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Attention to and memory of tasks has been linked to participants' ability to estimate time (Zakay, 1989). The present study examined attention to tasks and time estimation by looking at the amount of practice participants are exposed to before estimating the task's duration. Ninety undergraduate volunteers were exposed to either a low (1 trial) or high (10 trials) amount of time estimating practice and a Stroop task (Stroop, 1935) or color naming task. Two separate 2 (Task: Stroop or naming color patches) X 2 (Task familiarity: 1 or 10 task practice trials) X 2 (Time estimating familiarity: 1 or 10 time estimating practice trials) analyses of variance were conducted, one with time estimates as the dependent variable and the other with errors in time estimates as the dependent variable. No differences were found for the time estimate dependent variable. However, a significant Task Familiarity main effect and Task Familiarity X Time Estimating Familiarity interaction for the time estimation errors dependent variable supported the hypothesis that more automatic (i.e., practiced) tasks are estimated more accurately. Participants that practiced both time estimating and the task (both Stroop and color naming) were more accurate at estimating time than all other groups. The lack of a main effect for Task Type does not support the hypothesis that more difficult tasks (i.e., those that require more attention) are estimated less accurately. The results are discussed in light of the various models and hypotheses of time estimation and their implications for past and future research.

THE EFFECT OF AUTOMATICITY ON PROSPECTIVE ESTIMATES OF TEMPORAL DURATION USING STROOP INTERFERENCE

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CHAPTER 1

INTRODUCTION

Cognitive models that attempt to explain how people subjectively experience time focus primarily on memory and attention. However, memory and attention are also determined by the content of the event whose duration is being estimated. Familiarity of content, for example, influences encoding. The present study examines the effect of encoding familiar content on prospective time estimates.

Literature Review

The review of the literature begins with defining terminology used in time study and throughout this paper. Second, review of methodologies used in time estimation research is examined. Third, the early biological models of time estimation are briefly reviewed. The fourth focus of the review examines the two "traditional" camps of time estimation theory: attention and memory models. Attention models include the shared-attention model, attentional-effort model, and the dynamic-attending model. Memory models include the storage-size hypothesis and the contextual-change hypothesis. Fifth, Zakay's (1989) comprehensive model of time estimation is reviewed to fill in the gaps that exist in the five traditional models. Finally, the relation among levels of effort in encoding processes and time estimation is reviewed.

Terminology

Operational definitions of terms used in time estimation literature are needed to avoid ambiguity. Time is a measurable period during which an event, action, or process unfolds on a continuum from past to present to future. An interval is a start point (Point A) and an end point (Point B) along this continuum. Given this definition of time and interval, an interval's duration is the actual measure of time from Point A to Point B along the continuum. The actual measure of time is produced by a timing instrument such as a clock or metronome.

The subjective aspects of time are involved in estimating rather than measuring time. Subjective time is the personal sense of the passing of time, or the rate at which an individual thinks that time has passed. Time estimates are participants' reports of how much actual time they think has passed during an interval and is often the dependent variable in time estimation study.

Error in time estimates is the discrepancy between the time estimate and actual measure of an interval's duration and is the primary interest of time study. Two errors that can be made are overestimating and underestimating time. Overestimation occurs when an estimate is greater than the actual time. Underestimation occurs when an estimate is less than the actual time.

The experimenter attempts to ascertain whether time estimates change by altering the temporal environment or event. The event (e.g., presentation of stimuli) is the independent variable in time study and is what is manipulated during the interval. Events transpire during the interval, and tasks are what participants do during that event (e.g., observe stimuli or complete an activity).

Biological Models of Time Estimation

Historically, time estimation was first studied biologically where early models focused on time sensitive bodily processes (e.g., brain rhythms) involving alteration of the body's chemical or substance levels (Ornstein, 1969). Some early theorists studied how time estimation is controlled by physiological processes. For example, participants under the influence of hallucinogens underestimated time (Sterzinger, 1935; Vojtechovsky et al., 1968) and under the influence of stimulants overestimated time (Sterzinger, 1935). Fischer (1967) reported that stimulants are related to longer time estimates whereas tranquilizing drugs are related to shorter time estimates in controlled situations and postulated that drugs accelerate or decelerate an "inner clock."

Alternatively, Holubar (1960) hypothesized that the brain's alpha rhythm is the participant's inner clock. As Krus and Fletcher (1986) summarized, Holubar altered alpha rhythm by optical flicker stimulation and reported a positive relationship between alpha rhythm and estimate longevity. Although a relationship between biological functioning and time estimates is evident, some researchers (e.g., Ornstein, 1969; Osato, Ogawa, & Takaoka, 1995) credited these effects to degree of psychological strain. Therefore, time study expanded to include the cognitive processes that affect time estimating.

Methodologies Used in Time Study

In their review of the time estimation literature, Bindra and Waksberg (1956) described four methods for studying time estimation. First, the participant verbally estimates an experimenter-provided time interval (verbal method). Second, the participant produces a time interval (e.g., holds down a button) in response to an experimenter-provided time interval (production method). Third, the participant reproduces a time interval which the experimenter has demonstrated using a buzzer sound or light flash (reproduction method). Finally, the experimenter produces two events consecutively, and the participant then judges which interval is longer (comparison method).

Osato et al. (1995) reported that time intervals tend to be overestimated using the verbal estimation method and underestimated using the reproduction method. Druyan, Dani, and Hadadi (1995) confirmed these results and postulated that verbal estimates are longer because they require quantifying the duration by translating it into units of time and then remembering the experience.

For the verbal, production, reproduction, and comparison methods, participants can make prospective or retrospective estimates. For prospective estimation, the participant is told before the event that the event's duration must be judged. Retrospective estimation is when the participant is told after the event to judge its duration.

Cognitive Models of Time Estimation

Three attention models and two memory hypotheses attempt to explain how attention to an event and its memory can distort participants' time estimates. Although complementary, the models and hypotheses do contradict themselves, exposing gaps in the theoretical base. Zakay (1989) combined them to create a comprehensive model of time estimating behavior and his model is discussed in a separate section.

The models and hypotheses originate from Fraisse's

(1963) idea that time is remembered as changes occurring in the environment. For example, physical change when moving from one room to another produces the perception that time has passed.

Attention Models

The shared-attention, the attentional-effort, and the dynamic attending models are based on a bottleneck approach to attention. Bottleneck attention theories propose that humans have a limit to the quantity of information that can be attended to. In a divided attention task (e.g., dicotic listening), when paying attention to one message, the other must be ignored (Broadbent, 1958). In estimating time, if the event or task requires enough attention, attending to the interval's duration declines. However, bottleneck-based theories of attention underestimate the flexibility of human attention (Eysenck, 1982).

Shared-attention model. The shared-attention model (Hicks, Miller, Gaes, & Bierma, 1977; Hicks, Miller, & Kinsbourne, 1976; Thomas & Cantor, 1978) states that participants attending to an event encounter dual tasks competing for attention; attending to the event and attending to the task's duration. When attending to the event (e.g., watching a good movie) increases, less attention is allocated to temporal processing, and time judgments become less reliable. Marmaras, Vassilakis, and Dounais (1995) examined the effect of performing concurrent tasks of different levels of cognitive demand on estimating time by producing time intervals. Accuracy of the time intervals decreased as cognitive demands of the concurrent task increased.

Attentional-effort model. The attentional-effort model (Underwood & Swain, 1973) states that a positive relationship exists between attention to an event and time estimates. Underwood and Swain (1973) reported that on a reading task "passages [of similar length] requiring more attention for analysis were judged to be of greater duration than those requiring less attention" (p. 101). In contrast, Druyan et al. (1995) reported a negative relationship between complexity of a physical task (i.e., a task that requires more attention) and time estimates. The divergent results may be attributed to different tasks. In other words, variation in the task demands of the event influence time estimates in a way that the attentional-effort model cannot predict. Others (e.g., Boltz, 1998; Zakay, 1989) have proposed the opposite of the attentional-effort model; more attention to the task decreases time estimates.

Dynamic attending model. The dynamic attending model (Jones & Boltz, 1989) states that estimates of time depend upon either the anticipated ending of a structured event (e.g., a song; called the future oriented mode of attending) or the attention to an unstructured event (e.g., random sounds; called the analytical attending mode of attending). Future oriented attending explains anticipatory behaviors (e.g., expectations of when a song should end) and occurs with highly predictable temporal events (e.g., movies or songs). Judgment of time is influenced by the way an event's ending confirms or violates temporal expectancies. For example, if an event violates an expectancy by seeming to end later than anticipated, participants incorrectly judge it to be longer.

The analytic attending mode occurs with events with low temporal predictability (e.g., hearing random sounds). Time estimates of events with little structural predictability depend on the levels of attending involved. Boltz (1991) reported that attending that is focused on incoherent structural events (e.g., listening to random sounds) yields prospective time estimates that reflect counting strategies such as counting seconds.

Memory Hypotheses

The storage-size and the contextual-change hypotheses explain time estimation as the remembering of an event within the interval and the result of acquiring a greater storage of memories. These hypotheses differ on what memories (information or changes) explain time estimating.

<u>Storage-size hypothesis.</u> The storage-size hypothesis (Ornstein, 1969) predicts that as storage of information increases, the participant's perception of time duration increases. In other words, Ornstein (1969) reported that perceptible duration increases with the amount of information processed. Vroon (1970, Experiment I) had participants listen to 30 tones per minute and 60 tones per minute and told them to compare the duration of the two series of tones. As expected, the 30 tone duration was judged as shorter than the 60 tone duration. Other studies (e.g., Block, 1974; Bowers, 1979; Bowers & Richards, 1987; Jones & Natale, 1973; Schiffman & Bobko, 1974; Wilsoncroft & Stone, 1975) have supported the storage-size hypothesis using a variety of methodologies and tasks.

