

Countdown Timer Speed: A Trade-off between Delay Duration Perception and Recall

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We face delays in a variety of situations. They are either inevitable, e.g., due to system limits, or are intentionally added, e.g., advertisements. In many situations, a visual feedback is provided during the delay to manage expectations. This feedback is usually provided through progress bars, percentages, or countdowns, depending on design limitations such as screen size. In this article, we use 15-second delays and examine (a) how delays affect users' decision-making and task satisfaction, and (b) how to manipulate time perception to reduce the negative consequences of delays. Experiment 1 ($N = 421$) shows that faster countdowns increase task satisfaction and lead to more rational decisions in the subsequent task. In Experiment 2, we investigate the effect of countdown speed on delay perception and recall ($N = 531$). We show that faster countdowns lead to shorter perceived delays, while the delay will be recalled as longer after the task. The opposite is obtained for slower countdowns. We also increased the countdown rate and found a limit for the effect of increased speed. Thus, designers have to trade-off between how delays are perceived at the moment of experience and how they are recalled. We discuss the implications of these findings for user interface design.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in interaction design**; Graphical user interfaces;

Additional Key Words and Phrases: Delay, duration recall, countdown, impatience, task satisfaction, delay perception, feedback design, quality of service, loading bars, progress meters

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1 INTRODUCTION

Delays are inevitable in several real-life situations. They can be due to computational limits of computers, limited capabilities of humans to perform tasks, or even lack of sufficient human resources. Examples include but are not limited to downloading and installing an application or operating system, waiting for a page to load or a scan to be completed, or even waiting for the time of an

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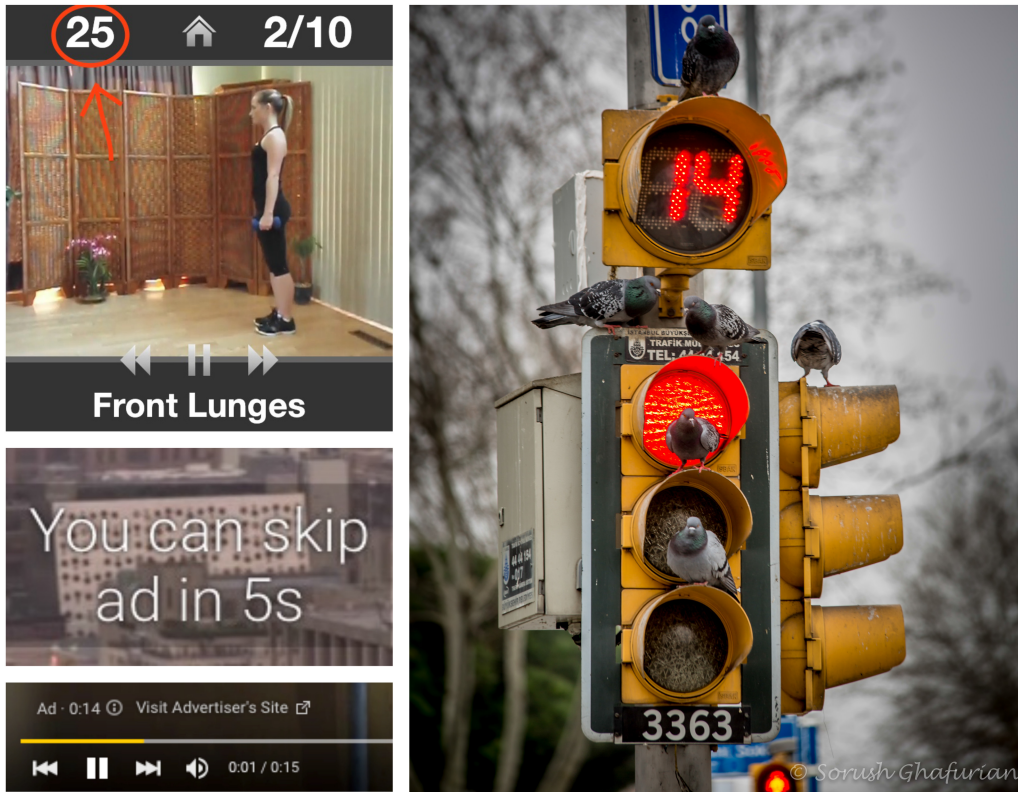


Fig. 1. Examples of countdowns faced daily: completing a virtual gym workout, e.g., on a smart-phone application showing the remaining time of an exercise (from *Ab Workout* app), watching advertisements while waiting for a video to play (from *YouTube*), or waiting at a red light.

activity to end. Furthermore, in many situations delays are necessary to facilitate resource sharing (such as traffic lights) or to produce revenue by showing an advertisement. Often, users receive visual feedback about these delays (e.g., using progress bars). Feedback provided during delays helps users manage expectations and direct attention elsewhere, which can affect perception of the duration of the delays. Figure 1 shows a few such examples. In this article, we examine the trade-offs involved in feedback design.

Feedback shown during delays improves users' tolerance for delays [22]. In many situations, the feedback is in shape of a progress bar, a countdown, or the percentage of the task completed. Several studies have focused on improving feedback shown during the delays, mostly by manipulating progress bars [15–17], which is a common type of feedback. However, progress bars cannot be used in all applications, especially where the screen size is limited or where continuous feedback is ineffective. In addition, progress bar design has limitations. A countdown does not have such limitations and can start from a very large number. Countdowns are easy to manipulate as they are not limited to screen size (as progress bars are), or to a maximum/minimum number (as percentages are). Countdown manipulation can be achieved simply by choosing a start value and a speed function. Nevertheless, manipulating countdowns and investigating the effects of using them as a type of feedback have seen limited attention. Therefore, countdowns are examined here as the type of feedback provided during delays.

We know that feedback improves users' tolerance of waiting times [22]. The nature of the feedback does affect task satisfaction [10, 15] and it also affects the way users use an interface [23]. In one study, it was shown that short system delays (between 0.5 and 2 seconds) do not impact accuracy in a simple task that was not intellectually demanding [13].

Here, we investigate longer delays (fixed-length, 15-second delays) in cases where the task after the delay has a higher cognitive load. We ask (a) whether impatience is persistent, extending beyond the waiting period, (b) why the speed of feedback (countdown) during a constant delay affects decision-making and task satisfaction, and (c) how impatience affects the task that follows. If it negatively affects the following task, the next question is: what can a designer do about it? Therefore we ask (d) what are the design trade-offs and limitations of manipulation of feedback speed, and what are the implications for designing user interfaces? We study different ways to manipulate time perception in search of clear ways to decrease impatience and increase task satisfaction.

The situations we examine are those faced by regular computer users, although the implications go beyond those interfaces. Delays are common when faced with systems/interfaces (e.g., traffic lights and security checks), and people's decision-making may be severely and negatively affected [3, 9]. This is another good reason to make waiting more tolerable.

In Experiment 1, we manipulated the speed of the countdown shown during a constant delay and studied how decision-making and task satisfaction were affected as a result of this manipulation. We hypothesized that a faster countdown shown during the same delay can affect people's time perception and reduce impatience and its negative consequences. In Experiment 2, we studied time perception and expanded this investigation to a larger range of countdown speeds to study the possible limitations. We then show and discuss the design trade-offs for choosing the appropriate feedback speed.

2 BACKGROUND

Delays can introduce a variety of negative effects. For example, they can negatively affect users' loyalty [3], productivity, and work satisfaction [29]. Yet, there are multiple situations where the delays are inevitable. Different types of visual feedback have been provided and manipulated in the literature to improve users' experience of delays. For example, Harrison et al. [16] showed that a backwards moving and decelerating progress bar has the best performance, as users showed a strong aversion to pauses, especially towards the end of the waiting period [15].

Further, a speed that changed based on a nonlinear function ($f(x) = (x + (1 - x)/2)^8$), was shown by Harrison et al. [15] to improve users' tolerance during short delays (5 seconds). Ghafurian and Reitter [10] used this nonlinear function in a countdown and showed that for a longer delay of 15 seconds, a nonlinear speed may no longer improve users' impatience as compared to a fast linear countdown [10]. In another study, it was shown that users are more tolerant of delays when the web pages load incrementally [7]. In addition, the visual appearance of progress bars has been modified to reduce the perceived wait time. Further, using feedback that enabled users to switch to another task (such as a game) during a delay was shown to be beneficial [17]. These proposed methods helped reduce the perceived waiting time.

