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Empirical Research Article

The Effect of CAPTCHA Exposure on Traveler's Online Behaviors

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Abstract

CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart) is everywhere. This research explores whether and how travelers' upfront exposure to a CAPTCHA influences their subsequent behaviors. In the travel decision-making context, we investigated the relationship between CAPTCHA and travelers' hotel preferences and intent to use cryptocurrency during the trip. In two experimental studies, we found that travelers exposed to a CAPTCHA (vs. not) preferred a robot-staffed to a human-staffed hotel (Study 1) and a pro-environmental to a quality hotel (Study 2). Exposure to a CAPTCHA also influences travelers' intent to use cryptocurrency during travel (Study 2). Preference for a pro-environmental hotel does not depend on the formats of CAPTCHA ("I am not a robot" or "I am human") while intent to use cryptocurrency is higher when travelers were exposed to the "I am not a robot" than "I am human" CAPTCHA. The results of two exploratory studies suggest several potential mechanisms by which CAPTCHAs affect travelers' behaviors and call for more research on this topic.

Keywords

CAPTCHA; robot detection; robot-staffed hotel; pro-environmental hotel; cryptocurrency; priming effect

1. Introduction

The recent Twitter-Musk drama (Proposed acquisition of Twitter by Elon Musk, 2022) centered on a dispute between the two parties over the magnitude of fake accounts on Twitter. Fake accounts, often called spam or bot accounts, refer to inauthentic accounts not run by humans. As such accounts are often used to perform malicious activities such as spreading disinformation, skewing online polls, posting fake reviews, inflating ticket sales, or disrupting online security, both researchers and practitioners have devoted their efforts to preventing as well as detecting fake accounts (see Awasthi et al., 2020 for a review). A similar problem could also arise with online academic research. Concerns over ' the "bot panic," computer programs that automatically complete tasks' (Lu et al., 2021, p.235) have escalated recently. One simple remedy for restricting malicious bot activities is to incorporate a CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart), or reCAPTCHA into online research or in websites.

What would be the implications for researchers and practitioners? CAPTCHAs may serve as "primers" in website visitors' decision making, and this poses an important question: would exposure to CAPTCHA influence website visitors' subsequent behaviors? For instance, would answering a simple CAPTCHA test on an online booking site influence travelers' decisions? Would CAPTCHA-exposed travelers' behaviors differ from those of non-CAPTCHA-exposed visitors? If so, how and why? As more and more travelers make their travel decisions online, understanding how this seemingly subtle step – passing a CAPTCHA test – at the early stage of online booking affects travelers' subsequent decisions and choices is important. Surprisingly, despite CAPTCHA's pervasiveness and possible relevance to consumers' decision making, little research has examined the impact of CAPTCHAs on tourism decision making. The purpose of this research is to fill this gap by exploring the impact of CAPTCHA on travelers' subsequent behaviors. Specifically, we investigated the effect of CAPTCHA on travelers' preferences for a robot-staffed hotel. Additionally, we examined the impact of two different types of CAPTCHA (i.e., "I'm not a robot" vs. "I'm human") on travelers' preferences for green (vs. quality) hotels and their intention to use cryptocurrency during travel. We explored these questions in two empirical studies. The results of our two exploratory studies provide initial insights into whether and how CAPTCHA influences travelers' decisions and call for future research in this topic.

The rest of this paper is organized as follows. We first briefly review the extant literature on CAPTCHA and develop hypotheses that explore the relationship between CAPTCHA and travelers' preferences for various travel options. Then, we present two empirical studies in which we tested our hypotheses. We conclude the paper by summarizing our findings and discussing their theoretical and practical implications.

2. Literature Review

CAPTCHA, the acronym for Completely Automated Public Turing test to tell Computers and Humans Apart, is a tool designed to differentiate humans from bots by providing challenges that are relatively easy for humans but difficult for bots to perform (e.g., identifying stretched numbers or letters). Since its inception in 2000 at Carnegie Mellon University (Singh & Pal, 2014), the CAPTCHA has been one of the most widely-adopted website widgets. Because of their usability and effectiveness, as of October,

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2022, CAPTCHAs were being used in nearly 40% of the top 10K websites and more than 20% of the top 1 million websites (Builtwith, 2022). Consequently, most website visitors are likely exposed to CAPTCHAs at a certain point, such as when signing up for a website or making various online transactions.