<u>Contextual-change hypothesis.</u> The contextual-change hypothesis (Block, 1978, 1985, 1989) predicts that time estimates increase as a linear function of the number of contextual changes. Context changes can be internal (e.g., changing from shallow to deep processing) or external (e.g., task demands, stimulus properties). Block and Reed (1978) reported that a task requiring both shallow and deep processing was remembered as longer than tasks requiring

either deep or shallow processing, which were remembered the same. All the models and hypotheses discussed thus far are summarized in Table 1.

Table 1

The Three Models and Two Hypotheses of Time Estimation

Model/Hypothesis	Prediction on Time Estimates
Shared-attention Model	Negative relation between attention to task and estimate reliability.
Attentional-effort Model	Positive relation between attention to task and estimation longevity.
Dynamic-attending Model	Highly structured events: underestimated when ended before expected. Unstructured events: estimation reflects counting strategies and is influenced by attention.
Storage-size Hypothesis	Positive relation between quantity of information processed and estimation longevity.
Contextual-change Hypothesis	Positive relation between the number of context changes (internal or external) and the estimation longevity.

Zakay's (1989) Comprehensive Model

Zakay (1989) recognized the differences in the five models of time estimation and combined them into a comprehensive model that explains time estimating in a variety of situations. This model addresses the focus of time estimating (i.e., retrospective versus prospective), the attention allocated to the event, and the memory for the event.

The primary assumption of Zakay's (1989) model is that attention is split between temporal and nontemporal information. Each dimension is independent of each other yet both compete for the same limited pool of attentional resources. Zakay's (1989) model is based on a bottleneck view of attention whereby attention is split between tasks regardless of the familiarity or automaticity of each task.

Zakay and Block (1997) found differences in prospective and retrospective time estimates, and that attentional models best explained prospective and the contextual-change model best explained retrospective estimating. In prospective time estimating, by consciously monitoring time, estimates should be highly accurate and reliable. However, time estimates and task performance will become less reliable and more variable as task complexity increases because less attention can be allocated to temporal processing and time estimates (Hicks et al, 1977; Hicks et al., 1976; Thomas & Cantor, 1978; Boltz, 1998; Druyan et al., 1995; Zakay, 1989).

In retrospective time estimating, most attentional resources are allocated to processing nontemporal information because there is no apparent reason to give attention to the passage of time. With retrospective time estimating, participants who are unaware that they had to estimate time until after the event must rely on memory of events to estimate time. Therefore, retrospective estimating increases as the number of chunks of information (Ornstein, 1969) or changes (Block, 1975, 1985, 1989) in nontemporal information increase (Zakay, 1989).

Critique of the Model

Zakay's (1989) comprehensive model includes attentional effort, amount of information, and event structure as predictors of time estimates. However, one variable not included, thus needs incorporated into the model, is task familiarity. Task familiarity (i.e., tasks that require less effort or greater automaticity of processing) influences how participants can divide attention between two tasks (Spelke, Hirst, & Neisser, 1976). Automatic processing, due to high stimuli familiarity, should leave more attentional resources for other tasks (Norman & Bobrow, 1975) such as time estimation. Therefore, the review of the literature now shifts to the automaticity of encoding processes.

Attention and Automaticity

One premise of the present study's rationale is that participants base their time estimates of an event by the attentional resources allocated to it. However, the event or task involved during the interval can have different levels of familiarity and thus require a different amount of attentional resources (Spelke et al., 1976). A more familiar event requires less attention for analysis (i.e., more automatic processing) than a new or unfamiliar event (i.e., more effortful processing; Hasher & Zacks, 1979). The duration of automatically processed tasks may be prospectively estimated more reliably than tasks requiring more effort because more attentional resources are available for temporal processing.

Automatic and effortful processing. The influence of attention on time estimation is described within the framework of automatic and effortful processing in memory (Hasher & Zacks, 1979). An easy task involving highly familiar items can be automatically processed at the same time as an effortful task (Spelke et al., 1976). Thus, an event with highly familiar information can be easily attended to leaving cognitive resources for processing other information (Norman & Bobrow, 1975).

Effortful or controlled processing is required by a difficult task involving unfamiliar items and tends to be serial; only one item is handled at a time (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). Participants presented with unfamiliar or difficult tasks have less cognitive resources available to allocate attention to, for example, temporal processing. Within the limited capacity information processing system, more difficult tasks may compete with other tasks for attention (i.e., refractoriness; Baddeley, 1998). Thus, an event with unfamiliar information depletes cognitive resources, making them unavailable for the processing of other information (Norman & Bobrow, 1975).

The Stroop Effect

The Stroop task (Stroop, 1935; see MacLeod, 1991, for a comprehensive review) has been important in studying interference in attentional processes. Although many variations of it exist (e.g., Pavese & Umilta, 1998), Stroop's (1935) original task required participants to name the ink color of incongruous color-name stimuli. Response times of participants naming ink color are longer in the incongruous condition than when naming color patches only. Words that are highly similar to the ink-naming response (e.g., the word yellow in orange ink) produce greater interference than words that are dissimilar to the ink-naming response (e.g., the word red in blue ink; Klopfer, 1996). In his review of the Stroop effect, MacLeod (1991) concluded a positive relationship exists between the semantic association of the word and the concept of color and the potential for interference.

Naming colors and reading colors' names both involve automatic processing because these tasks are highly familiar. However, when these two tasks contradict (i.e., the color-word incongruous Stroop task) interference is created. Processing with Stroop interference requires greater effort than naming the ink color of a color patch. Therefore, the Stroop task is a high effort task compared to color patch naming.

Conclusion

After reviewing the literature, one may come to question the attentional aspects of the time estimation models based on the idea that they do not make much intuitive sense. For example, when an individual drives across town on a regular route in normal conditions, time estimation seems to be accurate. On the other hand, when driving that route in poor weather with lots of traffic, time estimates may be less accurate. Was one trip attended to more than the other? According to Zakay's (1989) model, because time estimates are accurate in the regular condition trip, it was attended to less and more attention was allocated to time estimating. This explanation is counterintuitive because driving in both conditions require high attention. In this instance, the attentional-effort model makes more intuitive sense. However, comparing the subjective duration of movies and lectures may make more sense with Zakay's (1989) model.

The argument here is that attention to both trips, the movie or the lecture, may have been the same, but the familiarity of the events differed. Driving in regular conditions is more automatic because it is more familiar, thus attention is divided between driving and time estimating. Driving in aversive conditions can, therefore, be considered an effortful process requiring more attentional and cognitive effort and it is less familiar. Events that are automatically processed allow attention to be divided between the automatically performed task and other activities (e.g., temporal processing). Those events that require more controlled or effortful processing do not allow attention to be divided between the task and other activities (e.g., temporal processing). If more attention can be allocated to temporal processing, then the event duration can be estimated more accurately.

The hypothesis investigated in the present study is that the duration of events requiring automatic processing are timed more accurately than events that require effortful processing. Although similar to Zakay's (1989) model, this approach recognizes that content differing in familiarity is attended to differently. Highly familiar tasks require less cognitive effort than unfamiliar tasks by allowing attention to become divided leaving more cognitive resources available for other tasks (Hunt & Ellis, 1999; Spelke et al., 1976) like temporal processing.

The present study investigated the following three hypotheses: (1) tasks that require more cognitive effort (e.g., the Stroop task) are estimated with less accuracy and to be shorter than tasks that require little cognitive effort (e.g., naming colors) because available cognitive resources increase as cognitive efforts decrease. This hypothesis is the same as Zakay's (1989) model predicts and opposes the attentional-effort model in the direction of estimate longevity. (2) Time estimating of high effort tasks becomes more accurate and longer with practice of the task (e.g., practicing the Stroop task). Zakay's (1989) model and the attentional-effort model predict no differences on this variable because attention to the tasks is the same. (3)

Practicing time estimating leads to more automaticity of Stroop and/or time estimating tasks and thus leads to improvement in time estimating accuracy and increase in time estimate longevity. Again, Zakay's (1989) model and the attentional-effort model predict no differences on this variable because attention to the tasks is the same.

CHAPTER 2

METHOD

Participants

Participants were 90 (48 women, 42 men) volunteer introductory and developmental psychology students from a mid-size Midwest university. All participants were fulfilling research participation credit for their courses.

Design

This study employed a 2 (Task: Stroop or naming color patches) X 2 (Task familiarity: 1 or 10 task practice trials) X 2 (Time estimating familiarity: 1 or 10 time estimating practice trials) between subjects, experimental design. The first independent variable was task, either Stroop or naming color patches. The second independent variable was the number (1 or 10) of practice trials to become familiarized with the assigned task (Stroop or naming patches). The third independent variable was the number (1 or 10) of practice trials to become familiarized with estimating time.

