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Opening Pandora's Box: Pursuit of Negative Stimuli - A Replication of Hsee & Ruan, 2016

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Author's Note

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**Abstract**

Curiosity is defined as the desire to obtain information. It is the root of many great human achievements, but also motivates behavior that yields no benefit, such as browsing social media. Additionally, the uncertainty that sometimes triggers curiosity can be a detriment when tied with unpleasant outcomes, and even affect our emotions. In this experiment, we directly replicated one study from Hsee & Ruan's (2016) *The Power and Peril of Curiosity* to reinvestigate the effects they observed. The original study hypothesized and found that (1.) people are more likely to pursue a stimulus if the outcome is uncertain and expected to be negative and (2.) people will feel worse if the outcome of an uncertain stimulus is negative in comparison to a known stimulus. We directly replicated the methods used in the original study, we tested 2 groups on a computer interface with 48 buttons that played positive, negative, and neutral stimuli in the form of audio clips. One group was given a version where all but 4 buttons were random or where all, but 4 buttons were clearly marked. Contrary to the original study, our findings did not suggest that humans always have a tendency to pursue uncertain and likely negative stimuli. But we did find that the resolution of uncertain events with negative outcomes enhanced feelings of negativity. This research assisted in the advancement of the relationship between uncertainty and emotion, but 'opened Pandora's box' in terms of the need for further investigation on the topic of curiosity.

*Keywords:* Curiosity, emotion, pandora's box, uncertainty

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### Introduction

Curiosity is defined as the desire to obtain information and is an integral part of being human. Throughout life, it motivates behavior that can yield both positive and negative outcomes (Lowenstein, 1994). Curiosity can enhance many things in life; research has suggested that curiosity and gives potential for a positive experience (Ruan, Hsee, & Lu, 2015): hippocampal learning (Gruber, Gelman, & Ranganath, 2014); memory formation via reward centers of the brain (Kang et al., 2009); and better ways of engaging learning in students (Simon, 2001). But, just as curiosity killed the cat, it's possible that man can be negatively affected by curiosity.

In this replication of Study 3 of Hsee & Ruan's (2016) experiment *The Pandora Effect: The Power and Peril of Curiosity*, we sought to investigate if curiosity can "lead humans to seek information despite predictably undesirable consequences," which we call the Pandora effect, referencing mythological lore of Pandora's box (Hsee & Ruan, 2016). In mythology, after Prometheus stole fire from Mt. Olympus, Zeus sent Pandora to Prometheus' brother, who was watching over a special jar. The jar contained worldly evils such as death and suffering; and when Pandora eventually found the jar, curiosity led her to open the jar, releasing evils upon the world (Polome, 1998). In short, opening Pandora's Box represents detriments accrued from human curiosity. We will also discuss that Pandora's box could have a hedonic cost (affect people's feelings). The applications of this question are broad and studying the applications will help us gain insight on the effects of modern society's use of smart phones, social media, and popular culture.

In 1966, Berlyne described curiosity as seeking out stimuli that are not inherently beneficial – that humans and animals tend to seek out stimulus patterns while doing nothing once the patterns are identified (Berlyne, 1966). Studies prior to Hsee & Ruan (2016) show that curiosity can push people to seek out information, even if it is unpleasant or shows no benefit.

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People may seek out their spouses' sexual and medical history (Kruger & Evans, 2009), even though it rears no benefits; people may also search for the sexual histories of celebrities (McNamara, 2011) even though there are no long-term benefits associated. The feeling of uncertainty can also intensify people's reactions to stimuli (Bar-Anan et al. 2009). This was found by having participants repeat certain or uncertain remarks while watching positive or negative film clips; uncertain utterances led to stronger negative reactions to the clips. Research after Hsee & Ruan showed that boredom can lead to the pursuit of novel experiences (Bench & Lench, 2018), even if they are unpleasant.