The current literature mainly focuses on the development of effective CAPTCHAs in order to achieve the original goals of this tool. Even though there are several different types of CAPTCHAs, based on text, image, audio, or puzzles, and there are different pros and cons for each type (e.g., Saini & Bala, 2013; Singh & Pal, 2014; and see Moradi & Keyvanpour, 2015 for a review), CAPTCHAs are used widely to distinguish between human and bot users. Other researchers have also investigated various factors influencing the performance of CAPTCHA. For example, Belk et al. (2015) suggested that individual differences in cognitive style significantly influence preference for and performance in two methods (i.e., text-based vs. image-based CAPTCHA). The results indicated a match effect between cognitive processing style and types of CAPTCHAs. Individuals categorized as imagers preferred the image-based (vs. text-based) CAPTCHA and finished the task fast, while individuals with strength in verbal processing showed the opposite pattern. Brodić, Amelio, and Janković (2018) further demonstrated that demographics such as education level, gender, and age, as well as personal characteristics such as internet experience also significantly influenced performance with CAPTCHAs.

In academic research using online surveys, CAPTCHAs have been used frequently, with the recent development of new types of CAPTCHAs. For example, Qualtrics software has the option of Captcha verification in its platform. In travel and hospitality research, CAPTCHA authentication has also been used. For example, Bianchi, Milberg, and Cúneo (2017) used this method to increase the overall data quality in their survey. In a review of Amazon Mechanical Turk, Lu et al. (2022) also recommends using CAPTCHA to prevent fraudulent responses from bots or foreign sources.

Despite the popularity of this method, to the best of our knowledge, little research has explored how CAPTCHA influences the subsequent responses and behaviors in online research settings. If answering the CAPTCHA question itself in online research affects the subsequent responses for the main test, researchers should seriously consider this side effect of using CAPTCHA. This paper explores this problem. In the next section, we investigate this possibility, based on the current literature, and try to empirically test it.

3. Development of Hypotheses

3.1 The CAPTCHA Effect on Preference for Robot-Staffed Hotels

Prior research suggests various ways by which a CAPTCHA could influence travelers' behaviors. First, exposure to a CAPTCHA may result in the priming effect (Higgins, Rholes, & Jones, 1977; Srull & Wyer, 1980). When responding to a text-based (e.g., "I'm not a robot" or "I am human") or graphic-based (e.g., "Select all squares with traffic lights") CAPTCHA test, travelers are exposed to a certain concept, such as "robot" or "traffic lights." Such words then become more accessible in their memory and may influence subsequent responses (Srull & Wyer, 1980). Potential DVs in this case may include evaluations or choices of travel options associated with the activated concepts. For example, exposure to the "I'm not a robot" CAPTCHA test may influence travelers' preference for a robot- (vs. human-) staffed hotel (e.g., Kim et al., 2021). If so, would travelers prefer a robot-staffed hotel or human-staffed hotel?

Extant literature suggests that both directions are probable. On the one hand, prior findings in the priming literature suggest that travelers would prefer a robot-staffed hotel if they do not pay much attention to a CAPTCHA (Srull & Wyer, 1980; Wyer, 2008). On the other hand, people likely attempt to correct for the effect of the priming words (e.g., robot, human) if they are aware of the possibility that the activated concepts could be a basis for their subsequent judgments (Lombardi, Higgins, & Bargh, 1987). Thus, if travelers recognize the potential impacts of CAPTCHA on their subsequent judgment, they may exhibit less favorable attitudes toward a robot-staffed hotel. However, even when travelers are aware of the possibility, the opposite result may also ensue if travelers are less willing or unmotivated to correct for it (Martin, Seta, & Crelia, 1990). Furthermore, the direction would also depend on travelers' preconceptions about robots (e.g., hostility, extremeness of reaction). Herr (1986) found that those exposed to a moderately hostile individual later evaluated a person with ambiguous behaviors as hostile (assimilation effect) while those exposed to an extremely hostile individual evaluated the ambiguous person as less hostile (contrast effect). Along this line, a robot-staffed hotel can be evaluated either favorably or unfavorably depending on the valence and extremeness of a traveler's attitude toward robots. We proposed that CAPTCHAs may affect travelers' preference for a robot-staffed hotel (through priming), but the direction of the effect should be empirically investigated. This led to the following competing hypotheses.