The prospective verbal time estimates of the duration the computer takes to display the 18 word list is one dependent variable. The other dependent variable, error, is the absolute value of the difference between the estimated and actual duration. Groups were randomly assigned to one of eight conditions: (1) Stroop, practice Stroop, practice estimation (_n_ = 11); (2) Stroop, practice Stroop, no practice estimation (_n_ = 11); (3) Stroop, no practice Stroop, practice estimation (_n_ = 10); (4) Stroop, no practice Stroop, no practice estimation (_n_ = 12); (5) color patch, practice color patch, practice estimation (_n_ = 11); (6) color patch, practice color patch, no practice estimation (_n_ = 12); (7) color patch, no practice color patch, practice estimation (_n_ = 11); (8) color patch, no practice color patch, no practice estimation (_n_ = 12). With two dependent variables and three independent variables, each with two levels, two separate 2 X 2 X 2 analyses of variances (ANOVA) were used.

Materials

The computer used to display the Stroop words or color patches on the projector screen was a 233 MHz Pentium class computer using its system clock as the programs timer. Display was set at 16 bit high color and connected to a monitor projection device.

The software package used to create and display the words and patches is SuperLab for Windows, the Experimental Laboratory Version 1.01 (Cedrus Corporation, 1990-1996).

Words (randomly selected as outlined in the appropriate Appendices) were set so that the projected height was 15 cm, all uppercase, Arial font, and centered on a black background (see Appendix A for detailed computer configurations). The color patches (randomly selected as outlined in the appropriate Appendices) were text file images of colored squares that were 25 cm when projected (see Appendix A). In all conditions, the monitor displays the word "start" before and "end" (both in white letters) after the word set displays to avoid confusion and add clarity to the directions for when participants were asked to recall the duration.

The worksheets used for participants to record responses are in the appendices as follows: (1) Stroop responses during the interval in Appendix B, (2) Stroop responses during 1 practice trial in Appendix C, (3) Stroop responses for 10 practice trials in Appendix D, (4) color patch responses during the interval in Appendix E, (5) color patch responses during 1 practice trial in Appendix F, (6) color patch responses during 10 practice trials in Appendix G, (7) time estimating after the interval in Appendix H, (8) time estimating during 1 practice trial in Appendix I, and (9) time estimating during 10 practice trials in Appendix J.

Procedure

After signing the consent document (see Appendix K) participants were seated in a classroom in front of a projection screen and were asked to remove their watches. The experimenter then instructed participants according to their assigned group by reading the instructions that appear in the appropriate Appendices. For groups that received one practice trial, the actual testing began on the second trial. For groups that received 10 practice trials, the actual testing began on the eleventh trial.

Stroop task. For participants assigned to the Stroop condition, the Stroop task was used to elicit high effortful processing during the time interval. They viewed six sets of three words that are color-word incongruous (see Appendix M). Each set of three words were projected on the center of the screen for 6 s (2 s per word, no pause between words in the same set) with 7 s pauses between sets displaying the next set letter (white text). The entire display of the three sets of words was 78 s. Participants recorded Stroop responses (see Appendix B) and estimation responses (see Appendix H).

For participants assigned to the naming color patches condition, identifying color patches was used to elicit low effortful processing during the interval. The color patch groups viewed 6 sets of three color patches (see Appendix N). Each set of three patches was projected on the screen for durations the same as those in the Stroop condition. The entire display of the three sets of words was 78 s. Participants recorded patch responses on Appendix E and estimation responses on Appendix H.

Task familiarity. For participants doing an unfamiliar task, one 10 s practice trial of either the Stroop (see Appendix O) or color patches (see Appendix P) identification was given. The one practice trial was randomly selected from the 10 used in the familiar task groups. Participants marked practice responses on Appendix C for Stroop responses and Appendix F for color patch responses.

For participants doing familiar tasks, ten 10 s practice trials of either the Stroop (see Appendix Q) or color patches (see Appendix R) identification were given. The order of presentation was randomly selected as outlined in there appropriate Appendices. Participants marked responses on Appendix D for Stroop responses and Appendix G for patch responses.

Time estimation familiarity. Participants doing unfamiliar time estimation had one practice trial interval of 21 s, which had been randomly selected from the 10 used in the time estimating practice groups. The event estimated on the practice trials was the computer's display of a white dot preceded and proceeded by a blank black monitor. Participants marked responses on Appendix I. The experimenter then provided the participants with the correct response.

For participants doing familiar time estimation, 10 practice trials of estimating time were given. The order of the 10 practice trials of 16, 64, 44, 17, 72, 58, 68, 21, 45, and 51 s had been randomly selected from durations between 15 and 80 s. The event estimated on the practice trials was the computer's display of a single white dot preceded and proceeded by a blank black monitor. Participants marked responses on a form (Appendix J). The experimenter then provided the participants with the correct response after each trial.

In all cases the forms needed for each group were chronologically arranged into a booklet. Participants were instructed to not turn the page until told to do so. All instructions included in the appropriate appendix were read by the experimenter.

CHAPTER 3

RESULTS

This study employed two separate 2 (Task: Stroop or naming color patches) X 2 (Task Familiarity: 1 or 10 task practice trials) X 2 (Time Estimating Familiarity: 1 or 10 time estimating practice trials) between subjects analyses of variance (ANOVAs) with maximum alpha set at .05. The first analysis used the time estimates as the dependent variable. The second analysis used the time estimation error computed as the absolute value of the difference between actual time and time estimates. For follow up analysis, when appropriate, simple effects analyses and mean comparisons were used. Hartley's test of homogeneity of variance (F_{max}) was used because within group variance is critical when examining time estimating errors.

The ANOVA for time estimates (see Tables 2 and 3) revealed no significant differences for any of the main effects or interactions. The results of the ANOVA on time estimation errors are presented in Table 4 with means and standard deviations presented in Table 5. ANOVA for time estimation errors revealed a significant main effect for Task Familiarity, $F(1, 82) = 4.45$, $p < .05$, $\eta^2 = .051$. Participants in the low task familiarity condition (M = 21.67, SD = 14.07) were less accurate at estimating time

Table 2

Task by Task Familiarity by Time Estimating Familiarity

Analysis of Variance on Time Estimates

Source of Variation	SS	df	MS	F
Task (T)	77.68	1	77.68	.16
Task Familiarity (TF)	1162.03	1	1162.03	2.45
Time Estimating Familiarity (TEF)	237.70	1	273.70	.50
T X TF	1490.33	1	1490.33	3.15
T X TEF	51.83	1	51.83	.11
S X TEF	10.73	1	10.73	.02
T X TF X TEF	288.86	1	288.86	.61
Error	38820.35	82	473.42	

Table 3

Means and Standard Deviations for Time Estimates in Seconds

	Task				
	Stroop		Color Naming		
	Task Familiarity		Task Familiarity		
Time Estimation Familiarity	High	Low	High	Low	Total
High	70.73	67.40	71.91	59.45	67.37
	(9.97)	(32.54)	(12.15)	(18.35)	(19.77)
Low	68.18	73.42	79.58	61.33	70.68
	(23.74)	(19.50)	(29.96)	(18.49)	(23.60)
Total	69.45	70.68	75.91	60.43	69.10
	(17.81)	(25.73)	(23.05)	(18.03)	(21.79)

Table 4

Task by Task Familiarity by Time Estimating Familiarity

Analysis of Variance on Time Estimation Errors

Source of Variation	SS	df	MS	F
Task (T)	5.19	1	5.19	.03
Task Familiarity (TF)	759.95	1	759.95	4.45*
Time Estimating Familiarity (TEF)	174.26	1	174.26	1.02
T X TF	32.94	1	32.94	.19
T X TEF	587.15	1	587.15	3.44
TF X TEF	2119.76	1	2119.76	12.42**
T X TF X TEF	64.56	1	64.56	.38
Error	13996.80	82	170.69	

$^{*}p < .01$

$^{**}p < .001$

Table 5

Means and Standard Deviations for Time Estimation Errors in Seconds

	Task				
	Stroop		Color Naming		
	Task Familiarity		Task Familiarity		
Time Estimation Familiarity	High	Low	High	Low	Total
High	10.55	29.00	8.82	21.46	17.36
	(5.94)	(15.78)	(10.15)	(14.45)	(14.28)
Low	19.64	15.25	24.75	21.33	20.30
	(15.66)	(12.22)	(15.24)	(12.19)	(13.87)
Total	15.09	21.50	17.13	21.39	18.79
	(12.46)	(15.30)	(15.14)	(13.01)	(14.07)

Note. The lower the score, the more accurate the time estimate.

than participants in the high task familiarity condition (M = 15.99, SD = 13.77). There was also a significant Task Familiarity X Time Estimating Familiarity interaction, $F(1, 82) = 12.42$, $p < .001$, $\eta^2 = .132$. Table 5 shows the pooled means and standard deviations for this interaction and Figure 1 shows this two-way interaction to be disordinal. Mean comparisons revealed that task familiarity resulted in less time estimating errors only when paired with time estimating familiarity. Analysis of simple effects revealed that the only difference was participants highly familiar of the task and estimating time more accurately estimated time ($p < .01$) than participants in the other three groups.

The results of Hartley's F_{max} tests on time estimation errors are presented in Table 6. Hartley's tests revealed that within group variability for participants highly familiar with the task and estimating time was significantly less than the other three groups.