We replicated study 3 of Hsee & Ruan (2016) because of its relevance to modern day behavior. Technology and social media use have been advancing at a fast rate, and we wanted to observe any changes in how college-aged participants interact with uncertainty and curiosity. The original experiment observed 53 undergraduate students from the United States interact with a computer interface with 48 buttons. During the experiment, the participants were instructed that they could click any number of buttons during the experiment, and that they were not required to click any buttons. These buttons were labeled "water", "nails", or "?" and played audio samples of water pouring into a jar, fingernails on a chalkboard, or an equal chance of "nails" or "water". Participants were randomly assigned a condition with either 4 "?" buttons (certain condition) or 44 "?" buttons (uncertain condition).

In comparison to the certain condition with 4 "?" buttons, participants chose to click more buttons in the uncertain condition with 44 "?" buttons, even though they knew they were likely to experience the negative stimulus of nails on a chalkboard and were not required to do anything. Their decision also resulted in feeling worse when asked to rate how they were feeling

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on a 7-point scale. The study revealed that people are inclined to open Pandora's box, while incurring a hedonic cost from their action.

We planned to replicate study 3 of *The Power and Peril of Curiosity* as faithfully as possible and designed our methods to be as close to Hsee & Ruan as possible. We obtained the software interface used in the original experiment, meaning that our stimuli should mirror what prior participants experienced. We measured the mean difference between the uncertain and certain conditions using Cohen's  $d$  to assess the strength of the effect and an independent samples t-test to assess statistical significance. Our study had some key methodological differences from the original study, as we conducted our research as a class project. Most importantly, we had to ensure that participants that had already conducted this replication in another lab group were excluded. We sought to reaffirm that curiosity may lead people to seek out information that has no benefit or pleasure associated and we claimed that people have a pure desire to resolve curiosity. Specifically, participants in the uncertain condition should end up clicking more buttons than participants in the certain condition, feel worse when more buttons are clicked, and feel significantly worse in the uncertain condition.

### **Method**

#### **Participants**

We recruited 53 participants aged between 18 and 22 from a private university in the United States; participants were 55% female, 45% male, 73% identified as White/European, 16%

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identified as Asian/Asian American, 6% identified as Hispanic/Latino, and 4% identified as African American. Participants will be randomly recruited in the university library or by responding to online posts requesting participants. Participants were given the option to participate in a raffle for \$50. Two participants' data were excluded due to duplicate data from other trials, and two other participants' data were excluded due to an error in the testing software which caused repeated measurement of participants' emotion scores. Expedited Tufts University institutional review board approval was obtained prior to conducting this research.

### **Materials**

Participants used a researcher's laptop while wearing a pair of on-ear headphones. Each session was conducted in a quiet library study room with 1 participant and 2 experimenters.

Two separate computer interfaces were used depending on the condition randomly assigned to participants; an uncertain condition with 44 "?", 2 "water", and 2 "nails" buttons; and a certain condition with 4 "?", 22 "water", and 22 "nails" buttons. We obtained the same software interface used in the original experiment.

Clicking a button resulted in an audio sample playing for 4 seconds. Each sound was operationalized in the prior study on a 7 point, negative-to-positive scale, and found to be statistically significant. "Nails" buttons play a 4 second audio clip of fingernails on a chalkboard that was rated negative; "Water" buttons play a 4 second audio clip of water being poured into a jar that was rated neutral; When buttons were not pressed, a piano rendition of ("Twinkle Twinkle Little Star") played at a quiet volume for 300s which was rated as positive (Hsee & Ruan, 2016).

### **Procedure**

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**Design.** We conducted a between-groups experiment. The independent variables were an uncertain condition with 44 unknown buttons and a certain condition with 4 unknown buttons. Participants were randomized by assignment where every other participant was assigned to the uncertain condition. The dependent variables were the number of buttons clicked and the emotional rating score.

**Hypotheses.** We attempted to observe both hypotheses of the prior study: (1) People are more likely to choose a stimulus if the outcome is uncertain and expectedly negative (opening Pandora's box) than if the outcome of a stimulus is certain and either neutral or negative. (2) People will incur hedonic cost (will feel worse) if the outcome of a stimulus is uncertain and expected to be negative than it is certain and either neutral or negative.

