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Does Subjective Time Cost Explain Cognitive Task Choices?

Raina Ashley Isaacs
Illinois State University, risaacs1997@gmail.com

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RAINA A. ISAACS

36 Pages

The current literature suggests that subjective time duration could be the common currency used for task choice. However, few studies have been conducted that use non-physical tasks for their task choice options. Thus, the purpose of the current study was to examine if subjective time duration is the common currency for task choice regardless of task type. Participants first provided their subjective time estimates for each of the perceptual-motor and cognitive tasks that have been a priori determined to be at the medium difficulty level. Two cognitive tasks (item generation and math problem task) and one perceptual-motor task with a cognitive aspect (number sorting task) with varying levels of task difficulty (low, medium, high) were administered. Participants were presented with 27 task pairings and asked to choose which of the two tasks they wanted to complete and then presented with their chosen task. Once all tasks pairings were completed, participants answered questions about strategies they used to make their choices. Participants' subjective time estimates were not a predictor of task choices among these cognitive tasks. However, participants preferred the number sorting task to the other tasks at the medium and high difficulty levels of the other tasks. The objective time ratios were a better predictor of participants task choice. Future research should investigate difficulty level and other possible factors that influence task choice because subjective time estimates were not shown to be predictive of task choices in the current study.

KEYWORDS: task choice; cognitive effort; common currency

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RAINA A. ISAACS

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COMMITTEE MEMBERS:

Dawn M. McBride, Chair

Corinne Zimmerman

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CHAPTER I: INTRODUCTION

Throughout our lives we often make the decision to complete one task instead of another. Perhaps you have decided to clean your house and you are trying to determine which chore to start with. Do you start with folding the laundry or cleaning the bathroom? Some people might start with folding the laundry as it seems easy and takes less time to complete compared to cleaning the bathroom. We face these decisions on a daily basis with a variety of different tasks. There are many strategies that can be used to choose between two tasks, but one strategy, *subjective time duration*, may be the one used most often. The current study examined the idea that subjective time duration is the most used task choice strategy.

Previous researchers have provided possible explanations for these choices and identified multiple factors that influence task choice and decision-making. Thus far, seven factors have been identified. One factor that influences task choice is the *mere urgency* of a task, which is shown by people tending to pursue urgency over importance when making task choices (Zhu et al., 2018). A second factor is *cognitive demand*, which is the level of thinking or cognitive effort required to complete tasks (Fournier et al., 2019; Kool et al., 2010). People may weigh the *physical cost* of performing one task over the other (Rosenbaum, 2008, 2014; Rosenbaum et al., 2011). *Precrastination*, defined as the tendency to complete tasks as soon as possible, can also influence task choice (Rosenbaum et al., 2014). That is, people may want to "clear their minds" by completing the most cognitively demanding tasks first (VonderHaar et al., 2019). The fifth factor that can affect choices is *subjective difficulty*, which is the perception of task difficulty. This perception may be used in reference to a single task or when comparing the difficulty of two or more tasks (Cos, 2017; Feghhi, & Rosenbaum, 2019; Rosenbaum, & Bui, 2019). Finally, people may use estimates of *subjective time*, that is, how long they think a task will take to complete, or knowledge of *objective time*, which is how long the task actually takes to complete, to decide which task to complete (Dunn et al., 2017; Potts et al., 2018). An example of *objective time* is the time it takes to bake cupcakes, which includes the preparation and cooking time (both of which are explicitly specified on well-developed recipes). The following sections provide evidence for how these factors affect task choices.

Urgency

We are constantly choosing between tasks that have varying levels of importance and urgency. Zhu et al. (2018) stated that the mere urgency effect occurs when people are presented with two tasks and are more likely to perform unimportant tasks over important tasks simply because a deadline is given for the unimportant tasks. For example, people might choose to go to the grocery store to use a coupon before it expires before calling to schedule a doctor's appointment because the coupon has a deadline of when it can be used. That is, an assessment of task urgency draws attention to the time aspect of competing tasks and takes attention away from the payoff of the tasks.

Zhu et al. (2018) tested the mere urgency effect in five experiments. The goal of the first experiment was to establish evidence of the effect. Participants were asked to choose one of two tasks to work on with the knowledge that they would be rewarded with either three Hershey's kisses or five Hershey's kisses depending on which task they chose to complete. The promise of two different sized sets of Hershey's kisses as rewards was used to test whether participants would choose a lower payoff task with a deadline over a higher payoff task with no deadline. Zhu and colleagues found that participants did exhibit the mere urgency effect because participants were more likely to choose the lower payoff task with a deadline regardless of the reward. Overall, across the set of experiments, support was found for the mere urgency effect and the idea that in some cases, people have a tendency to choose urgency over importance/payoff. The mere urgency effect suggests that time plays a role in task choice because participants were more focused on the time by which they needed to complete the task than the task outcome.

Effort: Cognitive and Physical

Another factor that plays a role in decision making is cognitive demand, more specifically, avoiding tasks that are more cognitively demanding. The idea that people want to lessen the effort needed for a specific task is known as *the law of least mental effort* (Kool et al., 2010). The law of least mental effort suggests that people will choose the task that takes the least amount of cognitive effort in order to reduce both completion time and error rates. Kool et al. (2010) conducted six experiments to test this idea. In each experiment, participants were instructed to choose a series of tasks to complete using a demand selection tasks program, a program that presents participants with recurring choices between two alternative tasks that are associated with various levels of cognitive demand. The overall finding from the six experiments was that participants had a bias toward the less cognitively demanding tasks. Thus, the results supported the law of least mental effort.

