

Anchoring in Time Estimation:  
The Effects of Explicit Anchoring on Prospective Time Estimates

by

Mohammed Aswad

A thesis submitted to the Faculty of Graduate and Postdoctoral  
Affairs in partial fulfillment of the requirements  
for the degree of

Master of Arts

in

Psychology

Carleton University  
Ottawa, Ontario

©2022

Mohammed Aswad

**Abstract**

Quantitative estimates are biased when they are preceded by a guiding value. This is known as the anchoring effect (Tversky & Kahneman, 1974). Limited research has examined anchoring effects in duration judgment tasks. Five-hundred and twenty-eight undergraduates kept track of time while playing a Tetris game. The experiment consisted of a 4 (Durations: 30 seconds, 1 minute, 2 minutes, 4 minutes) X 3 (Anchors: 0.5, 1, 2) between-subjects design. After the task, the participants estimated the game's duration. As expected, raw estimates increased linearly with duration. However, evidence for anchoring was mixed. Overall, large anchors yielded overestimation, but small anchors did not yield underestimation. Moreover, these effects were inconsistent across durations. The results indicated that the anchoring bias might not emerge at short durations. Further research is required to replicate this research and determine the conditions under which anchors influence time judgments.

*Keywords:* Anchoring, Time perception, Prospective Estimates, Online experiment, Video game, Remembered Durations

**Table of Contents**

<b>Abstract</b> .....	<b>ii</b>
<b>List of Tables</b> .....	<b>v</b>
<b>List of Figures</b> .....	<b>vi</b>
<b>List of Appendices</b> .....	<b>vii</b>
<b>Time Perception</b> .....	<b>2</b>
<i>Predicted Versus Remembered Durations</i> .....	<b>2</b>
<i>The Two Estimation Paradigms</i> .....	<b>3</b>
<i>Internal Uncertainty and Variability</i> .....	<b>6</b>
<b>Anchoring in the Literature</b> .....	<b>9</b>
<b>Implicit Anchoring Effects on Time Estimates</b> .....	<b>12</b>
<b>Explicit Anchoring Effects on Time Estimates</b> .....	<b>17</b>
<b>The Current Study</b> .....	<b>18</b>
<i>Hypotheses</i> .....	<b>19</b>
<b>Method</b> .....	<b>20</b>
<b>Participants</b> .....	<b>20</b>
<b>Experimental Design</b> .....	<b>20</b>
<b>Materials</b> .....	<b>21</b>
<i>Qualtrics Online Survey Software</i> .....	<b>21</b>
<i>Video Game</i> .....	<b>21</b>

<b>General Procedure</b> .....	<b>21</b>
<b>Results</b> .....	<b>24</b>
<b>Participant Screening</b> .....	<b>24</b>
<b>Methodology and Assumption Checks</b> .....	<b>25</b>
<b>Time Estimation Analysis</b> .....	<b>27</b>
<b>Discussion</b> .....	<b>32</b>
<b>RATIO</b> .....	<b>33</b>
<b>Absolute Standard Error (ASE)</b> .....	<b>34</b>
<b>Internal Uncertainty (IU)</b> .....	<b>34</b>
<b>A Broader Look at Anchoring Bias</b> .....	<b>35</b>
<b>Limitations and Future Directions</b> .....	<b>39</b>
<b>References</b> .....	<b>42</b>

**List of Tables**

<b>Table 1.</b> <i>Estimated time to real time ratio for each experimental condition as a function of the length (short or long) of the first video game. ....</i>	<b>8</b>
<b>Table 2.</b> <i>Three anchor durations in seconds used during the experiment for each of the game durations and anchor RATIOS conditions .....</i>	<b>20</b>
<b>Table 3.</b> <i>Number of participants per experimental condition .....</i>	<b>24</b>
<b>Table 4.</b> <i>RATIO Analysis for Overestimation and Underestimation of Duration.....</i>	<b>29</b>
<b>Table 5.</b> <i>Outlier Participant Responses Removed .....</i>	<b>52</b>

**List of Figures**

<b>Figure 1.</b> <i>A Visual Representation of the Tasks Used in the Experiment</i> .....	<b>22</b>
<b>Figure 2.</b> <i>Mean Estimates for the Four Tetris Durations and the Three Anchor Conditions</i> .....	<b>26</b>
<b>Figure 3.</b> <i>Mean RATIO for the Four Tetris Durations and the Three Anchor Conditions</i> .....	<b>28</b>
<b>Figure 4.</b> <i>Mean ASE for the Four Tetris Durations and the Three Anchor Conditions</i> .....	<b>30</b>
<b>Figure 5.</b> <i>Mean IU for the Four Tetris Durations and the Three Anchor Conditions</i> .....	<b>31</b>
<b>Figure 6.</b> <i>RATIO Across Different Durations and Anchors</i> .....	<b>37</b>
<b>Figure 7.</b> <i>Proposed Anchor Effects Across on the Duration RATIO</i> .....	<b>38</b>

**List of Appendices**

<b>Appendix A.</b> <i>Consent Form</i> .....	<b>48</b>
<b>Appendix B.</b> <i>Debriefing Form</i> .....	<b>50</b>
<b>Appendix C.</b> <i>Data Cleaning and Descriptive Statistics</i> .....	<b>52</b>

## ANCHORING IN TIME ESTIMATION

### Anchoring in Time Estimation:

#### The Effects of Explicit Anchoring on Prospective Time Estimates

The COVID-19 pandemic has left many people wondering, “How long will this last?” Even excluding the events directly linked to these exceptional times, contemporary life is certainly fast-paced, and some may find it hard to believe that so much has happened during the last eighteen months (Bisson & Grondin, 2020). Experiences like these provoke many questions. How do humans experience time? Why do some periods feel much longer than others? Which factors influence people’s ability to estimate time? Those questions are the focus of the time perception literature, and they are challenging to investigate for methodological reasons.

The impetus for this thesis is a very simple fact: practical and ethical requirements require researchers to schedule participants for their studies. They must therefore provide a start time and an approximate duration for their experimental sessions. This can create an anchoring effect (Tversky & Kahneman, 1974). In other words, the participants’ estimates may be biased in the direction of the provided duration and may not be strictly related to the real duration of the task (König, 2005). Thus, the goal of this thesis will be to investigate the impact of anchoring on time judgments. To achieve this goal, I will first present a review of the current time perception literature. Next, I will briefly introduce dual-process models and explore the general effects of anchoring biases on time estimates. Then, I will review the few experiments that have directly measured the effects of anchoring on time estimates. Finally, I will propose an experiment to determine whether the current procedure used by laboratories for time perception experiments can systematically bias participants’ estimates.

## **Time Perception**

Many researchers have attempted to explain the nature of time perception in humans (Wearden, 2016; Vierordt, 1868; Fraisse, 1984; James, 1890). Initial theories of time perception were focused on biological mechanisms and the existence of an internal clock that continuously produced neural pulses (François, 1927; Hoagland, 1933). Such theories posited that an experienced duration could be defined as the sum of the neural pulses collected during an event. This purely physiological approach, however, failed to assess the importance of attention for time perception. This is because the neural pulses in these models are accumulated regardless of the environmental context or the nature of the task being performed (Brown & Stubbs, 1992). In fact, many experiments in the literature have shown that a concurrent task can reliably interfere with the participants' duration estimates (Block et al., 2010). This finding implies that, at least in part, cognition plays a role in a human's ability to perceive and estimate durations (see Brown & Stubbs, 1992; Block et al., 2010; Tobin & Grondin, 2009). Additionally, Michon (1972) proposed that humans perceive and experience time like they perceive and process other sensory information (i.e., sight, sound, touch, taste, and smell). Hence, if this analogy between time perception and the physical senses is true, then it follows that the ability to perceive time should also be vulnerable to some of the "glitches" and illusions that the other senses can fall prey to. Therefore, a systematic method for studying these effects on time perception is needed.

### ***Predicted Versus Remembered Durations***

A typical time perception experiment asks participants to perform a task and then to estimate its duration without the use of time-keeping devices. This type of duration is known as a *remembered* duration. Alternatively, however, some experimental designs ask participants to predict or estimate how long they think a task will last before it begins. Thus, this kind of design

involves a component of planning, where participants may use their task knowledge and prior experience as a guide to estimate the duration. This type of duration estimate is known as a *predicted* duration (Roy & Christenfeld, 2008).

A variety of tasks have been used to test participants' ability to remember or predict durations. For instance, some researchers have chosen uninteresting tasks such as watching a water kettle boil (Block et al., 1980). Other researchers have selected passive but more interesting tasks such as listening to music (Brown & Stubbs, 1992) or watching a video (Roy et al., 2019). Finally, some studies have used tasks that are both active and engaging such as puzzles (Hicks et al., 1976), video games (Tobin & Grondin, 2009), and surfing the internet (Bisson & Grondin, 2020). However, regardless of the task used, the mechanisms used in remembered durations rely heavily on one more factor; the awareness to the requirement to keep track of time. This factor determines whether participants' estimates lean more on memory processes or attentional resources

### ***The Two Estimation Paradigms***

People can attempt to estimate a duration in two different ways (Hicks et al., 1976). They can actively pay attention to the passage of time, or they can try to determine how much time has passed once they have completed a task or an activity. This distinction enables researchers to think of time perception as a cognitive task, which can be disrupted by limiting the available attentional resources required to keep track of it (Brown, 1997). In theory, it should be possible to impede a person's ability to estimate duration by focusing their attention on another task, thus providing evidence that attention is a necessary component in time perception. Hicks et al. referred to perceived durations that are attended to as *Prospective* and remembered durations as *Retrospective*.

In a between-subject design, Hicks et al. (1976) presented participants with a card sorting task that lasted 42 seconds. Half of the participants were told beforehand that they needed to pay attention to the passage of time, whereas the other half was simply told to focus on the card sorting task. Furthermore, the participants were assigned to an easy, medium, or hard condition as they had to sort the cards into one, two, or four sets. The results revealed that the participants who made a prospective judgment perceived the card sorting task to be 30% longer than the participants who had to make that judgement retrospectively. Furthermore, it seems that the estimates of the participants in the prospective condition followed a negative linear trend with respect to the task difficulty. In other words, the harder the task was, the lower the duration estimates were. These results indicated that, unlike the participants in the retrospective condition, prospective participants provided shorter estimates as task difficulty increased. Hicks et al. argued that this difference was the result of the lack of the necessary attentional resources to keep track of time.

Brown and Stubbs (1992) supported this idea when they further tested the effects of task interference on a participants' ability to estimate time. The participants were told to listen to a short (i.e., 7.7-minutes) or a long (i.e., 13.9-minutes) set of musical pieces and then judge their total duration. Half of those participants were prospectively told at the beginning of the experiment that they had to provide a duration estimate. The other half was only told about the duration estimates retrospectively at the end of the experiment. Furthermore, half of the participants were also given a concurrent reading task to perform while listening to the music. Brown and Stubbs hypothesized that if the concurrent reading task interferes with the participants' ability to keep track of the duration, then it would indicate that time perception requires active attention. The results of their experiment supported this hypothesis. Participants

who were told to actively keep attention to time made significantly more errors in the reading task compared to the participants who were not informed about the time estimation component beforehand. This finding indicated that the duration judgment and the reading task shared common attentional resources, and thus impeded each other when done concurrently. Furthermore, the duration estimates done in the prospective condition were found to be over 7% longer than those done in the retrospective condition.