H1a*: Travelers exposed to a CAPTCHA would prefer a robot- (vs. human-) staffed hotel.*

H1b*: Travelers exposed to a CAPTCHA would prefer a human- (vs. robot-) staffed hotel.*

3.2 The CAPTCHA Effect on the Preference for Pro-Environmental Hotels and Cryptocurrency Usage

Besides priming, CAPTCHAs may influence travelers' behaviors through identity salience. Given CAPTCHA's objective of telling computers and humans apart, exposure to a CAPTCHA inevitably triggers travelers' self-concept as human. A body of research has demonstrated that an individual's self-concept plays an important role in guiding choice and consumption (Sirgy, 1982; Malhotra, 1988; Aaker, 1999; Escalas & Bettman, 2003). For example, Aaker (1999) found that specific self-concepts (i.e., personality traits) made accessible by situational cues influence consumers' evaluation of a brand. In the travel context, Sirgy and Su (2000) showed that self-congruity (i.e. the match between a tourist's self-concept and the destination visitor image) significantly affects travel behaviors. Thus, we expected that travelers' self-concept as human, when made salient by exposure to CAPTCHA, would affect their subsequent behaviors.

A wide variety of travel options can be examined as potential outcomes in this case. For example, would a traveler's self-concept as human result in a more positive attitude toward a robot-staffed hotel? Would it increase or decrease the willingness to use cryptocurrency? What about preference for pro-environmental travel options? One possibility is that salient human identity may help travelers think more flexibly (compared to computers) so that they evaluate atypical travel options like a robot-staffed hotel or cryptocurrency more favorably (Jhang, Grant, & Campbell, 2012). Alternatively, according to self-verification theory (Swann, 1990), people seek to adopt behavioral strategies consistent with their existing self-concept. Therefore, when human identity is made salient, travelers would be less likely to choose travel options with non-human connotations (e.g., robot-staffed hotel, cryptocurrency). With the same logic, we can predict a more positive attitude toward pro-environmental options. Regarding pro-environmental option, self-enhancement theory (Schlenker, 1980) similarly suggests that travelers would choose a pro-environmental travel option because people often make choices to manage their self-concept positively. Thus, salient human identity may positively influence travelers' inclination for pro-social or pro-environmental behaviors.

Finally, when people perceive some discrepancy between their current self and their ideal or desired self, they become motivated to resolve self-deficits by engaging in specific behaviors called compensatory consumption (Rucker & Galinsky, 2008; also see Mandel, Rucker, Levav, & Galinsky, 2017 for review). For example, those experiencing spatial confinement (e.g., in narrow aisles) seek more variety in their choice to achieve greater freedom (Levav & Zhu, 2009). Powerless consumers more likely choose products that can signal status (Rucker & Galinsky, 2008). Importantly, this compensatory consumption can occur not just reactively but proactively when an individual expects to experience a self-threat in the future (Kim & Rucker 2012). Salient human identity in itself is generally not a self-threat. However, if someone has chronically perceived recent technological development (e.g., machine learning, artificial intelligence, humanoid robots) as a serious potential threat to humans, exposure to CAPTCHAs may discourage travelers from choosing a robot-staffed hotel or cryptocurrency to proactively compensate for a self-threat. Together, various theories suggest that salient human identity may positively or negatively affect some travel options associated with technology (such as a robot-staffed hotel, or the intent to use cryptocurrency during travel) as well as pro-environmental decisions. Again, the direction of the effect should be empirically investigated. Thus, we developed a set of competing hypotheses.