**Script.** Participants were randomly recruited in the university library and by response to online posts requesting participants. Participants were asked if they had already participated in a study conducted by an Experimental Psychology lab group and excluded if they answered yes. Participants were verbally briefed prior to beginning each experiment. Participants were first presented with an IRB-approved consent form and told that the study was about their reaction to sounds. Participants are told that they can leave the study and stop the experiment whenever they want. Participants were told that they will see 48 boxes labeled "water", "nails", or "?" on screen: If they click "nails" they will hear fingernails on a chalkboard for 4 seconds; if they click "water" they will hear water pouring into a jar; and if they click "?" they have an equal chance of hearing "nails" or "water". Participants are informed that the experiment will run for 300 seconds and that they can click on as many or few buttons as they wish throughout the duration of the experiment, and that they can choose to sit through the experiment without clicking any

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buttons. Further, they will hear the song “Twinkle, Twinkle, Little Star” playing on piano during the entirety of the experiment to prevent boredom. Participants were also told that they will be prompted to rate a response to the question “How do you feel?” every 30 seconds on a 7-point scale, with 1 indicating worse feelings and 7 indicating better feelings. Then the experiment will begin. At the conclusion of the experiment, participants will be handed an IRB-approved debriefing form.

**Preregistration.** The hypotheses, method, and analysis plan were preregistered prior to data collection (<https://osf.io/qhy4m/>). Our materials (<https://osf.io/epbfd/>), data (<https://osf.io/vnphb/>), and analysis scripts (<https://osf.io/8gxa5/>) are available on the OSF.

**Analysis.** To assess hypothesis 1, the number and nature of button clicks were recorded and grouped by condition. The mean difference between the uncertain and certain conditions was calculated using Cohen’s *d* to assess the strength of the effect and an independent samples *t*-test with a threshold of .05 to assess statistical significance. Hypothesis 2 was measured by evaluating correlation between clicks and feelings. Amount of button clicks, and self-reported feelings were assessed with Pearson’s *r* and independent samples *t*-tests. The mean difference of happiness between the uncertain and certain conditions was calculated using Cohen’s *d* to assess the strength of the effect and an independent samples *t*-test with a threshold of .05 to assess statistical significance.

## Results

**Hypothesis 1.** To restate, our hypothesis 1 was that people are more likely to choose a stimulus if the outcome is uncertain and expectedly negative than if the outcome of a stimulus is certain and either neutral or negative. To measure hypothesis 1, we first operationalized curiosity by measuring amount of button clicks in each trial of the certain and uncertain conditions. The

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results revealed that participants in the certain condition had a significantly higher mean number of buttons clicked ( $M = 40.29$ ,  $SD = 12.23$ ) compared to mean of the uncertain outcome ( $M = 32$ ,  $SD = 15.12$ ). The independent-samples t-test  $t(49) = 2.10$  showed a significant difference of  $p = .042$  between two condition's means by meeting the threshold previously set at  $p < .05$ . Cohen's D showed a medium effect size of  $d = 0.60$ , 95% CI for the mean difference = [0.01, 0.19]. These findings were the opposite of hypothesis 1 and our expectations – a successful replication study would show that participants clicked more buttons in the uncertain condition.

**Hypothesis 2.** To restate, our Hypothesis 2 was that people will feel worse if the outcome of a stimulus is uncertain and expected to be negative than it is certain and either neutral or negative. We observed a significant difference between condition and feelings. Participants in the uncertain condition had worse mean feeling scores ( $M = 4.32$ ,  $SD = .97$ ) than the means feeling scores of those in the certain condition ( $M = 5.10$ ,  $SD = .94$ ). The independent-samples t-test  $t(49) = 2.85$  showed a significant difference of  $p = .007$  between two condition's means by meeting the threshold previously set at  $p < .05$ . Cohen's D showed a large effect size of  $d = 0.81$ , 95% CI for the mean difference = [0.22, 1.41]. These results were in support of hypothesis 2 and follow those of the original study.

