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Time Perception during Retrospective and Prospective Paradigms with a Distraction

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TIME PERCEPTION DURING
RETROSPECTIVE AND PROSPECTIVE PARADIGMS WITH A DISTRACTION

by

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B.A., College of William and Mary, 2002

A Thesis Submitted to the
Department of Human Factors and Systems
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Human Factors and Systems

Embry-Riddle Aeronautical University
Daytona Beach, Florida
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This thesis was prepared under the direction of the candidate's Thesis Committee Chair, Dr. Shawn Doherty, Associate Professor, Daytona Campus, Dr. Dahai Liu, Associate Professor, Daytona Campus, and Dr. Ashley Lear, Assistant Professor, Daytona Campus, and has been approved by the Thesis Committee. It was submitted to the Department of Human Factors & Systems in the College of Arts and Sciences in partial fulfillment of the requirements for the degree of Master of Science in Human Factors & Systems.

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Abstract

Time duration estimates can play an intricate part of one's daily life. This study examined the time duration judgments in two paradigms, when participants were aware they were being timed (prospective) and when they were unaware they were being timed (retrospective). Furthermore, this study investigated the effect of an external stimulus, when an auditory stimulus was used, to determine the effect, if any, between both of these paradigms. To ensure the participants were engaged in a task, a simulation was used that required several tasks to be completed. To ensure the participants were engaged in the simulation, the performance of the primary was measured.

For this between-subject, fully factorial experiment, 60 participants were engaged in a simulation and placed in one of the four conditions: retrospective paradigm without a distraction, retrospective paradigm with an auditory distraction, prospective paradigm without a distraction, and prospective paradigm with the same auditory distraction. During the experiment, participants were required to perform one primary and three secondary tasks and at the end of the simulation produced a time duration judgment of the length of the experiment.

This study examined both the accuracy of the time duration judgment and the performance of the primary task. The only significant finding for this study showed the importance of how a simple auditory distraction has the ability to distort the time perceived. Data indicated that auditory distraction increases the time duration judgments recalled after performing a task.

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Introduction

It is a common experience that the perception of time is complex. Whether a person is participating in a sport, studying for a test, or even sitting in an air traffic control tower managing air traffic, understanding time in relation to the task is critical in the effectiveness and efficiency of completing and managing the assigned task. For example, Mellor (2002) describes attending a lecture that is of no interest to a student as time that is perceived as occurring slower than it actually is. When humans experience stress, like a car accident, time also slows down. Csikszentmihalyi (1997) provides an explanation of this when he states that when an individual is in a state of 'flow,' or in a situation where an outcome of the activity is transparent, instant feedback is provided on performance, there is a balance between ability to complete the activity and challenge, and attention is entirely focused on the task at hand, time is perceived to pass a lot more quickly. So, generally time is perceived to slow down when engaged in tasks.

Furthermore, time is also perceived and affected virtually through the use of technology. For instance, time perception and estimation is also influenced in human-machine interactions (HMI). Dzaack, Trósterer, Pape, & Urbas (2007) states that in HMI, time perception is altered through multitasking and decision-making processes, in addition to system malfunctions. Time perception exists and is altered by a delayed reaction in human-computer-network interactions (HCNIs). Caldwell and Wang (2010) support this when they write, "Caldwell and Paradkar (1995) report that user, task, and context factors (e.g., user expectations, amount of information, degree of emergency, sender-receiver distance, and frequency of network use), and not simply network capacity

factors, could significantly influence users' tolerance of HCNI delays" (p. 815). So, human-computer interactions create a delay in time perception.

The under- and over-estimations of time perception are investigated through cognitive modeling methods. Dzaack, et al. (2007) state that through cognitive modeling, or a quantitative method for studying the relationship between human cognitive processes, time is perceived through different duration estimation methods in HMI. Thus, explanations of why there are time delays or advancements are found through several approaches.

Time Perception

There have been many multiple forms of time perception that have been identified in the experimental literature. The first approach to examining time perception involves internal judgments of time. Block, Zakay, and Hancock (1999) state that the assessment of a duration occurrence from internal references is generally referred to as a reference memory. Reference memory is typically represented through four methods: the verbal estimation method, the method of production, the method of repeated production, or reproduction, and the method of comparison. "In the method of verbal estimation, a person uses such a numerical label to judge a past duration (e.g., 'estimate the length of that duration in seconds')" (Block, et al., 1999, p. 186). Hence, this type of reference memory describes when participants state a numerical amount of time, as they perceive it passing. Therefore, this form of time perception is based on internal judgments of passage of time and was the method used in the study.

Time is also internalized through the method of production. “In the method of production a person delimits an objectively measured duration corresponding to a subjectively defined time duration (e.g., “say *start*, then say *stop*, when it seems like 60 s [seconds] has elapsed”) (Block, et al., 1999, p. 186). Druyan, Dani, & Hadadi (1995) state that the difference between the method of verbal estimation and method of production is who determines when ‘start’ and ‘stop’ are initiated. In the method of verbal estimation the experimenter states when ‘start’ and ‘stop’ occur, then the participant provides a duration estimate, whereas in the method of production, the participant will state ‘start’ and ‘stop’ and provide a duration judgment (Druayan et al., 1995). Therefore, the method of verbal estimation and the method of production differ only by who initiates the time duration sequence.

The next duration judgment is the method of repeated production, or reproduction method. Block, et al. (1999) state, “In the method of repeated production, a person delimits consecutive objectively measured durations of requested length, usually 1 s (e.g., ‘press this button every 1 s until I tell you to stop’)” (p. 186). Like the method of verbal estimation, the experimenter initiates the sequence, however, this method is like the method of production where the participant determines the duration of the specified time period (Druayan et al., 1995). Thus, the method of reproduction incorporates characteristics of the methods of verbal estimation and production.

The method of comparison is the last method of reference memory. “In the method of comparison, the experimenter delimits two durations, and the subject estimates them by comparing the two” (Druayan et al., 1995, p. 711). So, the experimenter has complete control over the experiment, and the participant is forced to draw their time

duration judgments based on information presented by the experimenter. The method of comparison is similar to the method of verbal estimation because the experimenter has control over when the experiment begins and ends. The method of comparison is also like the method of reproduction because the participant interprets their duration judgment from the parameters set by the experimenter. However, regardless of which method is employed, time distortions may occur, as seen in the following two experiments.

The first reference memory experiment is the Libet et al. (1983) experiment (as cited in Haggard, 1999). In the experiment by Libet et al. (1983), participants were asked to watch a clock hand rotate every 2.56 s, and then the participants were requested to indicate the position of the clock hand. After recording the clock position, the clock continued to turn for another arbitrary period of time. The participants were again requested to either record the exact or estimated clock hand position (Haggard, 1999). The results indicated that the participants judged the time that passed during a task as shorter than what actually occurred. This reflects the verbal estimation of time perception and because time is perceived shorter, there is also time distortion. This illustrates that in verbal estimation experiments, time can be distorted.

Another example of reference memory methods is when Haggard (1999) replicated Libet et al.'s experiment. Haggard (1999) subjected seven right-handed, 20 to 40 year old participants to three conditions measuring perceived time of actions: the "Libet condition," the "wheel judgement condition," and the "wheel return condition." The "Libet condition," correlated with Libet et al.'s experiment where participants sat in front of a computer with a clock face, with intervals of 5 s marked 0 to 60 s, for a period of 4000 milliseconds (ms). The participants were tasked to initiate, at their leisure, the

clock by pressing down on a key on the computer's keyboard. There was an approximate 1.2 to 2.5 s delay after the key was released in which the clock actually stopped. The participants were then prompted by the computer to enter the time that had passed, at which point the key was pressed and released. The participants were also asked to rate, between 0 and 7 s, the position of the clock based on the time that they felt had passed.