All such modifications can make delays more tolerable by positively influencing people's time perception. Time perception is generally affected by multiple factors [2, 4], including the level of attention and activity. That is why someone waiting in a line perceives 15 minutes much longer than someone who is working hard and has 15 minutes before a deadline [6, 24]. Further, daily caffeine consumption is shown to enhance the accuracy of time estimation [20]. Amount of information processing is also shown to be a factor affecting time perception [2, 18]. All of such factors can also influence one's perception of delays. Thus, we believe that delay duration perception can be affected by countdown speed.

Depending on how the passing of time is perceived, time durations can be underestimated or overestimated. For example, Svenson (2008) showed the effect of driving speed on time perception. People overestimated the time saved from increasing driving speed, when increasing speed happened from a higher speed, as compared to a lower speed [28]. The time saving bias was also observed in another study, which argued that this bias can be generalized to other contexts such as health care: time saved was overestimated at the care center, when the working speed was increased from a higher speed point, as compared to a lower point [27].

Ahn et al. [1] proposed a model of *memory markers* to explain how durations are perceived. Based on this model, the mind encodes memory markers (episodic memory traces based on cognitive or sensory experiences) belonging to specific time periods and stores them in memory. These memory markers can be in any sensory or cognitive form, such as visual, auditory, or tactile. A span of time with more memory markers will be perceived to pass faster than a span with less memory markers. However, the span with more memory markers will later be recalled to be longer, as we refer to those markers when estimating a duration in the past [1]. Here, we refer to this model and assume that small changes such as counts in the countdowns or moving bars in progress bars can be also encoded as memory markers.

3 EXPERIMENT 1

In the first experiment, the effect of countdown speed on users' timing decisions and overall satisfaction is investigated.

3.1 Method

In this experiment, we used countdowns with different speeds to manipulate users' impatience during a constant delay. We studied the effect of impatience on people's decisions after experiencing the delay, as well as their satisfaction.

3.1.1 Participants and Incentives. Participants were recruited on Amazon Mechanical Turk (MTurk). A total of 318 US-based volunteers (105 female, 212 male, and 1 unknown; age mean: 33 yrs, age range: 18-77) completed the experiment¹. Participation was limited to US residents who had at least 50 approved HITs² and a prior MTurk approval rate of 96% or higher. Each participant played one practice round and five rounds of a game. Participants received an initial payment of \$0.40 and a bonus according to their performance in the game, which was considerably larger than the initial payment. Participants' attention was required during the game and we controlled it by (a) making sure that they did not switch pages (they had to stay on the experiment page), and (b) asking them to press a button quickly after the end of each game round, the time of which was randomly drawn from a uniform distribution (0 to 30 s). Data from one participant (gender: unknown) was discarded as the participant failed to pass the attention checks.³ This left 317 participants' data (105 female and 212 male)⁴. The participants were recruited at approximately the same time of the day, in the afternoon in all North American time zones (4 p.m. Eastern time).

3.1.2 Task. The task consisted of the following two parts: a survey and a game.

The Survey: The survey consisted of the following four parts: (a) demographic questions, such as gender and age; (b) basic attention/integrity questions (e.g., "please choose the middle option"),

¹Additional data from 104 participants was gathered for two non-linear conditions, which are not discussed here.

²Human Intelligence Tasks.

³The data can be downloaded from <http://moojan.com/data/CookieMonster.html>.

⁴Note that the attention loss was not considered as an indicator of impatience, because it can also indicate many other situations on MTurk, such as lack of attention in general or multi-tasking for completing different HITs in parallel.

The figure displays two side-by-side panels of a survey interface. Each panel contains three questions with corresponding Likert scales ranging from 'totally disagree' to 'totally agree'.

Left Panel (NFC questionnaire):

- Question 1: "I try to anticipate situations where there is a likely chance I'll have to think in depth about something." Scale: 11 dots.
- Question 2: "I only think as hard as I have to." Scale: 11 dots.
- Question 3: "The idea of relying on thought to get my way to the top does not appeal to me." Scale: 11 dots.

Right Panel (risk propensity questionnaire):

- Question 4: "I take risks regularly." Scale: 11 dots.
- Question 5: "I really dislike not knowing what is going to happen." Scale: 11 dots.
- Question 6: "I usually view risks as a challenge." Scale: 11 dots.

Fig. 2. Example of the survey. A subset of the NFC questionnaire is shown on the left and a subset of the risk propensity questionnaire is shown on the right.

to make sure that the participants were on task and paying attention; (c) questions that assessed one's risk propensity, or in other words, one's tendency to take risks [21] (e.g., "I really dislike not knowing what is going to happen"); and (d) questions assessing Need For Cognition (NFC), which measures one's tendency to engage in and enjoy thinking [32] (e.g., "I would rather do something that requires little thought than something that is sure to challenge my thinking abilities"). Figure 2 shows an example of the survey's interface.

The Game: Participants played six rounds of the game. The game was an asymmetric game with one user playing against a computer opponent. The game was developed to require deep cognitive processing and asked users to make decisions about *when* to act, as opposed to the more common question of *how* to act, which is typically found in economic or behavioural decision-making tasks. The game was a timing game inspired by FlipIt [30]. Our version was introduced in [9, 10].

The game is named after a familiar figure in children's TV, the Cookie Monster. A summary of the cover story of the game is as follows:

Cover Story: "You have invited your friend, the Cookie Monster, over for lunch. While he is waiting for you in the living room, you need to stay in the kitchen to cook for him. However, you have left some cookies (30×100) in the living room and you want to save them from the Cookie Monster. You know that he will start eating the cookies at some point, but you do not know when. You need to find a strategy to check on him. Any time you check on the Cookie Monster, you need to give him 100 cookies to cover up for not trusting him. If he starts eating the cookies, he will eat them with a constant pace of 100 cookies per second. He will stop eating when you catch him. To check on the Cookie Monster, you need to set different alarm clocks in advance. So every time the alarm goes on, you will check on him."

So in the game, participants play against their opponent, the Cookie Monster, who will act once during each round at a random time drawn from a uniform distribution. Participants need to decide on different times to *check* on the Cookie Monster to catch his action (eating the cookies) as soon as possible, after he has started eating the cookies. Each check and each second of latency in catching the opponent have costs. In this game, the net number of cookies that are saved from the Cookie Monster translates to a bonus payment. The final bonus is relatively higher than the initial payment (twice the initial payment in many cases), which motivates MTurk participants to think about their actions in the game to maximize their bonus. An example of the game interface is shown in Figure 3.

The game can be played in the following two ways: (a) the users make decisions during the round and check on the Cookie Monster as the game progresses, or (b) as a strategy game, where the users pre-set their timing choices and see the effects of their choices during the game round. Both variations reflect examples of decision-making in real-life (see [11] regarding importance

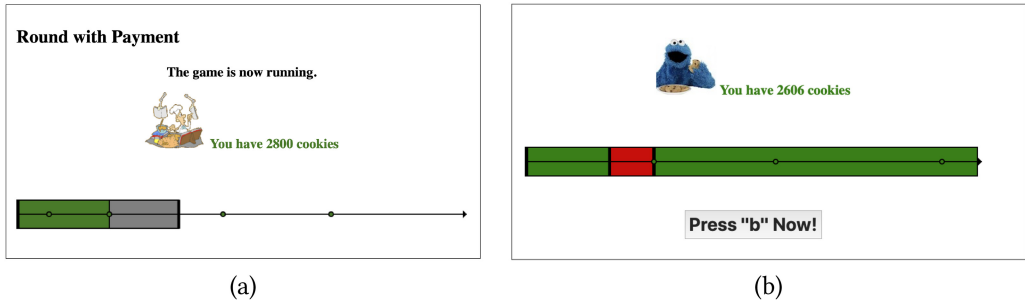


Fig. 3. (a) Example of an ongoing game round. The bar moves from left to right. Details are discussed in Figures 5 and 6. (b) Example of the ending of the round and the attention check. Participants have a short time to press the “b” key or a button appearing on the screen to receive their bonus, and therefore need to pay attention to the screen.

of these categories of decisions). As we are studying time perception and impatience, we used the second version in this article (the participants define their strategy beforehand). This way we made sure that (1) the participants had enough time to think about their strategies, and (2) we increased the inactive time, which can increase impatience.

