The Fun and Function of Uncertainty: Uncertain Incentives Reinforce Repetition Decisions

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This research studies repetition decisions—namely, whether to repeat a behavior (e.g., a purchase) after receiving an incentive (e.g., a discount). Can uncertainty drive repetition? Four experiments, all involving real consequences for each individual participant, document a counterintuitive reinforcing-uncertainty effect: individuals repeat a behavior more if its incentive is uncertain than if it is certain, even when the certain incentive is financially better. This effect is robust; it holds in both lab and field settings and at both small and large magnitudes. Furthermore, the experiments identify two theory-driven boundary conditions for the reinforcing-uncertainty effect: the effect arises (a) only if the uncertainty is resolved immediately and not if the resolution of uncertainty is delayed, and (b) only after, not before, one has engaged in repetitions. These results support a resolution-as-reward account and cast doubt on other explanations such as reference-dependent preferences. This research reveals the hidden value of uncertain incentives and sheds light on the delicate relationship between incentive uncertainty and repetition decisions.

Keywords: risks and uncertainty, motivation, gamification, customer retention, intermittent reinforcement, happiness, gambling, variety seeking, prediction, performance, goal pursuit, behavioral decision theory, incentive design, loyalty program

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Marketers are concerned with not only how to stimulate a one-time action but also how to drive repeated actions, such as repurchase rates and customer retention. Can uncertainty drive repetition? It is commonly assumed that consumers are averse to uncertain gains, and thus one would expect uncertain incentives to lead to fewer repetitions. However, some market observations hint otherwise. Examples include the long-lasting popularity of Kinder Eggs, Gachapon toys, and fortune cookies; the blooming business of subscription boxes in North America (e.g., food: Blue Apron; pet supplies: BarkBox); and the sweeping distribution of cash rewards through various mobile payment methods in East Asia (e.g., WeChat Pay). These marketing practices are all designed such that, after taking each action (e.g., after tap-and-paying with WeChat Pay), the customer receives an uncertain outcome (e.g., an uncertain cash amount) and then decides whether to repeat that action (e.g., whether to use WeChat Pay again). Of course, the effect of outcome uncertainty in real-life observations

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is hard to evaluate due to the lack of benchmarks and control conditions. Nevertheless, we conjecture that, under predictable conditions, an uncertain outcome can lead to more repetitions than a certain outcome, even when the certain outcome is financially better. When repeatedly taking an action and receiving its outcome, the individual has the unique opportunity to resolve the uncertainty, and we posit that uncertainty resolution serves as a mental reward that reinforces repetitions. In this research, we present empirical evidence from both field and laboratory experiments to reveal the hidden value of uncertain incentives in repetition decisions. Our focus is on uncovering a novel phenomenon, while we also offer a theoretical account and provide supportive evidence.

PREDICTIONS FROM PRIOR RESEARCH

Do people repeat an action more when the financial outcome of the action is certain or uncertain? As a stylized example, imagine that a mobile payment company offers its customers a cash reward every time they pay $40 or more with its app. Which of the following two incentive designs would boost customer retention more effectively?

> **Uncertain incentive:** The cash reward is either $2 or $4 with even chances, and the customer will find out whether it is $2 or $4 after each payment.
>
> **Certain incentive of the high value:** The cash reward is always $4.

Most existing research would predict that the customer will use this mobile payment more under the high-value certain incentive than under the uncertain incentive. One obvious reason is that, financially, this certain $4 reward dominates the uncertain $2 or $4 reward. Another reason is that, psychologically, the uncertain incentive is associated with risks, and people are risk-averse about gains (Holt and Laury 2002; Kahneman and Tversky 1979; also see "extreme uncertainty aversion": Gneezy, List, and Wu 2006; Newman and Mochon 2012; Simonsohn 2009).

While most research finds uncertainty aversion, exceptions do exist (Dhar, Gonzalez-Vallejo, and Soman 1995; Goldsmith and Amir 2010; Mažar, Shampanier, and Ariely 2016). One such exception relevant to the present work is the research by Goldsmith and Amir (2010). That research focuses on single-shot decisions and finds that buyers respond as positively to an uncertain promotion as they do to the best possible outcome in this uncertain promotion. An innate optimism account is offered to explain the effect: when the buyer does not know what she will receive, she implicitly expects the best and behaves accordingly. While this account can explain why the buyer may respond to an uncertain promotion as positively as to a certain promotion ex ante, it makes no prediction about whether she is more or less likely to repeat the purchase after receiving the reward. If anything, it would expect the buyer to be less likely to repeat in the uncertain-promotion case than in the certain-promotion case, because she could be disappointed by the actual reward in the uncertain-promotion case. But, as we will elaborate on later, we predict and find the opposite.

Another related finding is a positive uncertainty effect in goal-persistence decisions reported by Shen, Fishbach, and Hsee (2015): consumers work harder to pursue an uncertain reward than to pursue its best possible outcome. This effect requires that the uncertainty of reward remains unresolved before the goal is attained. However, repetition decisions do not meet this requirement; in repetition decisions, since the consumer receives outcome feedback repeatedly, uncertainty is duly resolved at each repetition. Therefore, the finding on goal-persistence decisions cannot be used to predict the effect of uncertainty on repetition decisions with timely outcome feedback. As we will explain, the presence of timely feedback—specifically, the presence of immediate resolution after each repetition—is critical for uncertainty to have a positive effect on repetition decisions.

