy and data security influence their willingness to adopt digital tracing, since sensitive health information is shared with public health authorities to monitor virus transmission [6, 45]. However, much of our understanding is based on examining people's perceptions and use of contact tracing technology in one country. Previous HCI studies have shown that people perceive and use technology in different ways across cultures, with preferences between technology and non-technology solutions often varying by culture [7, 87]. In addition, as governmental strategy for addressing COVID-19 has largely moved from localized lockdowns (e.g., closing borders) to tracing people as they travel [40, 82], people are increasingly experiencing digital tracing strategies from different regions. Understanding how aspects of culture relate to people's perceptions of tracing technology is therefore important both to support people as they move between countries, and to design tracing technologies which align with people's cultural perspectives.

We therefore use Hofstede's cultural dimension model to understand cultural influences on people's perceptions of contact tracing technology. This model distinguishes nations' preferences on six characteristics: *individualism versus collectivism*, *power distance (PD)*, *uncertainty avoidance (UA)*, *masculinity versus femininity*, *long-term versus short-term orientation*, *indulgence versus restraint* [31]. Hofstede's model has been used in prior CSCW literature to help explain how culture influences people's use of collaborative and social technologies [11, 26, 64, 66]. In the context of COVID-19, studies have shown that these dimensions have impacted public health outcomes, with some dimensions contributing to individuals' willingness of participating in disease control measures while some others preventing [19]. However, current HCI studies in the space have mainly focused on *collectivism versus individualism* to examine people's perceptions and usage of contact tracing technology [18, 19]. Looking more broadly at the influence of cultural dimensions can offer a richer understanding of how aspects of culture relate to perspectives and how to design culturally-situated technologies.

To understand culture's impact on people's perspectives toward human and technological approaches to contact tracing, we replicate a survey conducted in the United States by Lu et al. [45] in South Korea, comparing 200 respondents' perspectives with those in the U.S. study. South Korea provides a useful contrasting lens with the United States, since it differs from the U.S. on all six of Hofstede's cultural dimensions [32]. Though individuals across cultures have varied orientations based on their background and personality, contrasting the overall tendency between South Korea and the U.S. offers a useful lens into how cultural aspects influence people's perceptions around human and digital tracing. We further examined how people perceived paper and QR codes for visit records to public places, an additional tracing measure in South Korea where participants had often experienced both human and technological approaches to tracing.

Overall, South Korean participants preferred digital tracing to human tracing, contrasting with Lu et al.'s study in the U.S. where no significant preference was observed [45]. Compared with the U.S. participants, South Korean participants perceived that digital tracing would provide higher data security and ability to provide emotional reassurance, but lower accuracy [45]. We discuss how these differences align and contrast with South Korea's typical cultural dimensions, such as South Korea's high power distance helping explain participants' perception that human tracing has

greater accuracy than digital tracing. Other dimensions may jointly impact perceptions, such as tendencies toward collectivism, high power distance, and femininity, may have led South Korean participants to feel different types of self-guilt in human tracing. The greater perceived emotional pressure from human tracing may further explain participants' wishes for having some indulgent behaviors during contact tracing, diverging from South Korea's restraint culture.

We specifically contribute:

- An understanding of how culture influences perspectives on contact tracing approaches, by comparing perspectives of people in South Korea to people in the U.S. We find that South Korean participants favored digital tracing over human tracing, whereas no significant difference was observed in Lu et al.'s study of the U.S. [45]. Overall, South Korean participants felt digital tracing would provide more personal agency, better protect data security, and mitigate emotional and social pressure brought by human interactions in contact tracing.
- A characterization of what aspects of culture influence perspectives toward contact tracing approaches, using Hofstede's cultural dimension model as an analytic lens. For example, South Korea's *collectivism*, *high power distance*, and *femininity* may all contribute to participants' perceived emotional pressure from human tracers in different ways. They therefore preferred digital tracing because it could better avoid COVID-19 social stigma in such cultural contexts.
- Insights on how to design contact tracing technology in ways which are sensitive to culture. We suggest technology to highlight benefits for individuals based on specific cultural dimensions, such as incorporating rewards or articulating mental burden depending on a culture's level of individualism, power distance, and/or indulgence. We also recommend leveraging technology to facilitate interactions between individuals and contact tracers in human tracing, especially in collectivist and high power distance cultures where people may perceive interaction with human tracers as uncomfortable.

2 BACKGROUND

Contact tracing is mainly categorized into three touchpoints: identifying, either technology or human tracers trace COVID-19 positive cases' whereabouts and other information to identify close contacts; notifying, close contacts will be notified by either approach to be asked to self-quarantine; monitoring, positive cases or close contacts will share their daily symptoms with public health authorities through technology or human tracers during self-quarantine [12, 13, 45].

The strategies and implementation of contact tracing in COVID-19 have varied in countries and regions, with manual tracking and tracing technology as two major distinct methods. Nearly fifty countries and regions have developed national contact tracing apps [67, 90], with most national apps allowing people to opt-in, while some are involuntary [15, 16, 67, 77, 90]. Human tracing, as the traditional approach, has been widely used, even in countries that have developed national tracing technology [42, 56]. Therefore, exploring people's cultural perceptions toward both digital and human tracing can provide insights on designing tracing technology to facilitate human tracers' jobs, as well as understanding of people's expectations towards the roles of human tracers in digital tracing.

South Korea has implemented a national contact tracing strategy driven largely by a centrally-coordinated digital system that has integrated GPS, credit card transactions, QR codes, surveillance cameras, and an official contact tracing app required for people in self-quarantine [60, 62, 82]. The traditional manual approach has also been used to investigate each case, with human tracers leveraging data from the digital system to verify positive cases' whereabouts and identify close contacts [43]. At the time of writing, participation in contact tracing is mandatory for positive cases, as well as close contacts who are in 14-day self-quarantine [69]. In contrast, how contact tracing is

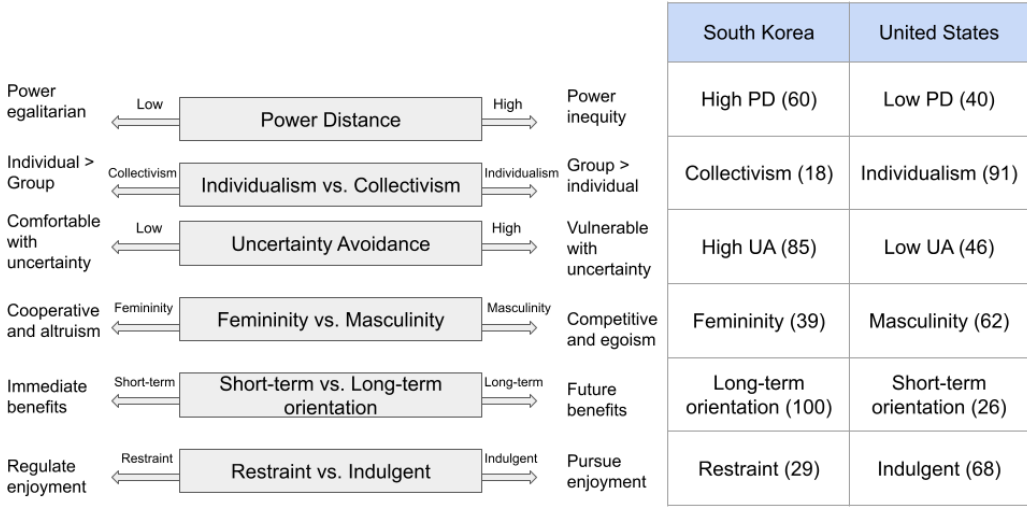


Fig. 1. The six cultural dimensions defined by Hofstede. The model scores a country's tendency towards each dimension on a scale from 0 to 100, with 50 separating low from high [33]. South Korea is a culture with high power distance, collectivism, high uncertainty avoidance, femininity, long-term orientation, and restraint, while United States is the opposite (scores in parentheses) [32].

implemented varies in different states in the U.S. Almost half of states have developed their own voluntary contact tracing apps, while some other states rely solely on human tracing [38, 45, 71]. In addition, human tracers in South Korea are mainly healthcare providers (e.g., physicians and nurses) who have undergone epidemiological training or public health officers, while some U.S. local public health authorities have also trained volunteers with no medical backgrounds to help with tracing [56].