3.1.3 Procedure. Figure 4 shows the procedure of the experiment. After signing the consent form, participants first responded to the survey. After completing the survey, participants played six rounds of the game. Before starting the game, participants received detailed game instructions, along with visual feedback (see Figures 5 and 6). The first round was a practice round, followed by five real rounds (data from the first round, which was specified as a practice round, was removed). In each round, participants had as much time as they needed to decide on the timing of their checks (Step 1 in Figure 4 shows an example of a check added to the timeline by clicking on the timeline). After their decision was final, they started the game round. After starting the round, a *fixed-length, 15-second* delay was intentionally added (Step 2 in Figure 4). The delay was accompanied by *countdowns*, the speed of which varied based on the experimental condition. Participants were told that the delay was due to the process of saving their check times (see Figure 7).⁵ Afterwards, they watched the game round (Step 3 in Figure 4). At the end of the task (i.e., after completing the survey and playing six rounds of the game), the participants were informed about the bonus they had earned and were given an opportunity to leave comments about the task.

3.1.4 Countdown Conditions. Although the delay lasted 15 seconds in all conditions (except for the control condition), the starting count, and as a result the speed of the countdown varied to manipulate impatience and time perception. The conditions of the experiment were the following:

- **NoWait (control):** There was no delay (and thus no countdown) before the start of each round.
- **5CD:** The 15-second delay was accompanied by a message “*Saving the checks*” and a countdown from **5 to 1**. Therefore, each count lasted **3** seconds.

⁵This design places the countdown manipulation in the previous round rather than the current round, but adds a constant, longer waiting period (watching the game round) in between the manipulation and the observation. Therefore, the first round is excluded as the participants experience the delay after they decide on their checks in the very first round. This way, participants also form an expectation of a similar delay in the future round, which has been shown to relativize people’s perception of delays or waits occupied with activity [19].

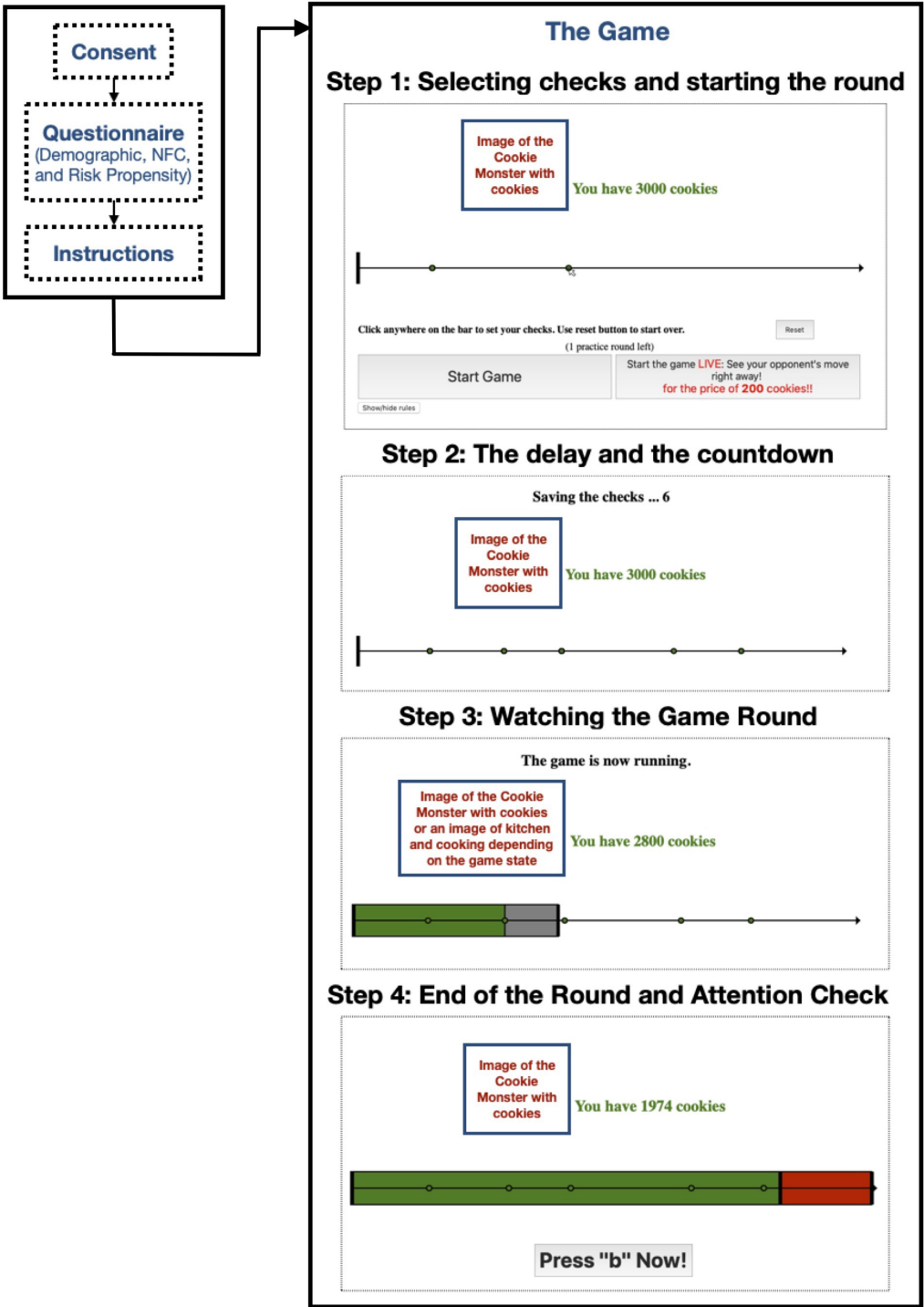


Fig. 4. Procedure of Experiment 1. Screen shots of the game are used, where images are replaced with the boxes describing each image.

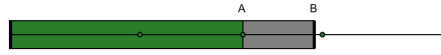


Fig. 5. Visual feedback of a game in progress. The game has progressed to point B and the player's most recent check has been at point A. No information about the situation after point A is known (therefore it is shown as gray). The dots on the bar show the pre-set checks, which participants placed by clicking on the desired points of time on the game bar.



Fig. 6. Feedback shown when a round is over. In this example, the Cookie Monster played at point A and the player made their last check at point B and caught the Cookie Monster's action.

Saving the checks ... 4

Fig. 7. The countdown shown to participants. Participants were told that the delay was because their checks (actions) were being saved.

- **10CD**: The 15-second delay was accompanied by the same message and a countdown from **10 to 1**. Each count lasted **1.5** seconds in this condition.
- **15CD**: The 15-second delay was accompanied by the same message and a countdown from **15 to 1**. Each count lasted **1** second in this condition.

Participants were randomly assigned to the above conditions. The experiment was between subject, and thus each participant only experienced one of the aforementioned conditions.

To ensure that the participants were paying attention, they were not allowed to switch to other windows on their screen and they were required to press a key immediately after the end of each round (the time of which was unknown and varied between the first check of the participant to the end of the round).

3.1.5 Hypotheses. We hypothesized that the counts in the countdown can affect people's time perception by providing information during a delay. As a faster countdown will provide more information during the same period of time, more information processing will be required and, as a result, time may pass faster. This could reduce users' impatience, improve decision-making, and increase users' satisfaction. Therefore, the hypotheses of this experiment were:

- (1) E1-H1: Speed of the countdown shown during the delay can affect impatience, leading to more "checks" (i.e., "checks" that are closer to each other) in each game round.
- (2) E1-H2: Faster countdowns can lead to better decisions in each game round, or in other words, a sequence of checks that would be closer to what a rational player would suggest.
- (3) E1-H3: Faster countdowns can lead to more satisfaction, in other words, more positive comments about the task.

3.2 Analysis

Here, we will explain the rational strategy for playing the game and introduce two measures that we use for analyzing participants' actions, Δt and $\Delta t_{rational}$, which will be discussed in the next sections.

3.2.1 The Rational Strategy. The rational strategy would find the best check times by maximizing the expected utility. Unlike humans, a hypothetical rational player would not have

Table 1. Rational Strategy for the Cookie Monster Game

| Round Duration (s) | Number of Checks | Timing of Checks (s) | Expected Utility |
|--------------------|------------------|----------------------|------------------|
| 30 | 5 | (8, 14, 18, 22, 26) | 2,400 |

computational limits (e.g., [12]) and would select a sequence of check times that maximize the expected utility [26]. The rational strategy, which is proposed by the authors in [9], is as follows:

Given the maximum duration of the game (d), and assuming that the cost is 1 per time unit (the time unit is assumed to be 1/100 seconds as each 1/100 seconds of latency costs 1 cookie in the game), the rational player finds the best time for the next check at time t , given the previous unsuccessful check at time t_{prev} . The rational model assumes future rational checks and recursively calculates the sequence of the check times that maximizes the expected utility. The rational strategy is calculated as below:

$$\begin{aligned}
 U(t, t_{prev}) = & -MoveCost \\
 & + \sum_{k=t_{prev}}^t \frac{1}{d-t_{prev}} (k-t_{prev} + d-t) \\
 & + \max \left[0, \frac{d-t}{d-t_{prev}} \max_{t < m < d} U(m, t) \right]
 \end{aligned}$$

This function iterates over all possible opponent move times (k) up to the proposed check time (t). The probability of the opponent's move at a time would be $\frac{1}{d-t_{prev}}$ (inverse of the remaining time since the last unsuccessful check). In case the opponent's action is not caught by the player, we iterate over all possible future times for the opponent's action (m). Therefore, the payoff would be a sum of (1) start until the opponent's move, and (2) from the player's successful check to the end of the game. Further, if the opponent does not play before t (the probability of which is $\frac{d-t}{d-t_{prev}}$), we assume rational future checks.