A number of research studies on task choices have focused on choices between two physical tasks. For example, researchers have asked participants to choose between walking and reaching tasks (Rosenbaum, 2008, 2014; Rosenbaum et al., 2011). Rosenbaum (2008) investigated the costs of walking while reaching for an object to determine how these tasks relate to the ways people coordinate their walking and reaching behaviors. Participants were asked to pick up a bucket on a table while walking on either side of the table. After picking up the bucket, participants were to continue walking to the target location, deposit the bucket, and then return to their starting point. Participants viewed longer reaches to be more effortful than longer walks. Rosenbaum et al. (2011) sought to extend this research due to the lack of studies examining walking and reaching as a combined task rather than as separate tasks. Rosenbaum et al. (2011) specifically wanted to know whether motor planning was the same (combined) or different (separate) for the walking and reaching tasks. Participants chose to walk along the right side of the table if the bucket was on the right side, along the left side of the table if the bucket was on the left side, and when the bucket was in the middle, they had a right-hand bias. These findings add support to the idea that people choose based on reducing physical effort.

Based on these results, Rosenbaum and colleagues (2008, 2011) suggest it is possible that a common currency, defined as a single factor people use for task choice, exists for physical tasks. This assertion is based on Rosenbaum et al.'s line of research and findings from behavioral ecology, which examines behavioral choices by estimating the costs of alternative choices. Behavioral ecologists aim to predict behavioral choices and to develop models that can predict the likelihood of making one choice over the other based on various constraints (Rosenbaum et al., 2011). Rosenbaum et al. (2011) argued that two types of cost, cost of walking and reaching, can only be compared if a common currency exists. Furthermore, if individuals are consistent in their task choices, then it is likely they have access to the common currency. If a common currency exists for the choice between or among physical tasks, then it is possible that a common currency exists for other task choices in other modalities and across task modalities (e.g., cognitive tasks, perceptual-motor tasks). Although these studies did not examine completion time, task difficulty, or other modalities as factors that influence task choice, they are suggestive of the idea that a common currency exists for task choice.

Precrastination – Reducing Cognitive Load

Consistent with the idea that we choose tasks that require less cognitive effort (Kool et al., 2010), recent studies suggest that we order tasks in such a way as to reduce overall cognitive effort. While further testing the walking/bucket carrying task, Rosenbaum et al. (2014) discovered a new phenomenon. They found that people tend to complete a task as soon as possible, which they called precrastination. Participants were instructed to pick up one of two buckets placed at varying distances from them and carry the bucket to the end of an alley. The buckets were placed either on the left or right side of the walking path. Participants had a strong preference for choosing the bucket closest to their starting point and carrying it farther rather than choosing the bucket farther from the starting point and carrying it a shorter distance. Rosenbaum et al. suggested that participants may have viewed completing the sub-goal of picking up the closer bucket as bringing them closer to completing the main goal of bringing the bucket to the end of the alley and reducing their working memory load for completing that sub-goal, even if that involves more physical effort. Thus, precrastination is the tendency to complete tasks as soon as possible even at the expense of additional costs.

Fournier et al. (2019) investigated precrastination using physical tasks that had to be completed while also completing a task that added cognitive load. In their studies, participants picked up two buckets from different stools placed at varying distances from them and brought both buckets back to the starting table. In Experiment 1, the number of balls in each bucket also varied throughout the trials. This factor was varied to assess participants' sensitivity to the load-bearing demand of the task. In Experiment 2, the amount of water in the cups varied throughout the trials because carrying a full cup of water requires more cognitive effort than a half-full cup of water; therefore, if precrastination is sensitive to cognitive effort it should be reduced if the task requires more cognitive effort when completed early. In addition, to the transport task (balls or water) half of the participants in each experiment were given five digits to remember during the transport task to add a cognitive load. After completing the transport task, those participants verbally recalled the five digits. In Experiment 1, participants precrastinated (i.e., picked up the closer bucket that had to be carried farther) when little attention was required to complete the transport task (e.g., when the buckets contained only golf balls). In addition, participants who were given the memorization task tended to precrastinate more compared to participants who were not given a concurrent cognitive load. In Experiment 2, precrastination was reduced when more attention was required to complete the transport task. The results of these experiments support the idea that people are more likely to choose to complete the task that will lead to reducing their cognitive load.

Precrastination - How is Cognitive Effort Estimated?

Despite evidence that amount of cognitive effort affects task choices, it is not yet clear which aspects of a task determine estimates of the amount cognitive effort needed. Two factors that seem to influence estimates of cognitive effort are time and accuracy. One suggestion is that people determine how effortful a task may be based on the time it takes to complete the task (Cos, 2017) and how many errors one could make during the task (Dunn et al., 2017; Feghhi & Rosenbaum, 2019). People tend to associate higher completion times with higher levels of effort, which often leads them to choose a task with lower completion times (Dunn et al., 2017). In addition to time cost, error likelihood has also been associated with effort (Dunn et al., 2017). Higher error likelihood tasks are considered to be more effortful than tasks with lower error likelihoods. Dunn et al. (2017) investigated the effects of perceived time cost and effortfulness on decision making, by comparing tasks with high error likelihood and low time cost with tasks with low error likelihood and high time cost. Participants were presented with one word displayed at 110 degrees on the left side of the screen (diagonally and upside down) and two words displayed at 0 degrees on the right side of the screen (horizontal and upright). Given these two options, participants were asked to choose which one they thought was more effortful and time demanding to read aloud. The overall findings provided evidence that both time cost and error likelihood judgments predicted effort judgments for these tasks. Error likelihood predicted effort judgments more often than time cost, but both time cost and error likelihood affected effort judgments.

Feghhi and Rosenbaum (2019) investigated how people judge the difficulty of perceptual-motor and cognitive tasks. Specifically, they were interested in whether task difficulty judgments for each task are independent of each other or interactive. Participants were instructed to choose between two paths that required them to pick up and carry an empty cardboard box through a gap to a table at the end of the alley. Participants were also asked to remember digits, either six, seven, or eight digits that were associated with a wide gap or a narrow gap. They could choose to walk through a wide gap or a narrow gap while carrying the box. Each gap was associated with a list to memorize of six, seven, or eight digits that they were to recall after carrying the box through the gap they chose. The six conditions were all the possible pairings of gap width (wide and narrow) and digits to memorize (six, seven, and eight). The participants did factor task difficulty into their gap choice by considering the probability of error for both the physical task and the cognitive task. The researchers found that the difficulty of walking though narrow gap compared to wide gaps was the same as the difficulty of memorizing an extra .55 digits. Thus, judging the difficulty of multiple tasks appears to be independent. Participants based the subjective difficulty of the memorization task and walking through the gap while carrying a box as independent judgements rather than dependent upon each other. People take into account the errors of the cognitive task and the physical task separately when choosing which combination of tasks to complete. If people take into account errors that could be made during a choice of tasks, they will more likely choose the task that appears to be the easiest in terms of reducing the number of errors that could occur.