In summary, duration estimates conducted under prospective conditions tend to be less variable than those conducted under retrospective conditions (Block & Zakay, 1997). This is possibly because retrospective durations are only remembered at the end of the experiment, as opposed to prospective estimates which are continuously updated within working memory throughout the task. These differences between paradigms make the prospective design much more suitable for the current study. Furthermore, considering the current situation which prohibits access to a controlled laboratory environment, it is significantly more difficult to limit the participants' access to watches and other time devices, which is vital for a retrospective design. On the other hand, informing the participants in the instructions about the upcoming duration judgment and the importance of not using a watch is an accessible solution to that issue. The only problem with prospective designs, however, is their vulnerability to the task difficulty. This is because a higher cognitive load can cause participants to underestimate the duration in prospective designs (Block et al, 2010). Additionally, research has shown that a higher cognitive load can even introduce higher estimate variability in the data (Brown, 1997), thus requiring higher powered experimental designs.

### *Internal Uncertainty and Variability*

Traditionally, measures such as the Coefficient of Variation (CV) or Weber's Fraction (WF) have been used as a measure of variability in psychophysics research (Grondin, 2008). However, both of those measures require participants to complete multiple trials. Thus, they are unsuitable for experiments with a single estimate design such as many time judgement experiments (Grondin & Plourde, 2007). Consequently, some researchers adopted a variable which measures the subjective uncertainty. This is done by asking the participants to provide a minimum and a maximum interval after providing their estimate. This window of subjective uncertainty has been referred to by a few different names, including Weber's Fraction-like Index (Tobin et al., 2010), Relative Uncertainty (Bisson & Grondin, 2013; 2020), and Internal Uncertainty (Walker et al., 2021).

Tobin et al. (2010) examined subjective uncertainty in an experiment where they recruited 116 participants in video gaming centers to play games of their choice. Those participants were then asked either prospectively or retrospectively to estimate the duration of the gaming session. Participants were also assigned to one of three duration conditions: 12, 35, or 58-minutes. After the session, participants were asked to provide a duration estimate, a minimum, and a maximum. Three different variables were analyzed in this experiment: the estimate to real duration ratio (i.e., RATIO), the magnitude of error (i.e., ASE), and the internal uncertainty (i.e., WF). When the RATIO was analyzed, participants were found to have overestimated both the prospective and the retrospective conditions. Overestimation was higher in the prospective condition, however. Additionally, there was a significant effect of task duration. Participants had a higher RATIO of estimation in the 12-minute condition compared to the other conditions. In other words, participants perceived the "short" condition to be

proportionally longer than the two other conditions. Additionally, when the magnitude of error and the internal uncertainty were assessed, participants had a larger magnitude of error and were more uncertain about their estimates in the shortest condition (i.e., 12-minute) compared to the other durations. Surprisingly, however, neither the magnitude of error, nor the internal uncertainty were affected by the estimation paradigm. This result conflicted with the existing research, which shows that retrospective estimates are more variable compared to prospective estimates (see Block et al., 2010).

Walker et al. (2021) also examined subjective uncertainty. They presented two hundred and ninety-two participants with a visual and memory search task. Task difficulty (easy vs. difficult), task duration (8- vs. 58- minutes), and paradigm (prospective vs. retrospective) were manipulated in a between-subject design. First, Walker et al. found that there was a significant main effect of duration where the 58-minute condition was underestimated, and the 8-minute duration was overestimated. This effect, however, was qualified by a significant interaction between paradigm and duration. Only the participants in the 8-minute condition had a significantly larger overestimation in the prospective condition compared to the retrospective one. Additionally, a significant main effect of duration was found on the variability of the estimates. Specifically, participants in the 8-minute condition displayed more variability in their estimates compared to those in the 58-minute condition. However, once again, the results were qualified by a significant interaction between task duration and paradigm as the effect emerged in the 8-minute condition only. For now, the key finding is that task duration itself can affect participants' subjective duration estimates.

### *Effects of Duration on Estimates*

The effect of task duration on participants' subjective estimates of time is a well-documented phenomenon. One such effect is known in the literature as Vierordt's law (Woodrow, 1951). This effect suggests that the participants tend to overestimate short durations and underestimate long duration (Vierordt, 1868). Additionally, there should exist a *Point of Indifference* that does not yield any over- or underestimation of the duration. For example, Tobin and Grondin (2009) instructed 116 participants to play a Tetris game for a short duration of eight minutes and a long duration of 24 minutes. Participants also had to complete a control reading task for 8 minutes in-between the two gaming sessions. Their ability to accurately estimate time was calculated as a ratio (i.e., the participants' estimated duration divided by the actual duration). As can be seen in Table 1, participants overestimated the short duration, and underestimated the long one.

**Table 1.**

*Estimated time to real time ratio for each experimental condition as a function of the length (short or long) of the first video game.*

First Session	8 min video game	8 min reading	24 min video game
Short	1.48 (0.51)	1.63 (0.59)	0.73 (0.21)
Long	1.28 (0.50)	1.37 (0.55)	0.86 (0.31)

*Note.* This table is reproduced from Tobin and Grondin (2009). Values smaller than one indicated underestimation and values greater than one indicated overestimation.

While these effects have been well established in the literature, it was expected to only emerge in designs that present participants with multiple consecutive estimates of varying durations (Grondin, 2008). This is because Vierordt's law was thought to be an effect of central tendency (Murai & Yotsumoto, 2016). However, Walker et al. (2021) demonstrated that it is possible to find an effect of task duration that mirrors Vierordt's law with a single estimate

design. While the range of durations used in Walker et al. (8-minutes vs. 58-minutes) is much longer than the one used in the current experiment, similar effects due occur a shorter duration.

In an experiment that set to extend Vierordt's law into a duration range of a few minutes, Roy and Christenfeld (2008) recruited 207 participants in a between-subjects design. Participants were presented with 700 sheets of paper, then were asked to count 50 (1.25-minutes), 100 (2.64-minutes), 250 (6.24-minutes), or 500 (15.08-minutes) of them. The type of estimation was also manipulated in this experiment. Half of the participants had to predict the task duration before doing the task, while the other half performed the counting task and then were asked to estimate its duration retrospectively. The results showed a very similar trend in both remembered and predicted durations. Participants overestimated the short durations. However, participants' tendency to underestimate the duration increased as the task duration increased. More importantly, the point of indifference for this range of durations was slightly under two minutes. Thus, considering that the durations used in this experiment will be similar (Yarmey, 2000), this will be the point of indifference that will be assumed. Additionally, task durations that are shorter than two minutes will be considered as short durations, and those that are longer than two minutes will be considered as long durations.

### **Anchoring in the Literature**

The notion that one's estimates, beliefs, and decisions are susceptible to bias is well-documented in the cognitive psychology literature (Kahneman, 2011; Stanovich et al., 2018). The dual-process model has been especially helpful in explaining this phenomenon. It suggests that cognition is divided into two distinct components: System 1 and System 2 (Evans, 2008). System 1 encompasses associative and implicit learning processes. Its operation is typically not accessible to consciousness. It is passive and automatic. It develops as a result of a person's

previous experiences, memories, and internal beliefs. On the other hand, System 2 involves working memory and executive functions. It is volitional and allows humans to plan tasks, learn new skills, and communicate with others. The dual-process model proposes that humans often have to fight their initial impressions whenever they need to make a rational and calculated decision. In other words, those two categories of cognition may compete whenever a solution, decision, or estimate is needed. Thus, people often display systematic biases that can influence their behavior. For instance, the use of heuristics can have a direct impact on an individual's ability to estimate the frequency of events. For example, after the events of September 11th, 2001, Americans greatly overestimated the number of deaths due to plane crashes because of the news coverage of that attack (Psychology Today, 2009). This effect was explained using the availability heuristic; that is, people's tendency to over rely on easy to recall examples to evaluate claims or solve problems (Gilovich et al., 2002). Related biases can also influence remembered durations (Bouton, 1993). The current thesis will be concerned with another type of bias that has the potential to influence duration estimates, the *Anchoring bias*.

Tversky and Kahneman (1974) defined anchoring as a bias in estimation caused by giving participants an explicit initial numerical value before they attempt to make a quantitative estimate. In an early demonstration of the phenomenon, they used a spinning wheel to present the participants with an arbitrary initial value for the percentage of African countries in the United Nations. Then, they asked the participants to indicate whether the real percentage of countries was above or below that number and to provide a numerical estimate for the actual percentage. The results showed that the participants consistently underestimated the percentage when presented initially with a lower number and overestimated the percentage when presented with a higher initial number. This result was especially surprising considering that participants

knew that the initial value was randomly selected and could not have been related to the correct answer. Yet, it biased their judgments.

In another experiment, Tversky and Kahneman (1974) presented two groups of students with a simple multiplication question and asked them to solve it within five seconds. One group was given the equation “ $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = ?$ ” and another was given the equation “ $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 = ?$ ”. These two equations obviously yield identical answers, but the time limit prevented participants from fully calculating the answer. Since English readers are primed to read from left to right (Kinoshita, 2000), the two groups’ estimations began with large or small values, and once more, anchoring effects emerged. The first group generated significantly larger estimates compared to the second group.

The evidence of the effectiveness of numeric anchors is well documented (See Furnham & Boo, 2011 for a review). Furthermore, the participants in Tversky and Kahneman (1974) showed anchoring effects when the anchor design was *explicit* (i.e., the anchor was expressively and clearly using the fortune wheel). However, a similar trend was also seen when the anchor design was *implicit* (i.e., using an incidental introduction like the multiplication task). In other words, even without being given an explicit number, participants’ estimates were still anchored depending on the value they started with. Thus, it is reasonable to argue that both explicit and implicit anchors can impact the results when the participants are asked to provide a time judgment. Moreover, these observations lead to a conclusion that is difficult to escape: participants’ judgments in time perception experiments are most likely biased because experimenters tell them how long the experimental session will last. Thus, it is important to explore the magnitude of these effects and determine if they undermine the internal validity of the research conducted in this area.

Unfortunately, there is not a single article in the literature that has investigated the effects of anchors on remembered durations, whether explicitly or implicitly, with the exception of Roy et al. (2019). Instead, the limited research that has attempted to extend the effects of anchoring to duration estimates used a predicted duration design. Moreover, this makes the participants' estimates susceptible to other cognitive errors, such as the planning fallacy. Kahneman and Tversky (1977) observed that the participants often underestimated the duration of a task when planning for it. This error is seen as the result of the participants' sole focus on an ideal scenario of that task and the neglect of any instances of failure in previous attempts. This phenomenon presents a challenge to experiments that wish to investigate anchoring effects on duration estimates. This is because some of the systematic biases demonstrated by the participants could be explained by either a planning fallacy or an anchoring bias. For example, when a short duration anchor is presented to the participants, they are expected to underestimate the task duration. Similarly, if a planning fallacy bias is present, participants are also expected to underestimate task duration. Hence, it is important to disentangle these issues to clearly understand the effect of anchoring when participants are asked to predict durations.