Table 1 shows the rational strategy for our 30-second game. We cannot ascribe rationality to participants' actions, as we do not expect them to come up with the aforementioned rational solution (e.g., due to humans' computational limits). However we will use the rational model to study how impatience due to delays may indirectly affect rationality of the participant's timing decisions across conditions.

3.2.2 Strategy Analysis. We used two measures to compare the behavior of the participants. First was Δt (timing), and the second was $\Delta t_{rational}$ (rationality).

Δt measured the average time that the participants chose to wait between their consecutive checks in each round. Δt also reflects how frequently the participants "checked" on the Cookie Monster. A higher Δt would show that the participant has decided to wait more between his/her checks, resulting in fewer checks. However, a smaller Δt would show more frequent checks.

The second measure was $\Delta t_{rational}$, which measured how close the participants' checks were to what a rational model suggests. We calculated $\Delta t_{rational}$ by comparing the participant's timing of each check to what a rational strategy would suggest. To calculate these timing differences, we used the rational model in a dynamic game; assuming the current state of the game (participant's actions so far and the remaining time), we calculated the next rational check proposed by the rational strategy. Then we compared the timing of participant's next check with the new check suggested by the rational model.

For example, assume that in a 30 s game round ($30 * 100 = 3000$ cookies), a participant has first checked at 4 s. The time difference between the participant's check and the rational model's check

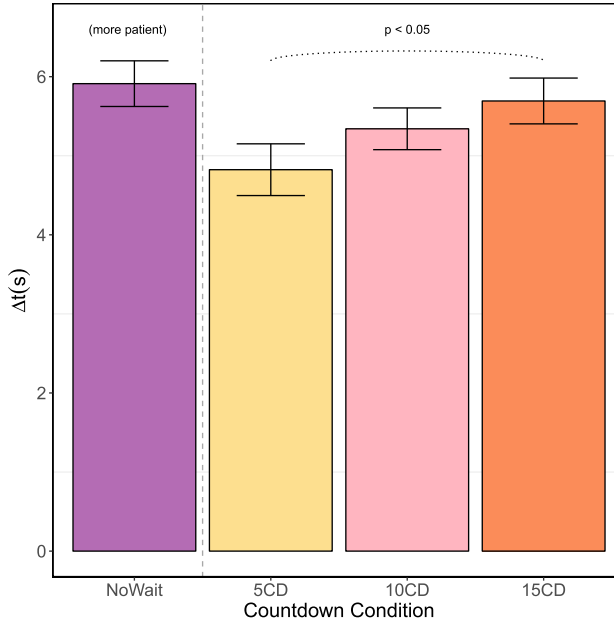


Fig. 8. Δt , the average time that participants chose to wait between the consecutive checks in each condition ($N = 56$ to 92 participants per condition). Participants who saw the slower countdowns chose to wait less between their checks than the faster countdowns. 95% confidence intervals are obtained using bootstrapping. Y axis shows time difference in seconds.

(Table 1) would be $\Delta t_{rational-1} = t_{rational} - t_{subject} = 8 - 4 = 3$ s. After this check, the remaining time of the round would be 26 s. The dynamic rational model then calculates the first best check time for a game round of 26 s, which would be at 7 s (i.e., $7 + 4 = 11$ s in the current game). Thus, the next suggested rational check is 11 s into the round. Assume that the participant's second check is at 10 s into the round, then $\Delta t_{rational-2} = 11 - 10 = 1$ s. The next remaining time is 20 s, and therefore the next rational check will be 15 s into the game round.

We then calculate $\Delta t_{rational}$ by getting an average over the above $\Delta t_{rational-i}$ per round and condition. This measure is an indicator of how much people advance their timing in relation to a generally unknown, but anticipated time point. A positive $\Delta t_{rational}$ implies checks that are earlier than the rational model. Larger absolute values of $\Delta t_{rational}$ s show checks that are farther from the rational model's suggestion.

Therefore, Δt will show the frequency of the checks (for studying E1-H1), $\Delta t_{rational}$ will show how close the participants play to the rational strategy (to study E1-H2), and we will use the number of positive comments left by the participants to study task satisfaction (for investigating E1-H3).

3.3 Results and Discussion

Here, we will discuss how timing of checks and rationality of choices were affected by the countdown speed. Afterwards, we will discuss how countdown speed affected participants' comments.

3.3.1 Timing. Figure 8 shows the Δt measured for all participants and all conditions. Those who saw slower counts made more frequent checks and had a lower Δt . In other words, those who saw slower counts chose to wait less between their checks.

Table 2. Linear Mixed Effects Model Predicting the Time Difference between Checks (Δt) for Each Condition

| Covariate | Estimate | SE | <i>t</i> | Pr ($> t $) |
|-------------------|----------|-------|----------|----------------|
| Intercept | 6.537 | 0.442 | 14.791 | $< .0001$ |
| CountDuration (s) | -0.540 | 0.238 | -2.273 | $< .05$ |
| log (RoundNumber) | 0.172 | 0.118 | 1.455 | .146 |

RoundNumber is centered.

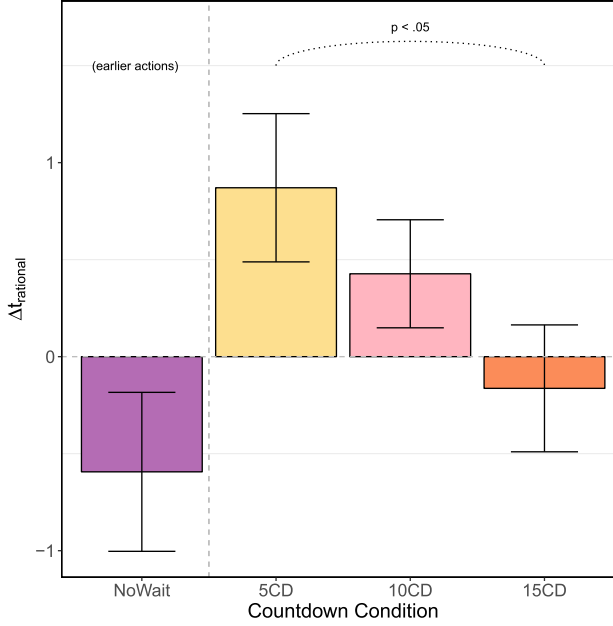


Fig. 9. Deviation of checks from what a rational model suggests ($\Delta t_{rational}$). Participants who saw the faster countdowns selected check times that were closer to what a rational model suggests. 95% confidence intervals are obtained using bootstrapping. Y axis shows time difference in seconds.

We fit a regression model to predict participants' Δt . Table 2 shows the results⁶. CountDuration shows the time that each count lasted in each condition (CountDuration: 1 for 15CD, 1.5 for 10CD, and 3 for 5CD). The number of the round (RoundNumber) is included in the model to control for the learning effect. All predictors are centered. RoundNumber is log-transformed due to the nature of the learning effect. A random intercept is fit for each subject. Δt is significantly affected by count duration; those who saw slower countdowns made checks that were significantly earlier (i.e., more frequent checks), as compared to those who saw faster countdowns (E1-H1 supported).

3.3.2 Rationality. Next, we studied how rationality of checks was affected by the countdown speed. As mentioned before, we do not expect participants to come up with the rational strategy for playing this game; however, a between-condition comparison to a rational model provides valuable information about how the speed of a countdown can indirectly affect the rationality of timing decisions. Figure 9 shows the results for the aforementioned $\Delta t_{rational}$ measure.

⁶The measured risk propensity is not used in the analysis as no effect of risk propensity was observed, and including it in the analyses did not improve the models.