OUR PREDICTIONS

We propose a *reinforcing-uncertainty effect*: that uncertain incentives can lead to more repetitions than certain incentives. In the mobile payment app example, we predict that an uncertain reward of either $2 or $4 will lead to more mobile transactions than a certain reward of $3. In fact, even when an uncertain incentive is financially worse than a certain incentive—for example, the certain reward is $4 instead of $3—we predict that the uncertain incentive will still lead to more repetitions than the certain incentive. In other words, we predict a positive effect of uncertainty in repetition decisions.

Why can uncertainty be reinforcing? We offer a *resolution-as-reward* account. An uncertain incentive implies that the exact promised financial outcome remains unknown initially, and at the time, it is not immediately clear whether an individual would want to approach or avoid the unknown (Ely, Frankel, and Kamenica 2015; Golman and Loewenstein 2018; Herrnstein and Prelec 1991; Hertwig and Engel 2016; Loewenstein 1994). However, it is a pleasant experience for the individual to resolve uncertainty (Hsee and Ruan 2016; Ruan, Hsee, and Lu 2018; also see neural evidence: Peysakhovich and Karmarkar 2016; and animal research: McDevitt et al. 2016). After the individual has had this resolution experience and has gone through repetitions as such, she will eventually realize that an uncertain incentive not only offers a financial benefit with an unknown magnitude (which she knew from the beginning), but also promises a pleasant experience of discovering the unknown with his action.

Stated more formally, the hidden value in the uncertain incentive is the *uncertainty resolution utility*—namely,

how one feels about knowing the unknown. Importantly, uncertainty resolution utility exists in addition to the *outcome acquisition utility*—namely, how one feels about the outcome itself. When an incentive is uncertain, the outcome acquisition utility may be high (if one receives the best outcome in the uncertain incentive) or low (if one receives the worst outcome). However, regardless of the size of the outcome acquisition utility, the uncertainty resolution utility remains positive, because one always moves from an undesirable state of not knowing to a desirable state of knowing (Ruan et al. 2018). That is, even if the mobile payment user does not always receive the best outcome ($4), she may still keep tapping her phone to pay for the pleasure of discovering which cash reward she will receive next time. Over time, even when she has already become numb to receiving a reward (outcome acquisition), she may still have fun finding out the reward (uncertainty resolution).

Compare the motivational mechanisms of certain and uncertain incentives. If a person repeats an action with certain incentives, she experiences only the outcome acquisition utility. By contrast, if a person repeats an action with uncertain incentives, she experiences both the outcome acquisition utility and the uncertainty resolution utility. In other words, under outcome certainty, only one force drives repetition, but under outcome uncertainty, two forces do: outcome acquisition and uncertainty resolution. Thus, we predict that compared with a certain incentive of the *same* expected value, the uncertain incentive will be more reinforcing, and compared with a certain incentive of a *higher* expected value, the uncertain incentive may still be more reinforcing, because the uncertainty resolution utility may offset the disadvantage of the outcome acquisition utility. Putting both together, we predict that:

> **H1:** Uncertain incentives can lead to more repetitions than certain incentives, even when the uncertain incentives are financially worse than the certain incentives (the reinforcing-uncertainty effect).

According to our theory, the critical factor underlying the reinforcing-uncertainty effect is uncertainty resolution, which is rewarding and hence reinforcing. This resolution-as-reward account implies that an uncertain incentive without resolution would not lead to more repetitions. Specifically, the account predicts two boundary conditions for the reinforcing-uncertainty effect.

First, if uncertainty is not immediately resolved after each repetition, uncertain incentives will not be as reinforcing as certain incentives. Uncertainty resolution functions as a positive reinforcer, and as prior research details (Ferster and Skinner 1957; Hsee, Yang, and Ruan 2015; Skinner 1969), a reward reinforces a behavior only if the delivery of the reward is contingent on—that is, immediately follows—the occurrence of the behavior. Therefore, an uncertain incentive with immediate resolution is reinforcing, but an uncertain incentive without immediate resolution (i.e., staying in suspense while deciding whether to repeat the action) loses its uncertainty resolution utility, cannot offset the disadvantage of outcome acquisition utility (if any), and hence is not as reinforcing as a certain incentive. Thus, we hypothesize that:

> **H2:** The reinforcing-uncertainty effect occurs only if the uncertainty is resolved immediately after each repetition and disappears if the uncertainty is not immediately resolved.

Second, if resolution is yet to be experienced—for example, if, before engaging in an activity, one is asked to decide whether to engage in the task—uncertain incentives will not be more motivating than certain incentives of equal or higher expected values. Before engaging in an activity, the individual has no exposure to the resolution experience and is unable to accurately anticipate its positive effect (Andrade and Iyer 2009; Ariely, Loewenstein, and Prelec 2006; Buechel et al. 2014; Hsee et al. 2003, 2015; Woolley and Fishbach 2016; see Hsee and Hastie 2006 for a review). By contrast, after and while engaged in an activity, the individual has enjoyed the resolution experience and will find this experience rewarding. That is, the uncertainty resolution utility kicks in only after repetitions start. Thus, we hypothesize that:

> **H3:** The reinforcing-uncertainty effect occurs through, not before, repetitions; that is, the effect does not occur at entry, when people have yet to engage in repetitions.

