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Connecting Perceptual Organization To Time Perception

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CONNECTING PERCEPTUAL ORGANIZATION TO TIME PERCEPTION

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ABSTRACT

Previous research suggests that the organizational cue, connectedness, can influence time judgments of geometric shapes. The stimuli of those experiments consisted of geometric shapes with lines. In the organized set of stimuli, the lines joined the shapes together , and in the unorganized set of stimuli, the lines floated in whitespace amongst the shapes. However, connectedness affected time judgments in two seemingly opposing directions in previous experiments. The current experiment sought to clarify the differences between the results of the earlier experiments by modifying the instructions of the second task to have participants count the number of disjoint shapes. In this experiment, there were no differences between the time judgments for the organized and unorganized images. The results may suggest that the way the participants interpret the stimuli influence their time judgments.

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CHAPTER 1

INTRODUCTION

Our perception of time keeps us organized. We keep track of time so we know when to begin and end tasks. However, our perception of time is easily manipulated. On the best of days, we simply know when it has been long enough to check the clock for the real time. The goal of this master's thesis is to further investigate how time can be manipulated.

CHAPTER 2

LITERATURE REVIEW

Timekeeping Models

There is some debate about how we keep track of time, but there are two broad classes of timekeeping models: dedicated models and intrinsic models (Ivry & Schlerf, 2008). Dedicated models suggest that modular regions in the brain are responsible for timekeeping. Modular regions are areas with one specialized function. Regions implicated as assisting in timekeeping include the cerebellum, the frontal and parietal lobes, as well as the basal ganglia (Grondin, 2010). In these dedicated models, each region has its own designated task having to do with tracking time. In one variant, an oscillator region generates pulses, and the more pulses that are detected by a counter, the greater the amount of time that is perceived by the person (Ivry & Schlerf, 2008). These make up an kind of "internal clock." When resources are taken away from the regions responsible for counting pulses, time seems to become shorter. Thus, easier tasks should seem to last longer because you have more resources to catch pulses.

However, dedicated models that suggest that we have an internal clock cannot explain how factors outside of the supposedly modular regions affect time judgments without contradicting themselves (Birth, 2014). Once activity from the "non-dedicated" regions affects the theoretical modular clock's timekeeping performance, it is no longer a clock. This is because performance is impacted by the activity or inactivity of other processes, which should not be the case if the tool is like a clock.

Intrinsic models suggest that our general brain processing can be used to generate time perception (Ivry & Schlerf, 2008). Time is something inherent in what the brain is processing and perceiving that allows the person to make an educated guess about duration. One popular intrinsic model is the *energy model*. In this model, time judgments can be influenced by the amount of energy involved in processing (Eagleman & Pariyadath, 2009). Eagleman and Pariyadath suggest that the energy used at the neuronal level can predict time judgments. Efficiently coded processes will lead to shorter duration judgments because they consume less energy. A duration in which minimal energy is used to process stimuli will be judged as shorter than a duration in which a larger amount of energy is used to process stimuli. However, intrinsic models are often flexible to the point that they cannot easily narrow down the how the brain tracks time.

Factors Affecting Time Perception

Energy efficiency.

Consistent with the idea that simply varying neural energy can affect time judgments, duration judgments are affected by many different sensory factors. For example, when a stimulus is an unexpected occurrence (an oddball), it seems to last for a longer amount of time than an expected stimulus when they had the same duration (Pariyadath & Eagleman, 2007). According to the energy model, this is because the expected stimuli are processed more efficiently and take less energy.

However, there are results that conflict with the energy model. Increasing the participants' cognitive workload with a secondary task sometimes seems to cause a decrease in the subjective duration (Molet, Alessandri, & Zentall, 2011; Zakay, Nitzan, & Glicksohn, 1983). Molet et al. (2011) suggested that increasing cognitive load led to underestimation because participants paid less attention to the time judgments;

furthermore, they found that increased physical activity led to the participants overestimating the duration, but they were uncertain of the cause. They proposed that physical activity made the participants' internal-clocks more sensitive to the generated pulses. However, the reasons for the discrepancies between the energy model and the results are unclear.

Emotional responses.