## Discussion

Our goal for this experiment was to directly replicate study 3 of *The Power and Peril of Curiosity* and observe any changes in results. In addition, we sought to reaffirm that curiosity may lead people to seek out information that has no benefit or pleasure associated with a task. Contrary to hypothesis 1, we found that people were more likely to choose a stimulus if the outcome is certain and either neutral or negative compared to uncertain and expectedly negative (opening Pandora's box). In support of hypothesis 2, we found that people will incur hedonic

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cost (will feel worse) if the outcome of a stimulus is uncertain and expected to be negative than it is certain and either neutral or negative.

Our replication results were similar those in *The Power and Peril of Curiosity* in the fact that; there was a significant effect ( $p = .007$ ) of the uncertain condition on the participants feelings, which was similarly large to the effect size ( $d = .81$ ) found in the replicated study ( $d = 1.11$ ) (Hsee & Ruan, 2016). Our results deviated from those in *The Power and Peril of Curiosity* in the fact that the significant effect of the condition on the total clicks was different from what was found in the original study. Participants clicked more buttons in the certain condition ( $M = 40.29$ ) than the uncertain condition ( $M = 32$ ), compared to the original results where participants clicked more buttons in the uncertain condition ( $M = 39.29$ ) and less in the certain condition ( $M = 28.16$ ). In both instances, independent samples T-tests showed that the results of both studies were significant. (Hsee & Ruan, 2016).

Our results in hypothesis 1 draw similarities to the observations of Berlyne, 1966, where he observed that animals appear seek our stimulus patterns, and then never act on them. Even though the stimuli we tested was expected to be negative or neutral in the certain condition, we observed participants click significantly more buttons than those in the uncertain condition. It appeared as if participants were seeking out stimulus patterns that were already known (that all nails and water sounds were uniform) and not altering their behavior when they found the pattern (exhibiting a ceiling effect for buttons clicked), which supported Berlyne's observations. (Berlyne, 1966). Similar to the results of McNamara, 2011 and Kruger & Evans, 2009 where participants sought out the sexual histories of partners or celebrities, there were no long-term benefits for seeking out the stimuli in our study (McNamara, 2011), (Kruger & Evans, 2009). The fact that the certain condition elicited more clicks complicates the explanation of our results

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in respect to the findings of McNamara and Kruger & Evans. In this instance, we believe that we observed a completion bias, boredom, obligation to click buttons, or a mix of these explanations that caused the certain condition to have more clicks. Similar to knowing the sexual history of a spouse or celebrity, our stimuli were operationalized as neutral and negative, so the buttons should not have been particularly attractive to click, especially when the outcome was known. These parallels allude to Berlyne's observations that animals have a tendency to seek stimuli for no apparent reason even when the patterns are recognized, or that there is no real call back to a theory with these results and that further research is needed to make a concrete claim about curiosity. The results of hypothesis 2 paralleled those of with Bar-Anan et al., (2009) where both studies observed different forms of uncertainty affecting participants emotions negatively. Although their study did not involve curiosity, it studied how the "feeling of not knowing" affected people's emotions and found that uncertainty intensified negative feelings. (Bar-Anan et al. 2009). The results of Bar-Anan were similar to ours in the fact that both studies found uncertainty to enhance negative feelings. In addition, the unpleasantness of uncertainty that was supported by Bar-Anan's results could help explain our lack of clicks in the uncertain condition: it's possible that the unpleasantness of uncertainty, that was found in both studies, contributed to the number of buttons clicked. It is possible that the theory of Pandora's Box, that people seek out uncertain, unexpectedly negative stimuli, is mediated by people's increased avoidance of unpleasant feelings in daily life. In fact, more than one participant in the uncertain condition stated that they chose not to click buttons because they did not want to hear unpleasant sounds, meaning that the emotional detriment outweighed any curiosity these particular participants may have had.