3 RELATED WORK

3.1 Cultural Influences in HCI

Prior research has suggested that culture can greatly influence people's preferences around and use of technology, and aligning designs with people's cultural backgrounds can improve their experience with technology [14, 21, 29]. For example, HCI studies have drawn on the concept of high- (e.g., preferring visual elements in communication) and low-context (e.g., preferring numbers and text in communication) cultures to examine how culture influences the visual design of interfaces, such as graphic elements, textual components, and information architecture [48, 63, 65].

Hofstede's cultural dimensions theory [31] proposes six dimensions (Figure- 1) to examine cross-cultural differences, which have been widely adopted in HCI to offer suggestions for designing technology and understanding its use. *Collectivism versus individualism* and *uncertainty avoidance* are the two most used dimensions in HCI literature to explain cultural influences on people's acceptance to new technology [78].

- *Power distance (PD)* refers to the society's acceptance of unequal distribution of power, with higher power distance emphasizing hierarchical relationships and lower power distance pursuing equality in status [79]. High power distance tends to emphasize social hierarchy

when designing technology, such as highlighting the support of authorities (e.g., official organizations, certifications, experts) in the interface [2, 23, 83].

- *Collectivism* emphasizes the common good and strong interpersonal ties, while *individualism* stresses individuals' independence and benefits [31]. Research has suggested that people in collectivist cultures are more willing to participate in collaborative technologies (e.g., Q&A sites, polls) for communal benefit [61, 66], and have strong motivations to use social media and other technologies for impression management [75, 92].
- *Uncertainty avoidance (UA)* means the degree to which people in a society feel vulnerable or threatened by unknown or ambiguous situations, with higher uncertainty avoidance being more uncomfortable with vagueness [14, 23, 25, 30, 41, 44, 83]. Prior studies show that users in high UA cultures tend to prefer interfaces with limited options and richer information to avoid getting lost and making errors, while people in low UA cultures likely prefer minimalistic interfaces with more options for them to explore [14, 23, 29, 41, 83].
- *Masculine* cultures emphasize distinct gender roles and people being more competitive and assertive, while gender roles in *feminine* cultures are often overlapped and people prioritize domestic pursuits [23, 30, 41, 44, 83]. Some technologies in feminine cultures support cooperation and exchange of ideas between users, while some technologies in masculine encourage competition [23, 83].
- *Long-term orientation* pursues future benefits, while *short-term orientation* emphasizes immediate benefits of the past and present [23, 30, 41, 44, 83]. Short-term oriented users expect to complete tasks quickly when using technology, while long-term oriented users have more patience with new technologies [29, 41, 83].
- *Indulgence* means encouraging enjoyment of life, while *restraint* emphasizes regulating enjoyment through rigorous social norms [31, 44]. Technology designed to promote indulgence often provides interesting interactions and informal communication, while technology designed for restraint provides explainable interaction [57].

Through these different dimensions, we investigate how aspects of culture may influence people's perceptions toward contact tracing approaches.

3.2 Cultural Influence on COVID-19 Response

Individuals' responses to COVID-19, including their perceptions and participation of COVID-19 control and preventive measures, are influenced by their situated national cultures. Experiences from previous outbreaks suggest that culture plays a key role in how people perceive infectious diseases and respond to public health measures, and ignoring cultural influences could result in negative public health outcomes [27]. Scholars, therefore, have often applied Hofstede's cultural dimensions to explore governments' and people's responses to COVID-19 around the world [17, 27, 52, 53, 78, 89].

Literature has used many of Hofstede's cultural dimensions to understand perspectives on COVID-19 preventive and control measures, finding *collectivism*, *high power distance*, and *restraint* contribute to individuals' willingness of complying with COVID-19 public health measures [17, 27, 52, 78, 89], and are negatively associated with the growth of COVID-19 cases. For example, people in high power distance cultures tend to be more amenable to COVID-19 related measures, as they have more trust in public health authorities and governments [17, 27]. Conversely, some studies found people in high *uncertainty avoidance* cultures were reluctant about participating in new but controversial COVID-19 measures, such as whether digital tracing and wearing masks were effective in controlling the pandemic [17, 89].

Table 1. Seven qualitative themes identified in Lu et al.’s study [45], and participants’ preferred approach in terms of each theme and their reasons. People favored digital tracing when considering privacy, accuracy, and convenience, while preferring human tracing on data security, advice, emotional reassurance, and accessibility.

	Privacy	Data Security	Advice	Accuracy	Convenience	Emotional Reassurance	Accessibility
Preferred Approach	Digital	Human	Human	Digital	Digital	Human	Human
Reasons	Support anonymity	Prevent technology’s third party and data leakage issues	Provide personalized instruction	Prevent human errors	Reduce manual interaction burden	Provide human touch	Avoid digital inequality

Though we now have a good understanding of how different cultural dimensions have influenced people’s responses to COVID-19 public health measures and the spread of the disease, there is a lack of understanding on how different cultural dimensions might influence people’s perceptions toward contact tracing technologies.

3.3 People’s Perspectives on COVID-19 Digital Tracing and Human Tracing

While the field of HCI has mostly focused on exploring people’s perceptions and adoption of digital tracing [18, 39, 73, 74, 88], human tracers are often involved in the digital tracing process, such as reviewing collected data and contacting positive cases or close contacts [42, 43]. Therefore, examining people’s perceptions toward human tracing relative to digital tracing provides a more complete understanding of the frequently used approaches to contact tracing. Lu et al. [45] identified seven themes around people’s concerns for human tracing and digital tracing: privacy, data security, advice, accuracy, convenience, emotional reassurance, and accessibility (Table 1). How people perceive the respective strength and drawback of human and digital tracing leads to their favoring one approach over the other on each theme. Table 1 shows the U.S. people’s preferred tracing approach for each theme, and reasons for their preferences. They favored digital tracing for its perceived benefits in privacy, accuracy, and convenience, while preferring human tracing when considering security, advice, emotional reassurance, and accessibility [45]. However, this study only examined people’s perceptions toward digital and human tracing in the U.S. Because cultural dimensions appear to influence how people participate in public health measures, culture may similarly impact how people in other countries perceive two contact tracing approaches’ respective benefits and weaknesses on these seven themes. We therefore investigated how South Korean participants felt each tracing approach based on these seven themes, comparing their perceptions with those of U.S. people [45] focusing on the cultural differences.

Other HCI work has looked at perceptions of digital tracing in one country or across countries, finding some key aspects influencing people’s perceptions and adoptions of contact tracing technology, such as privacy, data security, and COVID-19 related negative emotions. People’s desire for privacy and data security influences how they perceive digital tracing, since they have to share personal health data, such as daily symptoms and recent whereabouts, when using these systems [6, 45]. Privacy and data security concerns were mostly around the mistrust of the government [4, 28, 59, 93], disclosure of data to third parties such as tech companies [43, 45, 59], and data storage infrastructure being unreliable or vulnerable [37, 45]. Utz et al. [88] found Chinese participants having high acceptance and willingness to share data while U.S. participants having lower acceptance and desiring data anonymity. Guilt, shame, and social stigma related to infectious diseases may also influence people’s willingness to use contact tracing technology. Jamieson et al. [39] found Japanese people worried about receiving exposure notifications would negatively impact their ability to work and socialize, leading to hesitation with using the national COVID-19 contact tracing app in workplaces.