### **Implicit Anchoring Effects on Time Estimates**

Evidence supporting the existence of implicit anchoring effects on time judgments can be found in Thomas et al. (2003). Their participants were asked to solve two different variations of the classic Tower of Hanoi task. It consists of multiple circular disks of different sizes inserted into vertical wooden poles. The goal is to move all the disks from the first pole to the last one without placing any larger disk over a smaller one. Thomas et al. asked the participants to complete both 3- and 4-disk versions of the task and told them to estimate the duration of each one. This manipulation led Thomas et al. to implicitly anchor the second estimate with either a

shorter or longer prior task. The results indicated that the participants underestimated the duration of the 4-disk task by approximately 51% when it was presented after the shorter 3-disk task. Yet, participants overestimated the duration of the 3-disk task by a factor of 1.5 times when it was presented after the longer 4-disk task. These results followed the expected trend produced by anchoring. Thus, they suggested that the first task acted as an implicit anchor on the participants' estimates for the second task and biased them accordingly.

However, Thomas et al. (2003) knew that the results of their previous experiment were equivocal because the 3- and 4-disk tasks were both used only once. Hence, it was impossible to distinguish the impact of task order from the duration of each task per se. Thus, in a follow-up experiment, they asked 94 participants to solve a 3-disk and a 5-disk version of the Tower of Hanoi consecutively while task order was counterbalanced. Furthermore, control participants were instructed to either do the 3- or 5-disk versions twice instead of doing both the 3-disk and 5-disk tasks. Finally, all participants were also asked to estimate the individual durations of each task. Once again, a similar trend to those established in the previous experiment was found. Indeed, participants who performed the 3- and 5-disk twice showed almost no bias in their estimation of the second task. Otherwise, the largest overestimation occurred when the 3-disk task was preceded by the longer 5-disk task, where participants overestimated the duration by a factor of 4.5 times. The smallest underestimation occurred when the 5-disk task was preceded by the shorter 3-disk task, where participants underestimated the duration by around 30%. Because the participants did not show an underestimation in the repeated tasks, concerns about the planning fallacy were dismissed. Thus, the results from this experiment provided further support to the implicit anchoring effects on duration estimates.

However, there were still some concerns about cognitive complexity being the main reason behind the observed estimation bias. This is because the 5-disk task contains more steps compared to the 3-disk task. Thus, making it more difficult for the participants. Hence, in their last experiment, Thomas et al. (2003) instructed fifty participants to solve a 3-disk and the 5-disk versions of the Tower of Hanoi task. However, half of the participants were instead presented with a repetitive task meant to lower cognitive complexity. It involved participants moving the disks between the different poles without any other restrictions or goals. Furthermore, the duration of the repetitive tasks was made to match the short and long tasks used in the other conditions. The results of the experiment once again were similar to the previous ones. The long 5-disk task was underestimated by 13% when preceded by the short 3-disk task. On the other hand, the short 3-disk task was overestimated by a factor of 2.5 times when preceded by the long 5-disk task. Furthermore, there was no evidence of task complexity having any effects on the duration estimates. Thus, the results also supported an implicit anchoring effect explanation of duration estimates.

Most recently, however, Roy et al. (2019) conducted several experiments which contradicted typical anchoring results including those of Thomas et al. (2003). In their first experiment, 400 participants were recruited using Amazon Mechanical Turk and were asked to listen to either a song for 170 seconds (i.e., short) or a newscast for 177 (i.e., long) seconds first, answer a questionnaire in the middle for 5 minutes, then listen to the other audio tape that wasn't presented first. They were then asked to retrospectively estimate the individual audio tapes and survey separately then the total duration of the session. Surprisingly, the results did not replicate previous anchoring experiments. Participants significantly overestimated the duration of the questionnaire, and the news report, showed no bias in the duration of the song, and

underestimated the duration of the full experiment. Additionally, there was a significant effect of the order of presentation. Participants had a higher tendency to overestimate durations when presented with the news report first compared to when the was presented first song. However, there are two main issues with this experiment that needed to be addressed before the results' validity could be established. First, the experiment was originally designed to investigate the effects of music on duration estimates and not to detect anchoring effects. When anchors were suspected, however, the purpose of the research was changed to include them in the analyses. Furthermore, due to the different tasks used for the duration estimates, there is no way to discern whether the difference in bias was due to the task used or the duration of that task. Thus, a new and dedicated design was built with these issues in mind.

In a second experiment, Roy et al. (2019) asked 54 participants to view a short, medium, and long video that lasted for 122, 172, and 235 seconds, respectively. Furthermore, the order of presentation of the short and long video was counterbalanced to examine anchoring effects. Similar to the previous experiment, participants were asked to estimate each video's duration as well as the total session duration. The results of the first experiment were replicated in this experiment, yielding more data that is inconsistent with the research in this field. The authors found that presenting participants with a short video first caused them to overestimate its duration. Furthermore, that overestimation carried over into the second video and caused participants to overestimate it as well. On the other hand, when participants were presented with a long video first, they underestimated the duration of the first video, causing them to also underestimate the second video. However, one thing that was left to address was whether those systematic biases in estimates were caused by the initial bias in the first estimate. If so, Roy and colleagues argued that removing that bias from the first video by supplying the participants with

the real duration should theoretically reduce or even remove the biases from the consecutive tasks. It is important to note, however, that no alternative explanation was offered to explain why the first video had an estimation bias.

In the last experiment, Roy et al. (2019) gave 59 participants another set of short, medium, and long videos with a random order of presentation. Similar to the previous experiment, participants were asked to watch the three videos and then estimate the individual video durations as well as the full experiment duration. However, two changes were made. The medium video was always presented first, with the order of the other two videos counterbalanced. Second, half of the participants were given the real duration of the medium video after their first guess, thus immediately correcting their initial impression. The key result of this experiment was the underestimation of the long video when the participants were informed about the real duration of the preceding shorter video. Roy et al. argued that this manipulation removed bias from most of the subsequent estimates. They further argued that if an anchoring effect had existed, the bias would not have disappeared from the short task. Thus, they concluded that their experiments provided evidence against the extension of anchoring effects to duration estimates.

However, an alternative interpretation of Roy et al.'s (2019) results is possible. First, this is the only publication in the literature that attempted an anchoring experiment using a retrospective design. Once the participants are aware of time being a requirement in the first session, the design is no longer retrospective in the following sessions. Instead, the design of the duration task becomes prospective. And this may be what happened in Roy et al.'s (2019) experiment, where the real duration of the first session was presented to the participants prior to the second session. This decision to provide the participants with an explicit numerical value

prior to their estimation of the second session may have caused an anchoring effect, similar to the results of Tversky and Kahneman (1974). Sadly, however, only one other experiment in the literature has ever attempted to explicitly anchor the participants' duration estimates in a prospective design. This was done by giving them a numerical anchor prior to the duration estimates.

### **Explicit Anchoring Effects on Time Estimates**

While some research has examined the impact of implicitly provided anchors on time judgments, almost no research has investigated the role of explicit anchors directly. In fact, König (2005) appears to be the only experiment that has attempted to do so. In a between-subject predicted duration design, thirty-two participants were presented with a questionnaire that took an average of 60 minutes to complete. However, before the questionnaire was provided, participants in the short anchor condition were asked whether they thought the task would take more or less than 30 minutes to complete. Likewise, participants in the long anchor condition were asked whether they thought the task would take them more or less than 90 minutes to complete. Thus, those two durations were used as explicit short and long anchors, respectively. The study also included a control group, which was simply asked to estimate the required duration without any specific anchor given. Interestingly, the results revealed that the participants significantly underestimated the task duration by approximately 14% when presented with a short anchor prior to giving the duration estimate. On the other hand, participants overestimated the task duration by a factor of 33% when presented with a long anchor. In other words, participants underestimated the predicted task duration when given a short anchor, were fairly accurate when given no anchor, and overestimated the predicted task duration when given a long

anchor showing a positive linear trend. Taken together, these results indicate that the participants' estimates were successfully biased using the anchor given during the instructions.

While innovative, König's research raises different concerns. First, despite the statistically significant results found in this single experiment, significance is generally unstable in studies with low sample sizes because they are more vulnerable to Type 1 error (Dumas-Mallet et al., 2017). Second, in the control condition of this experiment, participants were given no anchor, as opposed to giving them a neutral anchor to maintain consistency with the other two conditions. Finally, being the only experiment in the literature that intentionally attempted to study explicit anchoring effects on duration estimates, the results warrant further replication.

In summary, the findings of König (2005) extended the general anchoring effects found in Tversky and Kahneman (1974) to the time estimation literature. However, the contradictory results found by Roy et al. (2019) introduced some doubt concerning this relationship. Moreover, the only experiments that attempted to anchor the participants' duration estimates by explicitly giving them a numerical value prior to their estimates are König (2005) and one of the conditions in Roy et al. (2019). Finally, there is currently no research on explicit anchoring effects that use remembered durations as opposed to predicted duration designs. Thus, there is a vital need for more studies on the effects of explicit anchoring on remembered duration estimates.

### **The Current Study**

The current experiment aimed to investigate the effects of explicit anchors on prospective duration estimates. A variable called an *Anchor Ratio* was created for this experiment to operationalize the magnitude of the explicit anchors. It is the factor by which the real task duration was multiplied and then provided to the participants in the instructions as duration anchors. The calculation for the anchor ratio can be seen in Equation 2 below.

$$\text{Anchor ratio} = \frac{\text{Given task Duration}}{\text{Real task Duration}} \quad (2)$$

For example, when the Anchor ratio is equal to 1 and the actual task duration is equal to four minutes, the participants were told that the task would normally last four minutes. Similarly, when the Anchor ratio is equal to 0.5 or 2, and the actual task duration is equal to four minutes, the participants were told that the task would normally last two minutes or eight minutes, respectively.

This experiment also assessed the effects of task duration on participants estimates using 4 durations (30 seconds, 1 minute, 2 minutes, and 4 minutes) in a prospective design. The task used was a Tetris game, similar to Tobin and Grondin (2009) and the experiment was administered online using Qualtrics.

### ***Hypotheses***

First, I expected the raw time judgments to increase linearly with the actual task duration. In line with the extant literature, this result would replicate the well-known finding that participants' time estimates are sensitive to the actual task durations (Grondin, 2008). Second, consistent with past experiments such as Walker et al. (2021), I expected the shortest durations in this experiment (i.e., 30-seconds and 1-minute) to be overestimated and the long one (i.e., 4-minutes) to be underestimated. I further predicted that the 2-minutes condition would be the point of indifference, where no overestimation or underestimation occurs due to task duration. Third, I predicted to see a positive linear trend in the duration estimates that corresponds to the anchoring condition. Specifically, I expected the small anchor (i.e., 0.5) to cause an underestimation, the neutral anchor (i.e., 1.0) to cause no bias, and the long anchor (i.e., 2.0) to cause an overestimation in the duration estimates, respectively. Finally, in agreement with Tobin

et al. (2010), I expected the estimates in the short durations to have a higher internal uncertainty and a higher magnitude of the error compared to estimates in the long duration.

## Method

### Participants

Seven-hundred and eighty-eight undergraduates from Carleton University accessed the experiment online. Each participant was randomly assigned to one of twelve possible conditions so that at least 30 participants was tested in each one. All the participants were recruited through SONA, an online university research platform used to recruit undergraduates in exchange for course credits. The SONA listing informed the participants that the experiment could take up to 30 minutes. As compensation for their time, participants received .25% marks or bonus marks applied to an introductory course in psychology.