***H2a**: Travelers exposed to a CAPTCHA would prefer a pro-environmental (vs. quality) hotel.*

***H2b**: Travelers exposed to a CAPTCHA would prefer a quality (vs. pro-environmental) hotel.*

***H3a**: Travelers exposed to a CAPTCHA would be more willing to use cryptocurrency during travel.*

***H3b**: Travelers exposed to a CAPTCHA would be less willing to use cryptocurrency during travel.*

4. Study 1: Providing Initial Evidence of the CAPTCHA Effect

In this study, we tested H1 to provide initial evidence of the effect of being exposed to a CAPTCHA in travel decisions regarding the choice between human-staffed (vs. robot-staffed) hotels. We expected that exposure to the "'I'm not a robot" CAPTCHA would influence the preference for a robot-staffed hotel.

4.1 Method: Participants, Design, and Procedure

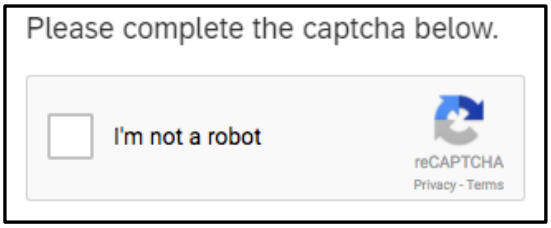
Participants of this study were 242 US Amazon MTurk online panelists (M_{age} = 41.40, SD = 12.13) recruited through CloudResearch. Of these, 121 (50.0%) of participants were female. They were randomly assigned to one of 2 (CAPTCHA: absent vs. present) between-subjects experimental conditions.

First, participants were invited to a short survey that consisted of multiple tasks. The first task was to pass the CAPTCHA test. Participants in the CAPTCHA present condition were exposed to the graphic-based CAPTCHA, available from the Qualtrics software, as shown in Figure 1. In contrast, participants in the CAPTCHA absent condition were exposed to the statement "go to the next page."

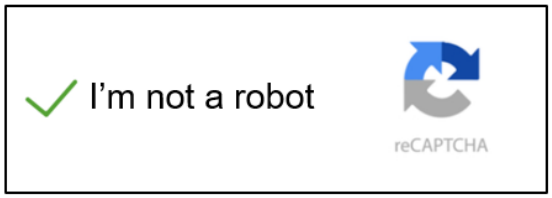
After that, all participants were asked to imagine that they planned to travel a city and book a hotel and that they found two hotels within their price budget, as shown in Figure 2. The stimuli were adapted from Kim et al. (2021). Then, participants were asked to choose one hotel option: robot-staffed versus human-staffed.

Finally, participants were asked to rate their mood along a 7-point scale (1 = very bad, 7 = very good) and provide their demographic information including their age and gender.

Study 1: CAPTCHA



Study 2: CAPTCHA I



Study 2: CAPTCHA II

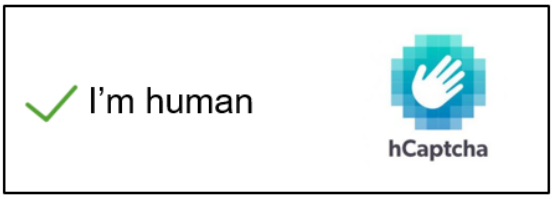


Fig. 1. Stimuli for Studies 1 and 2

Stimuli for Study 1

Stimuli for Study 2

Hotel	Hotel P	Hotel K
Review Rating	8.62 / 10	8.65 / 10
Location	420m from city center	430m from city center
Hotel Amenities	Bar/lounge & 24-hour front desk	24-hour front desk & Bar/lounge
Room Amenities	Air conditioning & Coffee maker	Air conditioning & Coffee maker
Award & Certificate		

Fig. 2. Stimuli for Studies 1 and 2

4.2 Results and Discussion

First, mood was not different across the two experimental conditions ($M_{CAPTCHA\ absent}$ = 5.36, SD = 1.43 vs. $M_{CAPTCHA\ present}$ = 5.24, SD = 1.32; F (1, 240) = .43, p =.514, η^2 = .002).