Table 6

Means and Standard Deviations of Time Estimation Errors in Seconds for the Task Familiarity by Time Estimating Familiarity Interaction

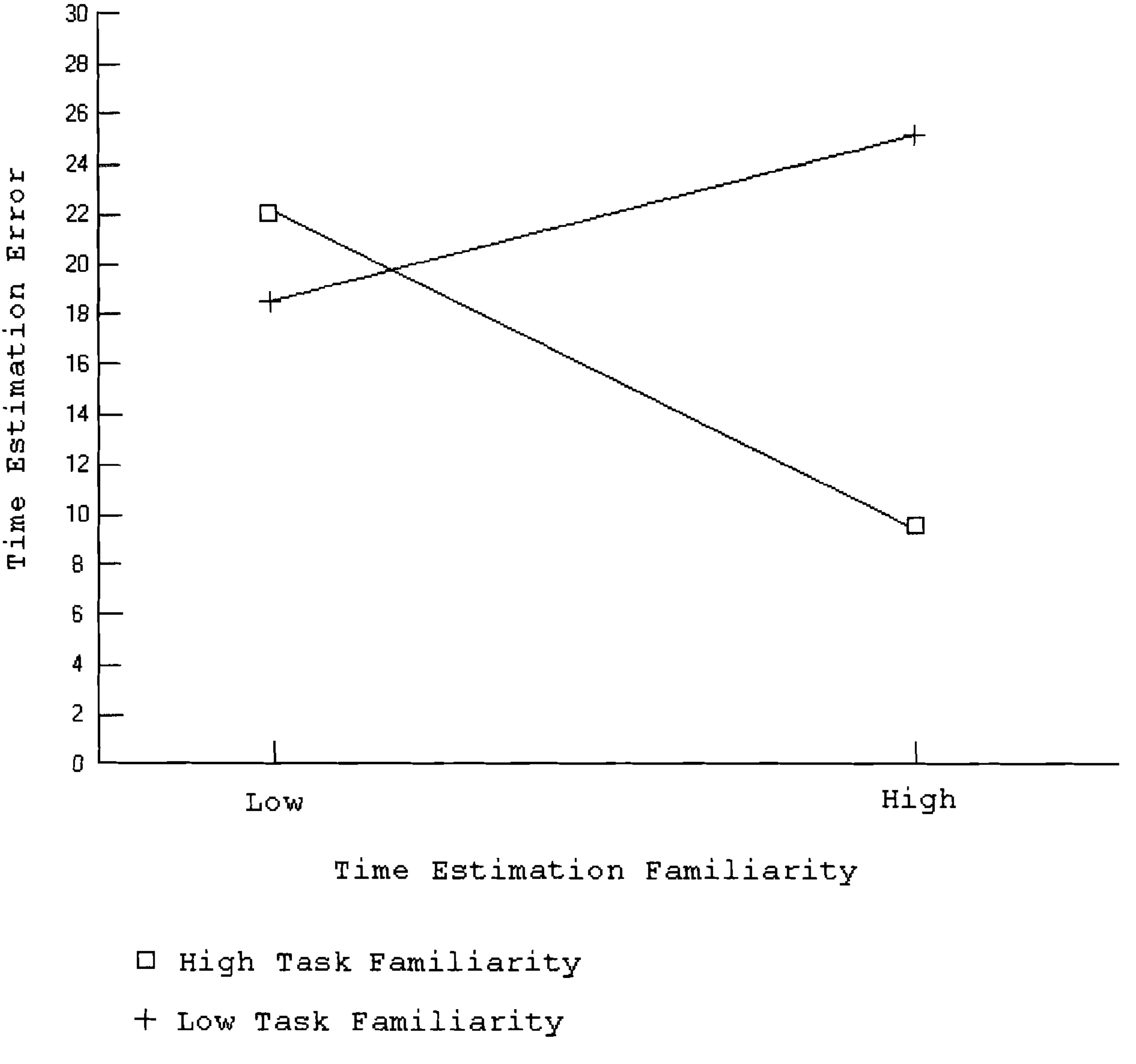
Time Estimation Familiarity		Task Familiarity		
		High	Low	Total
	High	9.68	25.05	17.36
		(8.16)	(15.21)**	(14.28)
	Low	22.30	18.29	20.30
		(15.31)**	(12.33)*	(13.87)
	Total	15.99	21.67	18.79
		(13.77)	(14.01)	(14.07)

Note. The lower the score, the more accurate the time estimate.

* 12.33 is significantly greater ($p < .05$) than 8.16; $F_{max} = 2.31$.

**15.31 and 15.21 are significantly greater ($p < .01$) than 8.16; $F_{max} = 3.52$ and 3.47, respectively.

Figure 1. Task Familiarity X Time Estimating Familiarity Interaction



CHAPTER 4

DISCUSSION

Hypothesis 1: Level of Cognitive Effort

The first hypothesis examined by the present study was tasks that require more cognitive effort are estimated with shorter, less accurate estimates than tasks that require little cognitive effort. This hypothesis is consistent with Zakay's (1989) model and the attentional-effort model in terms of underestimation or overestimation. The Stroop task required more cognitive effort than the color naming task so the expectation was that time estimation would be less accurate for the Stroop task. However, no differences were found, indicating the hypothesis was not supported.

One conclusion that could be made is that the Stroop task may not have required enough cognitive effort. With participants required to prospectively estimate time and complete the task at hand, cognitive effort may have become more equal. Future investigations on this variable may find it advantageous to use retrospective time estimates to make the distinction in cognitive effort clearer.

Hypotheses 2 and 3

The second hypothesis examined was time estimating of high effort tasks becomes longer and more accurate with practice of the task. This hypothesis was only supported in conjunction with the third hypothesis as indicated by the Task Familiarity X Time Estimating Familiarity interaction. The third hypothesis predicted that practicing time estimation leads to more automaticity of time estimation, thus improving accuracy. Task practice only increased time estimation accuracy when it was paired with time estimation practice.

The more familiar participants were with both the task and prospective timing, the more accurate their estimates were. However, longevity did not differ on any of the variables. Therefore, these data support the shared-attention hypothesis (Hicks, Miller, Gaes, & Bierma, 1977; Hicks, Miller, & Kinsbourne, 1976; Thomas & Cantor, 1978) because estimation reliability decreased as attentional resources were consumed by concurrently doing the task and estimating time. Practicing both makes the task more familiar and thus more automatic, freeing up cognitive resources for temporal processing.

Conclusions cannot be drawn in regard to Zakay's (1989) model because it explains longevity differences in time estimation rather than error in time estimating. However, the current study contributed to Zakay's model because it helps explain some of the variability that exists in estimating time. This study found that practicing the tasks improves time estimation accuracy and comparisons of the variability within groups showed that as familiarity to the tasks increased, prospective time estimates became more reliable and tended to cluster more around the correct response than groups less familiar with the tasks.

Implications for Past Research

The results of the current study provide some alternative perspectives on previous time estimation research. Some experiments' results need to be reconsidered in light of the acquired skills and abilities of the participants. For example, Vroon (1970) had participants discriminate between high and low pitch tones and then estimate the time interval to do that task. A confounder emerging from the current study is controlling for experience (i.e., familiarity) doing the task. Participants with more practice at discriminating tones (e.g., musicians) may perform the concurrent task more automatically than participants with less experience. Similarly, Jones and Boltz (1989) had participants judge the length of musical melodies. Although they specify that all participants had a minimum of four years of musical training, they did not specify a maximum amount of musical training.

Jones and Yee (1997) examined the effects of musical experience when participants listened to and judged the duration of musical melodies. As expected, those with more experience were more accurate at estimating the song's duration. However, because the experimenters used a mixed design, any other conclusions made by the study are questionable because some variables were repeated measures.

Literary competence is a variable to consider in evaluating studies by Rotter (1969) and Underwood and Swain (1973), whose participants estimated the duration for reading passages. Athletic ability needs consideration in Druyan and Hadadi's (1995) study on estimating time when the task was tossing a basketball. Competence in visual memory ability needs to be considered in Burt and Popple's (1996) study on remembered duration during an eyewitness recall task and Wilsoncroft and Stone's (1975) study on estimating time during a mirror image drawing task. Several conditions in Marmaras, Vassilakis, and Dounias' (1995) study may have automaticity effects both external to the experiment (e.g., mathematical ability) and internal to it (e.g., repeated measures).

As the aforementioned studies exemplify, a portion of the current body of research on time estimation may be confounded by automaticity effects due to differing amounts of familiarity/competence with the task. These automaticity effects come through acquired familiarity of the concurrent task either externally (i.e., expertise) or internally (i.e., repeated measures designs). When evaluating or comparing past time estimation research, it now is critical to question whether different levels of automaticity may exist within the experiment.

Implications for Future Research

As stated, close attention to participants' familiarity with tasks is important when designing an experiment. One suggestion to prevent automaticity from confounding an experiment is to use ambiguous stimuli for the task (e.g., light patterns or random sounds; see Ornstein, 1969) which would make the task equally difficult for all participants. Another suggestion is to avoid repeated measures designs in time estimation research because the practice effect may confound that particular variable.

Future research on the automaticity effect should look at different levels of automaticity by manipulating practice that has occurred both within and external to the experiment. For within experiment practice, varying amounts of practice trials could give a clearer picture of automatic processing's effects on time estimating. Practice that is external to the experiment consists of previously doing the task(s) included in the experimental design.

In conclusion, time estimation research is dominated by conflicting models, each based on few research studies. The purpose of this study was not to add another model, but rather to test Zakay's (1989) model and to make some intuitive sense from past time estimation research. Currently, there is no unified model to explain how people estimate time, what makes events seem longer or shorter, or what makes estimating time more accurate.