In the Pariyadath and Eagleman (2007) experiment, they increased the emotional salience of the oddball images to see if the salience would impact participants' duration judgments further (Pariyadath & Eagleman, 2007). Emotional salience is related to the attention grabbing ability of the image due to the activation of the amygdale. While the emotional salience did not increase the magnitude of the effects already present with oddball stimuli in that experiment, the emotional responses of participants can impact their perception of time (Droit-Volet & Meck, 2007; Smith, McIver, Di Nella, & Crease, 2011). However, emotional response had various influences on the time judgments based on the image arousal rating and the range of the potential image durations. For example, when images were presented for 100-300 ms, negative images were perceived as lasting for less time than their true duration; but, when images were presented from 400-1600 ms, emotionally negative images were judged as lasting longer than positive images when they were both highly arousing (Smith et al., 2011). Similarly, when color is perceived as emotionally positive or negative, positive colors lead to underestimation of duration while negative colors lead to overestimations (Gorn, Chattopadhyay, Sengupta, & Tripathi, 2004).

Visual processing.

With the energy model in mind, other activity, such as visual processing, would influence timekeeping. Visual resources can be used by other brain regions using common formatting (Cavanagh, 2011). The information related to visually perceived objects can be communicated with the rest of the brain for additional mid- to high-level processing. Because time judgments may be processed using non-time specific resources, the information derived from objects could be used to compute the elapsed duration. As an example, someone monitoring the position of a second hand on a clock could track time relatively easily.

As a less apparent example of the influence of visual perception on time-keeping, some scene characteristics may affect temporal processing: there is evidence to suggest that scenes with unorganized structures are judged as lasting for a shorter amount of time than scenes with normal structure (Varakin, Klemes, & Porter, 2013). The authors believe that the normal, organized scenes provide a more complex, complete picture than the unorganized scenes (see Figure 1 for sample images[1]). If the scene types have different levels of complexity, there will be different amounts of energy expenditure per scene type. According to the energy model, this will lead to differences in the scenes' perceived durations: compared to the unorganized scenes, participants would use more energy to process the normal scenes; this is not necessarily linked to the idea that one type is processed more or less efficiently (as in Pariyadath & Eagleman, 2007); instead, normal images may use more energy while being processed by participants. The unorganized images' contents may be dismissed because of the lack of time to process

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[1] All figures are in the appendices.

and/or mentally rearrange them, leading to less energy expenditure and a relatively shorter perceived duration.

Sound effects.

Other forms of information can influence our perception of time. The difference in the pitch of two sounds being played can influence participants' duration judgments (Crowder & Neath, 1995). When two consecutive tones are played, two very different pitches are judged as lasting longer than two very similar pitches, even when they are played for the same amount of time.

Sound and light interactions.

The modality of stimuli can change the participants' duration judgments: sound-based stimuli are judged as lasting longer than vision-based stimuli of the same duration (Goldstone & Lhamon, 1974; Wearden, Edwards, Fakhri, & Percival, 1998). Further, the interaction of these two modalities can be exploited to distort duration judgments by intentionally exposing participants to incongruent sensory information (Van Wassenhove, Buonomano, Shimojo, & Shams, 2008). The perceived duration of sounds could be influenced by the alteration of the duration of accompanying light, but not vice versa. A sound was judged as lasting longer than it really did when the accompanying visual stimulus lasted for a relatively longer amount of time, and a sound was judged as lasting shorter when the accompanying visual stimulus lasted for a relatively shorter amount of time (Van Wassenhove et al., 2008). However, the duration judgments about light were not influenced by varying the duration of the accompanying sound.

Magnitude effects.

Considering visual stimuli in general, stimuli with visual attributes of higher magnitudes (brightness, numerosity, color saturation, etc. (Alards-Tomalin, Leboe-McGowan, Shaw, & Leboe-McGowan, 2014) lead to overestimations of the elapsed time when compared to the attributes with lower magnitudes (Xuan, Zhang, He, & Chen, 2007). Four attributes were tested by Xuan et al. (2007): physical size, luminance, number of objects, and scalar magnitude. The greater the magnitude, the greater the subjective duration. Other researchers agree that larger stimuli are judged as lasting longer than smaller stimuli (Ono & Kawahara, 2007).