Next, we report four studies, of which two are field experiments (studies 1 and 4) and two are lab experiments (studies 2 and 3). We start with a field experiment demonstrating the reinforcing-uncertainty effect, then present converging lab evidence for the resolution-as-reward account to explain the effect, and at last, return to the field and demonstrate the effect at a large magnitude. All studies are incentive-compatible, entail real consequences for each individual participant, and involve no deception. The experimental designs in all studies include two basic conditions: a certain incentive and a dominated uncertain incentive; that is, the uncertain incentive always has a lower expected value than the certain incentive. We report additional studies (in supplementary materials 1 and 2) and additional experimental details and analysis results for all studies (in supplementary materials 3 to 5) in the web appendix.

STUDY 1 (FIELD EXPERIMENT): TESTING THE REINFORCING-UNCERTAINTY EFFECT

Study 1 was designed to test the reinforcing-uncertainty effect (hypothesis 1) and to test the effect in a naturalistic setting: a point-earning exercise program in a running club.

The running club is an independent nonprofit organization operated by college students at the Chinese University of Hong Kong. In the Spring Running event (i.e., our experiment), members could earn points by running, jogging, or speed walking on a standard 400 meter outdoor track during the 15-day event period, from Tuesday, March 17, 2015, to Tuesday, March 31, 2015. We predicted that running club members would complete more laps if they received an uncertain number of points for each lap than if they received a certain, larger number of points for each lap.

Method

Recruitment. The running club distributed a generic recruitment advertisement both on campus (e.g., leaflets in individual mailboxes in school housing facilities) and off campus (e.g., posters at the Mass Transit Railway [MTR] stations in the districts around the university); all materials were in colloquial Cantonese. By the end of the recruitment phase, 111 Hong Kong residents became new members of the club and signed up for the Spring Running event, of which 29 signups were not able to show up for various reasons (e.g., physical injuries and schedule conflicts) and the remaining 82 signups (49 women, average age = 20.03) actually became new members and took part in the Spring Running event. We included all new members as our research participants. (For logistic reasons, we did not have access to old members.)

Prior to the Event. On the weekend before the event, staff at the running club called each new member to explain the Spring Running event and its safety instructions. Then, the staff introduced the point-earning program. Half of the members were randomly assigned to the certain-point condition and were told that after each lap, they would receive five points for sure. The other half were randomly assigned to the uncertain-point condition and were told that after each lap, they would randomly receive either three or five points. At the end of each day, the members would receive a WhatsApp message summarizing the number of points earned on that specific day and the total number of points earned up to that date. After the 15-day event, the members could exchange their points for a gift card from a local café for the equivalent amount in Hong Kong dollars (e.g., 500 points = HK$500, approximately US$65).

During the Event Period. Upon arrival, each member first checked in with club staff and then began exercising on the track. To prevent possible information exchange between the two groups, the staff instructed each member to exercise alone, which usually was the case anyway; if members ran in a couple or a group, which was rare, the staff would advise them not to talk to each other while running. After completing one lap, each member came back to the staff to claim his or her points. The staff always held up two facedown cards with identical backs, one with a red face and one with a black face. The member in the uncertain-point group drew a card, found out the color, and then claimed the points that corresponded to that color (one color represented five points, and the other represented three points). The members in the certain-point group grabbed one of the two cards as a gesture of claiming points and always received five points. To minimize possible information leakage, the staff informed the members in the uncertain-point condition about the meaning of each color at their first drawing only and did not repeat this information later. In both conditions, after claiming the points, the member could decide whether or not to go for another lap.

Results and Discussion

The dependent variable was the number of laps each member completed during the Spring Running event. Consistent with our prediction (hypothesis 1), we observed the reinforcing-uncertainty effect; those in the uncertain-point condition ($M = 13.93$, $SD = 18.51$) exercised for more laps than those in the certain-point condition ($M = 7.45$, $SD = 6.19$; $t(80) = 2.10$, $p = .039 < .05$, 95% CI = [.3511, 12.6060]), even though the uncertain-point condition promised a worse financial outcome. In other words, people literally ran "the extra mile" (precisely, 1.61 more miles) for the uncertain incentive. In additional regression analyses, we found that the reinforcing-uncertainty effect sustained whether or not we controlled for the number of days one came to exercise (controlling: $B = 5.56$, $SE = 2.52$, $p = .030 < .05$, 95% CI = [.5394, 10.5862]; not controlling: $B = 6.48$, $SE = 3.08$, $p = .039 < .05$, 95% CI = [.3511, 12.6060]), and that the incentive manipulation did not affect the number of days ($B = .10$, $SE = .19$, NS), which is not surprising since members were incentivized to exercise for more laps, not to come for more days.

To better appreciate the robustness of these results, one must note the dominated-uncertainty paradigm adopted in this study, as well as in all later studies. In a comparison between an uncertain incentive and a certain incentive of a higher expected value, the null hypothesis is not that the two incentives will produce equal effects; instead, the dominated, uncertain incentive is expected to be less effective. Therefore, our finding that uncertain incentives lead to more repetitions is based on a strong test against uncertain incentives.

In sum, study 1 provides the first demonstration of the reinforcing-uncertainty effect—a strong form of "uncertainty loving" in repetition decisions—and it is a demonstration from the field. The next couple of studies switch to laboratory settings for a better-controlled examination.

STUDY 2: RULING IN THE RESOLUTION-AS-REWARD ACCOUNT

Study 2 was designed to examine the role of uncertainty resolution in the uncertainty-reinforcing effect by manipulating the presence of resolution (hypothesis 2). Based on the resolution-as-reward account, the absence of resolution means the absence of a positive reinforcer, so it should, in turn, lead to the absence of the reinforcing-uncertainty effect.