The cultural dimension of *collectivism versus individualism* has been used in some studies to explain these aspects examined in across countries or one specific country context. For example, work has suggested that Americans with a collectivist social orientation had a higher perceived benefit of contact tracing apps than those with an individualist social orientation [74]. A desire to curb virus transmission for the common good makes people with collectivist tendencies tend to endure or ignore usability and privacy issues with contact tracing technology [18, 74]. However, current work has rarely used other cultural dimensions, limiting our understanding of how culture shapes people's perceptions toward contact tracing technology. Through examining the preferences of South Korean people in comparison to people in the United States, our study explores the influence of culture on people's perceived benefits and concerns around contact tracing technology.

4 METHODS

We deployed a survey in South Korea to understand how culture would influence people's perceptions toward different contact tracing approaches in November 2020. In the survey, we asked how South Korean respondents perceived the respective strengths and drawbacks of human tracing and digital tracing.

4.1 Survey Structure

We developed the survey based on Lu et al.'s survey on human and digital contact tracing deployed in the U.S. [45], translating it into Korean. We replicated main questions around human and digital tracing, and the optional demographic question section from the U.S. study. We leveraged the same five-point Likert-scale questions, and posed open-ended questions to understand people's attitudes toward human tracing and digital tracing. We asked participants to rate their comfort levels of these two approaches in three tracing touchpoints (identifying, notifying, and monitoring), such as *"How comfortable do you feel about the following approach (human tracing or digital tracing) of helping identify close contacts/being notified/monitoring?"*. Participants also rated how they felt comfortable sharing different personal information with each approach, such as whereabouts, close contacts, and identifiable information. We also added questions asking people's perceptions on recording visits to public places on paper and with technology (via a QR code), a required tracing measure in South Korea at the time of the study, as an example where participants had frequently experienced and interacted with both human and technological approaches to tracing. Participants also rated how they felt about the South Korea's official contact tracing app developed for citizens or foreigners required to self-quarantine, based on qualitative themes surfaced in the U.S. study [45]: *"Based on what you know about the official contact tracing app, how much do you feel the app is private/secure/accurate/convenient/emotionally reassuring/providing useful advice/accessible?"*. The survey took approximately 15 minutes to complete. The study was approved by the IRB of the Korean authors' institution, and was classified as exempt for the other authors' institution because it did not involve more than minimal risk to participants.

4.2 Recruitment

We created the survey on SurveyMonkey, and recruited responders from an Asian panel-based sampling platform for research in both industry and academia, Entrust Survey. We used this platform to stratify participants whose demographics represent South Korea's population, ending up with 200 complete responses from people who spoke Korean and lived in South Korea. We paid each participant ₩3000 (\$2.60 at the time of the study). We conducted this study in November 2020, which was before COVID-19 vaccines' rollout throughout the world and governments had to mostly rely on contact tracing and other public health measures to control the spread of the virus.

Table 2. Participants' self-reported demographic information.

Gender	Age	Educational Background	Annual Household Income
Female: 100 (50%)	18-27: 20 (10.0%)	Less than high school: 3 (1.5%)	≤ ₩35M (\$32K): 33 (16.5%)
Male: 100 (50%)	28-37: 33 (16.5%)	High school: 26 (13.0%)	₩35-50M (\$32K-45K): 52 (26.0%)
	38-47: 36 (18.0%)	In college: 10 (5.0%)	₩50-75M (\$45K-68K): 57 (28.5%)
	48-57: 41 (20.5%)	Bachelor's degree: 144 (72.0%)	≥ ₩75M (\$68K): 58 (29.0%)
	58-64: 57(28.5%)	In/completed grad school: 17 (8.5%)	
	65+: 13 (6.5%)		

Table 2 shows how participants self-identified their demographic information. Participant ages ranged from 20 to 69 (mean=47.8, sd=13.6), and the age distribution was similar to South Korea's, except our survey had less elderly people than the country as a whole (12.5% 65+ in 2020, versus 6.5% in our sample) [81]. 197 (98.5%) of participants' education level was high school or higher, and 161 (80.5%) had at least a bachelor's degree. The median annual household income of our participants fell between \$45,000 and \$68,000 annually, which was higher than South Korea's median household income (\$40,861 in 2021) [68]. All participants had South Korean nationality. Five participants (2.5%) had been in contact with public health authorities as a positive COVID-19 case or a close contact, and 27 participants (13.5%) had heard from someone close identified as positive cases.

4.3 Analysis

Our research team consists of researchers both from and based in the U.S. and South Korea. Two South Korean authors, who are fluent in both English and Korean, translated the survey answers from Korean to English, sharing them with the rest of the research team.

Similar to Lu et al.'s study, we used mixed-effect ordered logit models to analyze five-point Likert-scale questions in which people rated their comfort with human and digital tracing [45]. We compared the responses with Lu et al.'s participants' to examine whether there were cultural differences in people's perceptions toward contact tracing approaches and willingness of sharing data in contact tracing. We treated the comfort level Likert ratings as an ordinal response. We treated the contact tracing approaches (two levels), touchpoints (three levels), and countries (two levels) as categorical fixed effects, and participant IDs as a random effect. As for people's comfort with sharing different data types, we similarly treated contact tracing approaches (two levels), data types (seven levels), and countries (two levels) as categorical fixed effects. We used false discovery rate corrections to correct multiple comparisons in post-hoc tests. We similarly analyzed people's comfort preference between paper and QR codes for visit records. We also used descriptive analysis to examine participants' perceptions for South Korea's official contact tracing app's abilities to provide privacy, data security, accuracy, convenience, emotional reassurance, advice, and accessibility.

We qualitatively analyzed the open-ended answers through thematic analysis [10]. The first three authors first open-coded 30 survey responses each. They then met and generated a codebook, specifically focusing on how the socio-cultural context may influence people's perceptions by comparing potential themes with seven qualitative themes identified in the prior U.S. study [45]. Therefore, the seven themes generated from the U.S. study were used to help form the initial codebook. It contained all the themes from the U.S. study (privacy, convenience, data security, emotional reassurance, advice, accessibility, and accuracy) [45] and themes may reflect the socio-cultural difference from the U.S. study (e.g., cultural influence). They then discussed the codebook with the rest of the research team to iterate the codebook as well as giving definitions and examples for each subcode. The codebook first contained 10 parent codes (information privacy, convenience,

data security, emotional reassurance, advice, accessibility, cultural influence, social and interaction privacy, perceptions about the government's contact tracing strategy, and accuracy) and 13 subcodes. Then, the three authors utilized the codebook to code another 20 survey responses to calculate the inter-rater reliability, with five codes' kappa value over 0.8 (accessibility, advice, information privacy, perceptions about the government's contact tracing strategy, and emotional reassurance) and two codes' kappa value over 0.7 (social and interaction privacy, convenience). We did not have a high agreement for cultural influence (kappa value=0.324), data security (kappa value=0.543), and accuracy (kappa value=0.613). We therefore merged information privacy and data security as one parent code, and gave more detailed definitions for cultural influence and accuracy to resolve ambiguities and ensure consistency. The three authors then coded the rest of the survey responses.

We used Hofstede's cultural dimension model as a guiding theory to help interpret results in discussion. We chose Hofstede's cultural dimensions over other frameworks, such as Schwartz's cultural value orientations [72] and Trompenaars' seven-dimension cultural model [86], since it has been widely used to compare cross-cultural differences in different kinds of COVID-19 response, such as individuals' willingness to participate in digital tracing, wearing masks, and keep social distancing [17, 27, 52, 53, 78, 89]. This allows our findings to be more closely compared with prior work. Scholars also suggest that metrics across these models have significant overlap [20, 76], with Hofstede's model performing somewhat better in clustering nations with similar cultures [46]. In addition, Hofstede's model is widely used in related domains like infectious diseases control [36] and technology adoption [20]. However, we acknowledge there are flaws and critiques for each cultural framework [20, 46, 76, 80], such as Fatehi et al. suggesting that individualism and collectivism be divided into a horizontal and vertical dimension to better account for the dimension's complexity [22]. There is value in future research examining perceptions of or experiences with technology through a combination of multiple models' dimensions.