Table 3. Linear Mixed Effects Model Predicting the Time Difference between the Participant's Checks and the Rational Model's Checks

| Covariate | Estimate | SE | t | Pr ($> t $) |
|-------------------|----------|-------|--------|----------------|
| Intercept | -0.478 | 0.395 | -1.210 | .227 |
| CountDuration (s) | 0.471 | 0.213 | 2.218 | <.05 |
| log (RoundNumber) | -0.274 | 0.114 | -2.402 | <.05 |

RoundNumber is centered.

Countdown speed affected rationality of timing decisions. Participants who saw the faster countdowns selected checks that were closer to what a rational model suggests.

We fit a linear mixed-effects model to study whether this difference is significant. Table 3 shows the results. Like in the previous model, we took the learning effect into account and fit a random effect based on participant. As the countdown speed increases, participants play checks that are significantly closer to the rational model. This shows that the countdown speed has in fact affected the rationality of participants' timing decisions (E1-H2 supported).

Further, the performances of participants in the 5CD and 10CD conditions are significantly different from the control (NoWait) condition ($se = 0.488, t = 2.909, p < 0.005$ and $se = 0.436, t = 2.232, p < 0.05$, respectively). However, as the speed of the countdown increases, this difference decreases. There is no significant difference between the performance of people in 15CD and the control (NoWait) condition ($se = 0.432, t = 0.948, p = 0.344$), which suggests that when the countdown speed is fast enough, the negative effect of delays on users' decision making is no longer observed.

3.3.3 Task Satisfaction. Task satisfaction is measured by analyzing participants' comments. Leaving a comment at the end of the experiment was optional, thus many participants ended the experiment without leaving any comments. However, it is certain that those who left positive comments have been very satisfied with the experiment, despite the relatively large delay, as they took the time to leave a positive comment (on MTurk, where time is seen more directly as money) although it was not required.

Another method of measuring task satisfaction is to directly ask participants to report it (for example using a Likert scale). We chose not to directly ask the participants about their opinion, because (a) participants on MTurk try to maximize their bonus, and including satisfaction as a part of the experiment could have affected rating (as participants might have thought that a higher rating can affect their bonus), and (b) a proper attention check for a single question is not possible to implement, especially as there is no right and wrong answer to this question. We believe that although analyzing the comments that are left voluntarily limits the feedback received from the participants, it is the same for all the conditions, and it is relatively clear that those participants who left the positive comments did indeed enjoy the game (the satisfaction threshold is set to a higher level in this approach: those who are willing to spend their time to leave a positive comment after the experiment is done).

Positive comments were tagged using both an automated keyword spotting system and manual verification to ensure that no false positive/negatives exist. A total of 62 positive comments were detected (17 in NoWait, 6 in 5CD, 18 in 10CD, and 21 in 15CD).⁷ We investigated the effect

⁷ A total of 11 comments reported a possible error/typo (*below* was misspelled as *bellow* in one place), 12 comments only contained the end message or participants' MTurk ID, 8 comments were detected as neutral and contained general comments, 3 comments indicated no comments about the game (e.g., "No errors" or "No typos"), and 7 negative comments were detected (one indicating "payment was not great," the rest about (a) the attention checks being too fast or (b) about the pop-ups, which informed them that they should stay on task or about the outcome of the attention check).

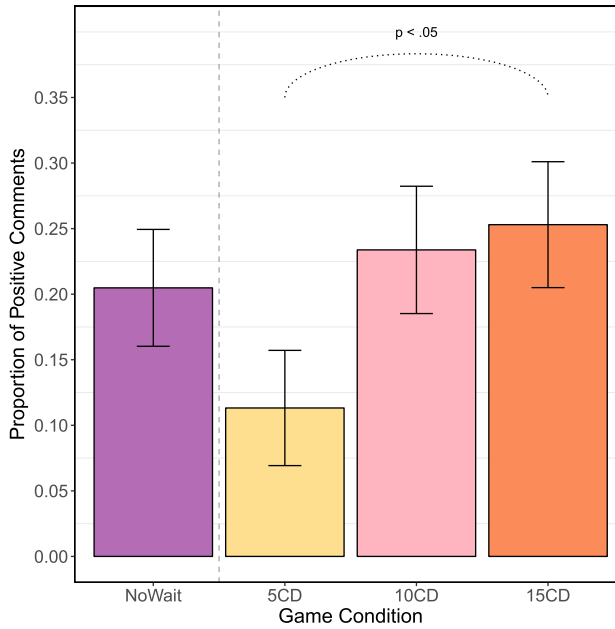


Fig. 10. The proportion of the positive comments to all the comments for each condition. (Only one binary data point per participant.)

of countdown manipulation on task satisfaction. Figure 10 shows the proportion of positive comments for each condition. The rate of positive comments increased significantly with a faster speed of countdown ($se = 0.246, z = 1.984, p < 0.05$; E1-H3 supported).

As participants on MTurk try to maximize their bonus money, we investigated whether the comments were affected by the bonus they received to make sure that the comments were only affected by the countdown manipulation. No effect of bonus was found on the comment type ($se = 316, z = 0.232, p = 0.816$).

Finally, an interesting observation was that the participants who experienced the 15-second delay accompanied by the fast countdowns (counts changing faster than 1.5 seconds) left more positive comments than those who did not experience any delay. Although this difference was not significant, one possible explanation could be that the delays accompanied by the message “Saving the checks” might have made the game look more sophisticated and affected participants’ perception of the game positively. These results could suggest that if the delay is small and is accompanied by a proper type of feedback, it might not affect users’ task satisfaction negatively, and might even impress the users and affect their satisfaction positively, perhaps by making the system look more sophisticated.

4 EXPERIMENT 2

We used Experiment 2 to further explore these effects and understand why faster countdowns improved impatience. One hypothesis is that faster countdowns reduced impatience because time passes faster when more changes happen [14]. One important question is how people recall the duration of a delay (accompanied by countdowns) later? In other words, does a faster counter also improve how a user recalls the delay?

We believe that in our study the changes in the countdown can act as the *memory markers* proposed by Ahn et al. [1]. As a result, we hypothesize that what people remember about the

duration of the delay is not necessarily in line with how tolerable the delay felt. If this stands, it means that there is no “best feedback speed” and the decision of best countdown speed may need to be made for each application.

As we study design trade-offs, another question is how far do the advantages of fast moving countdowns go. In other words, how far can a designer increase the feedback speed to decrease the perception of a delay? In the first experiment, we investigated counts progressing slower than and equal to one count per second. To better understand the design limits, in the second experiment we added and investigated countdowns that progressed faster than one count per second. We hypothesized that speeding up the countdowns to make delays more tolerable has a limit (as more changes means more information processing and humans have broad but limited information processing capabilities). After some point, increasing the speed is no longer beneficial and the feedback might become not better or even less desirable, making the delay less tolerable.

In this experiment, we investigate these questions empirically. We ask how countdown speed affects users’ perception of delays, what the cognitive mechanism is, and how it affects duration recall.

4.1 Method

In this experiment, we use countdowns that progress faster than 1 second. Other than the effects studied in the previous experiment, we ask how delays accompanied with countdowns are recalled afterwards.

4.1.1 Participants and Incentives. Participants were recruited on Amazon MTurk. A total of 538 North America-based volunteers (298 female and 240 male, age mean: 36.4 yrs, age range: 18-71) completed the experiment. Participation was limited to US residents who had at least 50 approved HITs and a prior MTurk approval rate of 96% or higher. Participation was also limited to those who had not played this game before. Similar to Experiment 1, participants’ attention was controlled during the game; (a) they were not allowed to switch pages and they had to remain on the experiment page, and (b) they were required to press a button quickly after the end of each game round, the time of which was random. Data from 7 participants (4 women and 3 men) were discarded as they failed to pass the attention checks. This left 531 participants’ data (122 to 127 per condition). Each participant received an initial payment of \$0.40 and a bonus according to their performance in the game. Day of week was recorded and later used to account for the possible influence of the weekday on participants’ performance.

4.1.2 Task and Procedure. The task and procedure in this experiment were similar to Experiment 1: participants first completed the same survey as in Experiment 1 and then played six rounds of the Cookie Monster game.


Similar to the previous experiment, a fixed-length 15-second delay was used in all conditions; however, two faster countdowns were introduced in this experiment (20CD and 30CD). The conditions of this experiment were as below:

- **5CD:** The 15-second delay was accompanied by a message “*Saving the checks*” and a countdown from **5 to 1**. Therefore, each count lasted **3** seconds.
- **15CD:** The 15-second delay was accompanied by the same message and a countdown from **15 to 1**. Each count lasted **1** second in this condition.
- **20CD:** The 15-second delay was accompanied by the same message and a countdown from **20 to 1**. Each count lasted **0.75** seconds in this condition.
- **30CD:** Participants experienced the same 15-second delay and saw the same message and a countdown from **30 to 1**. Each count lasted **0.5** seconds in this condition.