Method

One hundred three city residents (38 women; average age = 35.39) were recruited by the Downtown Chicago Lab, a private research facility in the Chicago Loop, United States, operated by the Center for Decision Research at the University of Chicago Booth School of Business. All were compensated $3 for their time (20 minutes). We conducted a training program for a calculation test in the lab. Each participant first read about the calculation test: it would start in 20 minutes, and the participant who answered the most questions correctly within 40 seconds would receive a $50 prize.

Each participant was in an individual session with an experimenter who assumed the roles first of the trainer and later of the examiner. During the 20 minute lead time, the participant could complete as many practice rounds (each also lasting 40 seconds) as he or she wanted. To encourage the participant to practice, the trainer gave out stars for each practice round the participant completed. At the end of the study, the stars could be exchanged for candies (one star = one candy).

There were three between-subjects conditions. The number of stars varied across the conditions: either one or two stars in both of the uncertain-prize conditions, and two stars in the certain-prize condition. In all conditions, the experimenter first showed the participant a stack of 200 cards faceup. Then, the experimenter shuffled the cards and held the stack with all cards facedown throughout the study. If the participant decided to do another practice round, he or she drew a card from the stack and placed it on the table. In the certain-prize condition, all cards were printed with two stars, and the participant could examine the card if desired. In both uncertain-prize conditions, half of the cards were printed with two stars and half with one star; in the uncertain-prize/with-resolution condition, the participant could examine the card, whereas in the uncertain-prize/without-resolution condition, the participant could not examine the card at the time it was drawn and instead had to place the card facedown on the table. Those in the latter condition found out how many stars were printed on each card only after the entire preparation period (20 minutes) had passed, but before the test started. Notably, each participant endured the same objective uncertainty whether or not he or she checked out the card after each round, and thus normatively, the two uncertain-prize conditions are equivalent.

Results and Discussion

The dependent variable was practice repetition—that is, the number of practice rounds a participant took. Consistent with hypothesis 1, we found that participants in the uncertain-prize/with-resolution condition ($M = 8.62$, $SD = 3.00$) completed more rounds than those in the certain-prize condition ($M = 4.85$, $SD = 2.88$; $t(66) = 5.28$, $p < .001$, 95% CI = [2.3413, 5.1881]), which replicated the reinforcing-uncertainty effect we observed in the field experiment (study 1). More importantly, in support of the resolution-as-reward account (hypothesis 2), we found that those in the uncertain-prize/with-resolution condition also completed more rounds than those in the uncertain-prize/without-resolution condition ($M = 3.74$, $SD = 1.63$; $t(67) = 8.43$, $p < .001$, 95% CI = [3.7201, 6.0295]), indicating that uncertainty resolution is the driver of the reinforcing-uncertainty effect. In addition, those in the certain-prize condition took marginally more rounds than those in the uncertain-prize/without-resolution condition ($t(67) = 1.98$, $p = .052$, 95% CI = [–.0117, 2.2318]), suggesting that people are averse to risks and smaller benefits. Thus, study 2 demonstrated that uncertainty resolution is critical for the reinforcing-uncertainty effect to occur. Without timely resolution, uncertain incentives do not have an overall advantage over certain incentives. Uncertainty resolution utility is an extra motivational force that only uncertain incentives possess.

STUDY 3: RULING OUT ALTERNATIVE EXPLANATIONS

Study 3 was designed to assess a few possible alternative explanations based on outcome variety. The structure of uncertain incentives has two distinct features: outcome uncertainty and outcome variety. Outcome uncertainty invites resolution, and as study 2 demonstrates, resolution does contribute to the reinforcing-uncertainty effect. Outcome variety introduces a list of alternative explanations: (a) hedonic adaptation (that varied outcomes are more resistant to hedonic adaptation than fixed ones; Frederick and Loewenstein 1999; Kahneman and Thaler 1991); (b) the contrast effect or reference-dependent preferences (that a good outcome appears better when a not-so-good outcome serves as the reference point; Hsee 1996; Morewedge et al. 2009; Tversky and Kahneman 1991; Zhang 2015); and (c) variety seeking (that varied outcomes may be seen as more valuable than fixed outcomes; Fishbach, Ratner, and Zhang 2011; McAlister and Pessemier 1982; Simonson 1990).

Do any of these "variety" explanations contribute to the reinforcing-uncertainty effect? We included a certain-varied condition as a second control to examine whether outcome variety is critical to the reinforcing-uncertainty effect.

Method

Seventy-eight city residents (33 women; average age = 25.73) recruited by the Downtown Chicago Lab participated in voluntary repeated purchases. All participants received $3 as compensation for their time (15 minutes) at the beginning of the study. In the lab, we conducted a sales promotion program that was a low-tech version of the WeChat Pay cash reward promotion. Both the purchases and discounts played out for real for each individual participant.

Each participant was in an individual session with an experimenter, who assumed the role of a salesperson. The participant first read about a sales promotion program for Band-Aid Flexible Fabric bandages: "Buy One Band-Aid, Get One Cash Coupon." The promotion program had the following rules. For every purchase, the buyer would receive a cash amount indicated by the coupon. If the buyer liked receiving the coupons, she should purchase Band-Aids one piece at a time (all participants followed this advice). She was required to make three purchases to get familiar with the promotion program, and after the three mandatory purchases, it was up to her to decide how many more Band-Aids to purchase. All transactions would be realized immediately after each purchase. At the end of the study, the buyer could take home the Band-Aids she bought.