Building on this work, Rosenbaum and Bui (2019) investigated a new hypothesis – the *sustainability hypothesis*. Sustainability was defined as how many times participants thought they could complete the task. The sustainability hypothesis states that the longer a task is deemed sustainable, the greater the subjective ease. Specifically, they were interested in the relationship between estimated and actual sustainability of tasks. Participants completed four verbal counting tasks and four bucket carrying tasks to become familiar with the tasks and to record the actual times it took to complete them. For the counting tasks, participants counted from 1 to 8, 12, 16, or 20. For the bucket carrying tasks, participants walked down an alley, picked up a bucket on one side of the alley, and carried the bucket to a table at the end of the alley. The four bucket trials included two empty buckets (one requiring a short reach and one requiring a long reach) and two trials with buckets loaded with pebbles (one requiring a short reach and one requiring a long reach). Participants in one group chose between the counting and bucket task and also made sustainability judgments after completing the tasks. Participants gave their sustainability judgments by stating if they could do each of the tasks 3, 9, 27, 81, or 243 times. Participants in the other group completed the same tasks but in the opposite order (i.e., sustainability judgments were completed first). When participants chose which task to complete, they were explicitly told to choose whichever task seemed easier.

Rosenbaum and Bui (2019) found that the probability of choosing the bucket task increased as count value increased. Additionally, task completion time increased with count values and were longer for far reaches than for near reaches. Based on the results, they suggested that task completion time is the most promising factor for judging the difficulty of tasks.

Most of the studies described thus far have required participants to select a task to do based on varying features. Few studies have addressed how we decide which task to complete first when the two tasks are not prerequisites of each other. VonderHaar et al. (2019) addressed this issue by comparing a cognitive task with a perceptual-motor task that was assumed to be less cognitively demanding. They tested the cognitive-load-reduction (CLEAR) hypothesis that predicts that people will choose tasks such that they can clear their minds of a task intention if possible.

Two consecutively tasks were employed. For the box-moving task, participants were presented with a computer screen displaying boxes containing the numbers 1 through 10. They were instructed to use a mouse to move these numbered boxes, in numerical order, from a starting table at the bottom of the computer screen to either an “odds table” at the top left or an “evens table” at the top right. In addition to the box-moving task, participants were to complete an item generation task at any time during the box-moving task when they were not currently moving a box. For example, on any given trial, they could complete the item generation task before clicking on any of the boxes, after moving all the boxes, or in between boxes. The participants completed the cognitive task (item generation task) before beginning the perceptual-motor task (box moving task) on a large majority of trials. This finding supported the main prediction of the CLEAR hypothesis, suggesting that people prefer to complete the more cognitively demanding task sooner to clear their minds for the next task.

The design used by VonderHaar et al. (2019) did not allow inferences about what factors contributed to the choice to do the cognitive task before the perceptual-motor task, nor was it clear from their data how participants defined cognitive demand. They did show that participants chose to complete the item generation task significantly later when more items (10 or 15 versus 5) were needed, conditions where the generation took longer to complete. This result is consistent with previous studies showing that tasks that take longer are less desirable.

As described above, the findings from a number of studies support the suggestion that time duration may be the common currency of task choice, but it is unclear what type of time duration – objective or subjective time – is the main factor of task choice (Dunn et al., 2017; Rosenbaum & Bui, 2019; Zhu et al., 2018). One suggestion is that task choice is based on which task can be completed faster, with the shortest completion time dictating that choice. Potts et al. (2018) suggested that subjective task duration is a common currency used when deciding which task to complete when tasks are of different types. For example, does completion time determine whether we do housework or complete an academic task at a given time? Participants in their study were asked to choose between a bucket carrying task (physical task) or a counting task (cognitive task). For the bucket task, participants picked up a bucket from either the left or right side of a table, using the corresponding hand to pick up the bucket, and then carried it to the end of an alley. For the counting task, participants counted aloud starting at 1 to a target value of 8, 12, 16, or 20. Researchers recorded the amount of time it took participants to complete the task they chose. Prior to selecting and completing the tasks, participants were asked to estimate how long they thought it would take to complete the tasks. The choice probabilities for selecting the physical task were better predicted by subjective time estimates for the cognitive task rather than objective task completion time, supporting the idea that subjective time estimates are a better predictor of task choice than objective time to complete the task. Potts et al. suggested that subjective time is the common currency for determining task choice across different domains of tasks (physical versus cognitive). Time estimation, specifically subjective time estimation, is related to other factors such as task difficulty, attention, and ability to judge time. Therefore, participants' subjective time estimates may depend on other performance-related variables. Yet, this study was the first to compare task choice across these domains. Thus, the generalizability of their results is unclear. The current study aimed to generalize these results to cognitive-cognitive task choice.

To summarize, time has been suggested in multiple studies (Gray et al. 2006; Potts et al. 2018; Rosenbaum & Bui, 2019) as the currency for task choice but subjective time duration seems to be the most promising currency for task choice. The current study further tested this hypothesis by comparing two cognitive tasks and one perceptual-motor task that contains a cognitive aspect. If the current study yields similar results to Potts et al.'s, the results would provide further evidence that subjective completion time estimates are a common currency for task choice regardless of the types of tasks people are presented with. Thus, one aim of the current study was to test the hypothesis that subjective time duration is the common currency.