The preference for the two hotels was significantly influenced by the presence of the "I'm not a robot" CAPTCHA ($\chi^2(1)$ = 4.00, p

=.046, φ = .13), as shown in Figure 3. Specifically, the preference for the robot-staffed hotel was higher in the CAPTCHA present condition (M = 23.1% [= 28/121] than in the CAPTCHA absent condition (M = 13.2% [=16/121]), supporting H1a rather than H1b. When we conducted a bi-logistic regression analysis with mood, age, and gender as covariates, the effect of CAPTCHA still remained significant (b = -.67, se = .35, Wald = 3.69, p =.055) even after controlling for the influence of other variables.

In summary, this study provided initial evidence of a CAPTCHA exposure effect on the other measurements in the subsequent task.

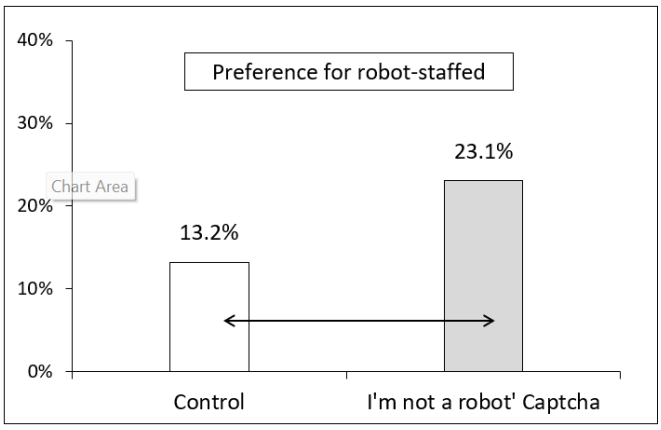


Fig. 3. Results of Study 1

5. Study 2: Testing Different Formats of CAPTCHA

In this study, we tested the different formats of CAPTCHA. We used two different forms of graphic-based CAPTCHAs (i.e., "I'm not a robot" and "I'm human"), with the control condition being a text-based non-CAPTCHA question (Singh & Pal, 2014). In addition, we tested two different measurements to assess H2 and H3. One was for the preference for an ethical choice option of a green hotel compared to a quality choice option (H2). The other was the behavioral intention to use cryptocurrency during travel (H3). We expected that exposure to a graphic-based CAPTCHA test would influence the preference for the ethical hotel option and the behavioral intention to use cryptocurrency.

5.1 Method: Participants, Design, and Procedure

The participants in this study were 360 US Amazon MTurk online panelists (M_{age} = 42.29, SD = 12.39) recruited through CloudResearch. Of these, 185 (51.4%) participants were female. They were randomly assigned to one of 3 (CAPTCHA: control vs. CAPTCHA present I [I'm not a robot] present) vs. CAPTCHA present II [I am human]) between-subjects experimental conditions.

The general procedure was very similar to that used in Study 1. First, participants were invited to complete a short survey with multiple tasks. The first task was to pass the CAPTCHA test. Participants in the CAPTCHA present I condition were exposed to a CAPTCHA test similar to the one used in Study 1, whereas participants in the CAPTCHA present II condition were exposed to a slightly different, "I am human" CAPTCHA, as shown in Figure 1. Participants in the control condition were exposed to a simple math task (i.e., 3 + 8 + 5 =?).

Following the first task, all participants were asked to imagine that they planned to travel a city and book a hotel and that they found two hotels as shown in Figure 2. The stimuli were adapted from Kim et al. (2020). Then, participants were asked to express their preference between a quality hotel (i.e., *Hotel P* – award-winning for quality aspects) and an ethical and green hotel (i.e., *Hotel K* – award-winning for pro-environmental aspects) using a 7-point scale (i.e., 1 = I will definitely choose Hotel P, 7 = I will definitely choose Hotel K). Then, participants responded to the manipulation check question about which hotel demonstrated better environmental sustainability, using a 7-point scale (1 = definitely Hotel P, 7 = definitely Hotel K, Cui et al., 2020).