The face value of the coupons, or the discount, varied across conditions: either 10 or 5 cents (in the uncertain-discount condition), 10 cents (in the certain-discount condition), and either 10 or 5 cents (in the yoked, certain-varied-discount condition). In the uncertain-discount and the certain-discount conditions, the salesperson held a stack of 200 facedown coupons throughout the study. After each purchase, the buyer drew a random coupon from the stack, saw the amount, and then indicated whether she wanted to make another purchase. In the uncertain-discount condition, half of the coupons were printed with "10 cents," and the other half with "5 cents." In the certain-discount condition, all coupons were printed with "10 cents." In the yoked condition, the salesperson lined up the coupons on the table in a predetermined sequence that corresponded with the sequence in the uncertain-discount condition, but in this case, all coupons were faceup—the buyer could see the discounts and decide whether to make another purchase based on the upcoming coupon.

Results and Discussion

The dependent variable was purchase repetition—that is, the number of purchases a participant decided to make after the mandatory three purchases. Consistent with hypothesis 1, the participants in the uncertain-discount condition ($M = 13.64$, $SD = 5.44$) purchased more Band-Aids than those in the certain-discount condition ($M = 9.42$, $SD = 5.36$; $t(50) = 2.81$, $p < .01$, 95% CI = [1.2067, 7.2457]). Those in the uncertain-discount condition also purchased more Band-Aids than those in the yoked, certain-varied-discount condition ($M = 8.65$, $SD = 3.07$; $t(50) = 4.10$, $p < .001$, 95% CI = [2.5493, 7.4288]), and as we expected, the participants in the fixed and varied certain-discount conditions made a similar number of purchases ($t < 1$, $p > .5$, NS). These results indicate that it is uncertainty, not variety, that promotes purchase repetition. (In fact, most uncertainty-seeking behaviors are specific to uncertainty and not to variety, though they can be easily confused; also see Webb and Shu 2018).

Studies 2 and 3 revealed that the hidden value within uncertain incentives is uncertainty resolution, not outcome variety. Together, these studies also ruled out another possible explanation for the reinforcing-uncertainty effect in study 1: the earning-target account (Camerer et al. 1997). According to this alternative account, participants possess a specific earning target for the activity they are engaged in, so an uncertain incentive should lead to more repetitions because it has a lower expected value and thus requires more repetitions to reach the earning target. This alternative account is inconsistent with the results of both the control condition of study 2, in which participants did not do more practice rounds for a small incentive (one or two stars with unresolvable uncertainty) than for a large incentive (two stars with certainty), and the control condition in study 3, in which participants did not make more purchases for a small known discount (5 or 10 cents with certainty) than for a large known discount (10 cents with certainty). For further evidence against this earning-target account, see the study in supplementary material 1. In that study, an uncertain incentive was more reinforcing than both a certain incentive of a higher expected value and a certain incentive of the same expected value as the uncertain incentive; the latter result ruled out the earning-target account.

STUDY 4 (FIELD EXPERIMENT): TESTING THE REINFORCING-UNCERTAINTY EFFECT AT A LARGE MAGNITUDE

In study 1, we showed the reinforcing-uncertainty effect in the field with relatively small incentives and with a somewhat playful customer retention program. In study 4, we went back to the field to test the reinforcing-uncertainty

effect (hypothesis 1) with more substantial incentives and in a more serious labor market. We designed and tested various incentives on a pay-by-task survey platform (similar to Amazon Mechanical Turk) affiliated with the Chinese University of Hong Kong. The certain pay we offered for each survey, HK$40 for 10 minutes, was more than four times the standard wage of part-time on-campus jobs at any public university in Hong Kong; for example, a business-school graduate student working as a part-time research assistant was paid HK$55 per hour (or HK$9.17 for 10 minutes) at the time of the study. The survey platform had a participant pool of over 3,000 active part-time workers from two major sources: current and past college students recruited from two large public universities (the Chinese University of Hong Kong and the Hong Kong Polytechnic University), and other residents openly recruited from multiple public part-time job websites (e.g., parttime.hk). Both the platform and its surveys were computer-based and mobile-device friendly, so workers could work from wherever they wanted without encountering the lab environment.

Study 4 was also designed to examine whether uncertain incentives have different effects on entry versus repetition (hypothesis 3). Entry refers to whether the participant entered the activity in the first place (namely, completing at least one survey), while repetition refers to the number of repetitions the participant completed after entering the activity. In this study, potential workers were free to decide whether to enter (i.e., whether to work on any surveys), and if so, how many times to repeat (i.e., how many surveys to complete). Thus, the study was intended to showcase the effect of uncertainty on both entry and repetition in a realistic and meaningful within-subject design. For a test of hypothesis 3 in a between-subjects design with random assignment, see the study in supplementary material 1.

Method

We posted a generic recruitment advertisement on the platform. It read (in colloquial Cantonese) that the survey platform would hold a three-week-long "Summer Survey Season" with survey opportunities available on a daily basis, that no other research activities would be conducted on the platform during the same period, and that payment for each survey would be issued upon completion (as is typical for the platform). To avoid undesirable self-selection in the recruitment stage, the advertisement did not specify any incentive scheme. From all respondents (over 3,000), we randomly selected and assigned 480 workers to either the certain-pay condition or the uncertain-pay condition (370 women, average age = 21.60; the sample size was determined in advance of data collection and based on budget constraints).