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APPENDIX A

Computer Configurations

[DOS text file format]

```
* SuperLab v2.0 experiment file.

#Script-Version     20
#Background-Color   0    0    0
#Background-Pattern 0    0    0    0
#Runtime-Options    20   0    0    0    0    0    0    0
#Input-Method  gnrc 20   0    0    0
#Timing-Method tick

#Plug-ins-Used 1
text Text-String    100

#Events
*  Event   Event     Response       Misc.     Correct
** Name    Type  Action   Duration  Flags     Response
blank      text 2    0    8    -2
blank2     text 2    0    8    -2
blank3     text 2    0    8    -2
4    text 4    1000 8    -2
3    text 4    1000 8    -2
2    text 4    1000 8    -2
1    text 4    1000 8    -2
start      text 4    500  8    -2
blank start     text 4    500  8    -2
SET A      text 4    6500 8    -2
SET B      text 4    6500 8    -2
SET C      text 4    6500 8    -2
SET D      text 4    6500 8    -2
SET E      text 4    6500 8    -2
SET F      text 4    6500 8    -2
SET G      text 4    6500 8    -2
SET H      text 4    6500 8    -2
SET I      text 4    6500 8    -2
SET J      text 4    6500 8    -2
START BLANK     text 4    500  8    -2
b    text 4    2000 8    -2
g    text 4    2000 8    -2
o    text 4    2000 8    -2
r    text 4    2000 8    -2
y    text 4    2000 8    -2
bg   text 4    2000 8    -2
bo   text 4    2000 8    -2
```

br	text	4	2000	8	-2
by	text	4	2000	8	-2
gb	text	4	2000	8	-2
go	text	4	2000	8	-2
gr	text	4	2000	8	-2
gy	text	4	2000	8	-2
ob	text	4	2000	8	-2
og	text	4	2000	8	-2
or	text	4	2000	8	-2
oy	text	4	2000	8	-2
rb	text	4	2000	8	-2
rg	text	4	2000	8	-2
ro	text	4	2000	8	-2
ry	text	4	2000	8	-2
yb	text	4	2000	8	-2
yg	text	4	2000	8	-2
yo	text	4	2000	8	-2
yr	text	4	2000	8	-2
BLANK END	text	4	500	8	-2
16s	text	4	16000	8	-2
blank20	text	2	0	8	-2
blank10	text	2	0	8	-2
64s	text	4	25000	8	-2
64s1	text	4	25000	8	-2
64s2	text	4	14000	8	-2
blank21	text	2	0	8	-2
blank11	text	2	0	8	-2
44s	text	4	25000	8	-2
44s1	text	4	19000	8	-2
blank22	text	2	0	8	-2
blank12	text	2	0	8	-2
17s	text	4	17000	8	-2
blank23	text	2	0	8	-2
blank13	text	2	0	8	-2
72s	text	4	25000	8	-2
72s1	text	4	25000	8	-2
72s2	text	4	22000	8	-2
blank24	text	2	0	8	-2
blank14	text	2	0	8	-2
58s	text	4	25000	8	-2
58s1	text	4	25000	8	-2
58s2	text	4	8000	8	-2
blank25	text	2	0	8	-2
blank15	text	2	0	8	-2
68s	text	4	25000	8	-2
68s1	text	4	25000	8	-2
68s2	text	4	18000	8	-2
blank26	text	2	0	8	-2

```
blank16   text 2    0    8    -2
21s  text 4    21000     8    -2
blank27   text 2    0    8    -2
blank17   text 2    0    8    -2
45s  text 4    25000     8    -2
45s1 text 4    20000     8    -2
blank28   text 2    0    8    -2
blank18   text 2    0    8    -2
51s  text 4    25000     8    -2
51s1 text 4    25000     8    -2
51s2 text 4    1000 8    -2
blank29   text 2    0    8    -2
blank19   text 2    0    8    -2
END  text 2    0    8    -2

#Text-String
*  Event   Font Font      RGB   RGB RGB  Vert Horiz
** Name    Name Size Text red   green      blue Pos. Pos. Flags
     Reserved
blank     Arial     100       65280     32768     0    0
     0    294  0
blank2    Arial     100       65280     32768     0    0
     0    294  0
blank3    Arial     100       65280     32768     0    0
     0    294  0
4    Arial     100  4    65280     65280     65280     0
     0    294  0
3    Arial     100  3    65280     65280     65280     0
     0    294  0
2    Arial     100  2    65280     65280     65280     0
     0    294  0
1    Arial     100  1    65280     65280     65280     0
     0    294  0
start     Arial     100  START     65280     65280     65280
     0    0    294  0
blank start    Arial     100       65280     65280     65280
     0    0    294  0
SET A     Arial     100  A    65280     65280     65280
     0    0    294  0
SET B     Arial     100  B    65280     65280     65280
     0    0    294  0
SET C     Arial     100  C    65280     65280     65280
     0    0    294  0
SET D     Arial     100  D    65280     65280     65280
     0    0    294  0
SET E     Arial     100  E    65280     65280     65280
     0    0    294  0
SET F     Arial     100  F    65280     65280     65280
```

```
     0    0    294  0
SET G     Arial     100  G    65280     65280     65280
     0    0    294  0
SET H     Arial     100  H    65280     65280     65280
     0    0    294  0
SET I     Arial     100  I    65280     65280     65280
     0    0    294  0
SET J     Arial     100  J    65280     65280     65280
     0    0    294  0
START BLANK    Arial     100       65280     65280     65280
     0    0    294  0
b    Wingdings 250  n    0    0    65280     0    0    294
     0
g    Wingdings 250  n    0    65280     0    0    0    294
     0
o    Wingdings 250  n    64768     46336     7680 0    0
     294  0
r    Wingdings 250  n    57088     0    0    0    0    294
     0
y    Wingdings 250  n    65280     65280     0    0    0
     294  0
bg   Arial     100  green     0    0    65280     0    0
     294  0
bo   Arial     100  orange    0    0    65280     0    0
     294  0
br   Arial     100  red  0    0    65280     0    0    294
     0
by   Arial     100  yellow    0    0    65280     0    0
     294  0
gb   Arial     100  blue 0    65280     0    0    0    294
     0
go   Arial     100  orange    0    65280     0    0    0
     294  0
gr   Arial     100  red  0    65280     0    0    0    294
     0
gy   Arial     100  yellow    0    65280     0    0    0
     294  0
ob   Arial     100  blue 64768     44800     7680 0    0
     294  0
og   Arial     100  green     64768     44800     7680 0
     0    294  0
or   Arial     100  red  64768     44800     7680 0    0
     294  0
oy   Arial     100  yellow    64768     44800     7680 0
     0    294  0
rb   Arial     100  blue 57088     0    0    0    0    294
     0
rg   Arial     100  green     57088     0    0    0    0
```

294 0
ro Arial 100 orange 57088 0 0 0 0
294 0
ry Arial 100 yellow 57088 0 0 0 0
294 0
yb Arial 100 blue 65280 65280 0 0 0
294 0
yg Arial 100 green 65280 65280 0 0
0 294 0
yo Arial 100 orange 65280 65280 0 0
0 294 0
yr Arial 100 red 65280 65280 0 0 0
294 0
BLANK END Arial 100 65280 65280 65280
0 0 294 0
16s Courier New 200 . 65280 65280 65280
0 0 294 0
blank20 Arial 200 65280 65280 65280
0 0 294 0
blank10 Arial 200 65280 65280 65280
0 0 294 0
64s Courier New 200 . 65280 65280 65280
0 0 294 0
64s1 Courier New 200 . 65280 65280 65280
0 0 294 0
64s2 Courier New 200 . 65280 65280 65280
0 0 294 0
blank21 Arial 200 65280 65280 65280
0 0 294 0
blank11 Arial 200 65280 65280 65280
0 0 294 0
44s Courier New 200 . 65280 65280 65280
0 0 294 0
44s1 Courier New 200 . 65280 65280 65280
0 0 294 0
blank22 Arial 200 65280 65280 65280
0 0 294 0
blank12 Arial 200 65280 65280 65280
0 0 294 0
17s Courier New 200 . 65280 65280 65280
0 0 294 0
blank23 Arial 200 65280 65280 65280
0 0 294 0
blank13 Arial 200 65280 65280 65280
0 0 294 0
72s Courier New 200 . 65280 65280 65280
0 0 294 0
72s1 Courier New 200 . 65280 65280 65280

```
     0    0    294  0
72s2 Courier New    200  .    65280     65280     65280
     0    0    294  0
blank24   Arial     200       65280     65280     65280
     0    0    294  0
blank14   Arial     200       65280     65280     65280
     0    0    294  0
58s  Courier New    200  .    65280     65280     65280
     0    0    294  0
58s1 Courier New    200  .    65280     65280     65280
     0    0    294  0
58s2 Courier New    200  .    65280     65280     65280
     0    0    294  0
blank25   Arial     200       65280     65280     65280
     0    0    294  0
blank15   Arial     200       65280     65280     65280
     0    0    294  0
68s  Courier New    200  .    65280     65280     65280
     0    0    294  0
68s1 Courier New    200  .    65280     65280     65280
     0    0    294  0
68s2 Courier New    200  .    65280     65280     65280
     0    0    294  0
blank26   Arial     200       65280     65280     65280
     0    0    294  0
blank16   Courier New    200       65280     65280     65280
     0    0    294  0
21s  Courier New    200  .    65280     65280     65280
     0    0    294  0
blank27   Arial     200       65280     65280     65280
     0    0    294  0
blank17   Courier New    200       65280     65280     65280
     0    0    294  0
45s  Courier New    200  .    65280     65280     65280
     0    0    294  0
45s1 Courier New    200  .    65280     65280     65280
     0    0    294  0
blank28   Arial     200       65280     65280     65280
     0    0    294  0
blank18   Courier New    200       65280     65280     65280
     0    0    294  0
51s  Courier New    200  .    65280     65280     65280
     0    0    294  0
51s1 Courier New    200  .    65280     65280     65280
     0    0    294  0
51s2 Courier New    200  .    65280     65280     65280
     0    0    294  0
blank29   Arial     200       65280     65280     65280
```

```
     0    0    294  0
blank19   Arial     100        65280      65280      65280
     0    0    294  0
END  Arial     100  END  65280      65280      65280      0
     0    294  0

#Trials
* Codes:
BEGIN
STROOP TESTING
6A1
6A2
6A3
6B1
6B2
6B3
6C1
6C2
6C3
6D1
6D2
6D3
6E1
6E2
6E3
6F1
6F2
6F3
STROOP END
PRACTICE STRP 1
1A1
1A2
1A3
PR STRP 1 END
PR STRP 10
10A1
10A2
10A3
10B1
10B2
10B3
10C1
10C2
10C3
10D1
10D2
10D3
10E1
```