Participants were then asked to rate their intention to use cryptocurrency during travel with 3 items each using a 7-point scale (1 = strongly disagree, 4 = neither agree nor disagree, 7 = strongly agree). The items (i.e., *I intend to use cryptocurrency payments in my travel planning (e.g., hotel, flight) in the future; I plan to use cryptocurrency payments to pay for my travel expenses in the future;* and *I predict that I should use cryptocurrency payments to pay for my travel expenses in the future*) were adapted from Radic et al. (2022). This measurement was highly reliable (Cronbach's α = .980). Therefore, the average of the three items was used for the main analysis.

Finally, participants were asked to indicate their mood, using the same scale applied in Study 1 and to provide their demographic information, including their age and gender.

5.1 Results and Discussion

Mood was not different across the three experimental conditions ($M_{\_Control}$ = 5.41, SD = 1.34 vs. $M_{\_CAPTCHA\ I}$ = 5.45, SD = 1.33 vs. $M_{\_CAPTCHA\ II}$ = 5.58, SD = 1.14; F (2, 357) = .62, p =.514, η^2 = .003).

The preference for the ethical and green hotel was significantly influenced by the experimental factor of CAPTCHA (F (2, 357) = 2.89, p =.057, η^2 = .016). Planned contrast further indicated that the preference for the green hotel (Hotel K) was higher in the CAPTCHA present I condition compared to the control condition ($M_{\_CAPTCHA\ I}$ = 4.75, SD = 1.97 vs. $M_{\_Control}$ = 4.18, SD = 1.94; contrast p =.025). The preference for the green option was also higher in the CAPTCHA present II condition compared to the control condition ($M_{\_CAPTCHA\ II}$ = 4.64, SD = 1.93 vs. $M_{\_Control}$ = 4.18, SD = 1.94; contrast p =.066), supporting H2a rather than H2b. However, there was no difference between the two CAPTCHA present conditions (contrast p =.680), as shown in Figure 4. To summarize, this result indicated that preference for the ethical hotel option during travel was higher when participants were first exposed to either kind of CAPTCHA format.

We also found that the behavioral intention to use cryptocurrency during travel was significantly influenced by the experimental factor (F (2, 357) = 4.78, p =.009, η^2 = .026). The intention to use cryptocurrency was higher in the control condition compared to the CAPTCHA present II ($M_{\_Control}$ = 2.60, SD = 1.92 vs. $M_{\_CAPTCHA\ II}$ = 1.94, SD = 1.49; contrast p =.003) condition. The intention to use cryptocurrency was higher in the CAPTCHA present I condition compared to CAPTCHA present II as well ($M_{\_CAPTCHA\ I}$ = 2.45, SD = 1.74 vs. $M_{\_CAPTCHA\ II}$ = 1.94, SD = 1.49; contrast p =.025). However, there was no difference between the CAPTCHA present I and control conditions (contrast p =.495), as shown in Figure 4. Therefore, H3b (vs. H3a) was supported only when the CAPTCHA contained the word "human."

In summary, this study showed that the behavioral intention to use cryptocurrency was reduced significantly only when participants were first exposed to a CAPTCHA stating "I'm human."