The Current Study

The research question in the current study was, "Does subjective time predict task choice, as it did for cognitive-physical task comparisons?" The research question extends Potts et al. (2018) study by investigating subjective time as the common currency for cognitive-cognitive task comparison. Participants were presented with pairs of tasks chosen from three possible tasks: number sorting (perceptual-motor task), item generation (cognitive task), or math problems (cognitive task). This design allowed a comparison of a perceptual-motor task with cognitive tasks and cognitive tasks with each other. Based on the method used in Kool et. al.'s (2010) study, the three task types were presented in pairs and each task varied in difficulty (i.e., low, medium, or high levels of difficulty) based on the length of the task. Participants provided their subjective time estimates for each task with medium difficulty levels before they began choosing between tasks. After all tasks were completed, participants were asked to provide information about the strategies they employed for their choices.

The evidence for subjective estimated completion time as a determinant of task choice is prevalent for all types of task choice as reviewed above. Thus, based on the results of the Potts et al. (2018) study, Hypothesis 1 for the current study is that subjective time duration estimates will predict task choice probabilities.

The law of least mental effort is the idea that people want to reduce the effort needed for a specific task (Kool et al., 2010). Thus, Hypothesis 2 is that there will be a main effect of task difficulty. This hypothesis is based on Kool et al.'s results that participants had a bias towards the less cognitively demanding tasks.

Hypothesis 3 is that participants will choose the item generation and number sorting task less often as the difficulty level increases. This hypothesis is based on Potts et al.'s results that the probability of choosing the physical task (bucket task) increased as the cognitive task (counting task) became more difficult.

Since Vonderhaar et al. (2019) was not able to report anything regarding what factors contributed to participants' task choices, we asked participants to indicate what strategies they used to make their task choice. The strategies participants provided at the end of the study indicated whether participants were intentionally (or unintentionally) making choices based on the subjective time estimates.

CHAPTER II: METHOD

Participants

Based on a power analysis using GPOWER (Erdfelder et al., 1996), with a small to medium effect size of Cohen's d = 0.15, I needed a total of 73 participants to achieve power of 80% or higher. Recruitment of participants (N = 80) occurred through Illinois State University's SONA system. Participants received course credit for their participation. The sample was mostly female (81.3%), and White (76.3%), with an average age of 19.28 (SD = 1.96).

Materials and Design

The independent variables of the study are Task Type and Difficulty Level. Each independent variable includes three levels. The levels for Task Type include the number sorting task, category item generation task, and math problems. The Difficulty Level include low, medium, and high based on the number of items required to be completed for the task. The dependent variables include participants' subjective completion time estimates given for the medium difficulty level of each task, objective completion time for tasks chosen in the trial pairs, and the proportion of times each task was chosen in the presented pairs. The study was a within-subjects design.

The three tasks (number sorting, category item generation, math problems) were presented to participants in pairs. Pairings of the tasks were based on the type of task and difficulty level with each possible pairing of task type and difficulty levels presented once. Variations of each task included the three levels of difficulty (low, medium, and high). All possible pairings of task type and difficulty level created 27 total trials. Two attention check questions were interspersed in the trials to ensure participants were paying attention. The attention check questions appeared every 9 trials and were multiple choice questions. If participants missed one or both of the attention check questions, they were removed from the analyses. Only one participant missed an attention check question and was subsequently removed from the analyses.

Number Sorting Task

In the number sorting task, 4 to 8 numbers appeared in a random order to the left side of the computer screen in the "Items" column. Participants were asked to sort the numbers in numerical order into "odd" and "even" spaces on the screen. Odd numbers were to be moved to the "Odds Table" on the right side of the computer screen. Even numbers were to be moved to the "Evens Table" on the right side of the computer screen. When participants moved a number, a red number appeared next to it indicating that they had clicked on the number and the order of numbers moved to help determine their accuracy in completing the task. The red number stayed with the number after participants clicked on it and moved it to one of the tables.

Category Item Generation Task

In the category item generation task, the participants were given a category for which they needed to generate a list of items. The 19 categories were adopted from Van Overschelde et al. (2004) and were chosen based on the average number of items generated in those category norms. One category was used for the practice trial, and the other 18 categories were used in the experimental trial pairs. Participants generated their items by typing either 5, 10, or 15 items into the blank spaces provided, depending on the difficulty level condition for that trial. Participants typed in their answers to ensure they generated the correct items for the category and the appropriate number of items. The categories included sports, clothing items, colors, four-footed animals, musical instruments, articles of furniture, kitchen utensils, body parts, states, fruits, types of music, professions, male names, cities, things taken from a burning home, relatives, countries, vegetables, and toys. The category label and number of items to generate were counterbalanced across participants.

Math Problem Task

In the math problem task, participants completed simple single- and double-digit addition and subtraction problems. The math problems were presented on the computer screen. Participants could use their own scratch paper and pencils to complete the math problems but typed their answers into a box on the screen for each problem. They were not allowed to use a calculator or their phone to assist them in solving the problems. Participants completed either 3, 6, or 9 math problems for this task.

Questionnaire

Before completing a practice trial for each task, participants were a given an open-ended survey with questions regarding how long they thought it would take to complete each task (for the medium difficulty level) in seconds. At the end of the study, they were also asked what strategies they used to choose which task to complete in the pairs with open-ended questions. In addition, participants answered three questions that asked which task they liked the most, which task they liked the least, and which task they found the most difficult. They also reported their gender, age, and racial identification.

Procedure

The experiment was administered online in Qualtrics. After obtaining participants' informed consent, they were given detailed instructions for all three tasks. Before completing the practice trials, participants gave their estimates for how long they thought it would take to complete the medium difficulty level for each task (6 number sorts, 10 item generations, and 6 math problems) in seconds. Participants then completed a practice trial for each task at the medium difficulty level. Then they began the experimental trials. Across the 27 trials, participants were presented with all possible pairings of task type and level of difficulty.

Each trial presented two task options for the participants to choose from to complete. The participants were instructed to click the circle next to the task they wanted to complete. The task they choose then appeared on the screen. After the participants completed their task, they scrolled until they reached the end of the page and clicked on the red arrow at the bottom right of the screen to move onto the next task pairing. Once participants completed all 27 trials, they were given the open-ended questionnaire. Finally, participants were debriefed.