10E2
10E3
10F1
10F2
10F3
10G1
10G2
10G3
10H1
10H2
10H3
10I1
10I2
10I3
10J1
10J2
10J3
PR STRP 10 END
PATCH TESTING
P6A1
P6A2
P6A3
P6B1
P6B2
P6B3
P6C1
P6C2
P6C3
P6D1
P6D2
P6D3
P6E1
P6E2
P6E3
P6F1
P6F2
P6F3
PATCH TSTNG END
PR PATCH 1
P1A1
P1A2
P1A3
PR PATCH 1 END
PR PATCH 10
P10A1
P10A2
P10A3
P10B1

```
P10B2
P10B3
P10C1
P10C2
P10C3
P10D1
P10D2
P10D3
P10E1
P10E2
P10E3
P10F1
P10F2
P10F3
P10G1
P10G2
P10G3
P10H1
P10H2
P10H3
P10I1
P10I2
P10I3
P10J1
P10J2
P10J3
PR PATCH 10 END
PR est 1
PR est 10
END

#Blocks
STROOP.........      0    0
--------Group 1      0    0
PR 10.1   0    0
PR EST 10.1    0    0
TEST1     0    0
--------Group 2      0    0
PR 10.2   0    0
PR EST 1.2     0    0
TEST2     0    0
--------Group 3      0    0
PR 1.3    0    0
PR EST 10.3    0    0
TEST3     0    0
--------Group 4      0    0
PR 1.4    0    0
PR EST 1.4     0    0
```

```
TEST4      0    0
PATCH..........      0    0
--------Group 5      0    0
PR 10.5   0    0
PR EST 10.5     0    0
P TEST5   0    0
--------Group 6      0    0
PR 10.6   0    0
PR EST 1.6      0    0
P TEST6   0    0
--------Group 7      0    0
PR 1.7    0    0
PR EST 10.7     0    0
P TEST7   0    0
--------Group 8      0    0
PR 1.8    0    0
PR EST 1.8      0    0
P TEST8   0    0

#Block-Trials
PR 10.1   BEGIN     10A1 10A2 10A3 10B1 10B2 10B3 10C1
PR 10.1   10C2 10C3 10D1 10D2 10D3 10E1 10E2 10E3
PR 10.1   10F1 10F2 10F3 10G1 10G2 10G3 10H1 10H2
PR 10.1   10H3 10I1 10I2 10I3 10J1 10J2 10J3 PR PATCH 10 END
PR 10.1   END
PR EST 10.1    PR est 10
TEST1     BEGIN     6A1  6A2  6A3  6B1  6B2  6B3  6C1
TEST1     6C2  6C3  6D1  6D2  6D3  6E1  6E2  6E3
TEST1     6F1  6F2  6F3  PR PATCH 10 END     END
PR 10.2   BEGIN     10A1 10A2 10A3 10B1 10B2 10B3 10C1
PR 10.2   10C2 10C3 10D1 10D2 10D3 10E1 10E2 10E3
PR 10.2   10F1 10F2 10F3 10G1 10G2 10G3 10H1 10H2
PR 10.2   10H3 10I1 10I2 10I3 10J1 10J2 10J3 PR PATCH 10 END
PR 10.2   END
PR EST 1.2     PR est 1
TEST2     BEGIN     6A1  6A2  6A3  6B1  6B2  6B3  6C1
TEST2     6C2  6C3  6D1  6D2  6D3  6E1  6E2  6E3
TEST2     6F1  6F2  6F3  PR PATCH 10 END     END
PR 1.3    BEGIN     1A1  1A2  1A3  PR PATCH 10 END     END
PR EST 10.3    PR est 10
TEST3     BEGIN     6A1  6A2  6A3  6B1  6B2  6B3  6C1
TEST3     6C2  6C3  6D1  6D2  6D3  6E1  6E2  6E3
TEST3     6F1  6F2  6F3  PR PATCH 10 END     END
PR 1.4    BEGIN     1A1  1A2  1A3  PR PATCH 10 END     END
PR EST 1.4     PR est 1
TEST4     BEGIN     6A1  6A2  6A3  6B1  6B2  6B3  6C1
TEST4     6C2  6C3  6D1  6D2  6D3  6E1  6E2  6E3
TEST4     6F1  6F2  6F3  PR PATCH 10 END     END
```

```
PR 10.5   BEGIN     P10A1     P10A2     P10A3     P10B1
     P10B2     P10B3     P10C1
PR 10.5   P10C2     P10C3     P10D1     P10D2     P10D3
     P10E1     P10E2     P10E3
PR 10.5   P10F1     P10F2     P10F3     P10G1     P10G2
     P10G3     P10H1     P10H2
PR 10.5   P10H3     P10I1     P10I2     P10I3     P10J1
     P10J2     P10J3     PR PATCH 10 END
PR 10.5   END
PR EST 10.5    PR est 10
P TEST5   BEGIN     P6A1 P6A2 P6A3 P6B1 P6B2 P6B3 P6C1
P TEST5   P6C2 P6C3 P6D1 P6D2 P6D3 P6E1 P6E2 P6E3
P TEST5   P6F1 P6F2 P6F3 PR PATCH 10 END     END
PR 10.6   BEGIN     P10A1     P10A2     P10A3     P10B1
     P10B2     P10B3     P10C1
PR 10.6   P10C2     P10C3     P10D1     P10D2     P10D3
     P10E1     P10E2     P10E3
PR 10.6   P10F1     P10F2     P10F3     P10G1     P10G2
     P10G3     P10H1     P10H2
PR 10.6   P10H3     P10I1     P10I2     P10I3     P10J1
     P10J2     P10J3     PR PATCH 10 END
PR 10.6   END
PR EST 1.6     PR est 1
P TEST6   BEGIN     P6A1 P6A2 P6A3 P6B1 P6B2 P6B3 P6C1
P TEST6   P6C2 P6C3 P6D1 P6D2 P6D3 P6E1 P6E2 P6E3
P TEST6   P6F1 P6F2 P6F3 PR PATCH 10 END     END
PR 1.7    BEGIN     P1A1 P1A2 P1A3 PR PATCH 10 END     END
PR EST 10.7    PR est 10
P TEST7   BEGIN     P6A1 P6A2 P6A3 P6B1 P6B2 P6B3 P6C1
P TEST7   P6C2 P6C3 P6D1 P6D2 P6D3 P6E1 P6E2 P6E3
P TEST7   P6F1 P6F2 P6F3 PR PATCH 10 END     END
PR 1.8    BEGIN     P1A1 P1A2 P1A3 PR PATCH 10 END     END
PR EST 1.8     PR est 1
P TEST8   BEGIN     P6A1 P6A2 P6A3 P6B1 P6B2 P6B3 P6C1
P TEST8   P6C2 P6C3 P6D1 P6D2 P6D3 P6E1 P6E2 P6E3
P TEST8   P6F1 P6F2 P6F3 PR PATCH 10 END     END

#Trial-Events
BEGIN     blank     blank2    blank3    4    3    2    1
     start
BEGIN     blank start
6A1  SET A     START BLANK    bo
6A2  yb
6A3  og
6B1  SET B     START BLANK    rg
6B2  ob
6B3  yo
6C1  SET C     START BLANK    gy
```