In the week prior to the survey season, the research assistant sent out a customized email to each worker with his or her individual incentive scheme. The email explained that the Summer Survey Season would last for 21 days, from Monday, August 8, 2016, to Monday, August 28, 2016, and that twice a day, at 8 a.m. and 8 p.m., a new survey would become available for 12 hours and the previous survey would automatically expire; that is, only one survey was available at a time. This procedure was designed to prevent workers from completing all the surveys at once without receiving payment information from the previous task. Therefore, all workers went through the same decision-making process: after completing each survey, all workers first found out the payment for that survey and then decided whether to take the new active survey.

The email also said that each survey was expected to take about 10 minutes to complete and that workers would be paid upon completion of each survey. Workers in the certain-pay condition further read that they would receive HK$40 for each completed survey, whereas workers in the uncertain-pay condition further read that they would receive either HK$20 or HK$40, with even chances, for each completed survey.

Notably, the repetition decision in this study was structured differently from previous lab studies (e.g., study 2). The platform did not require workers to take every survey until they decided to quit; rather, they could take as many surveys as they liked during the 21-day period and could skip as many surveys as they wanted in between. The interval between surveys was substantially longer—from 12 hours to 20 days—than in any of the previous studies, so this structural feature had the potential to dilute the pleasure of uncertainty resolution and challenge the generality of the reinforcing-uncertainty effect.

Results and Discussion

The setting in this field experiment resembled a real labor market, which typically involves self-selection; workers could choose whether to work, and those who chose to work could decide how many times to repeat the work. Accordingly, we analyzed both (a) entry (the percentage who took at least one survey) and (b) repetition (among those who took at least one survey, the average total number of surveys completed and the average probability that a worker completed a survey at each possible survey). Finally, we also explored the combined effect of entry and repetition.

Entry. Among all potential workers who were informed about their pay scheme, we observed that uncertain incentives had a significant negative effect on entry decisions; fewer potential workers chose to take a survey for the uncertain HK$40 or HK$20 pay than for the certain HK$40 pay (67% vs. 88%; $\chi^2 = 28.50$, $p < .001$, 95%

CI = [13.1206, 27.7127]). This negative effect may have occurred either because the expected pay in the uncertain-incentive condition was lower, or because participants were risk-averse, or both.

Repetition. Among the actual workers (those who entered and completed at least one of the 42 possible surveys), we found that uncertain incentives had a significant positive effect on repetition decisions; on average, actual workers incentivized by the uncertain pay completed about six more surveys over the entire survey period ($M = 25.96$, $SD = 13.45$) than actual workers incentivized by the certain pay ($M = 20.31$, $SD = 14.65$; $t(371) = 3.82$, $p < .01$, 95% CI = [2.7397, 8.5667]). Therefore, consistent with hypothesis 1, the reinforcing-uncertainty effect occurred even when incentives were substantial.

We constructed a dynamic decision model to examine, across all possible surveys, the likelihood that an actual worker would take any given survey. We found that an actual worker incentivized by the uncertain pay was, on average, 13% more likely to take any given survey than an actual worker incentivized by the certain pay ($B = .1346$, $SE = .0348$, $p < .01$, 95% CI = [.0661, 0.2031]). This finding sustained even when we controlled for the exact incentive received ($B = .1401$, $SE = .0394$, $p < .01$, 95% CI = [.0627, .2176]; incentive size had no effect: $B = .0164$, $SE = .0363$, NS, suggesting a different mechanism from Yang, Gu, and Galak 2017).

Entry and Repetition Combined. Among all potential workers, we found that by simple counts, a similar total number of surveys was completed under the uncertain pay scheme (4,265 surveys) as under the certain pay scheme (4,180 surveys). Even though the counts are close, the economic value of this difference is remarkable: for a similar output, survey researchers saved HK$42,880 (approximately US$5,500) by adopting the uncertain pay scheme.

With the dynamic decision model, we found that overall, uncertain incentives still had a positive effect. As time went on, a potential worker incentivized by the uncertain pay became significantly more likely to take any given survey than a potential worker incentivized by the certain pay ($B = .0021$, $SE = .0008$, $p < .01$, 95% CI = [.0005, .0036]). This finding is important. It implies that if the maximum number of repetitions had not been restricted—this study allowed only a maximum of 42—the positive uncertainty effect on repetition would have overridden the negative uncertainty effect on entry and yielded a net positive effect. In other words, the more repetitions an activity allows, the larger an advantage the uncertain incentive has over the certain incentive.

GENERAL DISCUSSION

Our research reveals that human reactions to uncertainty are more complex and nuanced than commonly thought. Contrary to what traditional economic theories would prescribe and what other behavioral decision theories would predict, we find a reinforcing-uncertainty effect: people repeat a task more for an uncertain incentive than for a certain incentive, even when the uncertain incentive is financially worse. Empirical evidence from four experiments, in both lab and field, show this positive effect of uncertain incentives on repetition decisions (see supplementary material 4 for a meta-analysis of all studies). We also find empirical evidence in support of the resolution-as-reward account: the resolution of uncertainty operates as a positive reinforcer of repetitions, and this uncertainty resolution utility is the hidden value inside of uncertain incentives (see supplementary material 2 for additional empirical evidence on uncertainty resolution utility). In the remainder of this section, we speculate on how our research is related to other phenomena in the extant literature and suggest directions for future research.

Relationship with Other Positive Uncertainty Effects

It is intuitive and often correct to expect a negative effect of uncertainty (Bragger et al. 1998; Camerer and Weber 1992; Duke, Goldsmith, and Amir 2018; Ellsberg 1961; Fantino, Navarro, and O'Daly 2005; Gneezy et al. 2006; Massey and Wu 2005; von Neumann and Morgenstern 1947; Webb and Shu 2017), so whenever a positive uncertainty effect occurs, we naturally pause and ponder: What is happening? We conjecture that the answer lies in the types of decisions in which uncertainty occurs.