In Results, we refer to individual participants with PXX, where XX refers to their unique participant number.

4.4 Limitations

We chose to compare people's perceptions toward contact tracing strategies between South Korea and the U.S. for their distinct cultural dimensions and contact tracing implementations. However, many other country-specific differences also shape people's perceptions of contact tracing, such as COVID-19 public health messaging, political factors, and health beliefs. Comparing South Korea and the U.S. enables understanding of how each cultural dimension might impact people's perceptions toward human tracing and digital tracing. However, insights from countries that have different tendencies on these cultural dimensions than South Korea and the U.S. could further surface or confirm different cultural dimensions' influences on people's preferences, and further exploration in other countries which differ on some cultural dimensions would be valuable to have deeper understandings of cultural influences. In addition, though we aim to objectively describe our participants' perspectives on contact tracing, our cultural backgrounds have inevitably had some influence on how we interpret their stated preferences and what we chose to highlight. Future work should continue to involve people of varied cultures and backgrounds as participants and researchers to better understand perspectives around contact tracing.

Cultural dimensions represent how countries or cultures as a whole have different preferences on a society's values, rather than individuals. The preferences of individuals may align with or be different from those of the nations they were raised in or currently live in. In looking at different cultural dimensions, we are generalizing across the perspectives of specific people in South Korea and the United States. It is important to recognize that individuals often have distinct perspectives based on their background and personality. Our findings should therefore not be taken

Table 3. South Korean and the U.S. participants' favored approaches for seven qualitative themes identified in Lu et al.'s study [45]. Participants indicated the same favored approaches on privacy, convenience, advice, and accessibility. However, South Korean participants had different favored approaches on security, accuracy, and emotional reassurance.

		Privacy	Security	Accuracy	Convenience	Emotional Reassurance	Advice	Accessibility
Favored approach	South Korea	Digital	Digital	Human	Digital	Digital	Human	Human
	United States	Digital	Human	Digital	Digital	Human	Human	Human

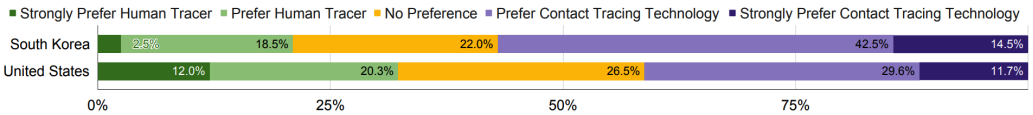


Fig. 2. A higher proportion of South Korean participants preferred contact tracing technology to human tracing than Lu et al.'s sample in the United States [45].

as conclusions about the perspectives of all people from a particular country or nationality on contact tracing, but rather considerations for aligning contact tracing to the needs of multiple cultural backgrounds.

Our sample had fewer older adults than South Korea's demographics, which may lead to our participants' overall more positive attitude towards technology because having fewer accessibility issues. Though about 80% of our sample had a bachelor's degree (compared to 56% of participants in Lu et al.'s study of Americans), our participants' higher education rate is relatively on par with South Korea's high education rate [47, 58]. 89% of South Korean adults between 25 and 64 have obtained upper secondary education degrees [58]. Differences in perspectives observed may therefore be somewhat influenced by education as well as cultural differences. The median annual household income of our participants was slightly higher than South Korea's. Though prior work about contact tracing has suggested that people with higher education and income levels tend to welcome technology and may worry less about digital equity [3, 45], we observed that participants expressed similar accessibility concerns to participants in Lu et al.'s U.S. study and perceived lower accuracy, suggesting influences of socioeconomic status may have been minimal [45].

5 RESULTS

5.1 Comparison between U.S. and South Korea data

We primarily highlight areas where South Korean participants' perspectives on contact tracing approaches differed from the U.S. study [45] by comparing their quantitative data (Table 4) and qualitative themes (Table 3).

Overall, South Korean participants had a more positive perception towards digital tracing than human tracing ($z=14.25$, $p<0.0001$, 95% CI 0.67-0.92 higher on a 5-point Likert scale) (Figure 2), in contrast to no observable presence in Lu et al.'s study of people in the U.S. ($p=0.22$) [45]. Table 4 shows South Korean participants were more comfortable with digital tracing on all the three touchpoints, while the U.S. study only had an observed comfort preference on the monitoring touchpoint, which was also towards digital tracing. In addition, we observed an interaction effect where South Korean participants had less comfort with human tracing than digital tracing when sharing personal data ($z=-14.98$, $p<0.0001$, 95% CI 0.16-0.94 lower on a 5-point Likert scale), while the U.S. participants expressed the opposite preference ($z=3.53$, $p=0.0004$, 95% CI 0.77-1.44 higher on a five-point Likert scale).

Table 4. Comparison of quantitative differences between perceptions of U.S. and South Korean participants. U.S. participants overall had no measured preference towards digital or human tracing, while South Korean participants overall were more comfortable with digital tracing. Significant differences among touchpoints were only observed for the U.S. participants when monitoring, while South Korean participants preferred digital tracing for all the three touchpoints.

	United States	South Korea
Overall comfort preference between two approaches	No significant difference (2(1, N=1476)=1.53, p=0.22)	More comfortable with digital tracing (z=14.25, p<0.0001, 95% CI 0.67-0.92 higher on a 5-point Likert scale)
Comfort preference between two approaches at three touchpoints	Identifying	
	No significant difference (p=0.48)	More comfortable with digital tracing (z=11.96 p<0.0001 95% CI 0.90-1.51 higher on a 5-point Likert scale)
	Notifying	
	No significant difference (p=0.41)	More comfortable with digital tracing (z=4.79 p<0.0001 95% CI 0.35-0.94 higher on a 5-point Likert scale)
	Monitoring	
	More comfortable with digital tracing (Z=3.64, p<0.001, 95% CI 0.28-0.93 higher on a 5-point Likert scale)	More comfortable with digital tracing (z=8.70 p<0.0001 95% CI 1.16-1.79 higher on a 5-point Likert scale)

Qualitatively, participants in both studies described favoring the same approach on privacy, convenience, advice, and accessibility to the U.S. participants (Table 3). However, South Korean participants expressed different respective benefits and drawbacks of digital and human tracing on security, accuracy, and emotional reassurance. How South Korean participants perceived digital and human tracing's benefits and drawbacks on these three themes likely led to their overall preference on digital tracing over human tracing, which was not observed in the U.S. study. Notably, participants' preferences towards each theme reflect people's overall trends, and individuals' preferences varied to some degree.

To help explain the interaction effect we observed where culture tended to influence participants' perceptions on human versus digital tracing, we present qualitative themes which offer explanation of South Korean participants' more positive attitudes toward digital tracing than human tracing: accuracy, emotional reassurance, and data security. In each subsection, we introduce reasons which accounted for South Korean participants' attitudes toward digital tracing and human tracing: individuals' agency associated with accuracy, self-consciousness brought by participating in contact tracing, and social impacts of information disclosure related to data security.