In the wheel judgment and wheel return cases, Haggard (1999) used a car steering wheel, in which a handle was attached to a revolving arm that was 11.5 centimeters (cm) from the center. Like the clock used in the first condition, the device was marked 0 to 60 s in five-minute (min) intervals. Participants were required to rotate the device for a period of 2560 ms. A pressure key was provided in the handle to begin and end the trial and participants were able to control when to press the key whenever they were ready to begin. Haggard (1999) writes that in the wheel judgment trial, participants were told to continue for at least another half rotation of the wheel after releasing the pressure key and used a scale under the wheel to report the location of the handle in minutes where they let go of the handle after the pressure key was released. For the wheel return condition, Haggard (1999) had the participants also continue through another half rotation, after releasing the pressure key, but they then stopped rotation completely and relocated the handle back to where they released the pressure key for 500 ms. Participants then provided feedback on their accuracy of placing the handle back when they let the pressure key go.

Looking back, the results of the participant's feedback in Haggard's (1999) experiment showed similar results to Libet et al.'s (1983) experiment in that the participants in both experiments perceived time occurring faster than it actually did

when pertaining to the anticipatory awareness of one's action. This notion is supported by the "Libet condition," the "wheel judgement condition," and the "wheel return condition" where they produce similar numerical and statistical data to Libet et al.'s (1983) experiment (Haggard, 1999). Haggard's (1999) experiment also confirms that distortion in time perception occurs in reference memory situations when using the method of production. By being fed information during the experiment, the participants still lost track of time, therefore, creating time distortion. Hence, these experiments illuminate time distortion using methods of reference memory.

Unlike reference memory, or perceiving time through internal factors, time may also be perceived through external factors. Hancock and Weaver (2005) state that contributing factors of temporal distortions of perceived time from the external environment can include stressful conditions and dramatic differences in perceived environments based on an individual's ability to survive. Thus, time perception based on external information is based on survival and competition queues within an individual's exterior environment.

There are several examples of how the external environment distorts time perception. Hancock and Weaver (2005) describe a survey conducted by Fair where 28 pilots experienced an ejection from their aircraft (Fair, 1984, as cited in Hancock and Weaver, 2005). The pilots were asked time distortion questions related to their experience, in which their survey reported 75% of the pilots reported time distortion, 18% reported that they did not experience time distortion, and 7% were unsure if time distortion occurred. In this particular life-threatening situation, three-fourths of the pilots noted experiencing time distortion. Furthermore, Fair's survey indicated that of the 82%

of pilots that either experienced or were uncertain if they experienced a temporal distortion, 64% noted that they felt like time slowed down, whereas, 18% reported that time appeared to speed up (Hancock and Weaver, 2005). Based on this survey, the majority of pilots experienced time slowing when encountering an external situation.

Another example of how the external perception of time creates distortion is described in Watts and Sharrock's (1984) phobia experiment (as cited in Hancock and Weaver, 2005). The experiment consisted of 35 participants with a fear of spiders. Each participant was placed next to a 3-centimeter spider that was confined to a transparent container for 45 seconds. Watts and Sharrock (1984) conducted two trials in which each participant was requested to report how much time passed. In both trials, when compared with controls, the participants' reported time indicated that fear shortens estimated lapsed time.

Conclusively, another reason behind the distortion of perception of time is distraction or the disruption in the flow of a task. Horváth and Winkler (2010) write, "Distraction is an involuntary attentional change triggered by events which are irrelevant with respect to the current behavior. Whereas, distraction has often adverse effects on the immediate task performance, it may be crucial in many situations where behavioral goals have to be changed to adaptively follow situational changes" (p. 229). Therefore, distractions slow down one's ability to perform because the mind is acclimating to the new stimulus that is not central to the task at hand.

Horváth and Winkler (2010) investigated auditory distraction in a task. The researchers conducted an experiment using 24 paid participants, which were broken down into two groups, 'active' and 'passive.' Both groups were predominately right-handed

females between the ages of 19 to 25 years old. In the ‘active’ experiment, two different conditions were used, a ‘discrimination’ and ‘detection’ condition. The ‘discrimination’ condition subjected the participants to four different tones consisting of long and short tones with varying harmonies. The participants were directed to press a button with their strongest hand for the long tones only. In the ‘detection’ condition, there was a continuous tone added to the same four tones in the ‘discrimination’ condition. In the ‘detection’ condition, the participants were told to press the button with the same hand when they heard a ‘gap’ in the continuous stream of sound. The participants in the ‘passive’ experiment were instructed to watch a silent movie and ignore any auditory noise. Variance due to the many diverse types of trials conducted within a given task provided inconclusive results for the ‘discrimination’ condition. However, when applying an auditory distraction in a ‘same task-related’ condition, as in the ‘detection’ condition, the participants responded slower and had a more difficult time determining the gaps following an inconsistent glide or transition of tones.

Furthermore, the results of the ‘passive’ experiment indicate distractions exist when adding an auditory stimulation to any situation. In the ‘passive’ experiment, participants still responded to the auditory stimulation despite being told to ignore any auditory stimulation. Horváth and Winkler (2010) state, “This result confirms that attention-change in distraction is actually a switch from a task-relevant to a task-irrelevant aspect of the stimulation (i.e., switching attention from watching the movie to the sound; see also Horváth et al., 2008b)” (p. 237). Therefore, distractions cause a break in performance where attention is shifted from one task to another.

Retrospective versus Prospective Paradigms

Whereas time is perceived in internal and external environments, time distortion may be influenced through two paradigms involving time perception. The first paradigm is when a participant is either unaware they are being timed or there is no time keeping device, in which they have to perceive time based on the mental record of the task given. The second paradigm is where they are aware of a clocking device and intentionally keep track of the time. These two paradigms are referred to as retrospective paradigms and prospective paradigms.

Time in retrospective paradigms involves a participant experiencing an untimed task and therefore reconstructing time perceived from memories, or through internal time perceptions. Block, et al. (1999) continue to support this notion with their term *retrospective paradigm*, or the *remembered duration*, when duration of time is estimated based on memories. So, a participant's awareness of being timed or not, determines how time is perceived by the individual. This is important when creating a distraction within an experiment. When the participants are aware that their tasks are clocked, they are more engaged in the time passing versus performing the task.

Unlike retrospective judgments, time in prospective tasks is constantly monitored because participants know that time is recorded and make a conscious effort to be in tune with the time passing (Mangels and Ivrey, 2001). Block, et al. (1999) coin this phenomenon a *prospective paradigm*, or *experienced duration*, and argue this phenomenon occurs in situations when the individual is conscious of himself or herself and his or her surroundings during a period of time, and the duration is based on the

amount of attention an individual gives to receive time perceived. So, in a prospective paradigm, participants are aware their tasks are being timed.

When comparing retrospective tasks and prospective tasks side by side, they are fundamentally different but share similar characteristics. For example, Brown & Stubbs (1992) mention both prospective and retrospective timing judgments share factors: disruption from the demands of untimed tasks; experience an increase from a rise in physical duration; the order in which the stimulus duration occurs; and certain factors involving stimulus context affect. Thus, both prospective paradigms and retrospective paradigms have similarities but also differences.