### Experimental Design

The experiment consisted of a 4 (Durations: 30 seconds, 1 minute, 2 minutes, 4 minutes) X 3 (Anchoring Ratio: 0.5, 1, 2) between-subjects design. Each participant performed only one of the twelve duration and anchor ratio combinations and then was asked to give a duration estimate for the game, as well as a minimum and a maximum value for that estimate. Thus, the experiment used a prospective time judgment paradigm. A full list of the anchor durations and ratios can be found in Table 2.

**Table 2.**

*Three anchor durations in seconds used during the experiment for each of the game durations and anchor RATIOS conditions*

	Game Duration (in seconds)			
Anchor RATIO	30	60	120	240
0.5 (Short Anchor)	15	30	60	120
1.0 (No Anchor)	30	60	120	240
2.0 (Long Anchor)	60	120	240	480

## **Materials**

### ***Qualtrics Online Survey Software***

Many studies in the literature have compared the results of laboratory and online-based research. For the most part, the results indicate that online research replicates research conducted in laboratories (Krantz & Dalal, 2000). In fact, even the results from cognitive psychology research, which often require precise timing, can be replicated by online-based research (Hunston & Francis, 2000). Qualtrics (Qualtrics XM – Experience Management Software, 2020) was used to create the experiment. It is an online platform that provides many tools useful for research requiring timing and HTML-based content.

### ***Video Game***

Similar to the methodology of Tobin and Grondin (2009), the game used was a version of the classic game Tetris, which was embedded into Qualtrics using HTML code. The base code is available on GitHub and is included in the references section. The full experiment can also be found at [https://carletonu.az1.qualtrics.com/jfe/form/SV\\_6JrSW7blhEa8vmm](https://carletonu.az1.qualtrics.com/jfe/form/SV_6JrSW7blhEa8vmm). Tetris is a tile-matching game involving speed and coordination where players aim to align the differently shaped pieces into straight horizontal lines. Players must achieve this goal before the pieces stack vertically and fill the allocated space. The version of the game used in this experiment had a single difficulty setting for all conditions to control for task difficulty.

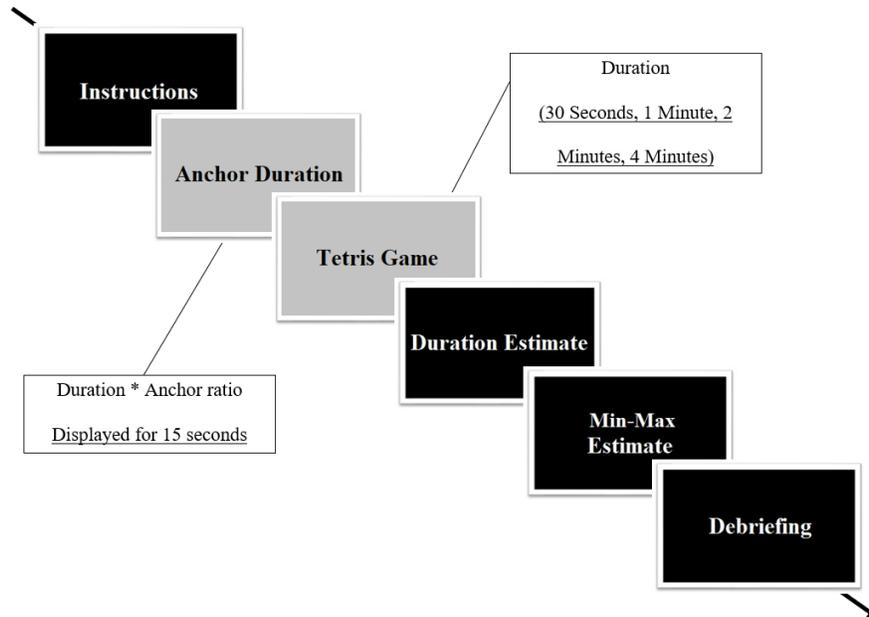
## **General Procedure**

At the start of the experiment, the participants' consent was collected using an online form. The full form can be found in Appendix A. After agreeing to participate, the participants were redirected to the experimental screen. Otherwise, the experiment was terminated. The full procedure for this experiment is summarized in Figure 1. Participants were then shown a

welcome screen and asked to provide some demographic information. This welcome screen was displayed until the participants filled in the required information.

**Figure 1.**

*A Visual Representation of the Tasks Used in the Experiment*



*Note.* Experiment showing three Anchors (0.5, 1, 2) and four Durations (30 Seconds, 1 Minute, 2 Minutes, 4 Minutes). The grey boxes represent the parts of the experiment that change according to the condition.

During the instructions phase, the participants were presented with the following introduction: “The following experiment aims to investigate your ability to **estimate the duration** of a Tetris video game session.” Participants were then instructed to put away their phones and to not look at the time on any of their devices. Participants were also given instructions on how to full-screen the experiment on their specific browser. This was done to ensure that no clock was displayed on the computer screen.

After the instructions, Qualtrics randomly selected one of the twelve possible game durations and anchoring combinations. Before the game started, instructions about the Tetris game were presented to the participants in case they were not familiar with the game. Afterwards, participants were assigned an anchor corresponding to their condition. This was done by displaying a white screen to the participants for 15 Seconds with the following phrase: “Your gaming session will begin shortly. The computer will randomly generate the duration of the game, but your session should last approximately X Seconds (i.e., Y Minute(s)). It might be shorter or longer, however,” where X and Y are the number of anchoring seconds and minutes, respectively. Afterwards, the game session started, and the participants were instructed to play Tetris for its full duration. Once the game ended, participants were asked to estimate the duration of that session using the following question: “**Without looking at the time**, how long (in Minutes and Seconds) was the Tetris game displayed on the screen?”. The participants were then asked to provide a minimum and a maximum value for the duration using the following question: “At a **Minimum**, how long (in Minutes and Seconds) was the Tetris game displayed on the screen?” and “At a **Maximum**, how long (in Minutes and Seconds) was the Tetris game displayed on the screen?”. Participants answered these questions by moving a sliding bar that displayed time in seconds with a range of zero- to 600-seconds (i.e., 10-minutes). In order to aid the participants in their estimates, the question contained the following note “Please note: every division on the slider is a full minute and the value displayed on the slider corresponds to the total number of seconds you estimated”. Finally, the participants were debriefed about the experiment and then thanked for their participation. The full debriefing information can be found in Appendix B of this document.

## Results

### Participant Screening

Before the main analyses were conducted, the data were screened for potential issues and outliers. Potential participants accessed the experiment a total of 788 times on Qualtrics. 107 participants closed the software before they initiated the experiment, however. Thus, they were removed from the data set, and 681 completed experiments remained.

Unfortunately, an error in the SONA system settings allowed participants to access the experiment via Qualtrics more than once, allowing them to submit multiple responses. To address this issue, responses were filtered by IP address and by date. When multiple entries were discovered for the same IP address, only the first attempt was kept, and all further ones were discarded. This led to the elimination of an additional 153 participants. Therefore, the data for the remaining 521 participants were entered into the analyses. Table 3 shows the number of participants who completed the experiment in each of the conditions.

**Table 3.**

*Number of participants per experimental condition*

Anchor	Duration	N
0.5 (Short Anchor)	30 Seconds	47
	1 Minute	46
	2 Minutes	36
	4 Minutes	43
1.0 (Neutral Anchor)	30 Seconds	48
	1 Minute	48
	2 Minutes	47
	4 Minutes	36
2.0 (Long Anchor)	30 Seconds	49
	1 Minute	43
	2 Minutes	43
	4 Minutes	35

Finally, due to the skewed nature of the data obtained, a visual inspection of boxplots was used to remove outliers. For each of the following analyses, any participant's estimate that was located beyond the whiskers of the boxplots (i.e.,  $>1.5 * IQR$ ) was labelled as an outlier and was removed. The full list of outliers for each condition can be found in Appendix C.

### **Methodology and Assumption Checks**

Unfortunately, the data violated several assumptions of ANOVAs including homogeneity of variance and heteroskedasticity in the data. Additionally, the data were not found to be normally distributed. It should be noted, however, that most published work that has analyzed time perception data (e.g., Tobin et al., 2010; Thomas & Handley, 2008; Roy et al., 2019; Bisson & Grondin, 2020) had used uncorrected ANOVA for their analyses. Moreover, ANOVA have been found to be fairly robust in the fact of such violations (Blanca et al., 2017). Nonetheless, all results should be interpreted cautiously.

### **The effect of the anchors of participants' time estimations**

A 4 (Durations: 30 seconds, 1 minute, 2 minutes, 4 minutes) X 3 (Anchoring Ratio: 0.5, 1, 2) between-subjects two-way ANOVA was conducted on the raw duration estimates. The data are shown in Figure 3. First, a significant interaction between Anchor and Duration on estimates was found,  $F(6,484) = 2.521, p = .021, \eta^2 = .03$ . Upon further analysis, a significant simple main effect of Anchor was found at the 4-minutes duration,  $F(2,484) = 11.46, p < .001$ . Participants in this condition judged the duration of the 2.0 Anchor to be larger than that of the 0.5 Anchor ( $MD = 53.15, SE = 17.45, p = .009$ ). The simple main effects for the other three durations did not reach significance (all  $ps > .124$ ).

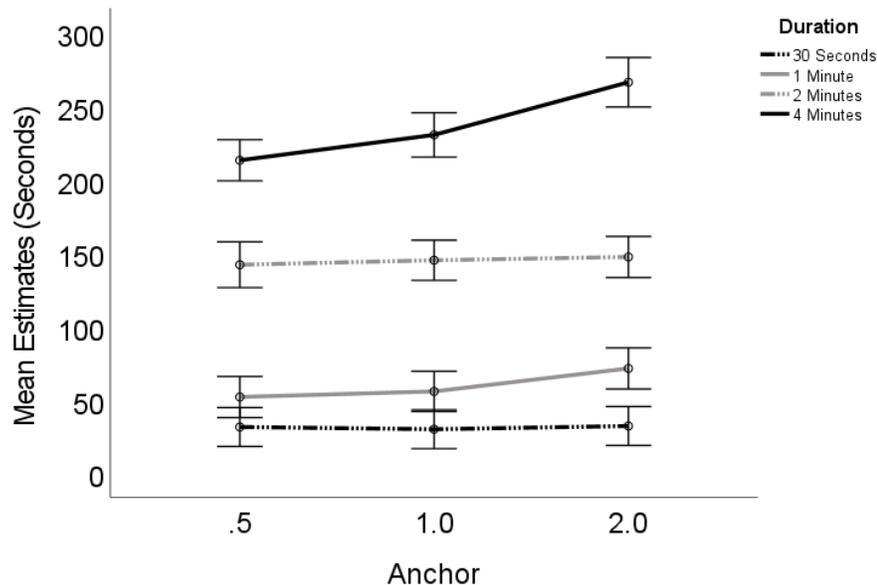
Additionally, the results revealed a significant main effect of duration,  $F(3,484) = 471.77, p < .001, \eta^2 = .745$ . Post-hoc tests revealed that the mean estimates of the participants at the 30-

seconds condition were smaller than those at the 1-minute condition ( $MD = -28.42$ ,  $SE = 5.641$ ,  $p < .001$ ). Similarly, estimates that were made under the 1-minute condition were smaller than those made at the 2 minutes condition ( $MD = -85.40$ ,  $SE = 5.871$ ,  $p < .001$ ). Finally, estimates made under the 2 minutes condition were smaller than those made under the 4-minute condition ( $MD = -88.43$ ,  $SE = 6.114$ ,  $p < 0.001$ ). Thus, the participants' duration estimates increased as task duration increased. These results indicate that the participants were able to distinguish between the four durations and in the correct order. Hence, the duration manipulation was successful.