5.2 People's Agency in Technology and Human Tracing

Participants in the U.S. study felt digital tracing could provide greater accuracy, mainly because of its ability to capture information (e.g., recent whereabouts) more easily and avoid human errors [45]. However, though realizing some of digital tracing's advantages identified in the U.S. study, South Korean participants perceived human tracing to be more accurate, since tracers' authority would hold people more accountable in the contact tracing process, such as contributing more detailed personal data. In contrast, South Korean participants felt people could (un)intentionally make mistakes and even ignore tasks in digital tracing when they are not monitored by human tracers. Participants also often wondered whether digital tracing would introduce errors that a human could correct, such as sending notifications to people who are actually not close contacts by mistake. This different perception towards the two approaches' ability to ensure accuracy also

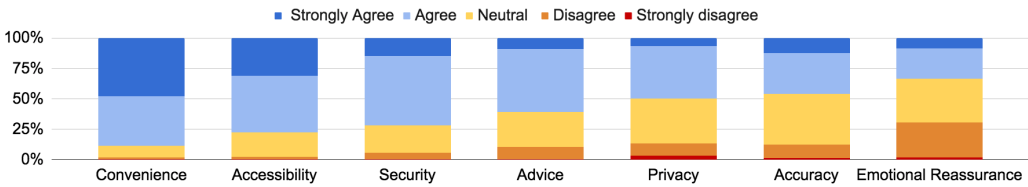


Fig. 3. Participants overwhelmingly valued the South Korea's official contact tracing app's convenience and accessibility, were generally positive on security, advice, privacy, and accuracy, and were skeptical on the app's ability to provide emotional reassurance.

made people feel differently about participating in contact tracing with technology versus with humans. Participants viewed human tracing as a requirement, while digital tracing could enable more personal agency.

5.2.1 Human Tracing: An Obligation, Leading to Greater Accuracy. Participants felt they would be obligated to participate in contact tracing if it was conducted by human tracers, as they often regarded human tracers as “officials”(P3) or “experts”(P131). The human tracers’ authority seemed to make participants view contact tracing more seriously: “I would feel the seriousness of the situation well and be careful of reacting to the follow-up actions”(P66). P97 similarly felt: “I would realize the seriousness of the situation and be more proactive in contact tracing.” Participants expressed a comparatively looser attitude towards digital tracing because “it is not compulsory, people may not participate actively”(P96). Therefore, some participants felt they could easily ignore messages sent by technology and escape the follow-up measures: “Those who think that they have no symptoms would be likely not to go do the testing because they think they are not the only one who received the message”(P86). Our data also suggested that participants were least comfortable with digital tracing notifying close contacts ($z=-4.27$, $p=0.0001$, 95% CI 0.35-0.94 on a 5-point Likert scale) among the three touchpoints. In contrast, human tracers’ authority made people feel they were obligated to take certain measures: “I would feel I’m clearly identified and have no choice but to go to testing”(P86).

Furthermore, participants thought human tracers’ authority would make individuals contribute more and in-depth data. Though prior work suggests people perceive that technology would provide more accurate information [45], participants more frequently mentioned accuracy when describing advantages of human tracing ($n=150$) than advantages of technology ($n=83$). Participants generally felt that human tracers would hold people accountable for data entry. First, since human tracers could raise people’s awareness of COVID-19, people would then have “a more careful and sincere attitude”(P14) when revealing their information: “I have an obligation to share information with human tracers and to be careful not to harm myself but also others, so I would share it faithfully with them”(P116). Second, some participants felt interacting with human tracers would make it difficult for them to lie or hide information: “It is hard to lie and less likely to answer insincerely. As humans are asking, they can catch nonverbal expressions and ask detailed questions”(P127). In addition, participants expected that human tracers’ expertise could help them identify whether the information told by positive cases or close contacts was accurate: “Experts with knowledge would be able to identify close contacts precisely and notice something difficult for a confirmed case to come up with themselves”(P26).

5.2.2 Digital Tracing: More Personal Agency, but with Uncertain Accuracy. In contrast to the obligatory nature of human tracing, participants appreciated that digital tracing could support more personal agency. However, participants did not agree on whether personal agency given to people would contribute to the accuracy of collected data. Some participants felt technology’s anonymity

could lead to less accurate data. Participants generally agreed (46.0%) or were neutral (41.5%) on whether South Korea's official contact tracing app was accurate (Figure 3). Participants suggested that people could selectively report or fake data when manually logging information via technology: *"A mobile app allows people to take enough time to think, so people might respond insincerely or fake the answers"* (P192). Participants also felt technology's anonymity would lead to less accountability: *"Respondents can state false information if they feel at a disadvantage because anonymity is guaranteed"* (P61) and less sincere logging: *"someone can write an answer as a joke"* (P45). However, some participants felt that digital tracing could allow them to participate at their own pace and contribute higher quality data by reflecting on their past with sufficient time, rather than being pressured by human tracers to respond quickly. For example, P134 perceived that human tracers would pressure them to recall and provide accurate data within a limited time: *"I need time to recall things which I cannot immediately remember, but if human tracers are waiting for me, I would feel like being pressed."* Therefore, they appreciated digital tracing: *"I would have enough time to think about the response and give more accurate and detailed answers"* (P36).

In contrast to U.S. study participants who mainly ascribed inaccuracy to potential mistakes around manual human entry [45], more South Korean participants questioned digital tracing's potential machine errors or trustworthiness (n=84) than human tracing's manual errors (n=69). Participants worried automatic information sent by machines would be *"spam messages"* (P1) or *"less sincere and reliable"* (P76), compared with communication with human tracers. For example, P21 suspected: *"[Digital] is [more] unclear than human notification because I would wonder if the results are notified accurately."* P84 felt apps would not be flexible enough to allow people to provide as detailed information as they might want: *"I may not be able to talk about every detail in the application, which may lead to various errors or misrepresentations."* Some participants felt that they would perceive automatic messages as spam or phishing: *"Text messages are likely to be misunderstood as spams or to be skipped that people may not recognize whether they have been notified or not"* (P128). Participants also worried about potential problems resulting from *"system errors"* (P159) during digital tracing. P143 was concerned about the credibility of a digital contact tracing system: *"The credibility around the accuracy of the system can be diminished due to its errors and omissions"* (P143). For example, P199 imagined receiving false notifications during digital tracing: *"System errors might lead to sending information to a wrong person."*

5.3 Feeling Self-Conscious about COVID-19

Participants in the U.S. study appreciated human tracers' ability to empathetically understand and comfort people who tested positive or their close contacts, and questioned technology's capability in providing emotional comfort [45]. Although some South Korean participants felt human tracers could provide comfort, they also felt human tracers could make them feel self-conscious about having or being in close contact with someone who got COVID-19, and digital tracing would provide more personal space. People often experience guilt and shame when getting in contact with an infectious disease [70, 94]. South Korean participants described being less willing to engage in human tracing because they cared more about these negative emotions prompted in social interaction than the human comfort it could provide. Digital tracing, as *"a machine"* (P38), could eliminate interpersonal communication, resulting in less guilt and shame.

5.3.1 Human Tracing: a Human Touch, but Adds Mental Pressure. Participants felt human tracers could be both emotionally beneficial and harmful, potentially both providing support and introducing guilt. Participants felt that being identified as positive cases or close contacts would make them be *"emotionally intimidated in situations like COVID"* (P145). Therefore, similar to prior work [45], some participants preferred *"more humane"* (P151) conversations with human tracers, feeling that

their expertise would make them mentally comforted: *"I would feel relieved that the human tracer is going to take care of me and can protect my safety and health"*(P31).