The general difference between retrospective and prospective paradigms is how time duration judgments are made between the two paradigms. For instance, retrospective paradigms, or retrospective judgments, are based on the degree of difficulty a stimulus requires to process. As the stimulation increases or becomes difficult to comprehend, time perception is interpreted as a shorter interval. “Retrospective duration judgments are selectively affected only by stimulus complexity and stimulus duration. Greater stimulus complexity leads to increased remembered duration (Ornstein, 1969)” (Klapproth, 2007, p. 750). Thus, as the amount of stimuli increases in complex tasks, retrospective durations are affected by perceiving time as a shorter interval. However, when the task load, or cognitive load, increases, the time perceived increases. “In the retrospective paradigm, the duration judgment ratio increases under high-load conditions relative to low-load conditions” (Block, Hancock, & Zakay, 2010, p. 339). Thus, increasing external stimuli decreases time judgment durations; whereas, intensifying cognitive loads increases time duration judgments in the retrospective paradigm.

Specifically, time distortion exists within a retrospective paradigm where both visual and auditory stimuli affect the time duration estimate. Klapproth (2007) writes, “There is some evidence that predominately those stimuli were retrospectively overestimated that were presented within the auditory modality (e.g., Brown & Stubbs, 1998, 1992; Zakay, Tsal Moses, & Scahar, 1994), whereas visually displayed stimuli were rather underestimated in the retrospective paradigm (e.g., Hicks, *et al.*, 1976; Block, 1992; Buena Martinez, 1992; Hicks, 1992)” (p. 752). So, an auditory stimulus has the ability to increase perceived time duration; whereas, visual stimuli can decrease it.

Prospective paradigms are different from retrospective paradigms because they are generally overestimated and closer to the actual time than retrospective paradigms. Block and Zakay’s (1997) meta-analysis found that most prospective judgments of time were greater by 16% more than in retrospective judgment tasks (as cited in Klapproth, 2007). So, in a prospective paradigm, time is typically perceived longer than in a retrospective paradigm.

Furthermore, in prospective paradigms, when participants are required to process elaborate information in a task, time duration is perceived even longer. Klapproth (2007) explains, “One variable which is supposed to influence prospective judgment only is processing difficulty. As processing difficulty increases, experienced duration increases (Hicks, Miller, & Kinsbourne, 1976; Block, 1992)” (p. 749). Therefore, not only is time perceived longer under normal prospective paradigm conditions, but also time perception increases more when the level of information difficulty increases.

However, when involved in a task, time in a prospective paradigm is generally perceived shorter. Kladopoulos, Hemmes, and Brown (2004) write, “Under prospective

temporal judgment procedures, time estimates are shorter when participants were engaged in a concurrent task during presentation of a temporal stimulus, than when not engaged in a task (for a review, see Brown, 1997)” (p. 221). Moreover, in a prospective paradigm, when task-load increases the duration judgment becomes even shorter. Block, et al. (2010) state, “In the prospective paradigm, the duration judgment ratio (i.e. the ratio of subjective duration to objective duration) decreases under high-load conditions relative to low-load conditions” (p. 339). Thus, a prospective paradigm is going to produce a more concise time duration judgment when involved in a task. So, time perception is affected differently in retrospective and prospective paradigms when examining the level of task difficulty and task load.

The retrospective and prospective paradigm principles are illuminated in two separate experiments. The first experiment shows how visual and auditory stimuli affect time estimation judgments. The Ortega, Lopez, and Church’s (2009) experiment used four types of stimuli, two visual stimuli and two auditory stimuli, to show how these variables affect time estimation judgments. The visual stimuli consisted of gray circles 4.5 centimeters (cm) in diameter in the middle of the computer screen, where one remained immobile and the other flickered at a 10 hertz (Hz) rate that changed between 50 milliseconds (ms) of gray and 50 ms of white background (Ortega, et al., 2009). Like the visual stimuli, the auditory stimuli also had a fixed and an alternating variable. The static auditory stimuli was set at 500 Hz and the fluctuating stimuli was arranged to play continuously at 500 Hz, alternated between 50 ms of clicks, and then ceased for 50 ms (Ortega, et al., 2009). Thus, for the intermittent condition, time was arranged at 50 ms for consistency. Furthermore, Ortega, et al. (2009) defined the duration of the

experiment a short duration of 200 ms, a long duration of 800 ms, and five in-between durations set every 100 ms. Based on these conditions, the time duration judgments support time distortion within a retrospective paradigm.

The results support that when comparing the steady conditions of both the audio and visual stimuli the duration judgment was underestimated for the visual stimulus and overestimated for the audio stimulus. Ortega, et al. (2009) write that they found the steady visual reflected the shortest duration judgments of all the conditions, whereas the blinking visual stimulus resulted in the longest duration judgments, and although both audio stimuli showed no difference between time duration judgments, they still produced a longer time duration judgment than the constant visual stimulus. The result of the two audio stimuli indicates that the intermittent audio stimuli produce no effect on time duration judgments (Ortega et al., 2009). Thus, in a study, either a continual or discontinuous audio condition can be used without producing an opposite time duration effect. Furthermore, a blinking visual stimulus will produce a longer time duration judgment, and a steady visual stimulus will produce a shorter time duration judgment.

Another example is the Boltz's (2005) multi-stimuli experiment that was conducted in both prospective and retrospective paradigms. Boltz (2005) tested three stimuli in four and eight learning trials: an auditory, a visual, and an audiovisual. The auditory stimulus was a sound played while the participant viewed a blank screen, the visual stimulus was a videotape of people performing various activities that rotated every 7.4 – 10.5 s without the auditory stimulus, and the audiovisual stimulus combined the same audio and visual stimuli in the same condition (Boltz, 2005).

The results from this experiment reiterate several things. First, prospective paradigms produce shorter, but overestimated judgment durations. Boltz's results for both the four and eight learning trials conditions showed the prospective paradigm to report shorter over- and underestimated time duration judgments for all stimuli (2005). Boltz (2005) also states that the prospective paradigm produced a mean error of 4% and a mean error of 14% for the retrospective paradigm. Thus, a prospective paradigm design is more accurate than a retrospective paradigm.

Secondly, participants in the longer trials produce more accurate judgment durations. According to Boltz's experiment, both paradigms experienced overestimations of time duration judgments for the four trials condition and underestimations of time duration judgments for the eight trials condition; however, the overestimations in the four learning trials were greater (2005). Boltz (2005) writes that there is a mean error of 4% for the eight learning trial and a mean error of 9% for the four learning trials condition. Thus, time durations in the eight learning trials are more precise.

However, these specific results suggest that the two learning trials have created a time judgment duration bias. In the Boltz (2005) experiment, the results show that all the four learning trials overestimated the time duration judgment, whereas the eight learning trials conditions were all underestimated, but deviated from the actual time duration the least. Boltz (2005) suggests that this reaction is a result of possible experimenter bias because of the significant differences between the two learning trials. Thus, it appears that a learning bias has been generated. Boltz (2005) states this is common especially in auditory stimuli conditions when she writes, "The finding is interesting because previous research has shown that auditory rhythms are acquired and

more easily reproduced than visual ones after fewer learning trials (Handel & Buffardi, 1968), leading one to expect an auditory advantage for remembered duration at earlier stages of learning” (p. 1372). Therefore, if a participant is exposed to an auditory condition repetitively, it will be easier for the participant to make a more consistent time duration judgment.