Motion effects.

When considering motion, acceleration can also lead to interesting effects on time judgments: when objects are accelerating and then become invisible, the time until the object would reach a point on the screen if the acceleration was constant is overestimated because further acceleration is not taken into account (Bootsma & Oudejans, 1993). Likewise, participants underestimate the time that elapses when the object is decelerating.

The Temporal Bisection Task

There are a few ways to go about evaluating how participants perceive time. For instance, participants could report numeric durations that correspond to the presence of some observed stimuli. Alternatively, participants could hold a button on a computer for the amount of time they believed a stimulus was present. In these methods, the true times could be compared to the participants' perceived times to evaluate whether there were differences between the real and subjective durations. However, recognizing that the participants' perceptions are their reality, this study made use of the temporal bisection task to compare the subjective duration judgments of sets of stimuli.

When testing for many of these time judgment differences, researchers often use a temporal bisection task. The temporal bisection task is a useful method for comparing how long stimuli are subjectively judged to last relative to one another. In a temporal bisection task, participants judge each trial's stimulus duration as closer to either a short standard time (e.g., 400 ms) or a long standard time (e.g., 1600 ms). Having a stimulus duration of 1000 ms while using a short standard of 400 ms and a long standard of 1600 ms creates a fairly ambiguous situation because 1000 ms is exactly between the two standards by which the participants are making their judgments. As the correct duration judgment becomes more ambiguous to the participant, the probability of the participant judging the duration as long or short becomes more similar.

Experimenters use the temporal bisection task to find the duration at which the participants respond "long" 50% of the time; this duration is known as a bisection point (aka, point of subjective equality). Because the participants respond long and short 50% of the time at the bisection point, that duration represents the turning point in the participants' judgment about the duration. The lower the duration of the bisection point, the earlier the participants begin to judge stimuli as "long." Thus, images with relatively lower bisection points are generally judged as lasting longer than images with relatively higher bisection points. When the standards are 400 and 1600 ms, one might think that 1000 ms would be the bisection point every time, but because of the malleable nature of time perception, the bisection point varies between people and stimuli.

Using a stimulus set in which every stimulus shares a common feature (i.e., a high-level [organization, orientation, etc] or a low-level [brightness, contrast, etc] feature) the stimulus set's average bisection point can be compared to that of another stimulus set's average bisection point. This is done to compare the two sets' biases regarding duration judgments. Some features may create more bias than others (in a consistent direction). As such, bisection points are ideal for comparing the effects of specific features on time perception.

Connectedness

Given that the organization of complex scenes has been tied to changes in time judgments (Varakin et al., 2013), the organization of simpler sets of stimuli may be able to reproduce the effects. Hays and Varakin (2015) selected the perceptual organization cue of connectedness to produce the organizational effects in a controlled way (see Figure 2 for sample stimuli). This cue is easily applied and manipulated to create organized and unorganized scenes.

Connectedness experiments.

Thus far, two experiments have been conducted regarding perceptual organization and time perception (Hays & Varakin, 2015). These two experiments investigated how organization would influence the duration judgments through temporal bisection tasks. The goal of the first experiment was to test whether or not simple geometric arrays could reproduce the earlier effects of scene organization (Varakin et al., 2013). In Experiment 1, participants (n=26) judged unorganized stimuli as lasting longer than organized stimuli (Hays & Varakin, 2015). This result contradicted the hypothesis, based on the Varakin et al. (2013), that organized stimuli would last for a longer time than unorganized stimuli.

The goal of the second experiment was to see how attending to the features within the stimuli, as well as attending to duration, may influence the duration judgments of the stimuli (Hays & Varakin, 2015). Thus, a second task was added to direct attention to the specific organizational features of the stimuli. The results of this experiment reversed the initial results; now, organized stimuli were judged as lasting longer than unorganized stimuli, which was consistent with the original hypothesis. The present experiment was designed to understand the basis for the contrasting findings of these initial connectedness experiments.