However, participants also felt that human tracers could raise people's self-guilt if identified as a positive case or a close contact. Our study surfaced different types of self-guilt during human tracing. First, while human tracers' authority could hold people accountable when providing data, participants felt it could also trigger their guilt around being unable to provide accurate data: *"I would fail to remember things and answer the sudden questions, and feel guilty as if I made some big problems"*(P104). P158 similarly felt: *"I could be so anxious that I can't remember much. I would feel scared."* Second, people's guilt related to COVID-19 could be enhanced when others know that they may be infected: *"I would feel resistant or shamed compared to using technology, because it can be unpleasant or embarrassing to have someone know my private life."*(P12). P157 expressed that they would feel shame if someone else had to monitor their symptoms: *"I would feel ashamed and annoyed to report nitty-gritty details to humans."* Finally, participants expressed guilt about using resources of the government, perceiving human tracing as less efficient and requiring higher labor cost than digital tracing: *"There may be a loss of national resource in that it takes protection and control effort, time and money to notify the contact directly by humans"*(P26). Some participants also felt sorry for human tracers, feeling that it would take substantial effort to notify contacts of potential COVID-19 exposure: *"I would just feel pressured and sorry as they would need to notify a number of people, and I would be one of their annoying tasks"*(P181). Participants worried about the toll that contact tracing would take on human tracers' physical and mental wellbeing: *"The human tracers would be very tired as they have to explain and inform all the same things. Also they can be hurt by people's emotional reactions"*(P109). Though human tracing was typically conducted remotely, some participants were still concerned about human tracers' risks of getting infected: *"There is no 100 percent certainty that the human tracers would not be infected, even if they wear perfect equipment"*(P60).

Similar to prior work [45, 51, 55], participants feared being stigmatized by human tracers for getting exposed to COVID-19 or being judged for their sensitive personal information. P147 described, *"I think I would feel like a student who gets scolded for not doing his homework properly. I don't even know what I did wrong, but I am criticized. It would feel bad."* However, our data surfaced a deeper envisioned fear than being discriminated against. Participants were least comfortable with human tracers identifying close contacts among the three touchpoints ($z=-5.70$, $p<0.0001$, 95% CI 0.87-1.47 lower on a 5-point Likert scale). Participants often imagined interviews for human tracing would feel like interrogations: *"I would feel the pressure of face-to-face contact tracing and the feeling of being interrogated. The pressure would be strong in many ways"*(P21). Some participants even imagined that having to be traced by humans would make them feel like criminals: *"I would feel intimidated to have conversations with human tracers and my mind might go blank. I didn't commit any crime, but I might feel as if I am a criminal"*(P195). South Korean participants were overall less comfortable sharing a confirmed diagnosis ($z=-5.07$, $p<0.0001$, 95% CI 0.40-1.04 lower on a 5-point Likert scale), the identities of close contacts ($z=-5.02$, $p<0.0001$, 95% CI 0.39-1.03 lower on a 5-point Likert scale), and recent whereabouts ($z=-3.84$, $p=0.0001$, 95% CI 0.23-0.86 lower on a 5-point Likert scale) than U.S. participants. We observed an interaction effect where South Korean participants were more comfortable with digital tracing for sharing these data than human tracing (confirmed diagnosis: $z=5.45$, $p<0.0001$, 95% CI 0.31-0.73 higher on a 5-point Likert scale; close contacts: $z=7.27$, $p<0.0001$, 95% CI 0.48-0.90 higher on a 5-point Likert scale; recent whereabouts: $z=7.22$, $p<0.0001$, 95% CI 0.47-0.90 higher on a 5-point Likert scale), while no significant difference was observed in the U.S. participants' preferences between two approaches (confirmed diagnosis: $p=0.23$; close contacts: $p=0.29$; recent whereabouts: $p=0.06$).

Participants felt that the fear and shame brought by human tracers would add to people's fear towards the virus, exacerbating the mental burden of learning that they would be a positive case or a close contact. P115 expressed: *"I think I am going to cry, in fact cannot even cry at will, if notified like this way about the bad news."* Participants felt that human tracers' role in alerting people about the situation might also increase people's mental burden because *"If I'm notified directly from people, I would feel like something big and serious happened and become terrified even more"*(P82).

5.3.2 Digital Tracing: Inhumane, but Less Discomfort. Most participants were skeptical that South Korea's official contact tracing app could provide emotional reassurance, with many participants either feeling neutral (36.0%) or disagreeing (30.5%) (Figure 3). However, participants often perceived digital tracing's inability to provide reassurance as an advantage, given human tracing's potential to apply pressure. Similar to prior work [45], participants felt technology could ease social anxiety for introverts or people who feel sensitive about social interactions. Furthermore, they perceived technology as a *"mechanical system"*(P14) which could mitigate negative emotions caused by being contacted about COVID-19 via providing necessary personal space.

Participants perceived that technology could enable people to digest or accept the shocking news about being positive cases or close contacts by themselves, removing any potential discomfort from being told the news by another person: *"When notified via automatically generated text messages, phone calls, or emails from the system, it seems to be more comfortable to accept than being told face to face by a person"*(P43). Participants felt they would also have less embarrassment about revealing sensitive information, such as whereabouts, to digital systems: *"Even if there's something I don't want to talk about, it's a machine anyway, so I'll feel less uncomfortable"*(P38). Participants felt that technology's efficiency could reduce the guilt they felt around spending national resources and slowing containment of the virus: *"I may feel efficiently managed by an organized system and less sorry for the public health authorities"*(P14). P142 similarly felt: *"I think investigating through technology is more appropriate for fighting with pandemics in modern society. The reason is that it has great significance in saving time and avoiding waste of manpower, and it is also preventing the second spread of COVID."*

A few participants felt the comfort provided by digital tracing would allow people to contribute accurate data, differing from most participants who felt human tracers would hold them accountable when reporting information. The perceived pressure brought by human tracers might make some participants *"distort or downplay the facts"*(P163) because *"I could feel so intimidated that I intentionally downplay the situation"*(P190). Therefore, some participants thought they would be more honest with digital tracing because it would provide *"a more comfortable environment"*(P41) that *"respondents would answer more accurately with a stable mind and clearer memory"*(P108). Participants also felt technology could decrease their embarrassment when disclosing personal information, therefore contributing more accurate data: *"It allows me to write down honestly without reluctance from situations where I have to tell the human tracers about embarrassing facts about close contacts or whereabouts"*(P128).

5.4 Information Disclosure and Its Social Impacts

Overall, South Korean participants questioned human tracers' ability to protect both information privacy and data security. Similar to the U.S. study [45], participants felt anonymous digital tracing had greater privacy than human tracing, though both approaches would have risks. Participants generally agreed (49.5%) or were neutral (37.9%) on whether South Korea's official contact tracing app provided privacy (Figure 3). South Korean participants generally had more trust in digital tracing's ability to prevent information leakage, since they associated a higher likelihood of leaking information with human tracers. In contrast, the U.S. study attributed better data security to human

tracing, because they felt technology would be more likely to be hacked and tech companies which develop apps could get access to people's data [45]. South Korean participants mostly feared that information disclosure would lead to negative social consequences, such as being socially isolated, typically associating this concern with human tracing. With technology, participants were mainly concerned about its black box design and wished to have more transparency.

5.4.1 Human Tracing: Higher Likelihood of Leaking Information and Causing Social Stigma. Participants questioned human tracers' ability to protect individuals' data, even though they often perceived human tracers as authority figures: *"I don't know how far I can trust officials who manage self-quarantine in which I have to provide them my personal information"*(P3), in contrast to the U.S. participants' trust of human tracers' authority in terms of preventing information leakage [45]. We did not observe a significant difference in South Korean participants and U.S. participants' comfort level of sharing personal identifiable information overall ($p=0.1102$). However, an interaction effect suggests that South Korean participants were more comfortable sharing this type of information with digital tracing than human tracing ($z=6.60$, $p<0.0001$, 95% CI 0.42-0.85 higher on a 5-point Likert scale), while the U.S. participants were marginally more comfortable with human tracing ($z=1.96$, $p=0.0506$, 95% CI 0.03 lower-0.37 higher on a 5-point Likert scale). South Korean participants felt human tracers could easily leak information either intentionally or accidentally: *"It's human work, so my information can be exposed to the public, which would make me mentally tired"*(P147). P103 worried: *"If human tracers are morally immature and lack security awareness, personal sensitive information can be leaked."* P14 also feared human tracers to be *"someone I know."*