Finally, in retrospective and prospective paradigms, there is little or no effect due to the auditory, visual, or audiovisual stimuli. The results from Boltz’s (2005) experiment indicate little variation between any of the different stimuli. Boltz (2005) writes “The most important finding is that there were no significant effects due to event modality: The visual, auditory, and audiovisual presentations of the events yielded similar mean ratio scores of 1.03, 1.02, and 1.02, respectively” (p. 1371). Thus, little significance is shown between the different stimuli.

On the other hand, Boltz (2005) does mention that, “Several studies in literature have reported that auditory and audiovisual events are judged to be significantly longer than visual ones when duration estimates are observed in prospective situations (Goldstone & Goldfarb, 1964; Goldstone & Lhamon, 1998)” (p. 1372). So, an auditory stimulus alone and an auditory stimulus combined with another stimulus show significant results as a longer time duration judgment, particularly in a prospective paradigm. Therefore, despite Boltz’s (2005) insignificant results between the various stimuli, the possible bias in this experiment created in the multiple learning trials could have distorted the results that would have otherwise supported research where an auditory stimulus is significant.

Conclusively, time is perceived through two paradigms: the retrospective paradigm and the prospective paradigm. The retrospective paradigm is when participants are not informed before the experiment that their performance will be timed. Whereas, in a prospective paradigm, the participant is aware they are being timed. Each paradigm is affected by internal and external conditions that cause either under- or over-estimated duration judgments and determine their accuracy based on actual time durations.

Time Perception Models

Based on both the prospective and retrospective paradigm principles, researchers offer several models that offer both similar and different perspectives on time perception. There are four specific time perception models that illustrate the characteristics of either a prospective paradigm, a retrospective paradigm, or both. Ornstein's (1969) storage-size model is based on the notion that time perception is developed through the amount and the level of difficulty required to interpret information (Pedri and Hesketh, 1993). Pedri and Hesketh (1993) state that Ornstein's (1969) model suggests that as the information becomes more difficult to interpret the time duration is perceived to be longer. Because this model relies profoundly on the lack of temporal information and time duration, it correlates with the retrospective paradigm. Lejeune (1998) writes that because Ornstein's storage-model pertains to the retrospective method because this model pertains to task duration, in addition, participants are not unaware of time constraints. Thus, Ornstein's storage-size model represents an example of a retrospective paradigm.

Like Ornstein's model, Block's (1978) contextual change model revolves around the notion that time perception is based on the retrospective paradigm where the demand

of information and tasks is placed upon participants. Block's model suggests that when there is an increase in amount of stimuli changes, time estimation also increases (Pedri and Hesketh, 1993). So, the more stimuli are added to a task, a longer time period will have been perceived. Block, et al. (2010) state that this model focuses on the retrospective duration judgment idea that when there is an increase in cognitive loads, such as high-priority events, there is an increase on time duration judgment ratio. So, when judgments are based on tasks or stimuli, the Ornstein model indicates that there will be an increase in the time duration estimate in a retrospective paradigm.

The attentional-allocation model is a model that implies that time duration judgments are related to the amount of attention given to a task. The attentional-allocation model was developed by Thomas and Weaver (1975) and Hicks, et al. (1976) and suggests that if participants are solely focusing their attention on a task, then time is typically perceived as shorter and inaccurate (Pedri & Hesketh, 1993). Pedri & Hesketh (1993) continue by saying that the attentional-allocation model suggests that if attention is centered on time, the time duration judgment could be perceived as having a longer but more accurate time duration estimate (Pedri & Hesketh, 1993). So, if participants are engaged in a simultaneous task, like a retrospective paradigm, the duration judgment will be briefer and less precise, whereas, in a prospective paradigm, where time is the focus, the time duration judgment will be stretched and more correct to the true length of time.

A continuation of the attentional-allocation model is the Attentional-Gate Model (AGM) by Block & Zakay (1996). Block, et al. (2010) state that the AGM is like the attentional-allocation model in that the AGM is based on the premise that attention to time determines the paradigm; however, the AGM suggests there is a gate that records

attention focused solely on time during a certain task. Since this model focuses solely on time awareness, it portrays only characteristics of a prospective paradigm.

In conclusion, the process of how time is perceived is multifaceted. Time perception is not only affected by the basic levels of time duration paradigms, but time perception is also affected by the conditions within and surrounding those paradigms. Examples of studies and models illuminate how time duration judgments are constructed as a result of experimental design and contributing factors. Based on the research and past experiments, in a prospective paradigm a participant is more accurate with the time duration estimate, whereas in a retrospective paradigm a participant will be more accurate with a task.

Hypotheses

For this experiment, time judgments will be made after a target selection task is completed in either a retrospective or prospective paradigm with either the presence or absence of an auditory distractor, resulting in the following hypotheses:

Hypothesis 1:	The time duration judgment in a prospective paradigm will be perceived more accurately than in a retrospective paradigm.
Hypothesis 2:	The duration of judgment in a prospective paradigm will be an overestimation of the actual time while the retrospective paradigm will be an under estimation of the actual time.
Hypothesis 3:	When a distraction is added, the time duration judgment will be overestimated and less accurate than when no distraction is present.
Hypothesis 4:	When a distraction is added, the time duration judgment will be overestimated in both the retrospective and prospective paradigms, however the time duration judgment will be more accurate for the prospective paradigm.

- Hypothesis 5: Fewer errors will occur in the primary target selection task for the retrospective paradigm than in the prospective paradigm.
- Hypothesis 6: More errors will occur for the primary target selection task when a distraction is added compared to the no distraction condition.

Methods

Participants

For this study, 60 undergraduate and graduate students from Embry-Riddle Aeronautical University were recruited. The study consisted of male and female participants between the ages of 18 – 33, with an average age of 23, due to the sample population available at the experiment location. All participants were right-handed, and to ensure consistency, they used the mouse with their right-hand.

Participants were recruited both through volunteers and students from Human Factors courses. Those participants from courses who came and fully participated in the study were offered extra credit.

Apparatus

This study used two apparatuses. The first apparatus was the software, Multi-modal Immersive Intelligent Interface for Remote Operations (MIIRO). MIIRO, a human-computer interactive software developed by IA Tech with the assistance of the United States Air Force Research Laboratory (AFRL), was designed to provide an immersive interface that simulated the maneuvering of an Unmanned Aerial Vehicle (UAV) through obstacles (IA Tech, Inc., n.d.). Since the MIIRO was used for both prospective military tactics and in human factors experiments, the MIIRO software

showed formats and interface design that manipulated UAV simulations (Tso, Tharp, Tai, Draper, Calhoun, & Ruff, 2003).

MIIRO ran on a computer through Java in a web browser or an independent application (Tso, et al., 2003). MIIRO required the use of two monitors: the left monitor depicted the Tactical Situation Display (TSD), or a topographical representation of the simulated UAV environment, routes, targets, other aircraft, and the Mission Mode Indicators (MMI), and the right monitor portrayed the Image Management Display (IMD) (Jaramillo, Liu, Doherty, Archer, & Tang, 2012). Both monitor depictions are illustrated in Figure 1.

Figure 1. Illustration of the Tactical Simulation Display (TSD) and the Image Management Display (IMD)
Source: Jaramillo, et al., (2012)

MIIRO was set up in Autonomous Control mode, where all UAVs were flown corresponding to a consistent flight plan and tasks adhered to indicate locations in all experiments in order for all the participants to focus on the tasks presented during the simulation. For this experiment, the participant encountered four different tasks, one primary and three secondary. The primary task was the Image Queue (IQ) task located on the IMD and was set to appear every 10 seconds and allowed the participant 15 seconds to respond. The IMD displayed dark shaded tanks, or enemy tanks, and light shaded tanks, or ally tanks. For the Image Queue (IQ) task, participants were required to

select, with the mouse, all the enemy tanks. If an enemy tank was not selected or if an ally tank was selected by mistake, the attempt was considered incorrect and was recorded.