6C2	br		
6C3	ob		
6D1	SET D	START BLANK	ry
6D2	go		
6D3	yr		
6E1	SET E	START BLANK	rg
6E2	ob		
6E3	yo		
6F1	SET F	START BLANK	by
6F2	rg		
6F3	gb		
1A1	SET A	START BLANK	br
1A2	yo		
1A3	og		
10A1	SET A	START BLANK	ro
10A2	yr		
10A3	bg		
10B1	SET B	START BLANK	og
10B2	by		
10B3	rb		
10C1	SET C	START BLANK	ry
10C2	yo		
10C3	ob		
10D1	SET D	START BLANK	gr
10D2	rb		
10D3	oy		
10E1	SET E	START BLANK	yb
10E2	go		
10E3	br		
10F1	SET F	START BLANK	yg
10F2	oy		
10F3	gb		
10G1	SET G	START BLANK	gr
10G2	oy		
10G3	rb		
10H1	SET H	START BLANK	ob
10H2	yr		
10H3	go		
10I1	SET I	START BLANK	yg
10I2	rb		
10I3	oy		
10J1	SET J	START BLANK	ry
10J2	gr		
10J3	yo		
P6A1	SET A	START BLANK	b
P6A2	y		
P6A3	o		
P6B1	SET B	START BLANK	r

```
P6B2 o
P6B3 y
P6C1 SET C     START BLANK    g
P6C2 b
P6C3 o
P6D1 SET D     START BLANK    r
P6D2 g
P6D3 y
P6E1 SET E     START BLANK    r
P6E2 o
P6E3 y
P6F1 SET F     START BLANK    b
P6F2 r
P6F3 g
P1A1 SET A     START BLANK    b
P1A2 y
P1A3 o
P10A1     SET A     START BLANK    r
P10A2     y
P10A3     b
P10B1     SET B     START BLANK    o
P10B2     b
P10B3     r
P10C1     SET C     START BLANK    r
P10C2     y
P10C3     o
P10D1     SET D     START BLANK    g
P10D2     r
P10D3     o
P10E1     SET E     START BLANK    y
P10E2     g
P10E3     b
P10F1     SET F     START BLANK    y
P10F2     o
P10F3     g
P10G1     SET G     START BLANK    g
P10G2     o
P10G3     r
P10H1     SET H     START BLANK    o
P10H2     y
P10H3     g
P10I1     SET I     START BLANK    y
P10I2     r
P10I3     o
P10J1     SET J     START BLANK    r
P10J2     g
P10J3     y
PR est 1  blank     blank2    blank3    21s  blank27
```

```
blank17
PR est 10 blank     blank2    blank3    16s  blank20
blank10   64s  64s1
PR est 10 64s2 blank21   blank11   44s  44s1 blank22
blank12   17s
PR est 10 blank23   blank13   72s  72s1 72s2 blank24
blank14   58s
PR est 10 58s1 58s2 blank25   blank15   68s  68s1 68s2
blank26
PR est 10 blank16   21s  blank27   blank17   45s  45s1
blank28   blank18
PR est 10 51s  51s1 51s2 blank29   blank19
END  BLANK END END
```

APPENDIX B

Stroop Response During the Interval

Please indicate the "ink" color of the print used for the text with a check mark. Although the text may read as one color, the "ink" color of the word may be different. Be sure to mark the "ink" color and NOT the color that the word reads. Answer the problems as quickly as possible without sacrificing accuracy because the computer is set to display the words on a timer. Words will appear in sets of three. Also, be aware of the passage of time because you will be asked to estimate the duration that the computer took to display all of the words (the amount of time between the words "START" and "END"). If you have any questions, please ask them now.

A)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

B)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

C)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

D)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

E)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

F)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

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APPENDIX C

Stroop Response During One Practice Trial

Please indicate the "ink" color of the print used for the text with a check mark. Although the text may read as one color, the "ink" color of the word may be different. Be sure to mark the "ink" color and NOT the color that the word reads. Answer the problems as quickly as possible without sacrificing accuracy because the computer is set to display the words on a timer. Words will appear in a set of three. If you have any questions, please ask them now.

A)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

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APPENDIX D

Stroop Response During 10 Practice Trials

Please indicate the "ink" color of the print used for the text with a check mark. Although the text may read as one color, the "ink" color of the word may be different. Be sure to mark the "ink" color and NOT the color that the word reads. Answer the problems as quickly as possible without sacrificing accuracy because the computer is set to display the words on a timer. Words will appear in sets of three. If you have any questions, please ask them now.

Please turn to the next page.

A)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

B)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

C)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

D)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

E)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

F)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

G)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

H)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

I)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

J)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

DO NOT TURN THE PAGE AT THIS TIME.

APPENDIX E

Color Patch Response During the Interval

Please indicate the "ink" color of the projected boxes with a checkmark. Answer the problems as quickly as possible without sacrificing accuracy because the computer is set to display the color blocks on a timer. Blocks will appear in sets of three. Also, be aware of the passage of time because you will be asked to estimate the duration that the computer took to display all of the blocks (the amount of time between the words "START" and "END"). If you have any questions, please ask them now.

A)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

B)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

C)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

D)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

E)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

F)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

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APPENDIX F

Color Patch Response During One Practice Trial

Please indicate the "ink" color of the projected boxes with a checkmark. Answer the problems as quickly as possible without sacrificing accuracy because the computer is set to display the color blocks on a timer. Blocks will appear in a set of three. If you have any questions, please ask them now.

A)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

DO NOT TURN THE PAGE AT THIS TIME

APPENDIX G

Color Patch Response During 10 Practice Trials

Please indicate the "ink" color of the projected boxes with a checkmark. Answer the problems as quickly as possible without sacrificing accuracy because the computer is set to display the color blocks on a timer. Blocks will appear in a set of three. If you have any questions, please ask them now.

Please turn to the next page.

A)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

B)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

C)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

D)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

E)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

F)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

G)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

H)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

I)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

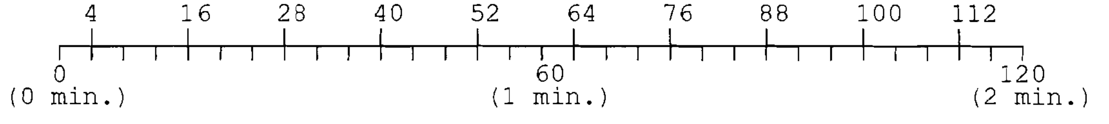
J)	BLUE	GREEN	ORANGE	RED	YELLOW
1.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐

DO NOT TURN THE PAGE AT THIS TIME.

APPENDIX H

Time Estimating After the Interval

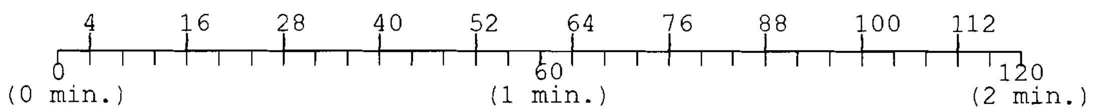
Below is a line that represents time. It is marked at 4 second intervals (each mark represents 4 seconds of time; some intervals have been labeled for your convenience). Please put a slash mark (/) on the line to indicate the amount of time that elapsed between the words "START" and "END." If you have no questions, you may proceed. After you are done, put your pencil down and look up at me. If you have any questions, please ask them now.



APPENDIX I

Time Estimating After One Practice Trial

Below is a line that represents time. It is marked at 4 second intervals (each mark represents 4 seconds of time; some intervals have been labeled for your convenience). Please put a slash mark (/) on the line to indicate the amount of time that the white dot appeared on the screen. If you have no questions, you may proceed. After you are done, put your pencil down and look up at me. If you have any questions, please ask them now.



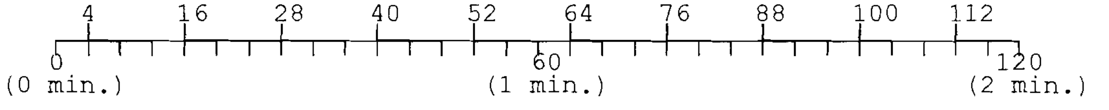
DO NOT TURN THE PAGE AT THIS TIME.

APPENDIX J

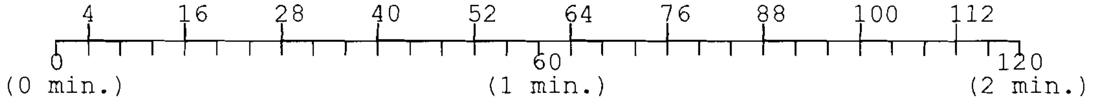
Time Estimating After 10 Practice Trials

Below are lines that represents time. They are marked at 4 second intervals (each mark represents 4 seconds of time; some intervals have been labeled for your convenience). Please put a slash mark (/) on the line to indicate the amount of time that white dot appeared on the screen. If you have no questions, you may proceed. After you are done with each problem, put your pencil down and look up at me. If you have any questions, please ask them now.

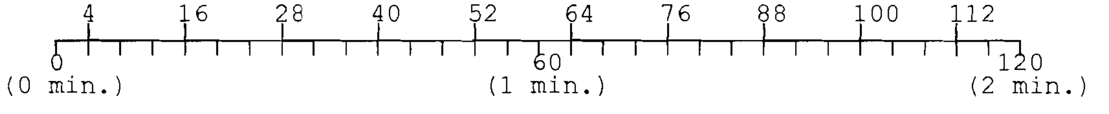
A)



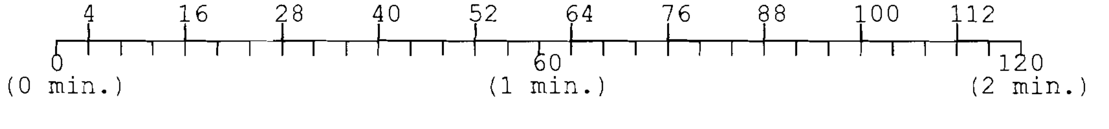
B)



C)



D)



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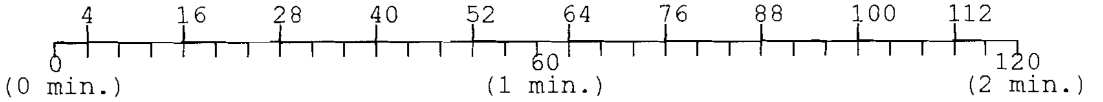
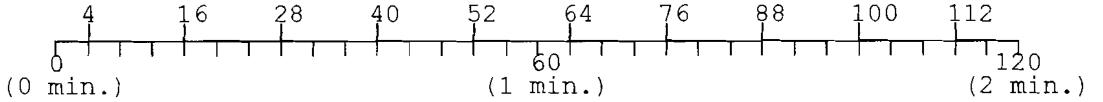
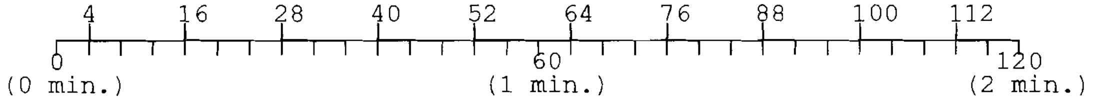
E)