We thought that a discussion of the operationalization of our variables was also an

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important discussion point in our comparison to prior literature. Although the study was not related to curiosity, Bar-Anan et al., (2009) operationalized degrees of certainty differently than our study. They classified certainty or uncertainty based on scripted words that participants read as they watched movie clips. The words either affirmed or disaffirmed understanding of the clips (Bar-Anan et al. 2009). In comparison, Hsee & Ruan's study design was not as robust – we used an uncertain situation, but there is a chance that participants did not process the uncertainty in a genuine way as the only affordance to strike curiosity were boxes with “?” that would play a negative or neutral sound: which is likely not the most stimulating of experiences for the busy mind of a millennial. Bench & Lench, (2018) had similarities to our study in operationalizing constructs, with one key difference. They operationalized stimuli in multiple levels ranging from “intensely positive ... [to] moderately negative” depending on the study, while we adopted the levels of stimuli used by the replicated study. We only chose 1 level for positive, neutral, and negative, and sometimes participants did not perceive the stimuli as they were originally rated (Bench & Lench, 2018).

There are key implications to this study that we will discuss in this section and later in the discussion of limitations that were found. We asked earlier if social media and technology has affected how college students interact with curiosity and uncertainty, and we cannot confidently conclude what effect was found without further research and discussion of the methods we replicated. However, we observed significantly more clicks in the certain condition than the uncertain. Generally, we found some possible explanations for our participants behavior: our participants either did not feel curious about the uncertain stimuli, felt like there was a task to complete by clicking all buttons or got bored and sought entertainment. It's possible that we observed people interacting with our experiment like they would when they are browsing

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through social media – seeking stimuli with no apparent goal or value, which would explain that our behavior on cell phones can have apply to our behavior in other parts of life.

The nature of our study and others reveals the need for a greater understanding on curiosity. Even though the original study showed that people may choose stimuli that are uncertain and expectedly negative, it did not gain support from our replication. Curiosity is a complex phenomenon that has to be examined from as many angles as possible. Replication is important as it reveals flaws and differences that can emerge due to a suite of factors. We replicated *The Power and Peril of Curiosity* faithfully, but factors such as participants and the original software caused error and deviance from the original results. And, it may be beneficial to continue to pursue Hsee & Ruan’s theory in different ways.

Our study had some key strengths and limitations that should be discussed. Our construct validity was good for the emotional rating score; scores were rated logically for the amount of time our study ran for, although a more thorough post-test could have been more accurate to measure emotion. On the other hand, total clicks did not appear to be a good measure of curiosity. After participants read the instruction screen in the original software, they were often confused of the goal, and appeared to be primed by the instructions on the software and briefing to think that clicking all the buttons was the goal. We also noticed that many participants, even in the certain condition, clicked all buttons before time was up. As stated earlier, this was not representative of curiosity, but more representative of people did not feel curious about the uncertain stimuli, exhibited completion bias (felt pleasure for completing the task of clicking all buttons), felt like there was a task to complete by clicking all buttons, got bored and sought entertainment, or felt uncomfortable sitting and doing nothing. This created a noticeable ceiling effect which can be seen in figure 1 in the appendix. In addition to participant behavior harming

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our internal validity, the computer software had 4 critical errors which caused the data in those trials to be unusable, lowering our sample size to 49. The computer software also allowed participants to click all buttons and still have time left, which may have further enabled the goal-seeking that we mentioned earlier. The robustness of our results was compromised by the fact that goal-seeking cannot be ruled out over curiosity to explain more clicks in the certain condition. We hypothesize that since the uncertain condition resulted in lower emotional scores, it's possible that the unpleasantness of uncertainty pushed less people to click all buttons.

We had weak external validity as there were only Tufts students between 18 and 22 who were mostly female, white and were recruited in the university library. There is a chance that our results may not be generalizable to the entire student body, let alone the population of Boston or the United States. Our statistical validity was acceptable, we achieved an initial N of 53, excluded bad data, and achieved medium or strong effect sizes. We could have had a more compelling story if we compensated for the ceiling effect of clicks in the certain condition, but a study with better design would be a better option.

First and foremost, we think that future research should investigate curiosity versus goal-seeking. Our results lost clarity due to participant confusion, and we believe that a further examination into this topic could yield useful insights into human motivation. What separates natural curiosity from people doing what they think they should be doing? Did we observe completion bias? Results would help researchers and companies design better experiments and products.