CHAPTER 3

EXPERIMENT DESCRIPTION

The results from Hays and Varakin (2015) suggest that inherent stimuli properties are not enough to consistently predict the participants' time judgments. Possibly, the focus of the secondary tasks can also influence the way in which participants create time judgments. This may be because there are multiple characteristics that influence duration judgments that can create contradictory judgments under different contexts. If that is the case, the task simply emphasizes the importance of characteristics to which participants attend. Furthermore, participants would then use information related to the attended characteristics to create time judgments.

Connectedness is an organizational cue that involves the formation of shapes and groups based on whether they are physically joined by lines or shapes. In previous research, Gestalt cues (i.e., grouping by similarity) were not perceived when they were not relevant (Mack, Tang, Tuma, Kahn, & Rock, 1992). This demonstrates that some Gestalt cues are not noticed by participants if they are not looking for them. Further research suggests that some aspects of connectedness are processed pre-attentively while others are not (Trick & Enns, 1997). In particular, specific shape formation (where the points of a polygon are connected by lines) seems to require conscious attention while clumping components together as a "shapeless blob" does not.

Thus, the organization of the stimuli may have been interpreted differently in the first two Hays and Varakin experiments (2015). In the first experiment, when connectedness was not being attended to by the participants through a classification task, the difference in magnitude (the difference in the number of separate objects) may have been the primary influence on the participants' time judgments. This is consistent with the idea that the objects within an organized array were perceived as one solid clump without any relationship information. Previous research also suggests that stimuli with a larger number of objects should be judged as lasting for a longer amount of time than stimuli with fewer objects (Alards-Tomalin et al., 2014). Matching this idea, organized arrays have fewer separated objects than unorganized arrays, and they were judged as short more often than the unorganized arrays in Experiment 1.

In the second experiment of Hays and Varakin (2015), there was a second task that directed attention to the organizational features: in half of the trials (which were randomly mixed with time judgment trials), participants classified the stimuli as organized or unorganized. With the additional task and trials, participants judged the organized stimuli as lasting longer than the unorganized stimuli. Perhaps the results of Experiment 2 were the reverse of Experiment 1 because the Gestalt cues were now a relevant, attended factor in Experiment 2. If the relationships between shapes and lines were only noticed in Experiment 2, their additional cognitive "information" may have contributed to the amount of energy required to process the organized stimuli, thus increasing subjective duration.

There are alternate explanations however. The change in results of Experiment 2 could be due to fatigue effects from having more trials than Experiment 1. Furthermore, the introduction of the second task may have interfered with participants’ ability to accurately track the passage of time (Brown & Boltz, 2002; Tse, Intriligator, Rivest, & Cavanagh, 2004). Finally, perhaps just paying attention to the arrays causes the mismatch.

Thus, the present experiment sought to further test the malleability of the direction of the time judgments' biases by having participants view the stimuli as they were shown in Experiment 2 with a different set of instructions. The focus of the instructions were shifted away from the connectedness cue, making the specific cues task-irrelevant once again. Instead, the stimuli were classified as having "six separate objects" or "two separate objects" (formerly known as *unorganized* and *organized arrays*, respectively). The goal was to direct the focus to the quantity rather than the organizational cue to see how the participants judge the duration under the new set of instructions. We know from previous experiments that arrays with more objects are normally judged as longer than arrays with fewer objects (Xuan et al., 2007). If the participants judged the two-object arrays as lasting longer than the six-object arrays (as in Experiment 2), then this would indicate an effect of attention, fatigue, or some other factor that needs to be explored. However, if the participants judge the two-object arrays as lasting for a shorter amount of time than the six-object arrays (as in Experiment 1), then this would support the idea that task-relevant attributes (such as connectedness or number) are important for influencing time perception.

To summarize, if changing the tasks leads to a different direction in time bias compared to Experiment 2, then there is evidence to suggest that time judgments are dependent on the task-relevant features of the visual stimuli being processed (i.e., connectedness and number), rather than time biases being dependent on either an absolute set of features (such as luminance, number, etc) inherent to the stimuli themselves or the introduction of a second task. Between Experiments 1 and 2, the cause of the change in results is ambiguous because of the difference in the number of tasks and the number of trials. This experiment will have the same number of tasks and trials as Experiment 2, but predict the same results as Experiment 1.