Finally, as seen in Figure 2, the results revealed a significant main effect of anchor,  $F(2,484) = 7.568$ ,  $p = 0.001$ ,  $\eta^2 = .030$ . Unfortunately, however, the Bonferroni-corrected post hoc analyses revealed no additional significant differences between the estimates made under any of the Anchor conditions. Thus, only the difference between the .5 and 2.0 anchors was significant.

### Figure 2.

*Mean Estimates for the Four Tetris Durations and the Three Anchor Conditions*



*Note.* A line graph representing the mean duration estimates for the four durations and the three anchors. The error bars represent 95% confidence intervals.

## Time Estimation Analysis

### *RATIO*

The dependent variable RATIO was calculated to examine the participants' under- and overestimate. The following equation taken from Tobin et al. (2010) was used:

$$\text{RATIO} = E_D / T_D \quad (3)$$

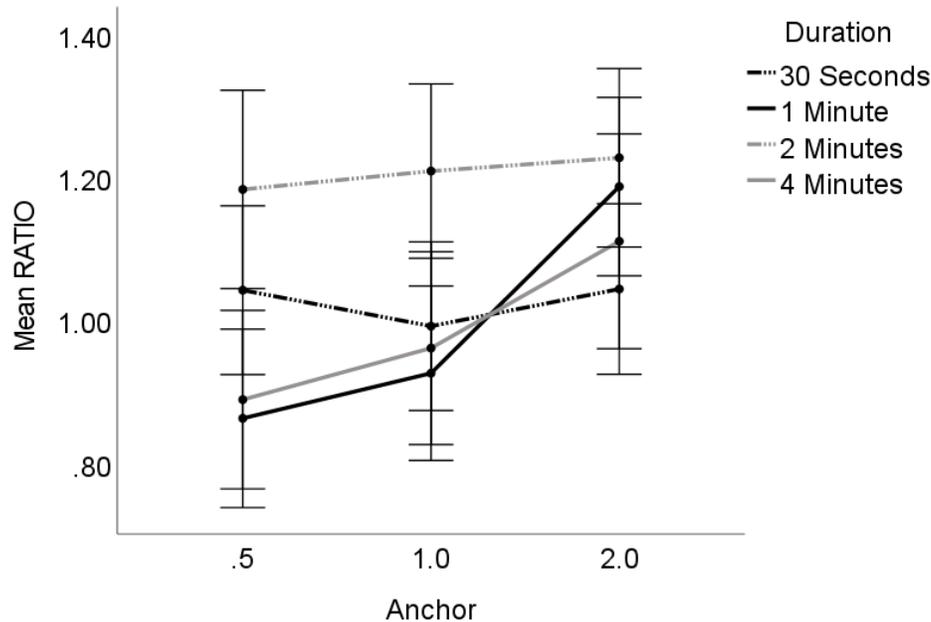
Where  $E_D$  is the estimated duration, and  $T_D$  is the real task duration. A ratio larger than one indicates that the participants overestimated the duration of the task or experiment, whereas a ratio under one means that the participants underestimated the duration of the task or experiment.

A 4 (Durations: 30 seconds, 1 minute, 2 minutes, 4 minutes) X 3 (Anchoring Ratio: 0.5, 1, 2) between-subjects two-way ANOVA was conducted on the duration RATIO for the different conditions. The results shown in Figure 3 revealed a significant main effect of duration,  $F(3,483) = 7.522, p < .001, \eta^2 = .045$ . Post-hoc tests revealed that the RATIO of the participants at the 2-minutes condition was significantly larger than that at the 4-minutes condition ( $MD = .235, SE = .055, p < .001$ ), 1-minute condition ( $MD = .217, SE = .052, p < .001$ ), and the 30-second condition ( $MD = .182, SE = .051, p = .002$ ). No other significant results were found (all other  $ps = 1.0$ )

The results also revealed a significant main effect of anchor,  $F(2,483) = 5.74, p = .003, \eta^2 = .023$ . Post-hoc analyses revealed that the RATIO of the participants at the 2.0 Anchor was significantly larger than that at the .5 Anchor ( $MD = .156, SE = .046, p = .002$ ) and the 1.0 Anchor ( $MD = .118, SE = .045, p = .029$ ). However, no significant difference was found between the 1.0 Anchor and the 0.5 Anchor ( $MD = .038, SE = .045, p = 1.00$ ). Finally, no significant interaction between Anchor and Duration on RATIO was found in the data,  $F(6,483) = 1.587, p = .149, \eta^2 = .019$ .

**Figure 3.**

*Mean RATIO for the Four Tetris Durations and the Three Anchor Conditions*



*Note.* A line graph representing the mean RATIO for the four durations and the three anchors. The error bars represent a 95% confidence interval.

Finally, one sample t-tests were conducted to determine if the ratios in each of the 12 conditions were different from a ratio of 1.0. Thus, the goal of these tests was to determine if the participants had significantly over- or underestimated the duration within the different conditions. To correct for the family-wise error, the Holm-Bonferroni method was implemented (Eichstaedt, 2013). Within the 2-minute condition, participants significantly overestimated the duration in the long anchor ( $M = 1.23$ ,  $t(41) = 3.55$ ,  $p < .001$ ) and the neutral anchor ( $M = 1.21$ ,  $t(43) = 3.34$ ,  $p = .0017$ ), but not in the short anchor ( $M = 1.18$ ,  $t(33) = 2.57$ ,  $p = .0149$ ). All other RATIOS were not significantly different from 1.0 after accounting for the family-wise error. The full results can be seen in Table 4.

**Table 4.***RATIO Analysis for Overestimation and Underestimation of Duration*

Anchor	Duration	Mean	SE	N	<i>p</i> -value	<i>t</i> -value	Rank
0.5 (Short Anchor)	30 Seconds	1.04	.06	47	.51	.67	10
	1 Minute	.86	.06	42	.03	-2.19	5
	2 Minutes	1.18	.07	34	.01	2.57	4
	4 Minutes	.89	.06	42	.08	-1.77	6
1.0 (Neutral Anchor)	30 Seconds	.99	.06	47	.87	-.16	12
	1 Minute	.92	.06	44	.23	-1.22	8
	2 Minutes	1.21	.06	44	.0017*	3.34	2
	4 Minutes	.96	.07	36	.56	-.59	11
2.0 (Long Anchor)	30 Seconds	1.04	.06	46	.49	.69	9
	1 Minute	1.19	.06	42	.0057	2.92	3
	2 Minutes	1.23	.06	42	.0010*	3.55	1
	4 Minutes	1.11	.08	29	.17	1.42	7

*Note.* \* Indicates a significant difference from a RATIO of 1.0 after a Holm-Bonferroni correction. RATIOS above 1.0 indicates over estimation, and a RATIO below 1.0 indicates underestimation of duration

***Absolute Standard Error (ASE)***

The second dependent variable was to be calculated was the absolute standard error. It assesses how far away a time estimate is from the actual task duration regardless of the direction of that relationship. The following equation taken from Tobin et al. (2010) was used:

$$ASE = |(E_D - T_D)| / T_D \quad (4)$$

Where  $T_D$  is the actual task duration, and  $E_D$  is the time estimate. A larger ASE means that the time estimate was further off from the real-time duration.

A 4 (Durations: 30 seconds, 1 minute, 2 minutes, 4 minutes) X 3 (Anchoring Ratio: 0.5, 1, 2) between-subjects two-way ANOVA was conducted on the duration ASE for the different conditions. The results shown in Figure 5 revealed a significant interaction between Anchor and Duration on ASE,  $F(6,483) = 2.845$ ,  $p = .010$ ,  $\eta^2 = .034$ . Upon further analysis, a significant simple

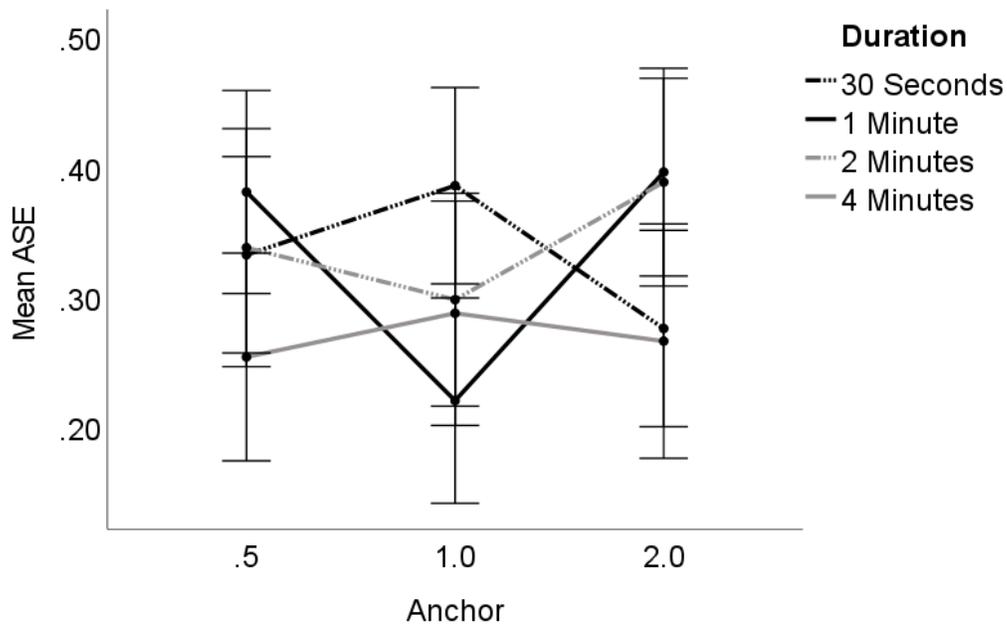
main effect of Anchor was found at the 1-minute duration only,  $F(2,483) = 5.86, p = .003$ .

Participants in the 1.0 Anchor condition made a smaller error magnitude compared to those in the 0.5 Anchor ( $MD = -.161, SE = .057$ ) and the 2.0 Anchor ( $MD = -.176, SE = .057$ ). No other simple main effects was significant ( $p > .131$ ). Finally, the main effects of duration,  $F(3,483) = 1.79, p = .148, \eta^2 = .011$ , and Anchor,  $F(2,483) = .773, p = .462, \eta^2 = .003$ , were not significant.

The results can be seen in Figure 4.

#### Figure 4.

*Mean ASE for the Four Tetris Durations and the Three Anchor Conditions*



*Note.* A line graph representing the mean ASE for the four durations and the three anchors. The error bars represent 95% confidence intervals.