Other directions for future research should include an investigation into the social media use, daily screen time on cell phones, and attention spans. As more people discover the addictiveness of social media, our observations made us wonder whether or not the prevalence of

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social media has affected people's cognition. Exploratory studies should first classify behavior exhibited on social media to supply to further research. Then, people with social media addiction should be imaged and compared to healthy brain images. Then, social media behavior should be investigated for any possible positive transfer into other parts of life. It would be useful for society as a whole to see the cognitive and behavioral differences between people who use social media versus those who do not, including how curiosity is affected.

In replicating *The Power and Peril of Curiosity* to investigate people's reaction and feelings towards uncertainty and unpleasant stimuli, we sought to reaffirm that curiosity may lead people to seek out information that has no benefit or pleasure associated, we claimed that people have a pure desire to resolve curiosity. Our results did not align with other research, as we observed participants interacting more with a condition with certain stimuli compared to the uncertain. Our results did align with prior research that claimed uncertainty can amplify negative emotion because of its relevance to modern day behavior. This study enhanced our understanding advanced and reaffirmed our knowledge of the relationship between uncertainty and emotion, but 'opened Pandora's box' in terms of the need for further investigation on the topic of curiosity and attention.

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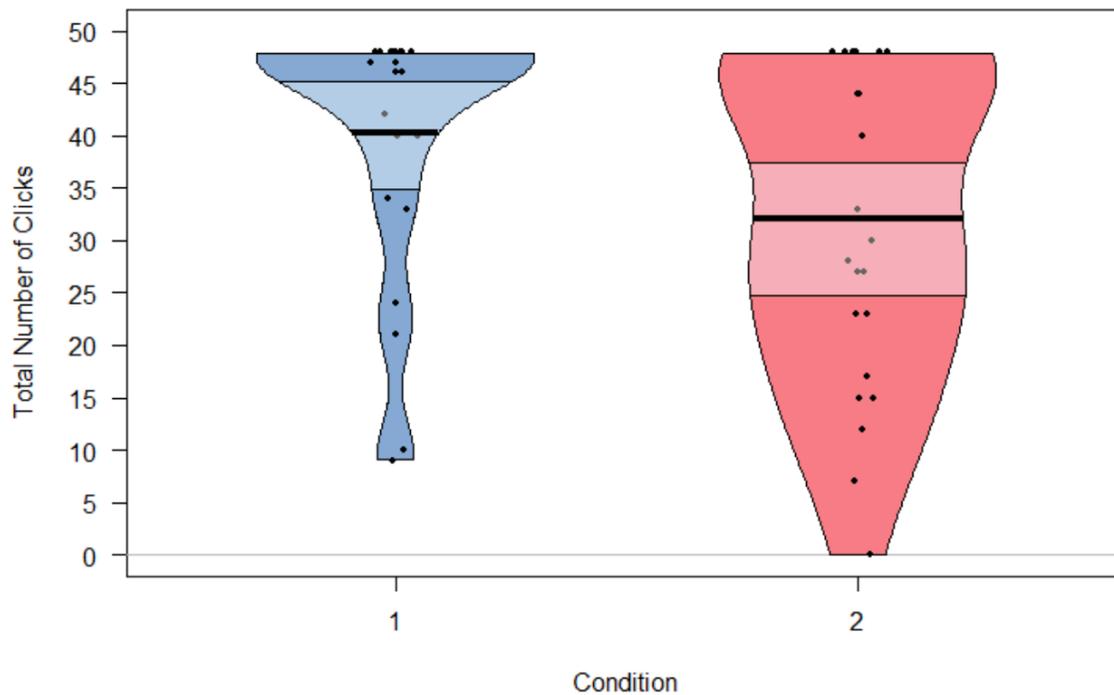
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Figure 1



*Figure 1.* Condition 1 is representing the certain condition, while 2 represents the uncertain condition. The figure shows that many participants clicked all the buttons in both conditions, yet the certain condition has both more instances of 48 clicks, a higher average number of clicks, and a minimum of around 10 clicks.