Final step! It is important that you reasonably answer these two questions.

Saving the checks ...

Did you experience any delay due to your checks being saved? (If so, there would have been a message similar to what is shown above right after you clicked to start the game)
 How long in **seconds** do you think was **the delay you experienced** in each round in this game?



You played 6 rounds of the game. We are wondering how long you think the longest possible round was. As you have noticed, the longest possible duration of a round was the same for all rounds. The actual round will be shorter, but it lasts the longest if the Cookie Monster is not caught until the very end (see the figures above). Each round started when the progress bar started moving.
 How long in **seconds** was **the maximum duration** of each round?

Fig. 11. Questions for assessing duration recall through the verbal estimation method [5].

Furthermore, after completing the six rounds of the game, participants' time perception was measured through the verbal estimation method [5]. Participants were asked to estimate (a) the duration of the delay, and (b) the duration of the game round. They were provided with detailed explanations and visual instructions to ensure that they did not misunderstand which duration they were asked to estimate. Figure 11 shows these two questions.

Finally, similar to Experiment 1, participants were given the opportunity to leave a comment about the task.

4.1.3 Hypotheses. We hypothesized that if counts in the countdowns acted as memory markers, how people recall the delays may not be in line with how tolerable the delays were felt at the time of experience. That is to say, although faster countdowns improve impatience, they may be recalled as longer after the experience. Further, we hypothesized that there is a limit for speeding up the countdown to make delays more tolerable. A speed that is too fast (e.g., faster than an information blink), may no longer improve impatience or be beneficial. Therefore, the hypotheses of this experiment are:

- (1) E2-H1: Speed of the countdown will be positively correlated with how long the delay will be recalled.
- (2) E2-H2: Speed of the countdown will be positively correlated with how long the duration following the delay (game round in our study) will be recalled.
- (3) E2-H3: Countdowns with counts changing at a speed close to 1 count per 0.5 seconds (e.g., in 30CD) may no longer improve impatience (as compared to the slower speeds, such as in 15CD and 20CD).

4.2 Results and Discussion

We first present results related to participants' estimation of the delay and the duration after the delay. We then present how speeding up the countdown affected task satisfaction and timing decisions.

4.2.1 Delay Estimation. We investigated whether delay recall was affected by the speed of the countdown, as hypothesized. Results are shown in Figure 12. A linear mixed effects model was

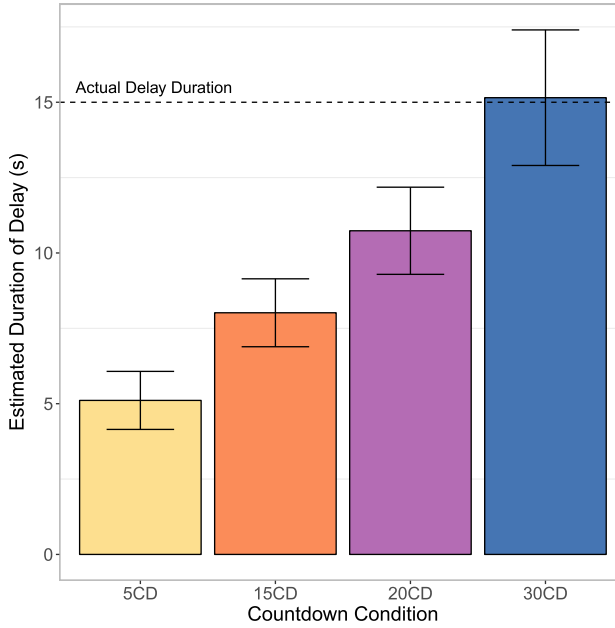


Fig. 12. Delay estimation for each condition ($N = 122$ to 127 per condition). The actual duration of the delay was 15 seconds in all conditions. Error bars show 95% confidence intervals obtained using bootstrapping. The actual duration of the delay was 15 seconds in all conditions.

Table 4. Regression Model Predicting Users' reported Estimated Duration of the Delay (in Seconds, $N=531$)

| Covariate | Estimate | SE | t | Pr ($> t $) |
|------------------|----------|-------|-------|----------------|
| Intercept | 9.557 | 0.650 | 14.70 | <0.0001 |
| CountDuration | -2.876 | 0.396 | -7.26 | <0.0001 |
| NeedForCognition | 0.072 | 0.051 | 1.42 | 0.157 |

CountDuration represents how long each count lasted in the countdown condition (in seconds). NeedForCognition and CountDuration are normalized before regression. A random intercept is fit based on the weekday the participant was run.

fit to predict the estimated duration of the delay based on the countdown speed (see Table 4). The measured NFC is used as a predictor in our models, as the tendency to think deeply can affect performance in the game, as well as time estimation. The speed of the countdown, shown during the same delay, significantly affected delay duration recall. Participants who saw faster countdowns estimated the duration to be longer after the task was completed. This effect was significant ($se = 0.396, t = -7.26, p < .0001$; E2-H1 supported). We did not observe an effect of NFC on delay estimation as shown in Table 4.

4.2.2 Estimation of Game Round Duration. Next, we ask whether perception/recall of a delay can also affect the estimation of the duration after the delay. That is, does the speed of the countdown during the delay affect how the duration of the task following the delay is recalled?

To this end, we asked participants to estimate the maximum duration of the game round, which was 30 seconds. We hypothesize that how people recall a delay can also affect how they recall

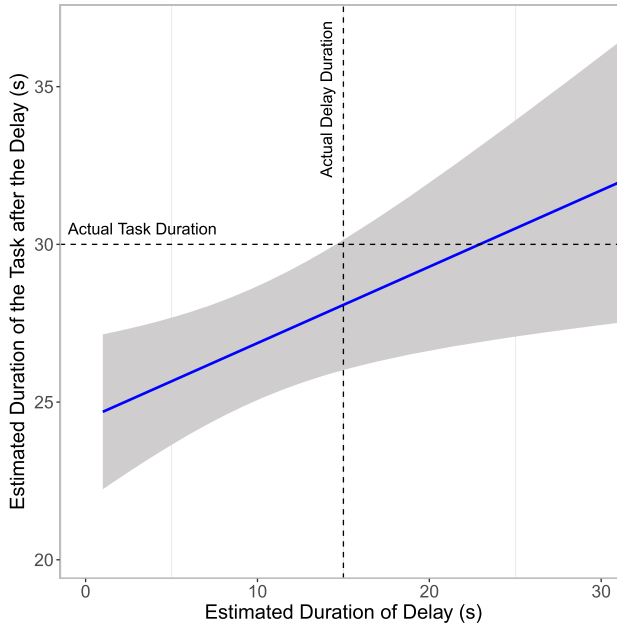


Fig. 13. Estimated duration of the task following the delay, based on the estimation of the delay before the task. The actual duration of the delay was 15 seconds and the actual duration of the task following the delay was 30 seconds in all conditions. The gray band shows 95% confidence level interval for predictions from a linear model.

Table 5. Regression Model Predicting Users' reported Estimated Duration of the Game Round (in Seconds)

| Covariate | Estimate | SE | <i>t</i> | Pr (> <i>t</i>) |
|------------------|----------|-------|----------|---------------------|
| Intercept | 25.803 | 0.903 | 28.59 | <.0001 |
| EstimatedDelay | 0.340 | 0.096 | 3.56 | <.0005 |
| NeedForCognition | -0.084 | 0.116 | -0.73 | .466 |

EstimatedDelay and NeedForCognition are centered. A random intercept is fit based on the weekday.

the subsequent duration, which can also explain why decision-making in the subsequent task was affected by the speed of the countdown.

Figure 13 shows the estimated duration of the game round, based on the estimated duration of the delay.⁸ The actual duration of the game round was 30 seconds in all conditions, and the actual duration of the delay was 15 seconds in all conditions. Results show that when the delay is recalled to be longer, the duration of the game round (the duration following the delay) is also recalled to be longer. To investigate whether this is significant, we fit a linear mixed effect model, predicting *task duration estimation* (estimated duration of the game round, which does not include the delay) based on delay estimation and NFC. Table 5 shows the results. Delay perception, as predicted, significantly affected the perception of the subsequent duration ($se = 0.096, t(530) = 3.56, p < 0.0005$). When a delay was recalled as being longer, the duration afterwards was also

⁸Estimated Delay > 30 s is removed due to low data density.