CHAPTER 4

METHOD

Participants

Thirty-six students from Eastern Kentucky University (23 females, M_{age} = 21, SD = 3) were enlisted using either the SONA system or a prepared verbal script. In order to participate, participants had to be 18 or older, have normal or corrected vision, and have no neurological disorders.

Stimuli and Apparatus

The same stimuli and equipment were used by Hays and Varakin (2015) in their second experiment. Two iMac computers with 21.5-inch widescreen LED-backlit monitors were used to present the stimuli on PsychoPy (Peirce, 2007). During the main experiment, there were two types of images: organized and unorganized images. In each image (see Figure 2), there were always 4 main shapes; the type, size, rotation, and color of each shape varied across images. Each shape was either a circle, a square, or a triangle. These shapes could were made to fit within circles ranging from 20 pixels in diameter to 70 pixels in diameter, but the sizes were chosen at random for every shape. The triangle was scaled to fit from a polygon with the points: (1,2), (0,0), (2,0). The colors could only vary between solid green, blue, and red. There were also always two lines, but the length, thickness, color, and rotation also varied. The lines in organized images always connected two shapes together without intersecting any of the other shapes or the other line. The lines in unorganized images were always drawn in whitespace. Each of the 50 organized images had a corresponding unorganized image. A corresponding image had the same shapes in the same positions, but organized images have shapes which are connected by lines while unorganized images have the same lines floating in a random position in space that does not overlap any other line or shape.

Procedure

The procedure is nearly identical to Experiment 2 by Hays and Varakin (2015). Throughout the experiment, the participants sat at an iMac workstation. On the computer, they entered the demographics for age, gender, and handedness, and were then presented with an initial set of instructions for the training phase. They were encouraged to ask questions at this point or during the training phase. The participants were instructed to put on a set of noise cancelling headphones for the remainder of the experiment.

During the training phase, participants judged the duration of a black outline of a box displayed onscreen as being either a long standard (1600 ms) or a short standard (400 ms). The participants used the "4" and "6" keys to respond after the stimulus disappeared. Before the start of the experiment, participants were randomly assigned to a response mapping condition that determined which button represented "short" or "long." During practice trials, if the participants judged the stimulus incorrectly, the computer produced a beeping noise. After 20 successful practice trials, the instructions for the test phase were displayed.

During the test phase, both the stimuli and the durations for which they could be displayed were different from the training phase. In a trial, the duration could be any of 400, 600, 800, 1000, 1200, 1400, or 1600 ms. Half of the trials were duration judgment trials, and the other half consisted of classification trials. Each stimulus was displayed 4 times (twice for each task), leading to 400 trials.

However, unlike Experiment 2 from Hays and Varakin (2015), the instructions for the second task were changed to relate to the magnitude, or the number of separate objects present. Rather than classifying the arrays as organized or unorganized, the second task was to categorize the number of objects on the screen as being either "2" or "6" (organized stimuli have two separate objects while unorganized stimuli have six separate objects). Time judgments were made with the "4" and "6" buttons on the keyboard number pad (with short and long being counterbalanced) and classification judgments were made with the "2" and "8" buttons (with "2" representing 2 distinct objects and "8" representing 6 distinct objects). During the stimulus classification task, participants classified the stimuli as organized or unorganized based on the examples within the instructions. Because the task was randomly selected at the end of each trial, the participants did not know which feature they needed to report ahead of time; thus, they needed to attend to both.

CHAPTER 5

RESULTS

Logit models were used to estimate bisection points in SPSS; a bisection point for each stimulus type (organized/unorganied) was computed for each participant. Across the two response mapping conditions, the average bisection points for the two types of organization (unorganized and organized) were compared using a mixed-ANOVA. However, 13 participants were dropped because of poor performance on the classification task (<90% accuracy), leaving n = 23. Regarding the main hypothesis that there would be a difference between the two array types (organized vs. unorganized), there was no main effect of Organization: the average bisection point for the unorganized group (M = 984 ms, SD = 247 ms) was not significantly different from the average bisection point for the organized group (M = 989 ms, SD = 240 ms); $F(1, 21) < 1$, $p > .05$. For a comparison of the bisection points across the experiments, see Figure 3. There was no main effect for the response mapping condition: the average bisection point when "6" represented "long" (M = 972 ms, SD = 334 ms) did not significantly differ from the average bisection point when "4" represented "long" (M = 1002 ms, SD = 349 ms); $F(1, 21) < 1$, $p > .05$. Similarly, the interaction effect between Organization and response mapping Condition was also insignificant; $F(1, 21) < 1$, $p > .05$, see Figure 4.