The first secondary task was the Mission Mode Indicator (MMI) events tasks. The MMI events were a display of green, yellow, and red lights on the top of the TSD screen. These lights arbitrarily changed from one color to the next. For each MMI event, when the yellow light illuminated, participants clicked anywhere on the display and a window appeared where the participant was required to enter the input number string correctly in order to reset the display back to green. Once the task launched, the participant had 10 seconds to respond for the low-task simulation. The MMI event is shown in Figure 2.

Figure 2: Illustration of the Mission Mode Indicator (MMI)
Source: IA Tech, Inc., (n.d.)

The next secondary task was the Ad-Hoc Targets or Popup Threats that appeared in a box on the screen. The participant was required to accept or reject the alternate route to avoid a threat. Ad-Hoc threats or Pop-up targets were set to appear randomly. The Ad-Hoc Target or Pop-up Threat is depicted in Figure 3.

Figure 3: Illustration of an Ad-Hoc Target or Pop-up Threat
Source: IA Tech, Inc., (n.d.)

The final secondary task for the simulation was the Unidentified Flying Object (UFO) Events. For the UFO Event task, the participant was provided a code before the experiment that appeared randomly. The UFO Event is depicted in Figure 4.

Figure 4: Illustration of a UFO Event
Source: IA Tech, Inc., (n.d.)

The clock on the monitor screen was covered by a piece of white tape to prevent the participants from viewing a clock. In addition to the two monitors and MIIRO software, a keyboard and mouse completed the operational software requirements for this apparatus.

The second apparatus was a Bluetooth[®] enabled device with a timer application that generated an intermittent (Morse code) sound that was projected through a generic

speaker system set at a Sound Pressure Level (SPL) of 60 decibels (dB) and was controlled through Bluetooth[®] technology. The speaker system was placed behind the MIIRO computer setup. Regarding the second apparatus, the timer application was set to present the intermittent noise for 10 seconds of noise at intervals of 3, 5, 6, and 9 minutes for the distraction group. These intervals were spaced accordingly to prevent the participants from associating the distraction with time. Furthermore, the intervals were placed randomly in the middle so the participant was not exposed to the distraction in the beginning or end. This allowed the participant three minutes to become immersed in the MIIRO simulation before being exposed to the distraction. Also, the last exposure of the distraction was not placed at the very end of the experiment to make sure the participant was still immersed in the MIIRO simulation towards the end of the experiment.

Design

This experiment consisted of a 2x2 between-subject, fully factorial design. The following were the independent and dependent variables for this experiment.

Independent variables: The first independent variable (I.V.) for this experiment were the time perception paradigms, retrospective (RP) and prospective (PP). The second I.V. was distraction, with distraction (WD) and without distraction (OD).

Dependent variables: The dependent variables (D.V.) for this experiment were the accuracy of the time duration and the performance of the primary image queue task. The performance on the primary task in the MIIRO software was captured to make

certain that participants were treating the task as the critical performance metric instead of ignoring the task and simply focusing on keeping track of time explicitly.

Procedure

The participants were divided into four conditions: retrospective paradigm without an auditory stimulus, retrospective paradigm with an auditory stimulus, prospective paradigm without an auditory stimulus, and prospective paradigm with an auditory stimulus. Prior to the actual experiment, participants were given several minutes for a training simulation that enabled them to familiarize themselves with the controls required to perform the task in the experiment. The training experiment included an example of an IQ task, MMI event, Ad-Hoc Target or Pop-up Threat, and UFO event. The participants were told to accept the Ad-Hoc Target or Pop-up Threat so the experiment was nine and a half minutes for everyone. The training experiment did not include the auditory stimulus. The data from the training experiment was saved; however, it was excluded from the rest of the data collected. The training simulation was directly followed by the recorded experiment.

The overall duration for each trial lasted approximately 30 minutes. This accounted for the set up time, several minutes for practice, the nine and a half-minute experiment, and time for each participant to complete their questionnaire. As each participant arrived, they were instructed to have a seat at the computer terminal. The participants were asked to turn off their cell phones and remove their watches, so the participant would be giving their undivided attention to the experiment. Prior to the experiment, the wall clock's battery was removed to prevent participants from receiving

time cues from the clock. The participant was handed a consent form and asked to read and sign it. The participants who were recruited from the Human Factors class were notified that extra credit would be received in return for participation. The participants were told that several minutes would be given to become acquainted with controls for the MIIRO software.

Once the consent form and briefing had been completed, the monitors were turned on. When the test period simulation began, the experimenter discreetly exited the participants' view behind the partition. After approximately 4 minutes, the experimenter returned and turned off the simulation. Following the practice simulation, the participant was advised that the real simulation was to begin and was asked to attempt to follow the simulation to the best of their ability. The UAV simulation was turned on, and the experimenter quietly exited the experiment area directly behind the partition. Once the experimenter was behind the partition, the timer application was started for the distraction groups only. After the completion of the simulation, each participant was tested for reference memory to rule out the possibility of exceptional time recall ability. Participants were given a command to "Start" followed by "Stop" 26 seconds later then asked to provide a time estimate of the interval. This post-experimental task was derived from the interpretation of Block et, al. (1999) description of testing reference memory based on the method of verbal estimation.

Upon the completion of the UAV simulation and reference memory task, the participant was handed a short questionnaire regarding task immersion, time perception, and time distortion. The participant was told to complete the questionnaire to the best of their ability. When the questionnaire was completed, the participant was thanked for

their participation in this experiment. The experimenter again provided contact information if the participant had any questions regarding their contribution to this study. The participant was then escorted to the laboratory exit.

In summary, this study used MIIRO, an unmanned aerial vehicle (UAV) simulation, to examine the effects on time perception and task performance in a human computer interaction (HMI) environment. The accuracy of the time judgment illuminated how time was distorted when performing a task. Time duration judgments were made in both retrospective and prospective paradigms where an auditory distraction was added or excluded to show how different situations affect time awareness and the difficulty of determining true time duration. A primary task performance through the MIIRO software was tested to ensure that participants were engaged in the task.

Results

Before the analysis was run, five out of the 60 participants were removed as outliers because the time duration judgment, reference memory judgment, or the performance for MIIRO's primary task fell outside two standard deviation beyond the group mean, a criterion decided prior to analysis. For example, one outlier was removed due to extreme underperformance of MIIRO's Image Queue task, or primary task. Specifically, all participants' accuracy for the MIIRO primary task was approximately 89% and this particular participant's accuracy was 26%. This is one example of the extremes of performance that were removed from the study. Thus, 8% of the total data was removed from the full set of data prior to the analysis. Once these outliers were removed, three separate analyses were conducted to fully examine the effects explored in

this experiment, one for the reference memory task, one for the time duration judgment, and one for the image queue task.