Participants' privacy and data security concerns were mainly around potential social pressure that they could receive from society if their COVID-19 exposure or identifiable information became known to the public. Compared with the stress brought by human tracers, societal pressure related to COVID-19 could cause more *"heartbreaking"*(P46) social consequences to anyone who was revealed as a positive case or a close contact. P15 described, *"if the personal information of individuals who are in self-quarantine is leaked out, it can cause serious damage to them and their families due to inappropriate rumors."* P76 felt that the social stigma caused by information leakage could even threaten people's jobs: *"I would be embarrassed, upset, and worried about privacy violations. My living and jobs can be disturbed."* Participants envisioned that they might be still stigmatized even if they recovered: *"There is a concern that my self-quarantine may be known to others, and if it is revealed, people would avoid me even if it is completely cured. It's going to be tough"*(P112). Meanwhile, some participants stressed the significance for the public to know when there were positive cases or who were close contacts, which also reflects the public's desire to know some identifiable information of people who have been exposed to COVID-19. Participants felt knowing information of close contacts or positive cases could let people take corresponding action to protect themselves: *"It's legitimate to protect the public's rights to know. It is important for the public to know the close contacts to avoid them and prevent further spread"*(P156). When checking into public places, some participants, such as P31, even appreciated that paper records did not protect privacy: *"Since I can check the number and identities of people in the place which I visit, I feel secure."*

Since participants felt human tracers were more likely to leak information, they more frequently expressed their fear towards social stigma in human tracing: *"Personal information protection may be poor, so it is likely to be vulnerable to security. And people would frown upon me due to the stigma against confirmed cases"*(P119). In contrast, participants perceived that technology's anonymity and its capability to protect data security could avoid social stigmatization: *"The testing can be reduced and unnecessary leakage of information to neighbors by human tracers' visiting can be prevented"*(P128). Also, participants felt messages from digital systems would not raise others' attention as human tracers would: *"If I receive notifications through automatically generated texts,*

phone calls, and emails from the system, I would be able to receive less attention from my surroundings and feel less embarrassed by this adverse situation"(P19).

When collecting visit records, participants similarly had more privacy and data security concerns for paper records than QR codes. Participants were more comfortable with QR codes than paper ($z=9.05$, $p<.0001$, 95% CI 0.75-1.30 higher on a five-point Likert scale). Participants worried that identifiable information on a paper sheet could be seen by *"everyone who visits behind me"*(P80) and *"many people are usually written on one sheet"*(P12). Participants were also concerned about disclosure of paper records to third parties, perceiving paper as managed by business owners instead of the government or a public health authority: *"My personal information can be viewed by business owners, employees, and other visitors, and someone can take photos or do something about it. My personal information can be leaked"*(P50). Participants also worried that paper records may be discarded improperly or lost easily, exposing people's personal data to danger: *"If the visit records are not appropriately discarded, then it is likely that the information is leaked and be misused for a crime"*(P163). Conversely, participants trusted the QR code because: *"It's a relief that the data is coded so others can't see it"*(P46).

5.4.2 Digital Tracing: More Secure and Fewer Social Disclosure Concerns. Participants were mostly positive about South Korea's official contact tracing app's data security, with 72.0% of participants agreeing that the app was secure (Figure 3). Participants perceived digital tracing to be more secure, feeling that people could not access data to leak individuals' identifiable information: *"Because personnel in charge, such as human tracers, do not check the personal information, the probability of leakage of sensitive information of individuals would be lowered"*(P133). The system's anonymity also made participants have less fear of information leakage: *"Texts, phone calls and emails from the system are anonymous, so there would be no concern about information leakage"*(P90). In addition, South Korean participants rarely had third-party concerns around digital tracing because they felt technology was built by the government, thus having less worry about whether commercial companies would access to people's information than the U.S. participants did [45]. Participants trusted public health authorities to keep people's data secure: *"Since the information is said to be delivered directly to the public health authorities, the risk of information exposure decreases"*(P19).

Participants did express privacy and data security concerns around digital tracing, but they were less associated with social pressure. Participants were instead worried about what kinds of data might be disclosed with technology. For example, participants expressed that they did not understand what information would be shared with the government if they scanned the QR codes: *"I don't know how much information is provided by taking QR codes. I have no choice but to use it, but I always feel uncomfortable"*(P3). P85 similarly worried: *"I'm worried because I don't know what part of my personal information is used by QR code."* Participants also feared that technology would keep their data longer than it needed to: *"Even after the self-quarantine period, I cannot escape from the anxiety that my personal information would be leaked"*(P137). Similar to with human tracing, participants expressed information privacy concerns around being monitored by and sharing personal data with the government or public health authorities: *"they [people in self-quarantine] think of the mobile apps negatively as the apps are monitoring them"*(P13).

6 DISCUSSION

Overall, South Korean participants were more comfortable with digital tracing than human tracing, in contrast to no significant difference observed among the U.S. participants' preferences in Lu et al.'s study [45]. Although participants recognized some of human tracing's benefits identified in prior work, such as advice and accessibility [45], they perceived that human tracing would impose more pressure on both human tracers and society at large. Participants mainly regarded

human tracers as authority personnel, thus feeling they would be more obligated to participate in tracing when interacting with human tracers. Although prior work has suggested that people typically believe contact tracing technology can provide greater accuracy [9, 37, 45, 62], South Korean participants expressed that human tracers' authority could hold individuals accountable, and they perceived more technological errors in digital tracing. Extending the social anxiety around human tracing identified in prior work [45], participants also envisioned greater emotional burden of human tracing, believing that human tracers could trigger people to fear or feel guilty about COVID-19 behaviors. Participants mostly worried about receiving negative social consequences around human tracing if their information was (un)intentionally disclosed, such as being criticized or stigmatized by the public. Technology concerns were more related with information privacy and transparency concerns.

We now reflect on how multiple cultural dimensions may contribute to South Korean participants' different perceptions on contact tracing approaches than the U.S. study, providing insights on how to design contact tracing technology from a cultural perspective.

6.1 Cultural Dimensions' Influences on People's Perceptions of Contact Tracing Technology

We discuss how various cultural dimensions may influence South Korean participants' different perceptions of contact tracing technology than the U.S. study. We find levels of collectivism and power distance primarily influence people's perceptions of contact tracing technology, and other cultural dimensions may also have some effect. However, among Hofstede's seven cultural dimensions, we did not note an association between long-term versus short-term orientation and how participants perceived contact tracing approaches to data security, emotional reassurance, and accuracy.

6.1.1 Collectivism versus Individualism. Collectivist culture's emphasis on social ties [31] may explain South Korean participants' favoring of digital tracing, as they perceived human tracing as more likely to cause negative social consequences due to information leakage. Since individuals in collectivist cultures tend to view themselves as members belonging to a group, people's self-assessment is greatly influenced by how other people perceive them [31, 35]. Chaemyoun (face-saving) culture is prevalent in South Korea, meaning that people value and prioritize their social reputation. For example, research has suggested that the biggest stressor for Korean men who lose their jobs is concern about their social reputation [91]. Travaglini and Moon [85] found that participants who valued collectivist relationships were more likely to perceive COVID-19 shame and guilt, with no significant association among participants who placed greater value on individualist relationships and these two emotions. Because people in collectivist cultures often place greater value on social reputation and have more COVID-19 shame and guilt, they may therefore more greatly fear information leakage in contact tracing. In addition, people's tighter networks in collectivist cultures could make information spread more easily, creating a larger negative influence on individuals if their COVID-19 exposure is unwillingly disclosed to others. One in ten of our participants knew or heard someone close to them was a positive case at a time when there had been relatively few COVID-19 cases in South Korea, suggesting that information spread may be high. COVID-19 related information, which is supposed to be anonymous in contact tracing, may be more likely to be disclosed to the public in the tight social networks of collectivist cultures. Given that participants perceived human tracing as more likely to violate people's privacy by leaking personal data, people may therefore be more inclined to use technology to avoid their social reputations being worsened.