#### *Internal Uncertainty (IU)*

A final dependent variable was calculated using the following equation:

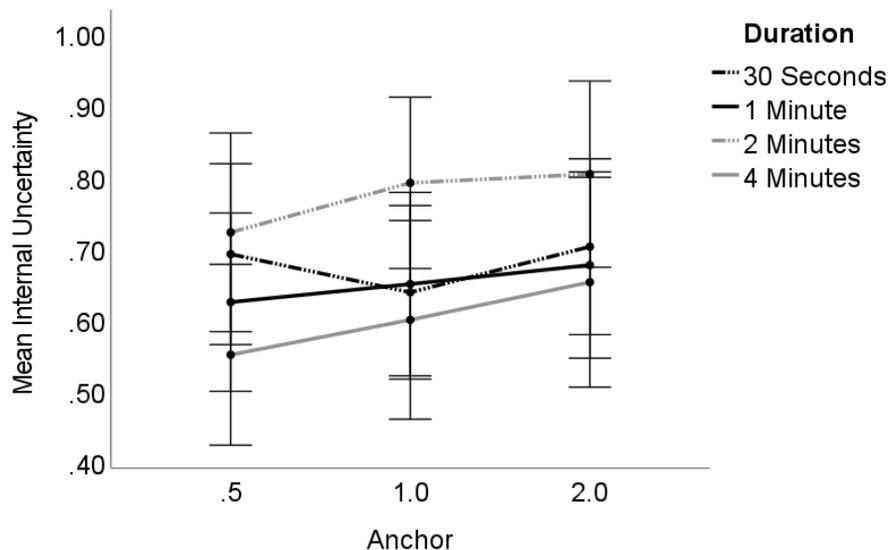
$$IU = (\text{Max}_T - \text{Min}_T) / T_D \quad (5)$$

Where  $Max_T$  is the maximum duration estimate,  $Min_T$  is the minimum duration estimate, and  $T_D$  is the actual task duration. Taken from Walker et al. (2021), it measures the subjective variability of the participants' duration estimates. A larger IU value indicates a larger subjective variability for the estimate. IU will be calculated using the maximum and minimum duration estimates for each one of the twelve conditions.

A 4 (Durations: 30 seconds, 1 minute, 2 minutes, 4 minutes) X 3 (Anchoring Ratio: 0.5, 1, 2) between-subjects two-way ANOVA was conducted on the participants' IU for the different conditions. The results are shown in Figure 5 and they revealed a significant main effect of duration,  $F(3,392)= 3.43, p= .017, \eta^2 =.026$ . Bonferroni-corrected post-hoc tests revealed that the IU of the participants at the 2-minutes condition was significantly larger than that at the 4-minutes condition ( $MD= .180, SE = .055, p=.007$ ). No other significant results were found (all remaining  $p >.111$ ) Finally, the main effects of anchor,  $F(2,392)= .862, p= .423, \eta^2=.004$ , and the interaction  $F(6,392)= .200, p=.997, \eta^2 =.003$ , did not reach significance.

### Figure 5.

*Mean IU for the Four Tetris Durations and the Three Anchor Conditions*



*Note.* A line graph representing the mean IU for the four durations and the three anchors. The error bars represent 95% confidence intervals.

## Discussion

The goal of this experiment was to investigate the effects of explicit anchors on the perceived duration. To achieve this goal, participants were asked to play Tetris for one session and then estimate its duration prospectively as well as provide its minimum and maximum. Short (i.e., 0.5), neutral (i.e., 1.0), and long (i.e., 2.0) anchors were crossed with durations of 30-seconds, one-minute, two-minutes, and four-minutes in a between-subjects design. First, raw time judgements were expected to increase linearly with the actual task duration. This was necessary to establish that the participants were able to distinguish between the different durations within experiment. Second, in line with past experiments such as Walker et al. (2021), the shortest durations in this experiment (i.e., 30-seconds and 1-minute) were expected to be overestimated and the long one (i.e., 4-minutes) to be underestimated. Furthermore, the 2-minutes condition was projected to be the point of indifference, where no overestimation or underestimation would occur due to task duration (Roy & Christenfeld, 2008). Third, it was hypothesized that the short anchor would cause an underestimation, the neutral anchor would cause no bias, and the long anchor would cause an overestimation in the duration estimates, respectively. Finally, consistent with Tobin et al. (2010), estimates in the short durations were expected to have a higher internal uncertainty and a higher magnitude of the error compared to estimates in the long duration.

### Raw Estimates

The raw task duration estimates established that participants were able to distinguish among all four durations from 30-seconds to 4-minutes. This was indicated by the highly significant differences in estimates across all duration conditions. Additionally, there was also a significant effect of anchoring bias on the raw estimates. Surprisingly, however, when family-

wise error was taken into consideration, no significant differences were found between the different anchoring conditions when all the durations were combined. Interestingly, when the 4-minutes condition was analyzed, participants perceived the duration of the long anchor to be larger than that of the neutral and the short anchor. While marginal in the overall experiment, this interaction indicates that the anchoring effects were more visible as the duration increased. This will be discussed in further detail later in the discussion. However, because the short durations are close to zero, anchoring effects may have been obscured by a floor effect. What follows is an analysis of the estimates-to-real duration ratio.

## **RATIO**

One of the more puzzling results of the experiment was that the participants systematically perceived the 2-minute condition to be proportionally longer than all other durations and significantly overestimated it. On the other hand, the 30-seconds, 1-minute, and 4-minutes conditions all had RATIOS closer to 1.0 indicating neither overestimation nor underestimation. This clearly contradicts the hypothesis regarding the point of indifference being around 2-minutes (Roy & Christenfeld, 2008) as well as the extension of Vierordt's law into single-estimate designs (Walker et al. 2021). One possible reason for this difference is that the current experiment used prospective design whereas Roy and Christenfeld implemented a retrospective one. Moreover, the current experiment did not use the same task as Walker et al. (2021) and the sessions were much shorter. Therefore, these factors may have contributed to a shift in the location of the point of indifference (Yarmmy, 2000).

An additional analysis was conducted on RATIO to assess anchoring effects on the participants' duration estimates. This analysis used a one sample t-test and compared each of the twelve groups to a RATIO of 1.0 to establish if over- or underestimation had occurred. The

results revealed no significant underestimation in any condition. Additionally, significant overestimation only emerged in the 2-minute condition. Nevertheless, the general trend of the data followed the expected trend for the most part. Participants in the short anchor condition tended to underestimate the duration, those in the neutral anchor condition made estimates closer to a 1.0 RATIO, and those in the long anchor condition overestimated the duration.

### **Absolute Standard Error (ASE)**

Surprisingly, neither duration nor anchor made a significant difference on the magnitude of errors. This contradicts the trend found in Tobin et al (2010) and Walker et al. (2021). Participants in both of these experiments made larger magnitude of errors in their respective short duration compared to the long one. However, both experiments also used much longer durations.

There was, however, an interaction between anchor and duration on the magnitude of errors. On average, participants in the 1-minute condition made smaller errors in the neutral anchor compared to both the long and short anchors. This was the trend I expected anchors to follow at the point of indifference (i.e., 2-minutes). This is because the point of indifference was theorized to lack any effect of task duration, meaning that only the bias due to anchoring existed. However, evidence from the RATIO analysis does not support the 1-minute being the point of indifference.

### **Internal Uncertainty (IU)**

Finally, participants' internal uncertainty was measured to assess estimate variability. Additionally, IU was meant to provide a subjective window into the participants' confidence with their duration estimate. Surprisingly, the only significant result was that the participants showed higher internal uncertainty in the 2-minutes condition than in the 4-minutes condition. While this

result is in line with previous research showing that short durations have more uncertainty compared to long durations (Walker et al., 2021; Tobin et al. 2010), it does not appear that the duration length was the reason. Rather, it seems to have been caused by the 2-minute condition itself. In other words, participants seemed to be highly uncertain about their duration estimate at the 2-minutes condition.

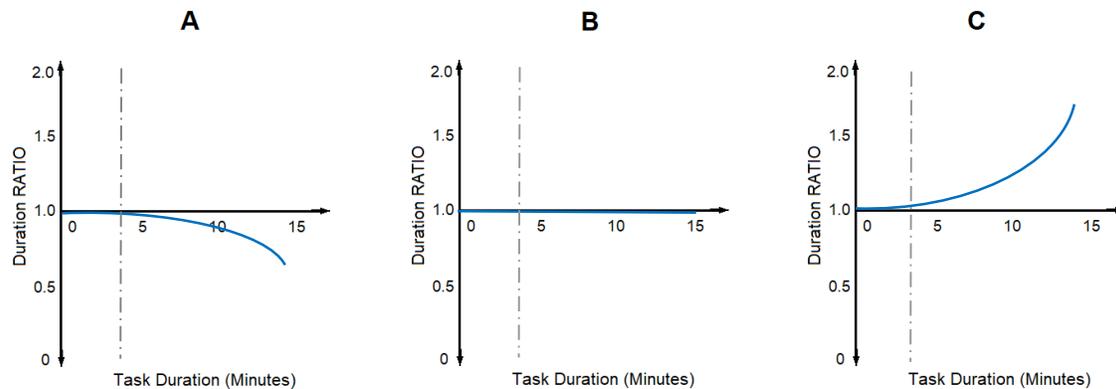
### **A Broader Look at Anchoring Bias**

The anchoring bias is generally considered to be the result of a heuristic used to make numerical judgements. Many calculations are cognitively taxing (Tversky & Kahneman, 1974). Thus, people will often try to reduce their effort by estimating answers instead of computing them using any information at hand as a starting point (Townson, 2019). Strack and Mussweiler (1997) developed the selective accessibility model to predict when anchoring effects should occur and under what conditions. It is based on two assumptions.

First, the selective accessibility model assumes that the strength of the anchoring effect depends on the accessibility of the anchor. To support this assumption, Strack and Mussweiler (1997) presented 32 participants with a questionnaire which asked them two consecutive questions. The first question contained a low or high anchor. Participants were asked whether a value for an existing landmark was higher or lower (e.g., “Do you think that the height of the Brandenburg gate is larger or smaller than 159 meters?”). This question was used to anchor a second one for which an exact value was required (e.g., “How high is the Brandenburg bridge?”). Additionally, the first question also manipulated the dimension that was queried. For example, if the participants were in the same dimension condition, both questions focused on the same property to be estimated, either the bridge’s height or width. If the participants were in the different dimension condition, however, one question focused on height and the other on width.

Thus, the initial question's dimension either made the anchor relevant or irrelevant in answering the second question. The results indicated that participants underestimated the value when exposed to the short anchor and overestimated it when exposed to the long anchor. More importantly, however, the anchoring effect was much stronger when both questions involved the same dimension. Strack and Mussweiler argued that dimension relevance makes the anchors more accessible and therefore more likely to influence participants' estimates.

The second assumption of Strack and Mussweiler's (1997) selective accessibility model was that the strength of the anchoring effect should depend on the anchor's realism. Similar to the first study, 32 participants were asked both a guiding question and an estimation question. Both questions used the same units. The semantic relationship between the two questions was varied, however. For example, participants were asked if the temperature in the Antarctic was higher or lower than 50 degrees Celsius. Then, they were asked to estimate the temperature either in the Antarctic (i.e., cold like the leading question) or in Hawaii (i.e., a much warmer location). The results were similar to those of the first experiment. When the objects of the two questions were more related to each other, participants' estimates were shifted in the direction of the anchor. Interestingly, however, when the two objects were very different from each other, the opposite effect occurred. Participants underestimated the value in the long anchor and overestimated it in the short anchor. Unrealistic values can either outright be ignored by the participants or even elicit the opposite of the expected trend. The selective accessibility model (Strack & Mussweiler, 1997) may therefore inform the interpretation of the current experiment's results and predict future results.