Reference Memory Task Analysis

To account for a possible variability, the post-experimental task was performed to account for reference memory. A two-way between-subject analysis of variance (ANOVA) was performed for the reference memory task. The results of the reference memory ANOVA indicated that there was no significance for neither the main effects or interaction between the main effects, where the effect of the paradigm on accuracy of the time duration judgments was $F(1,51) = 0.403, p = 0.529$, the main effect of the distraction was $F(1,51) = 2.894, p = 0.095$, and the interaction between the paradigms and the distraction conditions was $F(1,51) = 0.20, p = 0.888$. This suggests that there were no participants with an exceptional ability to recall time and this could be ruled out as a potential confound in the following analysis.

Time Duration Judgment Analysis

In order to evaluate participant judgments of time, the time duration judgment data was calculated as the change difference in the actual time duration judgment and the estimated time duration judgment between the two paradigms and the presence and absence of a distraction.

The descriptive statistics, or overall data, for these time duration judgments is shown in Table 1.

Table 1

Descriptive Statistics for the Delta Trial Time Duration Judgments

Descriptive Statistics				
Dependent Variable: Delta Time Duration Judgments				
Paradigm	Distraction	Mean (μ) in seconds (s)	Std. Deviation (σ)	N
Prospective	Without Distraction	10.77	257.244	13
	With Distraction	168.43	309.428	14
	Total	92.52	291.306	27
Retrospective	Without Distraction	-44.38	262.517	13
	With Distraction	161.13	252.271	15
	Total	65.71	272.988	28
Total	Without Distraction	-16.81	256.191	26
	With Distraction	164.66	276.202	29
	Total	78.87	279.825	55

A Levene's test of equality indicated equality of variance where, $p = 0.584$, thereby meeting this assumption necessary for an ANOVA to be performed. The results of the ANOVA suggested that the main effect of paradigm on accuracy of the time duration judgments was not significant, $F(1,51) = 0.181$, $p = 0.672$ and that there was also no interaction between the paradigms and the distraction conditions, $F(1,51) = 0.107$, $p = 0.745$. However, there were significant results for this analysis for the distraction condition $F(1,51) = 6.133$, $p = 0.017$, where time judgments with a distraction were overestimated compared to those without a distraction. The effect size (partial eta squared) identified that 11% of the variance in the study was accounted for by the distraction manipulation. These outcomes are depicted in Table 2 and Figure 5.

Table 2

ANOVA Source Table for the Delta Time Duration Judgments

Tests of Between-Subjects Effects							
Dependent Variable: Delta Time Duration Judgments							
Source	Type III Sum of Squares	df	Mean Square (μ^2) in seconds (s)	F	Sig. (p)	Partial Eta Squared (η^2)	Observed Power ^b
Corrected Model	471581.563 ^a	3	157193.854	2.134	0.107	0.112	0.513
Intercept	300006.594	1	300006.594	4.073	0.049	0.074	0.508
Paradigm	13385.462	1	13358.462	0.181	0.672	0.004	0.070
Distraction	451795.282	1	451795.282	6.133	0.017	0.107	0.681
Paradigm *	7845.569	1	7845.569	0.107	0.745	0.002	0.062
Distraction Error	3756738.547	51	73661.540				
Total	4570470.000	55					
Corrected Total	4228320.109	54					

a. R Squared = 0.112 (Adjusted R Squared = 0.059)
b. Computed using alpha = 0.05

Figure 5. Relationship Between the Paradigms and Distraction for the Time Duration Judgments (The error bars depict standard deviation around the means)

Image Queue Task Analysis

A two-way between-subject analysis of variance, or ANOVA, was used to examine the data from the primary image task of the MIIRO simulation, which evaluated the level of engagement the participants were in the simulated task. The descriptive data for this test can be found in Table 3.

Table 3

Descriptive Statistics for the Image Queue Task

Descriptive Statistics				
Dependent Variable: MIIRO Performance				
Paradigm	Distraction	Mean (μ) (%)	Std. Deviation (σ)	N
Prospective	Without Distraction	85.3846	4.31158	13
	With Distraction	85.3571	3.65023	14
	Total	85.3704	3.90412	27
Retrospective	Without Distraction	85.0000	5.40062	13
	With Distraction	87.3333	3.71612	15
	Total	86.2500	4.63980	28
Total	Without Distraction	85.1923	4.79182	26
	With Distraction	86.3793	3.75513	29
	Total	85.8182	4.27781	55

As shown in Table 4, there was no significance for any conditions regarding the MIIRO performance task. The interaction between the paradigms and distraction was not significant, $F(1,51) = 1.036$, $p = 0.314$ and neither the main effect of paradigm, $F(1,51) = 0.471$, $p = 0.496$, nor distraction was significant, $F(1,51) = 0.989$, $p = 0.325$. Therefore, all of the conditions were the same for accuracy in processing the MIIRO image task.

Figure 6 indicates no significant differences between the groups but does illustrate that, because of the high percentage of scores, all the participants were engaged in the primary performance task. The outcomes are depicted in Table 4 and Figure 6.

Table 4

ANOVA Source Table for the Image Queue Task

Tests of Between-Subjects Effects							
Dependent Variable: MIIRO Performance							
Source	Type III Sum of Squares	df	Mean Square (μ^2) (%)	F	Sig. (p)	Partial Eta Squared (η^2)	Observed Power ^b
Corrected Model	48.557 ^a	3	16.186	0.879	0.458	0.049	0.228
Intercept	403164.888	1	403164.888	21882.580	0.000	0.998	1.000
Paradigm	8.677	1	8.677	0.471	0.496	0.009	0.103
Distraction	18.213	1	18.213	0.989	0.325	0.019	0.164
Paradigm *	19.091	1	19.091	1.036	0.314	0.020	0.170
Distraction Error	939.625	51	18.424				
Total	406050.000	55					
Corrected Total	988.182	54					
a. R Squared = .167 (Adjusted R Squared = .101)							
b. Computed using alpha = .05

Figure 6. Relationship Between the Paradigms, Distraction, and the Performance of the Image Queue Task

Discussion

The purpose of this experiment was to examine estimated time duration judgments in relation to the actual time duration of a simulated task between two paradigms while introducing a distraction. The first four hypotheses were testing the effects of the prospective and retrospective paradigms, the presence and absence of a distraction, and the interactions between the four variables. The first hypothesis tested that the prospective paradigm would be perceived longer more accurately than in a retrospective paradigm. The second hypothesis tested that the prospective paradigm would be an overestimation of the actual time while the retrospective paradigm would be an under estimation of the actual time. The third hypothesis tested that when a distraction was added, the time duration judgment would be overestimated than when without a distraction. Finally, the fourth hypothesis tested when a distraction was added, the time duration judgment would be overestimated in both the retrospective and prospective paradigms, and however the time duration judgment will be more accurate for the

prospective paradigm. Based on the data, the first, second, and fourth hypotheses were not supported, though the third hypothesis was.

Although the literature review of past experiments supported the claim of a difference in time duration judgments between retrospective and prospective paradigms that was not found in this research, this study may suggest several things. This study first suggests that reading a single sentence to inform participants that their tasks were being timed was not enough to generate a reaction between the paradigm conditions and thus explaining the insignificance of the first two hypotheses. This may lead one to believe that a more in depth script must be used to help distinguish between the two paradigms. However, the current study proceeded with the shorter script because the literature suggests that the difference between the paradigms was a fairly robust manipulation, and also that the results from a pilot study conducted specifically for this experiment using the same script suggested that there might be a difference using this protocol. This did not hold, however, for the full study, and a more thorough script may be necessary to generate the differences between the paradigms described in the literature.