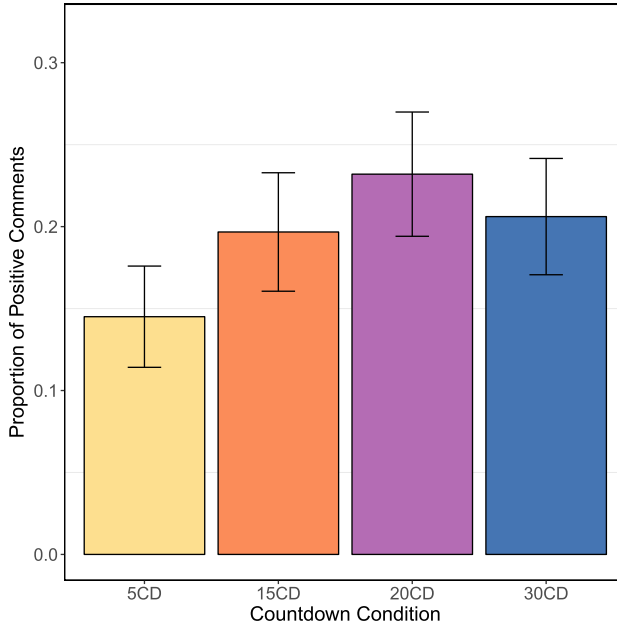


Fig. 14. The rate of positive comments for each condition. Standard errors are shown.

recalled as longer (E2-H2 supported). We did not observe any effect of NFC on game round duration estimation.

4.2.3 Task Satisfaction. To address the second research question (whether increasing the speed of the countdown is always beneficial) we investigated task satisfaction, which was examined for countdowns progressing slower than or equal to one second in Experiment 1. The data collection method was the same as for Experiment 1. A total of 99 positive comments were detected (19 in 5CD, 24 in 15CD, 29 in 20CD, and 27 in 30CD)⁹. Results are shown in Figure 14.¹⁰ For all the speeds, except for 30CD (which was hypothesized to be too fast and not beneficial), task satisfaction seems to increase as the speed of the countdown increases. A linear model excluding 30CD was fit to study whether the difference is significant. There seems to be a marginally significant effect of speed on task satisfaction ($se = 0.347, z = -1.90, p = 0.057$).¹¹ 30CD, however, seems to result in a lower task satisfaction (E2-H3 not rejected). Further investigation is needed to study why despite fast countdowns being more preferable (for speeds equal or slower than 0.75 counts per second), making countdowns too fast may no longer be desirable.

Similar to the previous experiment, no effect of bonus was found on the comment type ($se = 1.263, z = -0.07, p = .939$).

⁹A total of 7 comments reported a possible error/typo, 25 comments only contained the end message or participants' MTurk ID, 11 comments were detected as neutral and contained general comments (e.g., explaining why one has missed the attention check in a round), 9 comments indicated no comments about the game (e.g., "No errors" or "No comments"), and 3 negative comments were detected (one about the UI of the survey and two about the bonus button requiring immediate attention).

¹⁰Some examples of the positive comments are: "My grandkids would have loved this game. You are very creative. This was fun," "This was a lot of fun," "That sure was different, thank you and best wishes on your research!"

¹¹A regression model is fit predicting type of the comment based on CountDuration (how long each count lasts in the countdown). CountDuration is log-transformed as time is not perceived linearly. 30CD is not included in the model.

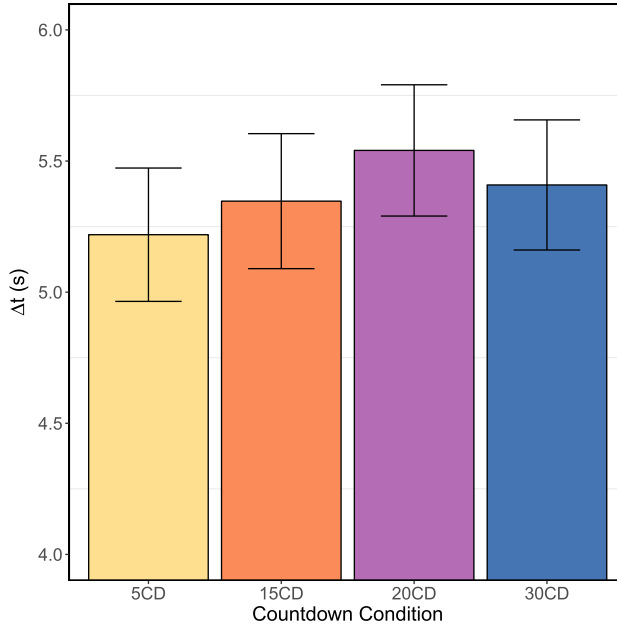


Fig. 15. The average time difference between checks (actions) in each round (Δt) for each condition. Lower values indicate earlier checks. 95% confidence intervals are obtained using bootstrapping.

4.2.4 Timing. Additionally, we investigated how time perception affected decision-making in the task. We know that impatience results in a smaller time difference between the *checks*, or in other words, earlier and more frequent checks in this game [10]. So far we showed that a faster countdown (with more changes) affects delay recall. If these counts act as memory markers, we also expect that the delay itself is more tolerable for users when more markers are present, as time is expected to pass faster when more memory markers exist (despite being recalled to be longer afterwards) [1].

Further, if making countdowns too fast is no longer desirable for the users (as supported by the results of task satisfaction), we expect that performance will not be improved in the 30CD condition.

Thus, we calculated an average time difference between check times for each round and each participant (Δt). Results are shown in Figure 15. A smaller Δt shows earlier and more frequent checks, which reflects impatience [10]. Based on the results, impatience seems to be reduced as the speed of the countdown increases, for all conditions except for 30CD.

To further investigate the significance of these results, we fit two linear models, one including 30CD and one excluding it. In both, we predict participants' average Δt in the game based on their delay estimation and the measured NFC.¹² When 30CD (the countdown hypothesized to be too fast) is excluded, those who estimated the delay as longer performed significantly better in the game and had a larger Δt (which, as shown before [10], reflects less impatient behavior in this game). Table 6 shows the regression model results. This is in line with the theory of memory markers; although those delays are recalled to be longer when more memory markers exist, they seem to have been more tolerable for the users, resulting in less impatient behavior during the game.

¹²A random intercept based on the weekday is fit in both.

Table 6. Mixed Effect Regression Model Predicting Average Δt of Subjects in All Game Rounds

| Covariate | Estimate | SE | t | Pr ($> t $) |
|------------------|----------|-------|-------|----------------|
| Intercept | 5.345 | 0.143 | 37.45 | <.0001 |
| EstimatedDelay | 0.042 | 0.019 | 2.15 | <.05 |
| NeedForCognition | 0.024 | 0.018 | 1.33 | .184 |

EstimatedDelay and NeedForCognition are normalized.

However, when 30CD is included, we did not observe the effect of countdown speed on Δt ($se = 0.012$, $t = 1.43$, $p = 0.154$; E2-H3 not rejected). This is consistent with the results of task satisfaction, as it suggests that although fast countdowns are beneficial, making them too fast is not necessarily beneficial anymore: there appears to be an optimal speed that is more desirable for users.

5 GENERAL DISCUSSION

We investigated the effects of countdown speed shown during a delay on users' time perception, timing decisions, and task satisfaction. We used countdowns as the type of feedback due to their flexibility, as unlike progress bars, they can be used in very simple user interfaces (e.g., traffic lights) and are not limited to e.g., the screen size.

In Experiment 1, we manipulated the speed of the countdown and showed that the speed of the countdown shown during the same delay significantly affects decision-making in the subsequent task (game rounds in our study) and overall satisfaction. Faster countdowns improved both decision-making (based on a rational model) and participants' satisfaction. Note that although significant, the difference between the timing decisions across the conditions may seem small (ranging between 0.5 s and 2 s of difference in timing and 1 s away from what a rational model would suggest). However, in these fast-paced, 30 seconds rounds, a difference of 1 s would be considerable¹³ as in some situations such as driving a fraction of second can lead to severe accidents (games or many sports are examples of other similar situations). The countdowns in the first experiment were slower than or equal to one second.

In the second experiment, we studied why a faster countdown was more tolerable. We asked whether delay recall was affected by the speed of the countdown. By answering this question, we aimed to provide more guidance for interface design and a better understanding of users' behavior and perception. The second design-related question asked in the second experiment was whether increasing the countdown speed is always beneficial for delay perception, or whether there is an optimal speed that is preferred by users.