CHAPTER III: RESULTS

Hypothesis 1: Subjective Time Estimates

Hypothesis 1 was that participants' subjective time estimates for each task would predict their task choice proportions. Pearson's *r* correlations were conducted to determine if there were any relationships between subjective time estimates, choice proportion for the math problems, item generation, and number sorting tasks, and mean proportions pooled across difficulty levels for each task. See Table 1 for means and standard errors for these two measures across conditions. There was a significant negative correlation between subjective time estimates for math problems and choice proportions for the math problem task at the low difficulty level, $r(78) = -.43$, $p < .001$, the medium difficulty level, $r(78) = -.36$, $p = .001$, and the high difficulty level, $r(78) = -.23$, $p = .039$. There was also a significant negative correlation between pooled math problems and subjective time estimates for math problems, $r(78) = -.43$, $p < .001$ (see Table 2). There were no significant relationships between subjective time estimates and choice proportion for the item generation task, all *r*s < +/- .07, all *p*s > .556 (see Table 3) or between subjective time estimates and choice proportion for the number sorting task, all *r*s < +/-.13, all *p*s > .235 (see Table 4). Thus, Hypothesis 1 was partially supported.

All analyses were repeated after removing 12 participants who failed to complete at least one of the practice trials of the three tasks or failed the attention check questions. There were no significant changes, but the significant negative correlation between choice proportion of the math problem task at the high difficulty level and subjective time estimates for math problems was no longer significant, $r(66) = -.23$, $p = .058$.

Table 1

Means and Standard Errors for Choice Proportions and Time Estimates for Each Task and Difficulty Level

Choice Proportions	Number Sorting	Item Generation	Math Problems
Low	0.60(0.03)	0.68(0.03)	0.68(0.03)
Medium	0.54(0.03)	0.43(0.03)	0.47(0.03)
High	0.54(0.03)	0.31(0.03)	0.26(0.02)
Pooled	0.56(0.02)	0.47(0.03)	0.47(0.02)
Time Estimations	32.48(5.98)	55.59(6.14)	66.11(8.96)

Note: Pooled choice proportion was calculated by taking the average of the three difficulty levels of the task. The time estimations are the subjective time estimates participants reported for the medium difficulty level of each task. The means and standard errors include all participants (N = 80).

Table 2

Correlations Between Choice Proportions and Subjective Time Estimates for Math Problems

Variable	1	2	3	4	5
1. Choice Proportion for Math/Low	-				
2. Choice Proportion for Math/Medium	.50**	-			
3. Choice Proportion for Math/High	.39**	.53**	-		
4. Pooled Math Problems	.79**	.86**	.76**	-	
5. Time Estimates for Math Problems	-.43**	-.36**	-.23**	-.43**	-

Note. The correlations include all participants ($N = 80$).
* $p < .05$
**$p < .001$

Table 3

Correlations Between Choice Proportions and Subjective Time Estimates for Item Generation

Variable	1	2	3	4	5
1. Choice Proportion for Item/Low	-				
2. Choice Proportion for Item/Medium	.49**	-			
3. Choice Proportion for Item/High	.39**	.66**	-		
4. Pooled Item Generation	.75**	.88**	.84**	-	
5. Time Estimates for Item Generation	-.04	-.02	.07	.02	-

Note. The correlations include all participants (N = 80).
* $p < .05$
**$p < .001$

Table 4

Correlations Between Choice Proportions and Subjective Time Estimates for Number Sorting

Variable	1	2	3	4	5
1. Choice Proportion for Number/Low	-				
2.Choice Proportion for Number/Medium	.45**	-			
3.Choice Proportion for Number/High	.52**	.54**	-		
4.Pooled Number Sorting	.82**	.80**	.84**	-	
5.Time Estimates for Number Sorting	-.13	-.07	-.01	-.09	-

Note. The correlations include all participants ($N = 80$).
* $p < .05$
** $p < .001$

Hypothesis 2: Choice Proportions

Hypothesis 2 concerned the law of least mental effort and a main effect of difficulty level for task choice proportions was predicted. To test this hypothesis, a 3 (Task Type: item generation, math problems, number sorting) x 3 (Difficulty Level: low, medium, high) repeated-measures ANOVA on task choice proportions was conducted. There was a main effect of Task Type, $F(2, 78) = 3.30$, $p = .042$. A post hoc comparison using the Bonferroni correction showed that the number sorting task was chosen more often than math problems task, $p = .036$, but there were no other significant pairwise comparisons, *p*s > .14. As predicted, there was a main effect of Task Difficulty, $F(2, 78) = 138.24$, $p < .001$. A post hoc comparison using the Bonferroni correction showed that task difficulty was significant across all three difficulty levels, all *p*s <

.001. That is, low task difficulty (*M* = 0.65, *SE* = 0.11) was chosen more often than the medium task difficulty (*M* = 0.48, *SE* = 0.01), which in turn was chosen more often than high difficulty (*M* = 0.37, *SE* = 0.01). Hypothesis 2 was supported.