**Figure 6.***RATIO Across Different Durations and Anchors*

*Note.* a RATIO of 1 indicates the lack of overestimation or underestimation. Panels A, B, and C represent an anchor ratio of 0.5 (short), 1.0 (neutral), and 2.0 (long) respectively. The dashed line identifies the largest duration used in the current experiment.

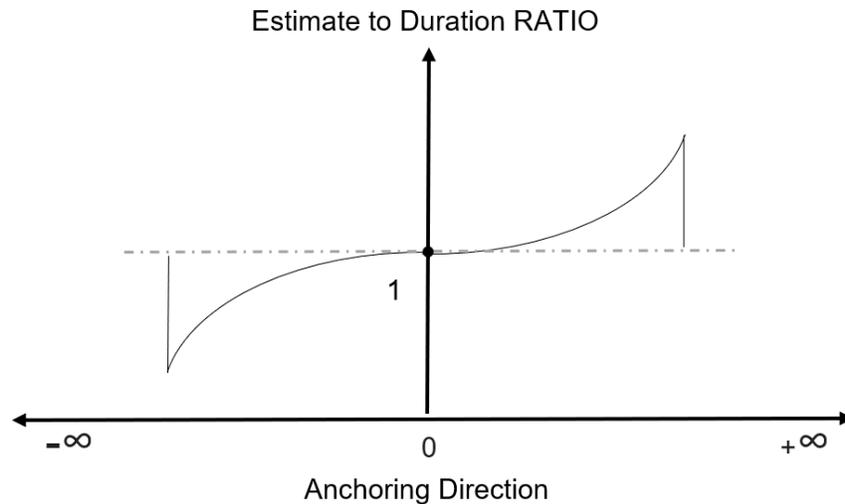
As illustrated in Figure 6, a time judgment obviously cannot produce a negative value. Therefore, a floor effect may exist, which can obscure the underestimation in short anchor conditions, especially when the task duration is short. This might be the reason why no underestimation was found in the current experiment. Furthermore, due to the proximity of the short anchor to the 0 value, participants may deem it unrealistic, thus dismissing the anchor entirely. On the other hand, although non-significant, participants overestimated the duration in several conditions when they were given the long anchor. This is due to their estimation being allowed to vary more freely compared to the underestimation in short durations.

Additionally, the suggestion that anchoring effects might be easier to detect with increasing durations is supported by the significant interaction that was found between the raw duration and the anchor used. Participants' judgments were significantly influenced by the short and long anchors in the 4-minute condition only. In other words, even if participants use a

heuristic that encourages anchoring, the relative increase in their estimates might be too small to be visible. This idea is illustrated in Figure 7.

**Figure 7.**

*Proposed Anchor Effects Across on the Duration RATIO*



*Note.* Grey line in the middle represents a RATIO of 1, where neither overestimation nor underestimation occur.

However, the selective accessibility model (Strack & Mussweiler, 1997) predicts that the realism of an anchor affects its ability to influence the participants' judgment. In other words, If the anchors are too large in either direction or unrealistic, it can lead to the participants ignoring the anchor, or even having the opposite effect. For instance, if an experiment is 5-minutes long, an anchor of 3-hours would be completely unrealistic and might render the anchor ineffective.

Another interesting implication from this model is the effect of units. It has already been established in this thesis that the frame of reference by which durations are compared matters (Yarmmy, 2000). However, this might also have an effect on the strength of the anchoring bias. People also often describe durations in multiple units that are used in conjunction with each

other. For example, a 3-minutes and 20-seconds duration is rarely described as 3.33 minutes or 200-seconds. This presents a challenge to a purely numerical or priming model of anchoring. This is because durations cannot be numerically anchored by a single continuum of numbers unless there was also a semantic understanding of how multiple units of time work together. Thus, further research is required on the effects of anchors on long durations, as well as well as those expressed in multiple versus single units.

### **Limitations and Future Directions**

Despite its mixed results, this thesis filled an important gap in the time perception literature. First, it defined explicit and implicit anchoring designs in the context of time perception research. Additionally, it is only the second experiment that set out to examine the impact of explicit anchors on duration estimates. It is also the first of its kind that has tested explicit anchoring effects on remembered durations. However, it also brings to light key issues that will need to be addressed in future studies. For example, can the method by which participants record time influence their estimates? It is already well known that there are some inherent differences between production, reproduction, and verbal estimation (Block et al., 2010). This particular experiment used a variant of verbal estimates (i.e., participants were required to present an explicit value for their perceived duration). However, participants had to move the slider bar towards the duration of their choice instead of providing an exact value by saying or typing. This choice might have influenced participants' estimates. This is because, regardless of the task duration, the slider displayed the full range of 600-seconds.

Another methodological issue in this experiment was the unfortunate error in the registration settings that allowed individuals to complete the experiment more than once. In order to address this issue, responses were filtered by IP address, geographical location, and date.

Thus, only the first response corresponding to each IP address was chosen. This led to the elimination of 153 survey submissions. There are also some odd results that need to be validated in future studies, such as the systematic overestimation that occurred at the 2-minute duration. This particular result lacks any clear theoretical or methodological explanation. Participants were clearly able to distinguish between all the durations of the experiment, and in the correct order. This included a 30-seconds, a 1-minute, and a 4-minutes respectively. Thus, it is not an issue of task duration per se. Additionally, the same game code, questions, data entrée method, and timers were used in all conditions. Thus, this difference in the participants' responses in the 2-minutes condition, compared to all other durations, is a puzzling result.

Finally, the thesis raises some interesting questions that can be explored. For example, excluding the current experiment, the few studies that set out to investigate anchoring effects on duration estimates used a predicted duration design instead of a remembered one. Thus, it is still unclear if anchoring effects behave the same way across different duration estimation designs. Moreover, to my knowledge, the only experiment in the literature that ever used a retrospective design in an anchoring study was Roy et al. (2019). Because its result failed to replicate well-known time estimation effects, it is difficult to evaluate their general applicability to an understanding of anchoring effects on time judgments. Thus, there is currently no data in the literature that can be used to predict anchoring effects in prospective versus retrospective designs. Similarly, there is not a single experiment in the literature that has directly compared explicit versus implicit anchor designs. Lastly, one of the main conclusions of this experiment was that anchoring effects might only be visible in long durations and using realistic anchors. Thus, a replication might be necessary where durations beyond eight minutes are used.

In conclusion, this thesis began with a single question: Can an approximate session duration given at the beginning of the experiment cause an anchoring effect on participants' duration estimates? Overall, the small number of experiments that have explored this question suggest that the answer is yes, but the current experiment failed to conclusively show anchoring when participants prospectively estimated short durations. Therefore, further research is clearly required to determine the conditions that allow anchoring to emerge in time judgment experiments.

### References

- Bisson, N., & Grondin, S. (2013). Time Estimates of Internet Surfing and Video Gaming. *Timing and Time Perception, 1*(1), 39–64. <https://doi.org/10.1163/22134468-00002002>
- Bisson, N., & Grondin, S. (2020). A New Perspective on the Relationships between Individual Factors and Time Estimates. *Timing and Time Perception, 8*(1), 25–54. <https://doi.org/10.1163/22134468-20191160>
- Blanca Mena, M. J., Alarcón Postigo, R., Arnau Gras, J., Bono Cabré, R., & Bendayan, R. (2017). Non-normal data: Is ANOVA still a valid option?. *Psicothema, 2017, vol. 29, num. 4, p. 552-557.*
- Block, R. A., George, E. J., & Reed, M. A. (1980). A watched pot sometimes boils: A study of duration experience. *Acta Psychologica, 46*(2), 81-94.
- Block, R. A., Hancock, P. A., & Zakay, D. (2010). How cognitive load affects duration judgments: A meta-analytic review. *Acta Psychologica, 134*(3), 330–343. <https://doi.org/10.1016/j.actpsy.2010.03.006>
- Block, R. A., & Zakay, D. (1997). Prospective and retrospective duration judgments: A meta-analytic review. *Psychonomic Bulletin and Review, 4*(2), 184–197. <https://doi.org/10.3758/BF03209393>
- Bouton, M. E. (1993). Context, time, and memory retrieval in the interference paradigms of Pavlovian learning. In *Psychological Bulletin* (Vol. 114, Issue 1, pp. 80–99). <https://doi.org/10.1037//0033-2909.114.1.80>

- Brown, S. W., & Stubbs, D. A. (1992). Attention and interference in prospective and retrospective timing. *Perception*, *21*(4), 545–557. <https://doi.org/10.1068/p210545>
- Brown, S. W. (1997). Attentional resources in timing: Interference effects in concurrent temporal and nontemporal working memory tasks. *Perception and Psychophysics*, *59*(7), 1118–1140. <https://doi.org/10.3758/BF03205526>
- Dumas-Mallet, E., Button, K. S., Boraud, T., Gonon, F., & Munafò, M. R. (2017). Low statistical power in biomedical science: A review of three human research domains. *Royal Society Open Science*, *4*(2). <https://doi.org/10.1098/rsos.160254>
- Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, *59*, 255–278. <https://doi.org/10.1146/annurev.psych.59.103006.093629>
- Fraisse, P. (1929). Perception and. *Environment*, 1–12.
- François, M. (1927). VI. Contribution à l'étude du sens du Temps. La température interne comme facteur de variation de l'appréciation subjective des durées. *L'année Psychologique*, *28*(1), 186–204. <https://doi.org/10.3406/psy.1927.6412>
- Furnham, A., & Boo, H. C. (2011). A literature review of the anchoring effect. *Journal of Socio-Economics*, *40*(1), 35–42. <https://doi.org/10.1016/j.socec.2010.10.008>
- Gilovich, T., Griffin, D., & Kahneman, D. (Eds.). (2002). *Heuristics and biases: the psychology of intuitive judgment*. Cambridge University Press.

Grondin, S., & Plourde, M. (2007). Judging multi-minute intervals retrospectively. *Quarterly Journal of Experimental Psychology*, *60*(9), 1303–1312.

<https://doi.org/10.1080/17470210600988976>

Grondin, S. (Ed.). (2008). *Psychology of time*. Emerald Group Publishing.

Hicks, R. E., Miller, G. W., & Kinsbourne, M. (1976). Prospective and Retrospective

Judgments of Time as a Function of Amount of Information Processed Author ( s ):

Robert E . Hicks , George W . Miller and Marcel Kinsbourne Published by : University of Illinois Press Stable URL : <https://www.jstor.org/stable>. *The American Journal of Psychology*, *89*(4), 719–730.

Hoagland, H. (1933). The physiological control of judgments of duration: Evidence for a chemical clock. *Journal of General Psychology*, *9*(2), 267–287.

<https://doi.org/10.1080/00221309.1933.9920937>

Hunston, S., & Francis, G. (2000). *Pattern grammar: A corpus-driven approach to the lexical grammar of English* (Vol. 4). John Benjamins Publishing.

Kahneman, D. (2011). *Thinking, fast and slow*. Macmillan.

Kinoshita, S. (2000). The left-to-right nature of the masked. *Psychological Bulletin*, *7*(I), 133–141.