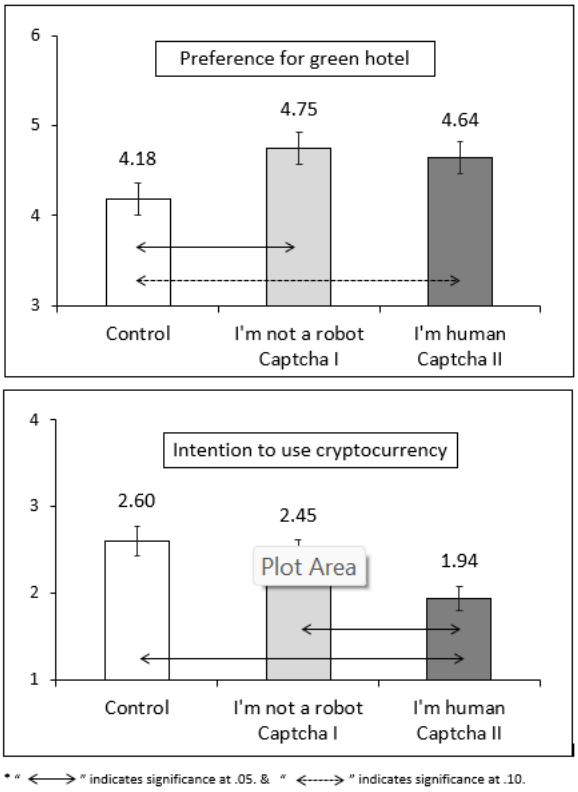


Fig. 4. Results of Study 2

5. General Discussion

In order to restrict malicious bot activities, the CAPTCHA is one of the easiest and most frequently used methods in online surveys and websites. This research examined the impact of prior exposure to a CAPTCHA test on various subsequent travel-related behaviors. We investigated the relationship between the use of a CAPTCHA and travelers' robot-staffed and pro-environmental hotel preferences, and their intent to use cryptocurrency during the trip. In two experimental studies, we found that travelers previously exposed to a CAPTCHA test (vs. not) preferred a robot-staffed to a human-staffed hotel (Study 1) and a pro-environmental hotel to a quality hotel (Study 2). We also found that the prior exposure to a CAPTCHA including the word "human" decreased travelers' intention to use cryptocurrency during travel (Study 2). To the best of our knowledge, this paper is the first to demonstrate the impact of CAPTCHA on subsequent responses in online surveys.

This research has important theoretical and practical implications. This is the first empirical study investigating the impact of exposure to CAPTCHA on travel behaviors in the tourism and hospitality context. Our empirical findings suggest the importance of considering the unexpected results of CAPTCHA types, especially in academic research. We focused on only a few areas: preferences for robot-staffed hotels or pro-environmental travel options. Future research needs to extend to various other areas such as preference for luxury travel and hospitality options or planned (vs. unplanned) travel behaviors. For instance, CAPTCHA could reduce human-related service during the travel planning stage.

This study also contributes to the current discussion on controlling empirical data collection, especially in online settings. One critical issue in current online data collection is to control fraudulent responses from bot- or machine-based agents (e.g., Chmielewski & Kucker, 2020). Based on this "bot panic" (Dreyfuss, 2018), the usage of CAPTCHA has been recommended to academic researchers (e.g., Lu et al., 2021). However, this paper clearly demonstrates the potential risk of using CAPTCHA in online research.

This study further extends our understanding of CAPTCHA by investigating different versions, comparing "I am not a robot" versus "I am human" CAPTCHA phrases. Compared to the previous literature, which has focused on the comparison of different modes of CAPTCHA, this paper investigated different messages in the same mode. Our findings suggest that the specific wording of CAPTCHA messages may significantly influence subsequent behavioral intention. In addition, this finding could contribute to our understanding of the role of information framing (e.g., Kim, Kim, & Kim, 2018; Kim et al., 2019) on travel decision-making. Further research needs to test the impact of the various CAPTCHA methods on travel and hospitality behavior, especially in new technology-enhanced environments such as the Metaverse (e.g., Koo, Kim, & Kim, 2022; Koo et al., 2022).

Lastly, this research has a straightforward practical implication for future research. When researchers want to check for robot activity with CAPTCHA systems in online surveys and other platforms, it is preferable to include the CAPTCHA statement on the last page of the survey. Alternatively, researchers might use other forms of CAPTCHA, which do not contain the words "robot" or "human." In addition, this research suggests potential additional preferences for technology-related products for online shopping settings. If customers are asked to respond to a CAPTCHA including robot wording, their preference for technology-related products could be temporarily increased. Future studies need to investigate the magnitude of the impact of CAPTCHA on subsequent behavioral changes in more depth.

In conclusion, the results of two experimental studies suggest several potential mechanisms by which CAPTCHA can affect travelers' behaviors and calls for more research on this topic. We hope that this research triggers significant further investigation on the impact of CAPTCHA on subsequent behavior.

Declaration of competing interests

The authors have no conflicts of interest to declare.

Acknowledgements

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