CHAPTER 6

DISCUSSION

When considered alone, these results are somewhat ambiguous. The results were inconsistent with both of the experiments by Hays and Varakin (2015). In the first experiment, the unorganized arrays were judged as lasting longer than the organized arrays. In the second experiment, the organized arrays were judged as lasting longer than the unorganized arrays. In the current experiment, neither array was judged as lasting longest.

There are several possible explanations, and the first has to do with difficulty. When two of the same task type are done at once, the difficulty increases (Proctor & Van Zandt, 1994). Because the current task involved two magnitude judgments (duration and quantity), the participants could have been influenced by the difficulty of the task. The standard deviations of the bisection points for each scene type in this experiment (compared to Experiment 2 by Hays and Varakin, 2015) were approximately 100 ms higher. More variability in duration judgment responses means the participants were less able to respond consistently to the real durations. That, along with the number of participants dropped due to their lack of accuracy, is consistent with the idea that the difficulty increased. However, a bivariate correlation did not suggest that the participants performed worse on one task compared to the other. Including all 36 participants (even those who did not meet the 90% criterion), there was a significant positive correlation between Counting Classification accuracy and Time Judgment accuracy ($r = .60$, $p < .001$). The mean Counting Classification accuracy was 90% (*SD* = 11%) and the mean Time Judgment accuracy was 87% (*SD* = 12%).

Another possible explanation for these results has to do with the inability to completely control the participants' cognitions. While attending to the number of objects due to the explicit instructions, they may independently recognize that the organizational cues are present. If participants recognized the presence of connectedness, it may ultimately affect their bisection points because they would not have to count the shapes with as much effort. Instead, they could check for the presence of a line that connects to any shape (like in Experiment 2 by Hays and Varakin). Whether or not participants discover this strategy could cause opposing trends in the bisection points. Consistent with this idea, the average bisection points for the two types of organization were approximately equal (meaning the varying "opposing" cognitive strategies could have washed out the differences).

By changing the task slightly, the results were completely different from either Experiments 1 or 2 by Hays and Varakin (2015). This brings up a two points worth noting. First, the differences in results between the first and second experiments may not be due to the introduction of the second task in experiment 2: the focus of the participants' task (i.e., number or organization) could be important. Second, the results of the experiments involving more trials (Experiment 2 by Hays and Varakin and this one) may not be due to fatigue and familiarity. The results could be dependent on the way the participants handle the visual information they perceive throughout the task.

There is further support for the idea that fatigue and familiarity did not influence the results of experiments. In similar, concurrent research regarding time estimation in relation to color and orientation, fatigue and familiarity were ruled out as causes of the changes in effects (Hays, Klemes, & Varakin, 2015) by doubling the number of trials and maintaining the use of one task (the time judgment task). If these results generalize, they would suggest that the participants in the present experiments were primarily influenced by some aspect of the classification task rather than by fatigue and familiarity.

As such, despite the lack of significance, it may be possible to interpret the results of the three connectedness experiments sensibly. First, perceiving connectedness can influence time estimations even if the task can change the direction of that influence. In the experiments did not invalidate the others' results; rather, they suggest cases that can modify the influence of connectedness. Second, the focus of simultaneous tasks can influence which information the participants use to create estimates of time. In the second experiment by Hays and Varakin (2015), the task's goals may have successfully directed focus to the organization of the shapes while the current experiment may have had a mixed focus (which would be consistent with the statistically insignificant results). Third, the demands of the tasks may influence how well the participants consistently interpret the information used for creating estimates of time; however, the way in which the participants cope with the demands of tasks may influence which information is selected as well as how consistently they interpret information. In the current experiment, the participants had to handle two magnitude tasks. In the previous experiments by Hays and Varakin (2015), they may have had an easier time making judgments because the tasks were more distinct: in the case of experiment 1, there was only one task, and experiment 2 had a magnitude task and an organization classification task rather than two magnitude tasks.