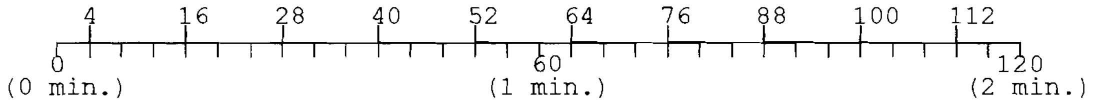
F)



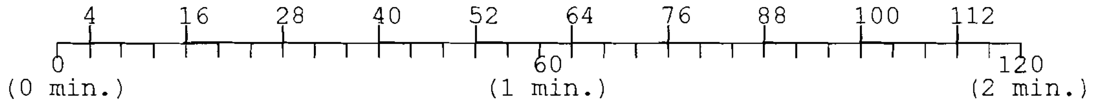
G)



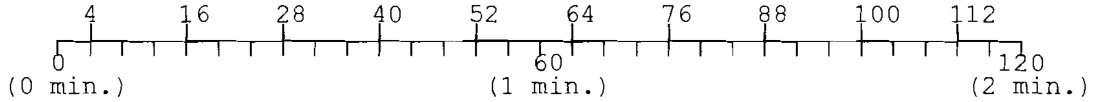
H)



I)



J)



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APPENDIX K

Participation Consent Letter

Read this consent form. If you have any questions ask the experimenter and he will answer the question.

You are invited to participate in a study investigating the relation between memory and time estimation. You will view a series of colored words and then you will be asked to try to estimate the length of time visual display ran.

Information obtained in this study will be identified only by a code number. Your name will be used only to indicate that you participated in the study to receive credit for your class.

Your participation in this study is voluntary. You should be aware that even if you agree to participate, you are free to withdraw at any time, and that if you do withdraw from the study, you will not be subjected to reprimand or any other form of reproach.

If you have any additional questions, feel free to contact Shawn Farris, Division of Psychology and Special Education, Visser Hall 310, 341-5803.

Thank you for your participation.

I,_________________ (please print name), have read the above information and have decided to participate.

I understand that my participation is voluntary and that I may withdraw at any time without prejudice after signing this form should I choose to discontinue participation in this study.

______________________________ ______________

(signature of Participant) (date)

____

(signature of Experimenter)

THIS PROJECT HAS BEEN REVIEWED BY THE EMPORIA STATE UNIVERSITY COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS

APPENDIX L

Institution Review Board Form

EMPORIA STATE UNIVERSITY

APPLICATION FOR APPROVAL TO USE HUMAN SUBJECTS

This application should be submitted, along with the Informed Consent Document, to the Institutional Review Board for Treatment of Human Subjects, Research and Grants Center, Plumb Hall 313F, Campus Box 4003.

1. Name of Principal Investigator(s) (Individual(s) administering the procedures): J. Shawn Farris

2. Departmental Affiliation: Division of Psychology and Special Education

3. Person to whom notification should be sent: J. Shawn Farris

Address: 116 S. Constitution, Emporia, KS, 66801

Telephone: (316) 342-8269

4. Title of Project: THE EFFECT OF AUTOMATICITY ON PROSPECTIVE ESTIMATES OF TEMPORAL DURATION USING STROOP INTERFERENCE

5. Funding Agency (if applicable): N/A

6. Project Purpose(s): To examine the way people encode information into memory and the effects on their estimation of time.

7. Describe the proposed subjects: (age, sex, race, or other special characteristics, such as students in a specific class, etc.): Introduction to Psychology (PY100) students and Developmental Psychology (PY211) students.

8. Describe how the subjects are to be selected: Students volunteer by signing a sign-up sheet

9. Describe the proposed procedures in the project. Any proposed experimental activities that are included in evaluation, research, development, demonstration, instruction, study, treatments, debriefing, questionnaires, and similar projects must be described here. Copies of questionnaires, survey instruments, or tests should be attached. (Use additional page if necessary.): Participants will look at a series of colored words or blocks flashed on a projector screen and will estimate the length of time that the words flashed while trying to decipher the color of words.

10. Will questionnaires, tests, or related research instruments not explained in question #9 be used? _____Yes __X__No (If yes, attach a copy to this application.)

11. Will electrical or mechanical devices be used? __X__Yes _____No (If yes, attach a detailed description of the device(s).): The only electrical device is a computer that will be used to flash the words on the screen

12. Do the benefits of the research outweigh the risks to human subjects? __X__Yes _____No This information should be outlined here: There is virtually no risk involved in this experiment; the activities are much like watching a slide show.

13. Are there any possible emergencies which might arise in utilization of human subjects in this project? _____Yes __X__No Details of these emergencies should be provided here.

14. What provisions will you take for keeping research data private? No personal data will be collected.

15. Attach a copy of the informed consent document, as it will be used for your subjects.

STATEMENT OF AGREEMENT: I have acquainted myself with the Federal Regulations and University policy regarding the use of human subjects in research and related activities and will conduct this project in accordance with those requirements. Any changes in procedures will be cleared through the Institutional Review Board for Treatment of Human Subjects.

______________________________ ______________

Signature of Principal Investigator Date

______________________________ ______________

Faculty advisor/instructor on project (if applicable) Date

APPENDIX M

Six Sets of Three Stroop Words

Six Sets of Three Words that are Color-Word Incongruent

The color-word combinations and the order of their presentation were randomly selected with the following restrictions: (1) color-word combinations must be incongruous, (2) a color cannot appear twice in any one set, and (3) a word cannot appear twice in any one set.

Set	Number	Color	Word
A	1	blue	orange
A	2	yellow	blue
A	3	orange	green
B	1	red	green
B	2	orange	blue
B	3	yellow	orange
C	1	green	yellow
C	2	blue	red
C	3	orange	blue
D	1	red	yellow
D	2	green	orange
D	3	yellow	red

Set	Number	Color	Word
E	1	red	green
E	2	orange	blue
E	3	yellow	orange
F	1	blue	yellow
F	2	red	green
F	3	green	blue

APPENDIX N

Six Sets of Three Color Patches

The color patches are the same as the color selected for the six sets of three words that are color-word incongruent.

Set	Number	Patch Color
A	1	blue
A	2	yellow
A	3	orange
B	1	red
B	2	orange
B	3	yellow
C	1	green
C	2	blue
C	3	orange
D	1	red
D	2	green
D	3	yellow
E	1	red
E	2	orange
E	3	yellow

Set	Number	Patch Color
F	1	blue
F	2	red
F	3	green

APPENDIX O

One Stroop Word Practice Trial

The color-word combinations and the order of their presentation were randomly selected with the following restrictions: (1) color-word combinations must be incongruous, (2) a color cannot appear twice in any one set, and (3) a word cannot appear twice in any one set.

Set	Number	Color	Word
A	1	blue	red
A	2	yellow	orange
A	3	orange	green

APPENDIX P

One Color Patch Practice Trial

The color patches are the same as the color selected for the one Stroop practice trial.

Set	Number	Patch Color
A	1	blue
A	2	yellow
A	3	orange

APPENDIX Q

Ten Stroop Word Practice Trials

The color-word combinations and the order of their presentation were randomly selected with the following restrictions: (1) color-word combinations must be incongruous, (2) a color cannot appear twice in any one set, and (3) a word cannot appear twice in any one set.

Set	Number	Color	Word
A	1	red	orange
A	2	yellow	red
A	3	blue	green
B	1	orange	green
B	2	blue	yellow
B	3	red	blue
C	1	red	yellow
C	2	yellow	orange
C	3	orange	blue
D	1	green	red
D	2	red	blue
D	3	orange	yellow

Set	Number	Color	Word
E	1	yellow	blue
E	2	green	orange
E	3	blue	red
F	1	yellow	green
F	2	orange	yellow
F	3	green	blue
G	1	green	red
G	2	orange	yellow
G	3	red	blue
H	1	orange	blue
H	2	yellow	red
H	3	green	orange
I	1	yellow	green
I	2	red	blue
I	3	orange	yellow
J	1	red	yellow
J	2	green	red
J	3	yellow	orange

APPENDIX R

Ten Color Patch Practice Trials

The color patches are the same as the color selected for the 10 Stroop practice trials.

Set	Number	Patch Color
A	1	red
A	2	yellow
A	3	blue
B	1	orange
B	2	blue
B	3	red
C	1	red
C	2	yellow
C	3	orange
D	1	green
D	2	red
D	3	orange
E	1	yellow
E	2	green
E	3	blue

Set	Number	Patch Color
F	1	yellow
F	2	orange
F	3	green
G	1	green
G	2	orange
G	3	red
H	1	orange
H	2	yellow
H	3	green
I	1	yellow
I	2	red
I	3	orange
J	1	red
J	2	green
J	3	yellow

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J. Shawn Farris

Signature of Author

7/30/99

Date

The Effect of Automaticity on Prospective Estimates of Temporal Duration Using Stroop Interference

Title of Thesis

Signature of Graduate Office Staff Member

August 9, 1999

Date Received