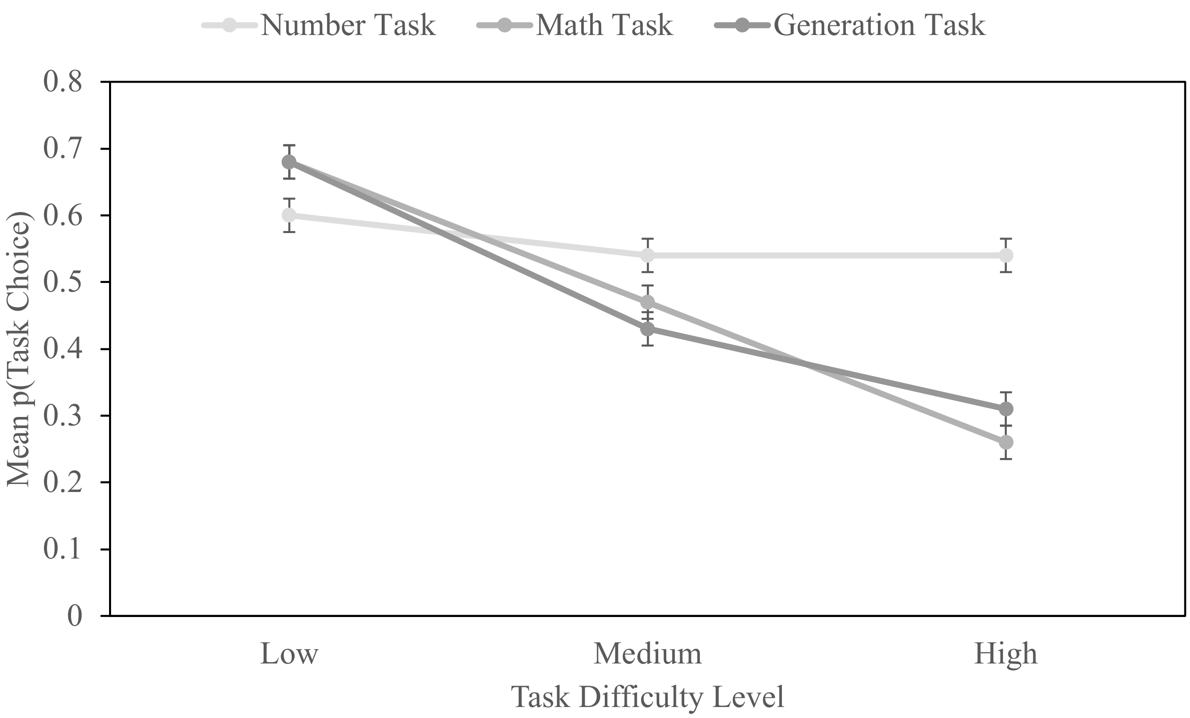
Hypothesis 3: Interaction between Task Type and Task Difficulty

Hypothesis 3 was that participants would choose the item generation and math problems tasks less often as the difficulty level increased. There was an interaction between task type and task difficulty, $F(2, 78) = 26.66$, $p < .001$. Figure 2 shows the means for each condition. A simple effects test showed that differences across tasks occurred at the high difficulty level, $F(2, 78) = 26.74$, $p < .001$, but not at the low difficulty level $F(2, 78) = 2.07$, $p = .133$, or the medium difficulty level $F(2, 78) = 2.39$, $p = .098$. Pairwise comparisons for the high difficulty level indicated that the number task was chosen more often than the other two tasks, both *p*s < .001, but the item generation and math problem tasks did not differ, $p = .252$. Hypothesis 3 was supported.

The analyses were repeated after removing 12 participants who failed to complete at least one of the practice trials of the three tasks or failed the attention check questions. There were no significant changes in the results.

Figure 1.

Mean Choice Proportions for Task Type by Task Difficulty Conditions with Standard Error Bars



Exploratory Analyses

Time Estimation Accuracy

Exploratory analyses were conducted using paired-samples *t* tests to see if participants overestimated or underestimated how long it would take them to complete each task. The subjective time estimates participants provided and objective time, how long it actually took participants to complete the task, for each task were compared. See Table 5 for the means and standard errors for subjective and objective times. There was a significant difference in the subjective time estimates and objective times for the math problems, $t(79) = 5.17$, $p < .001$, with participants overestimating how long they would take to complete. The difference between subjective time estimates and objective times for the number sorting task was not significant, $t(79) = 0.79$, $p = .433$, suggesting that participants correctly estimated completion time for this task. There was not a significant difference between subjective time estimates and objective times for the item generation task, $t(79) = -1.78$, $p = .051$, but for this task, participants underestimated how long the task would take to complete.

All analyses were repeated after removing 12 participants who failed to complete at least one of the practice trials of the three tasks or failed the attention check questions. There were no significant changes, but the difference between subjective time estimates and objective times for the item generation task became significant, $t(67) = -2.24$, $p = .029$.

Table 5

Means and Standard Errors for Subjective and Objective Time

Time Estimates/Duration	Number Sorting	Item Generation	Math Problems
Subjective Time Estimates	32.48(5.98)	55.59(6.14)	66.11(8.96)
Objective Time Duration	27.74(1.81)	68.46(4.35)	20.00(0.87)

Note. Time is reported in seconds. The means and standard errors include all participants (*N* = 80).

Reported Strategies

Frequencies were determined for the strategies participants reported using at the end of the study (see Table 6) and the task judgment questions regarding preferences and perceived difficulty (see Table 7). The top two strategies participants reported were about completion time (27.6%) and difficulty of the tasks (21.3%). As shown in Table 7, half of the participants reported that the item generation was their most liked task, but a majority also reported that this was the most difficult task.

Table 6

Percentages for Strategies Reported for Task Choices

Strategies	Examples	Percentages
Time	"The ones that took the least amount of time."	27.6%
Difficulty	"Whichever one was the easiest for me to complete."	21.3%
Mental/Ability	"My ability,"	20.0%
Enjoyment/Interest	"Whichever category looked fun."	11.3%
Less Tasks	"I usually picked the one with the lowest number of tasks."	10.0%
Mathematical	"I also liked choosing the math problems a lot since I'm a math major so stuff like that is just enjoyable to me."	7.5%
Other	"Whichever one seemed like the test would be over after I took it."	17.5%

Note. One participant did not provide their strategy for task choice. Some participants provided two strategy codes.

Table 7

Percentages of Participants' Responses for Preferences and Difficulty Questions

Tasks	Task most liked	Task least liked	Most difficult task
Item Generation	50.0%	28.7%	66.3%
Math Problems	27.5%	30.0%	31.3%
Number Sorting	21.3%	41.3%	1.3%

Note. One participant did not respond to any of the questions.

Objective Time Durations

Further exploratory analyses were conducted using Pearson's *r* correlations to determine if there were any relationships between objective time ratios for each task and mean pooled choice proportions across difficulty levels for each task. The objective time ratios are the mean time to complete the cognitive task (math problems or item generation) divided by the sum of that time and the time to complete the number sorting task. See Table 8 for means and standard errors. Figure 2 illustrates the relationships between objective time ratios for the cognitive tasks and mean choice proportions for the number sorting task.