Single-shot decisions (Goldsmith and Amir 2010) present the decision maker with different possible prospects, and the prospect that catches the most attention usually determines the direction of the uncertainty effect (the salience theory, Bordalo, Gennaioli, and Shleifer 2012). This attention account explains why optimistic decision makers behave as if they will receive the best possible outcome (Dhar et al. 1995; Dhar, Gonzalez-Vallejo, and Soman 1999; Gibson and Sanbonmatsu 2004; Goldsmith and Amir 2010; Wagenaar 1989). But importantly, an attention shift does not bring any additional psychological benefits; thus, the uncertain outcome in a single-shot decision cannot produce an effect more positive than its best possible certain outcome.

Single-shot goal-persistence decisions (Shen et al. 2015) have some unique features: there is an uncertain carrot hanging at a distant finish line (goal). When the decision maker is working toward it, the *unresolved* uncertainty can stimulate additional positive energy (e.g., excitement) to motivate the decision maker to work harder, if she indeed focuses on working. This additional positive energy explains why a decision maker would work even harder for an uncertain reward than for its best possible outcome as a certain reward.

Repetition decisions (the focus of this research) have some unique features too: after each repetition, there comes an opportunity to resolve uncertainty. As long as the decision maker keeps repeating the action, she will keep receiving not only the material reward but also the mental reward—uncertainty resolution utility. This additional mental reward explains why the decision maker would repeat the action even more for an uncertain incentive than for a certain, financially better incentive.

In sum, each psychological benefit is unique by itself and is also unique to the decision type that invites it. To identify the types of decisions is to precisely understand the psychological benefits that correspond with each, which in turn is to humbly appreciate the psychology of uncertainty. Future research may further investigate the fine lines between different psychological benefits and may integrate them into one systematic theoretical framework.

Relationship with the Intermittent Reinforcement Effect

Our research builds on and extends the animal learning research on intermittent reinforcement (Deslauriers and Everett 1977; Ferster and Skinner 1957; Hogarth and Villeval 2010; Skinner 1938). Like the typical intermittent reinforcement effect, our effect highlights the positive aspect of uncertainty. However, the typical intermittent reinforcement effect is about behavior extinction after incentives are removed (Hogarth and Villeval 2010; Lehr 1970), while our effect is about behavior acquisition while incentives are present. For example, the typical intermittent reinforcement effect shows that a pigeon is more likely to continue pressing a lever if lever-pressing used to yield uncertain rewards than if it used to yield certain rewards, even though it *currently yields no rewards*. Meanwhile, our effect shows that a human is more likely to repeat an action if the ongoing reward is uncertain than if it is certain. With only a few exceptions (Gonzalez, Eskin, and Bitterman 1963; Goodrich 1959; Ishida, Couvillon, and Bitterman 1992), most studies in the learning literature show negative effects of uncertain rewards at the acquisition stage (Finger 1942a, 1942b; Jenkins and Stanley 1950; Lewis 1956; Lewis and Cotton 1957; Sheffield 1949; Wilson, Weiss, and Amsel 1955). In the few exceptions, the positive effects of uncertain rewards seemed to occur only in special circumstances (e.g., the effect applied only to the initial running speed of a rat, but not to its later running speed), and it is not clear whether these circumstances are relevant to our findings. We expect future research to identify any potential relevancy.

Furthermore, the cause of the typical intermittent reinforcement effect also seems different from the cause of our effect. To our best understanding, the cause of the typical intermittent-reinforcement effect is ignorance: the pigeon that used to receive intermittent incentives, and now receives no incentives, does not know that the incentives have been removed. On the other hand, the cause of our reinforcing-uncertainty effect is uncertainty resolution: the uncertain incentive gives the person the opportunity to enjoy the pleasure of resolving uncertainty. Consistent with this reasoning, our studies show that the reinforcing-uncertainty effect occurs only if the uncertainty is resolved immediately after each repetition (e.g., study 2). This boundary condition would not apply to the typical intermittent reinforcement effect.

Future Directions: Possible Boundary Conditions and Other Moderating Factors

We have identified two boundary conditions for the reinforcing-uncertainty effect: whether one has engaged in the activity, and whether uncertainty is immediately resolved. There are other boundary conditions, however. One obvious boundary condition is the difference in expected value between the certain and uncertain incentives. The reinforcing-uncertainty effect is more likely to occur if the expected value of the uncertain incentive is close to the value of the certain incentive than if the former is far worse than the latter. If the expected value of the uncertain incentive is far worse than the certain incentive, then the uncertain incentive's advantage in the uncertainty resolution utility may not offset its disadvantage in the outcome acquisition utility, and as a result, the reinforcing-uncertainty effect will disappear or reverse. Another boundary condition is the magnitude of the worst possible outcome in the uncertain incentive—in particular, how bad the worst possible outcome is. The reinforcing-uncertainty effect is more likely to occur if the worst possible outcome is still acceptable than if it is not. If the worst possible outcome is below the acceptable threshold, this outcome can be construed as a loss and may trigger the effect of loss aversion, which might reduce or reverse the reinforcing-uncertainty effect.