König, C. J. (2005). Anchors distort estimates of expected duration. *Psychological Reports*, *96*(2), 253–256. <https://doi.org/10.2466/PR0.96.2.253-256>

- Krantz, J. H., & Dalal, R. (2000). Validity of Web-based psychological research. In *Psychological experiments on the Internet* (pp. 35-60). Academic Press.
- Lambert, S. (2020, November 13). Basic Tetris HTML Game. Retrieved December 14, 2020, from <https://gist.github.com/straker/3c98304f8a6a9174efd8292800891ea1#file-tetris-html>
- Michon, J. A. (1972). Processing of Temporal Information and the Cognitive Theory of Time Experience. *The Study of Time*, 242–258. [https://doi.org/10.1007/978-3-642-65387-2\\_17](https://doi.org/10.1007/978-3-642-65387-2_17)
- Murai, Y., & Yotsumoto, Y. (2016). Timescale- and sensory modality-dependency of the central tendency of time perception. *PLoS ONE*, 11(7), 1–16. <https://doi.org/10.1371/journal.pone.0158921>
- Prasad, N. R. (2021). Perception and reality. *Studies in Computational Intelligence*, 892(16), 193–218. [https://doi.org/10.1007/978-3-030-45619-1\\_15](https://doi.org/10.1007/978-3-030-45619-1_15)
- Psychology Today. (2009, March 23). *Fear and the Availability Heuristic*. Retrieved January 07, 2021, from [https://www.schneier.com/blog/archives/2009/03/fear\\_and\\_the\\_av.html](https://www.schneier.com/blog/archives/2009/03/fear_and_the_av.html)
- Qualtrics XM - Experience Management Software. (2020, June 11). Retrieved June 14, 2020, from <https://www.qualtrics.com/>
- Roy, M. M., Burns, T., & Radzevick, J. R. (2019). Unpacking, summing and anchoring in retrospective time estimation. *Acta Psychologica*, 192, 153–162. <https://doi.org/10.1016/j.actpsy.2018.11.012>

Roy, M. M., & Christenfeld, N. J. S. (2008). Effect of task length on remembered and predicted duration. *Psychonomic Bulletin and Review*, *15*(1), 202–207.

<https://doi.org/10.3758/PBR.15.1.202>

Stanovich, K. E. (2018). Miserliness in human cognition: the interaction of detection, override and mindware. *Thinking and Reasoning*, *24*(4), 423–444.

<https://doi.org/10.1080/13546783.2018.1459314>

Strack, F., & Mussweiler, T. (1997). Explaining the enigmatic anchoring effect: Mechanisms of selective accessibility. *Journal of Personality and Social Psychology*, *73*(3), 437–446.

<https://doi.org/10.1037//0022-3514.73.3.437>

Thomas, K. E., & Handley, S. J. (2008). Anchoring in time estimation. *Acta Psychologica*, *127*(1), 24–29. <https://doi.org/10.1016/j.actpsy.2006.12.004>

Thomas, K. E., Newstead, S. E., & Handley, S. J. (2003). Exploring the time prediction process: The effects of task experience and complexity on prediction accuracy. *Applied Cognitive Psychology*, *17*(6), 655–673. <https://doi.org/10.1002/acp.893>

Tobin, S., Bisson, N., & Grondin, S. (2010). An ecological approach to prospective and retrospective timing of long durations: A study involving gamers. *PLoS ONE*, *5*(2), 16–18. <https://doi.org/10.1371/journal.pone.0009271>

Tobin, S., & Grondin, S. (2009). Video games and the perception of very long durations by adolescents. *Computers in Human Behavior*, *25*(2), 554–559.

<https://doi.org/10.1016/j.chb.2008.12.002>

Townson, C. (2019). *The Anchoring Effect: A Meta-Analysis*. Michigan State University.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases.

*American Association for the Advancement of Science*, 185(4157), 1124–1131.

<https://doi.org/10.4324/9781912282562>

Vierordt, K. (1868). *Der Zeitsinn nach Versuchen*. H. Laupp.

Wearden, J. (2016). The psychology of time perception. In *The Psychology of Time Perception*.

<https://doi.org/10.1057/978-1-137-40883-9>

Woodrow, H. (1951). Time perception. In S. S. Stevens (Ed.), *Handbook of experimental psychology* (pp. 1224-1236). New York: Wiley.

Yarmey, A. D. (1999). *Yarmey-Retrospective*. 57(November 1998), 13.

<papers3://publication/uuid/54938EF3-C97C-43E9-97CB-8D4CAB1CEE23>

## Appendix A: Consent Form



### Consent Form

**Title:** Explicit Anchoring Effects on Duration Estimates

CUREB-B Clearance # -----

**Date of ethics clearance:**

**Ethics Clearance for the Collection of Data Expires:**

I \_\_\_\_\_, choose to participate in an experiment about prospective duration estimates. This study aims to measure how you perceive the length of different durations while you engage in a video game session. The researcher for this study is **Mohammed Aswad** in the Department of Psychology at Carleton University. He is working under the supervision of **Dr. Guy Lacroix** in the Department of Psychology at Carleton University.

---

#### Description of Study

In this experiment, you will be asked to play a Tetris video game session for a randomly selected amount of time. You will then be asked to provide a duration estimate for that session. This is a computer task that can vary in the amount of time it takes to complete, however the full experiment will not exceed 15 minutes.

#### Duration of study and Compensation

The experiment can range from a few seconds up to 15 minutes. Regardless of how long the experiment takes to complete, you will be compensated with 0.5% toward your course credit.

#### Risks and Discomfort

There are no potential physical or psychological risks associated with participation in this experiment.

#### Anonymity

All data collected in this experiment will be kept strictly confidential through the assignment of a coded number. The information provided will be used for research purposes only and you will not be identified by name in any reports produced from this study.

#### Data Storage

Anonymous data will be kept for 5 years and stored on a password protected computer. Only researchers involved in this study will have access to the data, however anonymous data may be made available to third parties for research purposes. Anonymized data will be used in a master's thesis defence presentation and may be used in future publications.

#### Right to withdraw

You have the right to withdraw your data at any time during the experiment or immediately after the experiment. You may do so for any reason and without academic penalty. Your participation in this study is completely voluntary. Should you choose to withdraw from the study, all information you have provided will be immediately destroyed. You will receive compensation for your participation in this study even if you choose to withdraw.

**Study Results**

If you would like a copy of the finished research project, you are invited to contact the researcher to request an electronic copy which will be provided to you.

**CUREB contact information:**

Should you have any ethical concerns with the study, please contact Dr. Bernadette Campbell, Chair, Carleton University Research Ethics Board-B (by phone: 613-520-2600 ext. 4085 or by email: [ethics@carleton.ca](mailto:ethics@carleton.ca)). For all other questions about the study, please contact the researchers.

**Researcher contact information:**

Mohammed Aswad  
Department of Psychology  
Carleton University  
Email: [mohammedaswad@email.carleton.ca](mailto:mohammedaswad@email.carleton.ca)

**Supervisor contact information:**

Guy Lacroix  
Department of Psychology  
Carleton University  
Email: [guy.lacroix@carleton.ca](mailto:guy.lacroix@carleton.ca)  
Tel: 613-520-2600, ext. 1541

---

Signature of participant

---

Date

---

Signature of researcher

---

Date

## **Appendix B: Debriefing Form**

### **Explicit Anchoring Effects on Duration Estimates**

#### **What are we trying to learn in this research?**

The proposed experiment aims to investigate the effects of explicit anchors on duration estimates. The main question that we attempted to answer was “What would happen to your duration estimate if we provided you with a false value for the duration

#### **What are our hypotheses and predictions?**

First, we are expecting the longer durations to be underestimated and the shorter durations to be overestimated on average (Woodrow, 1951). Second, the duration of the game session is expected to be underestimated if we give the participants a false duration that is shorter (i.e short anchor) than the real duration. Furthermore, we expect the opposite effect to happen if we give participants a false duration that is longer (i.e long anchor) than the real one (Konig, 2005). Third, I expect to find a positive linear trend in the duration estimates which corresponds to the anchor condition used. That is to say, participants will underestimate the task when given a short explicit anchor, show no bias when given no anchor, and overestimate the task when giving a long anchor. Finally, I expect shorter durations to be more variable in general. This is because even small

#### **Why is this important to scientists or the general public?**

Practical and ethical requirements force researchers to schedule participants for their studies. They must therefore provide a start time and an approximate duration for the experimental session. The research in this paper assesses whether this requirement maybe threatening the validity of time perception research. This is because the durations supplied at the beginning of the experiment might be creating an anchoring effect (i.e., the participants’ estimates may be

biased in the direction of the provided duration) (Konig, 2005). Thus, the goal of this thesis will be to investigate this issue

### **Where can I learn more?**

To learn more about general anchoring effects, check out the classic paper by Tversky, A., & Kahneman, D. (1974). To learn more about how these anchoring effects could impact duration estimates, check out Konig, C. J. (2005). Finally, to learn more about time estimation in general, check the book “*Psychology of time*” by Grondin, S. (2008).

Grondin, S. (2008). *Psychology of time*. Oxford: Elsevier Science.

Konig, C. J. (2005). ANCHORS DISTORT ESTIMATES OF EXPECTED DURATION 'x'. In  
O Psychological Reports (Vol. 96).

Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. In  
Source: Science, New Series (Vol. 185, Issue 4157).

### **What if I have questions later?**

If you have any questions concerning this research, please contact Mohammed Aswad ([mohammedaswad@cmail.carleton.ca](mailto:mohammedaswad@cmail.carleton.ca)) or Dr. Guy Lacroix ([guy.lacroix@carleton.ca](mailto:guy.lacroix@carleton.ca)).

Should you have any ethical concerns with the study, please contact Dr. Bernadette Campbell, Chair, Carleton University Research Ethics Board-B (by phone: 613-520-2600 ext. 4085 or by email: [ethics@carleton.ca](mailto:ethics@carleton.ca)). For all other questions about the study, please contact the researchers.

This study has received clearance by the Carleton University Research Ethics Board B, CUREB-B (Clearance # -----).

Thank you for participating in this research. Your time and effort are greatly appreciated!

**Appendix C: Data Cleaning and descriptive statistics****Table 5***Outlier Participant Responses Removed*

Measure	Count	ID
Estimate	25	128299, 129713, 123603, 128210, 115121, 128481, 125896, 124548, 129075, 130808, 128524, 128250, 127430, 114521, 131236, 129822, 130667, 107735, 131268, 113306, 107883, 126766, 119551, 129220, 128515
RATIO	26	128299, 123603, 129713, 129858, 128210, 115121, 128481, 125896, 124548, 129075, 128524, 130808, 128250, 127430, 114521, 131236, 129822, 130667, 107735, 131268, 113306, 119551, 107883, 126766, 129220, 128515
ASE	26	128299, 123603, 129713, 128210, 115121, 124548, 129075, 128524, 130808, 129363, 128250, 127430, 114521, 117217, 131533, 131236, 129822, 130667, 128909, 123665, 131497, 109603, 107735, 131268, 113306, 107883
WF	31	116346, 124363, 127360, 126980, 113634, 131521, 128299, 125179, 129858, 130772, 128263, 128210, 130808, 126745, 117052, 128250, 128464, 131161, 130310, 114521, 130667, 121053, 122873, 117061, 118659, 123958, 128515, 126766, 128457, 131374, 128613

Note. WF was additionally filtered using the following conditions:

- 1) Maximum  $\geq$  Minimum, Maximum  $\geq$  Estimate, Minimum  $\leq$  Estimate
- 2) An additional 86 participants were removed from WF for a total of 117 responses