However, not all the literature agrees that a difference between paradigms should be found and is consistent with the non-significant findings shown in this study. While this study failed to find a difference between the paradigms, even though most of the literature suggests a difference should be present, there is evidence suggesting that these paradigms do not produce different results and that the similarities between the paradigms cause more of a reaction. Some research has suggested that prospective and retrospective time duration judgments carry similar characteristics. Brown and Stubbs (1992) found no major findings in significance in their experiment between the two

paradigms. Brown and Stubbs (1992) note that, “Under retrospective conditions, subjects’ time estimates are based on temporal information that was acquired incidentally [see also Liebermann et al (1998)]. Given that time is such a fundamental aspect of the environment, it seems reasonable (at some level) temporal information is continually monitored and extracted from the ongoing flow of events” (p. 553). So, naturally time is continually calculated on some level. Brown and Stubbs (1992) continue when they write that conceive of retrospective paradigms as occurrences of ‘low-resolution timing’, in which time is processed on events; whereas, in a prospective paradigm, recall time in a sense of ‘high-resolution timing’ from temporal cues. So, humans are always naturally are keeping track of time in some way, and therefore it might be that retrospective methods really similar to prospective in that time is always being kept even if the participant is not being explicitly asked.

The lack of significance between the paradigm main effect and the interaction between the paradigms and the distraction could also be attributed to the participants simply not having a good reference memory, or ability to recall time perceived. This is suggested by the high variability in the time duration estimation data from all of the participants in the four conditions. This study’s reference memory results are supported in Haggard’s (1999) experiment, in which Haggard (1999) also concluded in that people tend have a poor sense of time perception.

Another possibility of the lack of significance in this study could be attributed to length of the experiment. For example, most experiments from the literature examined tasks that ranged from milliseconds to seconds. Compared to prior experiments, this

experiment was considerably longer. Thus, significance occurs in paradigms during considerably short time intervals but may not hold for longer intervals.

Regardless of the insignificance of the prospective and retrospective paradigms in the time duration judgment analysis, significance was demonstrated with the auditory distraction. This suggests that regardless of the paradigm condition, a distraction distorts time duration judgment. Referring back to Horváth and Winkler's (2010) experiment that even when told to ignore a distraction, participants were unable to avoid it, and in the current study time duration judgments were impacted. Furthermore, this could be related to Csikszentmihalyi's (1997) concept of 'flow' where one characteristic of this concept is that when someone is fully engaged in a task, time slows down. This implies that the reverse is true: When interrupted in a task, time speeds up. For example, when performing a task that immerses your full attention, it feels like only a few moments have passed, however the clock indicates that a few hours have passed. Therefore, the participant's state of 'flow' could be a factor in the time duration judgments for each paradigm.

Hypothesis five stated that fewer errors would occur in the retrospective paradigm than in the prospective paradigm for the primary target selection task, and hypothesis six stated that more errors would occur for the primary target selection task when a distraction is added compared to the no distraction condition.

The MIIRO performance task analysis showed no significance in relation to the paradigm, distraction, or in the interaction between the paradigm and distraction. This performance task highlighted two things. First, the primary objective for the performance task was to give the participants a task to do so they had something to base the time

duration judgment on. This experiment was designed so that the simulation, or task, would not interfere with the variables. This conclusion is supported by the data indicating no significance between the conditions.

Secondly, the task was designed to engage the participants. The data showed that based on the mean performance task results that regardless of condition, between 85.00 and 87.50 percent of the participants performed on the primary task. This suggests that the participants were engaged in the MIIRO simulation. It was important for the participants to be immersed in the MIIRO task in order to control the distraction. In other words, if the participants were not engaged in the task designed for them, it would be difficult to control for the task and the distraction.

Future Directions

Based on the results and discussion, there are several suggestions in order to possibly make this study stronger for future attempts. First, future studies could possibly elaborate more on the extent of which the participant is being timed to emphasize beyond a reasonable doubt that time is a critical factor within the prospective paradigm. Next, future studies could redesign the experiment and check the reference memory as a pre-experimental task instead of a post-experimental task to prime the prospective paradigm condition for time duration judgment. This should be done with care, however, as presenting the reference memory check in advance for the retrospective group may also influence their assessment of time internally as well.

Limitations and Challenges

For this study, several limitations and challenges were faced. The first challenge was determining how to set up an experiment that pertains to recalling time. Because the experiment required time duration judgments, it was important to avoid mentioning exact duration of the experiment, so the participants did not have a baseline of making their estimated time duration judgments. Thus, when recruiting participants, it was important to not mention how long the experiment was going to last. If asked the duration of the experiment, the initial response was, “participant paced.” If pursued for a definite time length, the second response was “not long.” If continually pursued, the same dialog was repeated once more before the perspective participant either accepted or declined the invitation to participate in the experiment. Furthermore, it was a challenge to remove all traces of time. This included the laboratory wall clock, discretely covering the computer monitor, making sure that all participants removed their watches, ensuring that the watch face was either down or put in their backpacks, and that cell phones were turned off.

Another major obstacle faced was the distraction used. To eliminate the possibility that the meaning of the auditory stimulus could be the source of the distraction, by trying to decipher a possible message within the auditory stimulus, participants were asked if they understood Morse code. If the participant was capable of deciphering Morse code, the auditory distraction could have been interpreted as another task.

Furthermore, another challenge encountered was that there was a lot of variability in this study with only 60 participants. This suggests that the variability would be smaller if there were more participants involved in this study. The power of time duration

judgments for the paradigm effect was 0.070 and the power of time duration judgment within the interaction between paradigm and distraction was 0.062. Given the low power of both the paradigm main effect and the interaction between the paradigm and distraction, this study implies that extremely high number of participants would be required in order to have a chance of seeing any true effect of the paradigm and an interaction between the paradigm and distraction if one exists.

Finally, another challenge was the innate ability of some participants to assess time more accurately. Haggard's (1999) reference memory experiment demonstrated that individuals are not exceptional at recalling time duration. However, to ensure reference memory was not a major confound in the study, a reference memory post-experimental task was tested a precaution.

Conclusion and Implications

This study used a basic experiment to examine the effects of prospective and retrospective paradigms when an external auditory stimulus is introduced on time duration judgments. This study shows, under this specific experimental design, that while engaged in a task a simple auditory distraction can distort how time is perceived. Through future research, stronger conditions may hold the key to showing significance in knowing whether or not time is a factor in recalling time duration.

Specific documentation was not found on industries using distractions to create an effect of speeding up time. The closest example found is how amusement parks in general provide customers with activities to do and videos to watch while waiting their turn ride the rollercoaster. However, there are many tasks and job requirements that

usually require employees to make time durations while encountering external distractions. Completing timecards is a good example of a task where employees are required to recall time duration judgments. At the end of the day, when employees document how many hours they have been spent on each project, they are sometimes required to recall time in some cases down to the tenth of a second. After encountering the numerous daily distractions, the conclusions of study would lead one to believe that the reported time durations allocated for each project would most likely be overestimated, and therefore an inaccurate representation of the time spent completing tasks.

Another example of how this study has implications is when nurses are distracted by the alarms on the medical equipment in an emergency situation. Nurses are put in a position where they need to remember how long ago medication was administered without looking at a chart to verify the exact time. According to this study, the distractions caused from the medical equipment could cause the nurse's time duration judgment from when the patient was administered the medication to be overestimated. Therefore, if the nurse overestimated the time duration from when the dose of the first medication was administered, this could potentially put the patient at a possible risk for an overdose of the same medication or a reaction by adding another medication.