To address the first question, we asked participants to provide us with an estimation of the duration of the delay after the game ended. Based on the memory markers model of time perception/recall, which was proposed by Ahn et al. [1], memory markers—episodic memory traces based on cognitive or sensory experiences—serve as anchors for time estimation. The more memory markers are encoded in the mind for a time period, the longer the duration of that period is recalled. However, that duration is perceived to be shorter while experiencing it [1].

We hypothesized that changes in the countdown can act as memory markers, which can affect how delay duration is recalled. If countdowns acted as memory markers, it was expected that

¹³As an example of what a 1s early action means, the longest waiting suggested by the rational model in this game is 8s for the first check, and 1s of difference means waiting 12% less than what is rational (or compared with the other conditions). This difference is more noticeable for the other checks in the round, for which 1s can mean waiting 25% less than what is rational (or compared to the other conditions).

the duration was recalled as longer for faster countdowns. However, the delay was expected to be more tolerable for the users during the game round (the latter was shown in Experiment 1). Additionally, we hypothesized that delay recall can also affect how long the duration after the delay (game round in our study) is recalled.

The results supported these hypotheses. As the speed of the countdown increased, the game round was seen as shorter, and the duration of the delay was recalled to be significantly longer. Additionally, delay recall reliably affected how the duration after the delay was recalled; the longer the delay was estimated, the longer the duration after the delay was estimated.

Further, if counts in the countdown acted as memory markers, the delay in the fast countdown (with more memory markers) was expected to be more tolerable. This indeed was supported by the results related to the decisions in the game (for all except for 30CD, which we hypothesized to be too fast). Participants' satisfaction also showed a trend that supported this hypothesis.

However, the results suggested that increasing the speed was no longer beneficial in 30CD. In 30CD, each count lasted only 0.5 seconds. This answers our second research question, i.e., increasing the feedback speed is not necessarily beneficial. Considering the feedback speed investigated in these two studies, a countdown changing every 0.75 seconds seems to be optimal and both satisfaction and decision-making seem to be impaired by a faster countdown (changing every 0.5 seconds). This rate may be rooted in humans' information processing ability (perhaps due to Attentional Blink [8, 25]) and needs to be investigated in future research.

As changing the start number of the countdown was critical for this study, an anchoring effect might have also affected participants' judgments. However, we believe that the effect of altered time perception is stronger, because (1) participants' estimations were not close to the starting number of the countdown (except in 5CD), for example, the countdown starting from 30 was perceived to last about 15 seconds in average; and (2) the speed and amount of information were identical during the game round, while participants' perception of the duration of the game round was also affected as a result of the countdown manipulation. These two suggest that people's time perception was actually affected as a result of a change in their internal clock's speed, which was affected by the speed of the countdown.

An interesting observation was that those who saw faster countdowns were more positive about the game, compared to those who did not experience any delay. This may suggest that small delays accompanied by a proper type of feedback (such as a fast countdown) may not have negative effects on users, and may even be positive.

The results presented in this article lead to suggestions for design. We conclude this section by discussing these design implications and addressing the limitations of this study.

5.1 Implications for Design

The findings of this study are valuable as they suggest that varying the countdown speed shown during delays can affect decision-making, time perception, and duration recall. In other words, these results indicate that the decision on choosing the speed of the countdown is important, and the design needs to vary based on the specific user interface and situation. That is to say, there are trade-offs between how the delay is perceived at the moment of experience and how it is recalled afterwards, and as a result, it is important to decide on the countdown speed based on the application.

In this section, we will discuss some examples of the applications that can benefit from using countdowns and discuss what we suggest for the countdown speeds. It is important to emphasize that we only studied 15-second delays in our experiments and some of the applications discussed in this section may involve longer delays. However, we believe that it would be informative to discuss

Table 7. Suggestions for the Use of Countdowns

| Situation | Examples | | Suggested countdown Speed |
|---|--|---|------------------------------|
| | Short Delays | Long Delays | |
| Minimizing delay perception at the moment is important | red traffic lights, downloading files, microwave and oven counters, loading images, short advertisements | OS installation, long advertisements | Fast |
| Minimizing delay recall is important | application upgrades | virus scan, OS and application upgrades | Slow |
| Decision-making after the delay is important | red traffic light, online shopping websites | red traffic light/left turn light | Fast |
| Minimizing both delay perception and delay recall are important | spinning pinwheel when switching tasks on a display | boot or shutdown process | Medium |

Only the suggestions for short delays are made based on the results of this experiment. Suggestions for longer delays are made assuming that the same results can be acquired for longer delays.

applications of both short and long delays, as we hypothesize that the effects will be similar for longer delays (time perception will be affected in the same way).

An example of where a faster countdown could be beneficial is when showing progress during an operating system installation. It is necessary that users do not interrupt an operating system installation due to impatience, as stopping such processes could cause harm to the system. Therefore, how the delay is perceived at the moment of experience can be much more important than how it is recalled in the future. Further, an advertising company may prefer to improve how tolerable the advertisements are at the moment, as more people will see the whole advertisement (as opposed to skipping it). So a faster countdown would be more beneficial in these situations.

On the other hand, for virus protection software, it may be more important that users recall the duration of the scan as shorter, because this can increase the tendency to start future scans. Further, we know that users postpone major upgrades due to their negative experience of long waiting times [31]. Therefore, if users recall the duration of an application update as shorter, it is more likely that they will update the application in a timely manner. This is important as such updates may fix important privacy and security issues.

Aside from delay duration perception, we have shown that decision-making in the task following the delay is significantly affected by delay perception and recall. Thus, in situations where decision-making in the task after the delay is important, faster countdowns can be beneficial. Examples would include an online shopping website, where customers' impulsive decisions due to impatience can impose costs on the company (e.g., the cost for returning items). Other examples include waiting at a red traffic light, which can affect timing decisions (e.g., when to change lanes), and countdowns before a game starts. These situations would benefit from using UI with a fast countdown.

Finally, in situations in which both delay perception and recall are important, for example, for a computer's boot or shutdown process, a medium-speed feedback would be beneficial. Table 7 provides examples of different situations, where each of these countdown speeds can be beneficial. It is worth emphasizing that we do not recommend changing the feedback speed in situations where an accurate estimate of the remaining time is required. For example, it is not appropriate to

change the speed of a green pedestrian light's countdown, as people need to estimate the remaining time to decide whether they have enough time to cross the street or not.

5.2 Limitations and Future Work

The results presented in this study showed that improving decision-making and increasing task satisfaction by speeding up the countdown timer has limits. We have shown that the best quality of decisions and the highest task satisfaction are achieved when countdown timer changes every 0.75 seconds, and will not be as beneficial if it changes to be faster at 0.5 seconds per count. However, speeds between 0.5 and 0.75 seconds were not investigated, while the optimal speed may be somewhere between these two speeds. Thus, to find the optimal speed, future research needs to investigate the countdown speeds between 0.5 and 0.75 seconds.

Furthermore, this research used delays that lasted 15 seconds. Further research is also required to examine the effect of countdown speed manipulation on a larger range of delays, especially to investigate whether the effects will be similar for longer delays.

Lastly, although literature supports that the effect of delay recall will persist (e.g., due to the memory markers stored in mind for that time period), a study where duration recall is asked days after the experience would be beneficial to ensure that the effects observed for delay recall will continue to exist beyond the day of the experiment.

6 CONCLUSION

Delays not only affect users' satisfaction and cause impatience, but also affect their decisions and performance in the subsequent tasks. We manipulated a simple and effective type of feedback, countdowns, and showed that using faster countdowns can significantly reduce impatience and its negative consequences. Fast linear countdowns (comparing speeds of 0.5, 0.75, 1, 1.5, and 3 seconds per count) used during a fixed-length 15-second delay also affected and increased task satisfaction. Countdown was used as the type of feedback, as it can be used in all interfaces, including very simple and limited UIs.

We also investigated how delay perception/recall was affected by the speed of feedback provided during a delay. Faster countdown speed was generally perceived to be shorter at the moment of experience, but significantly increased delay duration recall. This can be based in how changes are stored as memory markers in our mind.

Another question regarding speeding up the feedback was investigated. The results suggested that a faster countdown is beneficial for minimizing delay duration perception and reducing impatience, but has its limits. Above a certain countdown rate, momentary countdown perception is not improved further, even though delay recall is increased. This may be due to humans' information processing limitations.

Finally, this article discussed design trade-offs between delay duration perception and recall; based on the situation, designers have to trade-off how to spend users' delay perception time between how delays are perceived at the moment of experience and how they are recalled later.

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