Table 8

Means and Standard Errors for Objective Time and Pooled Choice Proportion

Difficulty Level	Math	Item Generation	Number Sorting
Low	8.06(0.29)	17.97(0.86)	8.45(0.37)
Medium	18.50(1.07)	43.72(2.34)	12.95(0.62)
High	38.95(1.64)	76.23(5.28)	16.49(0.77)
Pooled Choice Proportion	0.47(0.02)	0.47(0.03)	0.56(0.02)

Note. The means represent the mean objective times for each difficulty level. The means and standard errors include all participants ($N = 80$).

There was a negative correlation between objective completion times and pooled choice proportion for the math problems at the medium difficulty level, $r(71) = -.30$, $p = .012$, but not at any other difficulty level, ps > .056 (see Table 9). There was also a negative correlation between objective completion times and pooled choice proportion for number sorting task at the low difficulty level, $r(75) = -.24$, $p = .033$, and the medium difficulty level, $r(77) = -.30$, $p = .010$, but not at the high difficulty level, $r(76) = -.05$, $p = .637$ (see Table 10) (The dfs differ across tests due to participants' task choice). There were no other significant relationships, all rs < +/- .11, ps > .056. See Table 11 for the correlations for the item generation task.

All analyses were repeated after removing 12 participants who failed to complete at least one of the practice trials of the three tasks or failed the attention check questions. There were no significant changes, but the negative correlation between objective time for the number sorting at the low difficulty level and pooled number sorting was no longer significant, $r(64) = -.23$, $p = .064$.

Figure 2

Relationship Between Objective Time Ratios and Choice Proportions

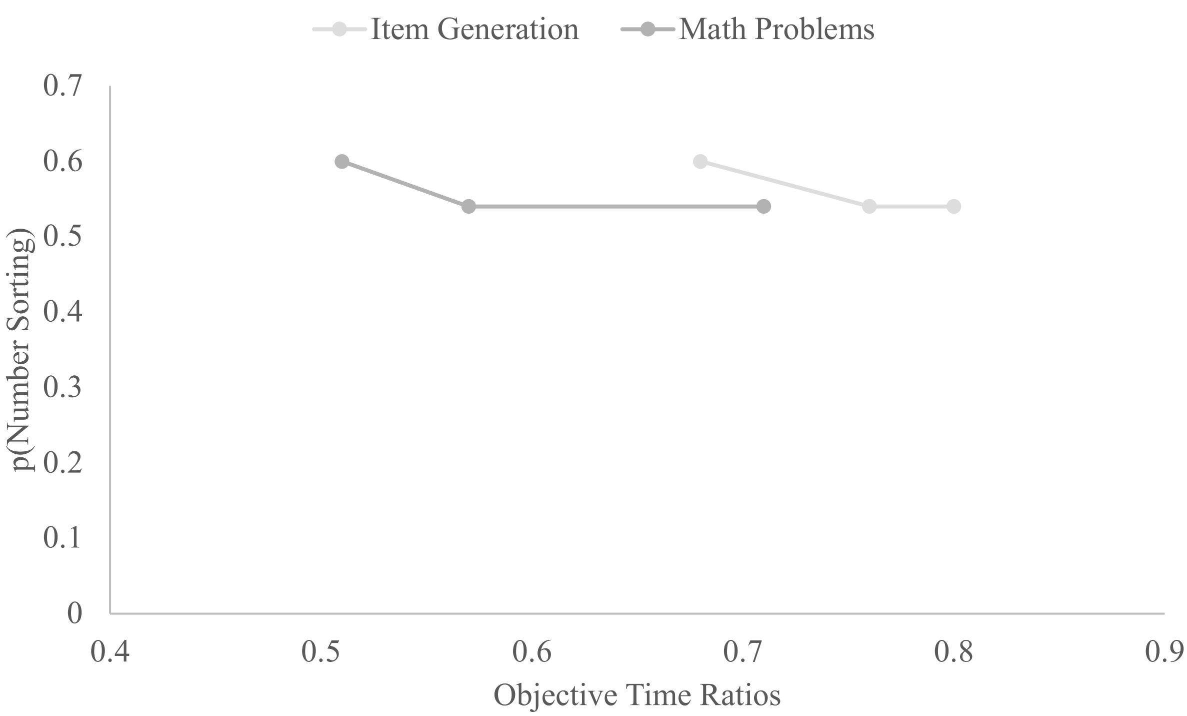


Table 9

Correlations Between Objective Time and Pooled Choice Proportion for Math Problems

Variable	1	2	3	4
Objective Time Math/Low	-			
Objective Time Math/Medium	.73**	-		
Objective Time Math/High	.75**	.69**	-	
Pooled Math Problems	-.17	-.29*	-.24	-

Note. The correlations include all participants (*N* = 80).
* *p* < .05
***p* < .001

Table 10

Correlations for Objective Time and Pooled Choice Proportion for Number Sorting

Variable	1	2	3	4
Objective Time Number/Low	-			
Objective Time Number/Medium	.58**	-	.	
Objective Time Number/High	.28*	.21	-	
Pooled Number Sorting	-.24*	-.30**	-.05	-

Note. The correlations include all participants (*N* = 80).
* *p* < .05
***p* < .001

Table 11

Correlations for Objective Time and Pooled Choice Proportion for Item Generation

Variable	1	2	3	4
Objective Time Item/Low	-			
Objective Time Item/Medium	.65**	-		
Objective Time Item/High	.45**	.65**	-	
Pooled Item Generation	.04	.04	-.11	-

Note. The correlations include all participants ($N = 80$).
* $p < .05$
** $p < .001$

CHAPTER IV: DISCUSSION

The purpose of the current study was to determine if subjective time duration is the common currency for task choice regardless of task type. The results of the study partially supported the main research hypothesis (Hypothesis 1) that participants' subjective time estimates for each task would predict their task choice proportions. Though Hypothesis 1 was partially supported, the results are not consistent with participants' task choice for all three tasks. The significant relationships appeared only for the math problem task. Therefore, subjective time estimates only predicted task choice for math problems, but not for item generation or number sorting. Participants may have been basing their task choice on the difficulty of the task or how interesting or boring the task appeared to them. However, the results supported Hypothesis 2, which predicted that a main effect of difficulty level would occur. Task difficulty did reduce participants' task choices overall across all three difficulty levels. In addition, the results did support Hypothesis 3 that participants would choose the item generation and number sorting task less often as the difficulty level increased. The difficulty level affected participants' task choice for the math problems and item generation tasks, but not the number sorting task. The number sorting task was chosen more often than the other tasks at the medium and high difficulty levels.