Collectivism may also influence participants' perceived self-guilt if participating in human tracing. Participants often expressed concerns about tracing positive cases or close contacts at large would put collective pressure on South Korea's infrastructure, especially for human tracing which would need high labor cost. Participants expressed more guilt around needing to use government resources in human tracing if they were to test as positive cases or be notified as close contacts. Therefore, participants favored digital tracing because they felt technology would be able to effectively and passively trace and manage data on a larger scale than humans.

6.1.2 Power Distance. High power distance cultures emphasize a power dynamic between individuals and authorities [31], which may make South Korean participants perceive human tracers as government personnel with power and themselves in humble positions. Participants felt human tracers, representing the government, had the power to require people to participate in contact tracing and share necessary data, thus creating more accurate data in the contact tracing process. By regarding human tracers as authorities, participants also envisioned greater pressure when interacting with human tracers, such as perceiving interviews with human tracers as interrogations. In comparison, some participants in the U.S. study just deemed human tracers as strangers [45], reflecting the egalitarianism in low power distance cultures [31].

South Korea's high power distance culture might also lead to participants' suspicion on human tracers' capability in preventing information leakage. Studies suggest that systems designed in high power distance cultures tend to believe that not everyone should be given equal access to systems for the sake of security [23, 49, 83]. Therefore, participants may resist human tracers' access to the database, because the risk of information leakage would increase if more people have a chance to see others' sensitive data.

6.1.3 Other Cultural Dimensions. South Korean participants' uncertainty around digital tracing's accuracy seems to be influenced by its high uncertainty avoidance culture. Some COVID-19 studies found people in high uncertainty avoidance cultures were hesitant to participate in innovative measures that aim to contain the virus transmission, such as digital tracing, because they were unclear about these measures' effects [17, 89]. Similarly in this study, participants often worried technology would make mistakes, such as sending notifications to the wrong people.

South Korea's feminine culture may also have influenced to participants' perceived self-guilt when interacting with human tracers. Participants more frequently felt sorry because they may place extra burdens on human tracers and even get them infected. Participants' concerns for the physical and emotional health of human tracers resonate with feminine cultures' caring for others [31]. Aligning with masculine cultures' lower emphasis on altruism [31], people in the U.S. study less often expressed guilt related to bringing potential physical and mental burdens to tracers during human tracing [45]. South Korean participants' fear of negative social consequences due to information leakage may be also related to femininity. People in feminine cultures are more likely to follow infection control and preventive measures to constrain the spread of contagious viruses, since feminine nations emphasize altruism and social goals [8, 17]. Being a COVID-19 close contact or positive case meaning people not following certain social rules and even infecting others, which may similarly bring negative impacts on one's social reputation if their situations are known by others.

However, participants' appreciation that digital tracing would provide more personal agency is somewhat in conflict with South Korea's restraint culture. Indulgent cultures encourage enjoyment of life, while restraint cultures emphasize suppressing enjoyment and following rules strictly [31]. However, South Korean participants expressed fear towards needing to follow contact tracing measures or tasks strictly in human tracing.

Overall, we find that multiple cultural dimensions jointly play a role in shaping people's perceptions toward contact tracing approaches, such as South Korea's collectivism, high power distance, and femininity together contributing to participants' perceiving greater emotional burden in human tracing than digital tracing. This joint effect may further result in some perceptions toward contact tracing approaches that conflict with the nation's cultural dimension. Though participants were situated in a restraint culture, they tended to prefer digital tracing as they still wished for certain levels of personal freedom and enjoyment. This indulgent tendency may be an outcome of collectivism, high power distance, and femininity, resulting in perceiving human tracing as having greater pressure and responsibility. Therefore, our work suggests that designing contact tracing technology with just one cultural dimension in mind could fall short of people's real needs, and even create stereotyped designs. Future work in countries with different cultural tendencies would help us better understand how dimensions interact to influence preferences toward contact tracing strategies. For example, examining perceptions in an individualist country with high power distance or a country with borderline high power distance and collectivism might help us understand whether emotional burden is impacted more by power distance, collectivism, or some more complex interaction between them.

6.2 Suggestions for Designing Culturally-Sensitive Contact Tracing Technology

Our findings suggest opportunities to design contact tracing technology with culture in mind, focusing on two aspects: 1) digital tracing should highlight individuals' benefits regardless of any cultural dimensions, 2) leveraging technology to facilitate social interactions between citizens and human tracers.

6.2.1 Designing Technology to Highlight Individuals' Benefits in Contact Tracing. While some researchers studying contact tracing in individualist settings have suggested highlighting personal benefits to enhance individuals' engagement [51], our work surfaces people's desire for some individualist and indulgent behaviors even in collectivist and restraint cultures. In individualist, low power distance, and/or indulgent cultures, one main concern around digital tracing is its low uptake rate if they perceive less personal benefits from the process. Therefore, contact tracing technology could highlight personal benefits to increase people's willingness of adopting the system. For example, digital tracing apps could leverage rewards, similar to rewards given for vaccination. National contact tracing apps could also pay users appropriate monetary rewards based on their engagement, since small monetary rewards are proven to greatly increase the actual uptake of contact tracing apps [54]. Conversely, the sustained use of contact tracing technology becomes a main concern in collectivist, high power distance, femininity, and/or restraint culture. Though people coming from these cultural backgrounds are more likely to participate in contact tracing, they may stop participating after a short time due to frequent interaction required to trace. Therefore, countries with these cultural dimensions might benefit from highlighting how sustained use of technology could help reduce the burden of contact tracing overall. Prior work recommends reinforcing positive aspects of contact tracing technology to boost people's willingness, such as using contact tracing apps' notifications to highlight benefits [38]. Public health messages could similarly propagate how technology could decrease people's mental pressure and the cooperation burden of contact tracing, such as "*You don't have to face the stress of talking to people about your health*", and "*Less work is needed to log your health data by using this digital tracing app.*" Strategies for improving uptake of contact tracing apps in cultures with properties such as individualism could be also used to sustain people's engagement.

6.2.2 Using Technology to Facilitate Social Interactions in Human Tracing. Although previous studies have suggested that human tracers are a good source of emotional support [42, 45], our study

surfaces how in some cultures, people instead have negative perceptions of the emotional impact of human tracers. Since South Korean participants felt more emotional pressure than comfort from human tracers, technology could be leveraged as a tool in human tracing to help individuals interact with human tracers, especially in places where human tracing is still the principle approach adopted. We suggest that technology's relative anonymity and convenience can be utilized in places where cultural dimensions relate with people perceiving more pressure than comfort from human tracers. For example, in collectivist, high power distance, and/or feminine cultures, contact tracing apps can include an anonymous communication channel to replace the traditional in-person and phone call interactions with human tracers. Messaging in these systems can aim to further remove the stigma associated with tracing, while still allowing data to be provided. In the manual tracing approach, human tracers need to interview positive cases about who they were in contact with, thus having access to people's identifiable information. Tracing technology therefore could be used to first process data by excluding demographic information, and then connect human tracers with anonymous close contacts to provide personalized instruction.

7 CONCLUSION

In examining how culture influences people's perceptions toward human and digital tracing by comparing survey responses from the U.S. and South Korea, we find evidence suggesting that collectivism and high power distance, may influence people's preference towards technology over humans in contact tracing in South Korea. Several cultural dimensions, such as collectivism, high power distance, and femininity, may make people feel that interacting with human tracers during contact tracing can apply more social and mental pressure and introduce opportunities for undesirable disclosures among highly-connected groups. We point to the value of designing contact tracing technology to situate in the cultures it is intended for, particularly suggesting that technology highlights the benefits of use for individuals and facilitates the social interaction between people and human tracers.

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