This research focuses on circumstances in which the probabilities of the uncertain outcomes are known. What happens if the probabilities of the uncertain outcomes are unknown? Previous literature shows ambiguity aversion in single-shot decisions (Fox and Tversky 1995). However, we surmise that ambiguity may promote repetition decisions, because repetition under ambiguity generates not only the pleasure of resolving uncertainty, but also the chance for real learning opportunities and real informational values. For example, if a consumer wanted to identify the different prizes and their respective likelihoods in Qatar's sweepstakes promotion, "Coca-Cola Under the Cap," she would first have to purchase and open a very large number of bottled drinks (assuming the prize information was not previously announced or easy to locate). Therefore, uncertain outcomes with unknown probabilities ("ambiguous" outcomes) may lead to even more

repetitions than uncertain outcomes with known probabilities ("risky" outcomes). Of course, this is only our speculation and awaits further research to test.

Other questions that await future research include whether the reinforcing-uncertainty effect is more likely to occur if the probability distribution of the possible outcomes in the uncertain incentive is even (50% vs. 50%) or skewed (e.g., 10% vs. 90%; Parducci 1965; Volpp et al. 2008), if the outcomes are familiar or unfamiliar (Kupor, Liu, and Amir 2018; Morewedge et al. 2009; Shen and Urminsky 2013), and if the decision maker is in a calculation mode or feelings mode (Hsee and Rottenstreich 2004; Rottenstreich and Hsee 2001).

Gambles, Games, and Gamification

Some people love gambling, so one may wonder: Can the reinforcing-uncertainty effect be subsumed by this kind of gambling phenomenon? We doubt so. In gambling, the best possible outcome is typically much better than the outcome of not gambling at all ($0). But in all our experiments, the best possible outcome in the uncertain-incentive condition is not any better than the outcome in the certain-incentive condition. We are not aware of any gambling research that shows that people would choose to gamble if the best possible outcome were not better than not gambling at all. Although our effect cannot be subsumed by the typical gambling phenomenon, our resolution-as-reward account can potentially explain why people enjoy gambling: the resolution of uncertainty each time a gambler plays the slot machine or spins the roulette wheel is reinforcing or even addictive.

One may also wonder: Does the reinforcing-uncertainty effect exist only in mere gamelike situations with trivial consequences? We doubt so, too. Our research shows that this effect can occur in serious contexts with consequential decisions; in study 4, for example, a single worker could potentially have earned up to HK$1,680. Even when the incentive for each repetition is bite-sized—such as whether to recycle a plastic drink bottle for 30 cents or whether to buy a dozen cage-free eggs at a $1.49 discount—the aggregate incentives are sizable across time and populations. Importantly, although the decisions we studied are serious and not games, the implementation of uncertain incentives can transform serious decisions that otherwise are not so fun into decisions that are fun. In other words, adding uncertainty can make an otherwise nongame activity gamelike. Indeed, this is the meaning of "gamification" (Bittner and Schipper 2014; Dicheva et al. 2015; Etkin 2016; Hamari, Koivisto, and Sarsa 2014; Huang, Etkin, and Jin 2017; Huang and Soman 2013; Shen and Hsee 2017). We next offer a few gamification ideas based on our findings.

Marketing and Public Policy Implications

As we noted at the beginning of the article, some companies are already taking advantage of incentive uncertainty in promotions. For example, WeChat Pay, one of the largest mobile payment applications in the world, awards an uncertain cash bonus to a customer once she uses the software to make a purchase. However, marketers and policy makers can do more to take advantage of the benefits of uncertainty when strategizing for retention purposes, especially when they are under budgetary constraints.

In addition to the contexts already tested or discussed, sustainability campaigns are a fascinating and relevant domain. For example, due to social responsibility (or social pressure), marketers incentivize repeated environmentally friendly behavior. Grocery retailers encourage customers to reuse cloth shopping bags with a negligible rebate, such as 10 cents off every purchase at a Whole Foods Market in the United States and Canada. Coffee shops encourage drinkers to bring their own mugs for a small discount, such as HK$3 off every beverage at a Starbucks in Hong Kong. Hotels and resorts encourage guests to "Choose Green" and skip housekeeping with a nominal reward, such as a food or beverage voucher worth £5 for every night at a Starwood hotel in the United Kingdom. Regardless of the baseline effectiveness of these specific incentive programs, we speculate that they would be more effective if the incentives were uncertain. Specifically, we predict that an uncertain rebate will lead to more frequent usage of cloth shopping bags, an uncertain discount will lead to more frequent usage of personal mugs, and an uncertain food or beverage voucher will lead to more skipping of unnecessary housekeeping services.

As another example, several US states currently require consumers who are buying bottled drinks to deposit an amount, included in the price, that is refunded if the bottles are returned to a recycling center or machine. Usually, the size of the refund is printed on the bottle and therefore is certain. However, we recommend changing the certain refund to an uncertain amount, essentially transforming the bottle-recycling machine into a bottle-recycling "slot machine" that we predict will gamify the otherwise tedious recycling activity and encourage people to recycle more. Then, recycling could be rewarding not only for the monetary return but also for the pleasure of uncertainty resolution.

DATA COLLECTION INFORMATION

The first author supervised the data collection for study 1 by staff at a running club in Shatin, Hong Kong, in 2015 and for study 4 by the survey platform research team at CUHK Business School, the Chinese University of Hong Kong, Hong Kong, in 2016. The first author also supervised the data collection for studies 2 and 3 by research

assistants at the Downtown Research Lab, operated by the Center for Decision Research at the University of Chicago Booth School of Business, Chicago IL, United States, in 2014. These data were analyzed by the first and third authors.

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