In addition, the shipping industry uses time perception to track and charge packages and cargo. When invoices are misplaced or lost, shippers are tasked with recalling when items left the warehouse. The numerous external distractions that shippers are exposed throughout the day, such as equipment noises, music playing, and employees shouting would cause the shippers to perceive the cargo was shipped earlier in the day than it actually was.

Finally, the above examples illuminate just a few instances in which time perception is important to tasks performed with distractions. Therefore, the relevance of this study is that it demonstrates that when a distraction is added, time appears to be perceived faster in real life scenarios.

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Appendix A

IRB Number: 13-208

Informed Consent Form

For the study:

Factors That Influence Retrospective and Prospective Paradigms

Conducted by Kristi Lontz

Advisor: Dr. Shawn Doherty

Embry-Riddle Aeronautical University

600 South Clyde Morris Boulevard, Daytona Beach, Florida 32114

The purpose of this study is to investigate factors that influence performance with an unmanned aerial flight task. This experiment will consist of one session. After your session, you will be asked to answer a brief questionnaire. It is pertinent that you stay focused on your simulated task, and when asked to take the questionnaire, attempt to answer the questions truthfully.

There are no known risks of this experiment. The benefits of this experiment will be an opportunity to experience a UAV simulation. Your participation is strictly voluntary, and you are able to terminate your involvement in this experiment at any point. If you choose to leave the experiment, you will receive extra credit based on what you have finished to that point. Your data will be reported only in the aggregate: A participant number will be used to track your performance in the study, so you will not be identified individually.

Thank you for your participation in this experiment. If you have questions, feel free to contact me during the study or at 386-871-8870. Also, you can reach my advisor, Dr. Shawn Doherty at 386-226-6249.

Statement of Consent

I, _____, sign this Informed Consent Form of my own free will. By signing this Informed Consent Form, I acknowledge that my participation in this experiment is entirely voluntary, meaning that I recognize that I am able to leave this experiment at anytime without any negative penalty. I also understand that if I chose to withdraw from this experiment before its completion, I will receive my extra credit earned to that point at that time. I understand that my results will remain anonymous and are for the sole purpose of this experiment.

Participant's name (please print): _____

Signature of participant: _____

Date: _____

Experimenter's name: _____

Signature of Experimenter: _____

Date: _____

I wish to have a copy of this consent form. _____ Yes _____ No

I wish to have a copy of the results upon experiment completion. _____ Yes _____ No

If you wish to have a copy of the results, what email would you like the findings sent to?

Appendix B

Prospective Experimental Introduction

Thank you for participating in this experiment. Before we can proceed with the experiment, please read thoroughly and sign this consent form. Please turn off your cell phone and remove your watch, so we have your undivided attention during the simulation.

For this experiment, you will be required to perform several simulated tasks, one primary and three secondary. You will be timed during these tasks. These tasks will appear on both screens. The left screen will represent the Tactical Situation Display, or the TSD, where all the secondary tasks will be performed. The right screen is the Image Management Display, or the IMD, where the single primary task is performed.

For the primary task, or Image Queue task, you will be presented several light and dark shaded tanks, which represent ally and enemy targets respectively. When this task appears, the tanks will be either selected or not. You will be required to deselect all ally targets, or light shaded tanks. Then, you need to select all enemy targets, or dark shaded tanks. Once you have determined that only enemy, or dark shaded, targets are selected, you will then select “Accept.” You will have a limited amount of time to complete this task.

There are three secondary tasks that you will also be expected to complete. At the top of the screen on the TSD, you will find a Mission Mode Indicator, or MMI. The light will randomly go from green to yellow to red. When the MMI turns yellow you will need to click on the MMI. A box will appear, and you are tasked to enter the “Input” number provided in the box and select “OK” by the time the MMI turns red.

The next secondary task on the TSD is a Re-Plan event. A box asking you to “Reject” or “Accept” a random diversion request will pop up in order to avoid a threat on the current Unmanned Aerial Vehicle, or UAV. For this experiment, please select “Accept.”

The last secondary task involves a random Unidentified Flying Object, or UFO event. This is a random task where you will be required to enter an “IFF Code” provided at the bottom of the TSD screen. This code will remain the same throughout the experiment.

Performance will be evaluated on all tasks; however, we ask you to concentrate on the primary task, or the Image Queue task.

You will be several minutes for a practice experiment to become familiar with the simulation and the controls. Afterward, we will proceed with the actual experiment.

Retrospective Experimental Introduction

Thank you for participating in this experiment. Before we can proceed with the experiment, please read thoroughly and sign this consent form. Please turn off your cell phone and remove your watch, so we have your undivided attention during the simulation.

For this experiment, you will be required to perform several simulated tasks, one primary and three secondary. These tasks will appear on both screens. The left screen will represent the Tactical Situation Display, or the TSD, where all the secondary tasks will be performed. The right screen is the Image Management Display, or the IMD, where the single primary task is performed.

For the primary task, or Image Queue task, you will be presented several light and dark shaded tanks, which represent ally and enemy targets respectively. When this task appears, the tanks will be either selected or not. You will be required to deselect all ally targets, or light shaded tanks. Then, you need to select all enemy targets, or dark shaded tanks. Once you have determined that only enemy, or dark shaded, targets are selected, you will then select “Accept.” You will have a limited amount of time to complete this task.

There are three secondary tasks that you will also be expected to complete. At the top of the screen on the TSD, you will find a Mission Mode Indicator, or MMI. The light will randomly go from green to yellow to red. When the MMI turns yellow you will need to click on the MMI. A box will appear, and you are tasked to enter the “Input” number provided in the box and select “OK” by the time the MMI turns red.

The next secondary task on the TSD is a Re-Plan event. A box asking you to “Reject” or “Accept” a random diversion request will pop up in order to avoid a threat on the current Unmanned Aerial Vehicle, or UAV. For this experiment, please select “Accept.”

The last secondary task involves a random Unidentified Flying Object, or UFO event. This is a random task where you will be required to enter an “IFF Code” provided at the bottom of the TSD screen. This code will remain the same throughout the experiment.

Performance will be evaluated on all tasks; however, we ask you to concentrate on the primary task, or the Image Queue task.

You will be several minutes for a practice experiment to become familiar with the simulation and the controls. Afterward, we will proceed with the actual experiment.

Post-Task

Thank you for participating in this simulation. Before we conclude this experiment, we have a post-task experiment. This task will require you to remain seated. I am going to say “start” and “stop”. “Start.” (26 seconds later) “Stop.” Please let me know how long you think has passed.

Survey

Congratulations. You have successfully completed the experiment. Please complete the following post-experimental survey to the best of your ability.

Debrief

Thank you again for participating in this experiment. Your involvement in this experiment has provided us information on a person’s ability to recall time under different conditions. We ask for your discretion to keep your experience during this experiment confidential. If you are interested receiving your personal results, we will email your results to the email address you provided on your consent form. Before I escort you back to the door, I have a question. “Do you know Morse Code?”

Appendix C

1) Did you feel engaged by the experiment task? ____ Yes ____ No

2) How much workload did you feel you experienced during the UAV task, in general?

____ High ____ Medium ____ Low

3) Please provide how much time you think it took to complete the experiment from start to finish (not including instructions or practice).

____ Hours ____ Minutes ____ Seconds

4) What information did you use to make your time estimate?

5) Do you feel you're a good judge of time, in general? ____ Yes ____ No

6) Please provide the following information:

Year in school (Please circle one of the following):

Freshman Sophomore Junior Senior Graduate Student

Major: _____

Age: _____

Gender (M/F): _____