The current research demonstrated both consistencies and inconsistencies with previous research. The results were inconsistent with previous studies that suggested that time, specifically subjective time, was a better predictor of task choice compared to other factors (Potts et al., 2018; Rosenbaum & Bui, 2019). In the current study, time was the top strategy that participants explicitly reported using to help them choose which task to complete. However, the results showed that participants' time estimates were not a good predictor of their task choices in the item generation or number sorting tasks. Participants either overestimated or underestimated how long each task would take them to complete for two of the tasks, which is inconsistent with previous research (Potts et al., 2018). The math problem task was the only task that participants overestimated how long it would take them, thus, if they thought it would take them longer to complete the math problem task than it actually did, their task choice may have been based on this factor. Participants' objective completion times were a better predictor of task choice; however, it was only a better predictor for two of three tasks (math problems and number sorting) suggesting that time may not be the common currency of task choice for all tasks. This research was not able to generalize previous findings to cognitive-cognitive task choice. However, the current findings were consistent with previous research showing that people will choose a physical task more often than a cognitive task as the perceived difficulty of the cognitive task increases (Potts et al., 2018). Specifically, the choice proportions for the item generation and math problems task decreased with higher difficulty levels relative to the number sorting task. The current findings were also consistent with previous research demonstrating that people want to reduce the amount of cognitive effort needed to complete a task (Kool et al., 2010). The current study showed that task difficulty affected people's task choices across all three difficulty levels. On the post-test questions, participants reported the item generation as the task they liked the most and the one they found most difficult. Participants may have viewed the item generation task as the most interesting compared to the number sorting and math problems task but found it difficult to generate items for some of the categories. Surprisingly, participants did not choose the item generation task more often overall. Their preferences for the tasks do not correlate with their task choices.

One implication of the current study is that teachers can use the results to determine how to present larger assignments, such as papers, presentations, or group projects, to students.

Teachers often assign these larger assignments toward the beginning and middle of the academic semester and only have one due date for those assignments. However, based on the strategies participants reported using, with reducing time and difficulty being the most common strategy, teachers should consider splitting the larger assignments into smaller components that have staggered due dates. Furthermore, these smaller sections will build upon each other that will lead to the final product. Breaking the larger assignments into smaller sections may reduce the perceived difficulty of the assignment and make it appear to take less time to complete, thus, potentially reducing procrastination and increasing the quality of the work.

Another implication of the study is that students can identify which strategy(s) they use to decide which assignments to complete. After identifying the strategy(s), students can learn how to use them to their advantage. For example, if students choose which assignment to complete first based on their interest they could start with the less interesting assignments and use the more interesting assignments as a reward or reinforcer for completing the other assignments, which is known as the Premack Principle. Additionally, the results of the current study can help students realize that their subjective time estimates may not be as accurate as they initially thought. Therefore, students should read the instructions of each assignment to determine which ones may be less time consuming and easier to complete. However, students should allocate extra time for completing each assignment if the assignment takes longer than expected.

The final implication of the current study is how the COVID-19 pandemic is affecting task choice. Teachers and students have been affected by the pandemic not only in terms of academia, but in their personal lives as well. Depending on the university, students either have in-person, hybrid, or online classes. Furthermore, their online classes may be synchronous or asynchronous. Mental health, motivation, access to the internet, and other necessary resources needed for school are affecting students and teachers differently. Therefore, teachers need to be more lenient with their deadlines and realize that larger assignments may seem more overwhelming to students. Breaking down those assignments may be even more beneficial to students during the pandemic. Smaller assignments can reduce students' academic stress and allow them to allocate more time to their mental well-being while coping with the current education environment.

Although the current research provided evidence for task difficulty and task type as factors in people's task choices, there are some limitations that need to be addressed. The current research only asked for subjective time estimates in seconds for the practice trials that were at the medium difficulty level. Some participants gave their time estimates in minutes rather than seconds, which may have affected their perception of how long the tasks would take them to complete. Furthermore, there was no additional information given about the three tasks, aside from the name of the task and the number of questions they would need to complete, when participants gave their subjective time estimates. Participants may have underestimated or overestimated how long the tasks would take at the medium difficulty level due to the lack of knowledge of what the task entailed. Finally, some participants skipped or did not do the tasks correctly for the practice trials and were subsequently removed from the analyses. Therefore, they may not have been paying attention to their task choice due to not being fully engaged in the study.

Future research should start with addressing some of the limitations of the current research. One major limitation was that participants only reported subjective time estimates for the three practice trials at the medium difficulty level. To address this limitation, future researchers could ask participants for their subjective time estimates for each difficulty level of each task type after completing the practice trials (Potts et al., 2018). Future researchers should also provide more information about the tasks at the practice trial to potentially allow for more accuracy when reporting subjective time estimates. Furthermore, future researchers should ensure that participants complete the practice trials correctly and do not skip the practice trials entirely. To address this limitation, a forced response option in the online experiment could be added to ensure participants cannot move forward with the rest of the experiment until they complete the practice trials. This limitation can also be addressed by having a researcher present during the experiment if conducted in-person rather than online.

In conclusion, multiple factors seem to influence task choice rather than one single factor. Participants reported a variety of strategies, with some indicating more than one, that influenced their task choice. Realizing that multiple factors for task choice exist can open the door to discover the most common factors individuals use for task choice and that the factors may change over time for each individual.

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