In the future, researchers should strive to create a pair of secondary tasks that are able to successfully simulates the direction of the bisection points of the first two experiments by Hays and Varakin (2015). The new tasks would seek to avoid the within task flexibility in cognitive strategies that the current counting task allows. This would help solidify the evidence in favor of the explanation that the task is capable of shaping the interpretation of the information that can influence the creation of an estimate of time.

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APPENDIX A

Figures

Normal Image

Jumbled Image

Figure 1. Scene-based Organization.

Note(s): Here is an example of an organized, normal scene and an unorganized, jumbled scene from Varakin, Klemes, and Porter (2013).

Source(s): Varakin, D. A., Klemes, K. J., & Porter, K. A. (2013). The effect of scene structure on time perception. *The Quarterly Journal of Experimental Psychology*, *66*(8), 1639–1652.

Unorganized, six-object array

Organized, two-object array

Figure 2. Array-based Organization.

Note(s): These images represent the two types of arrays: unorganized/six-object (left) and organized/two-object (right). The borders were added here to clearly distinguish them, and their dimensions are normally 640x480 (in pixels).

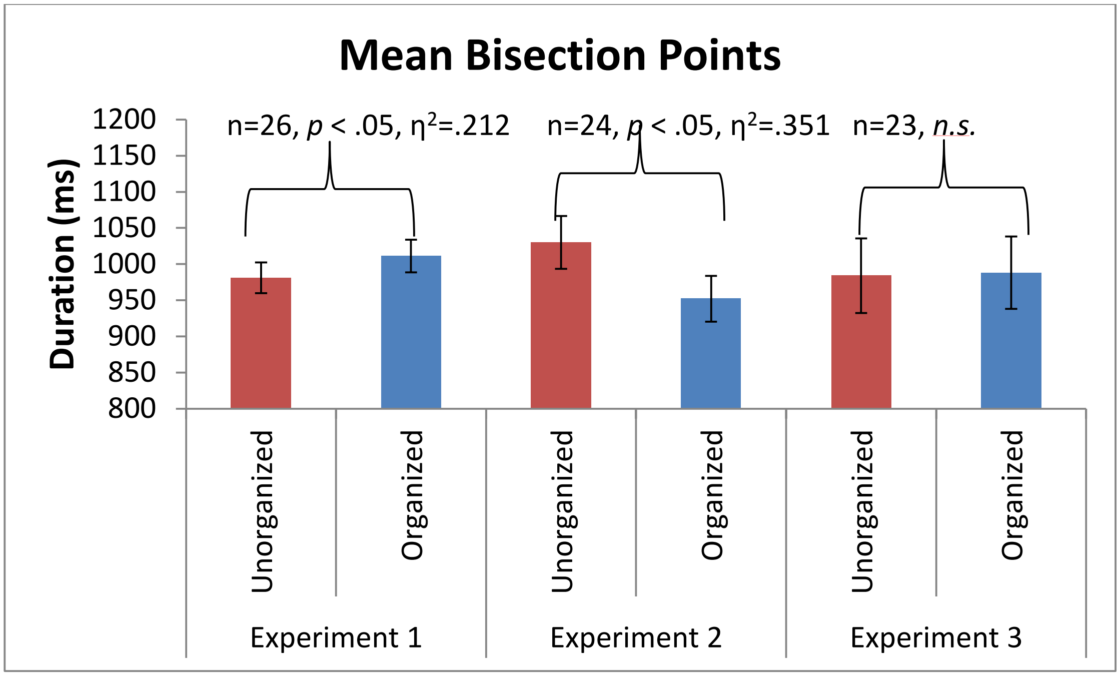

Figure 3. Experiments' Mean Bisection Points.

Note(s): This shows the average bisection points for unorganized and organized arrays across the three experiments. The error bars represent the standard error. Only the within experiment bisection points were compared. A relatively lower bisection point means the stimuli it represents were judged as lasting longer at a lower duration. This is interpreted as the participants perceiving the arrays within the relatively lower bisection point's group as lasting longer than the arrays within the relatively higher bisection point's group.

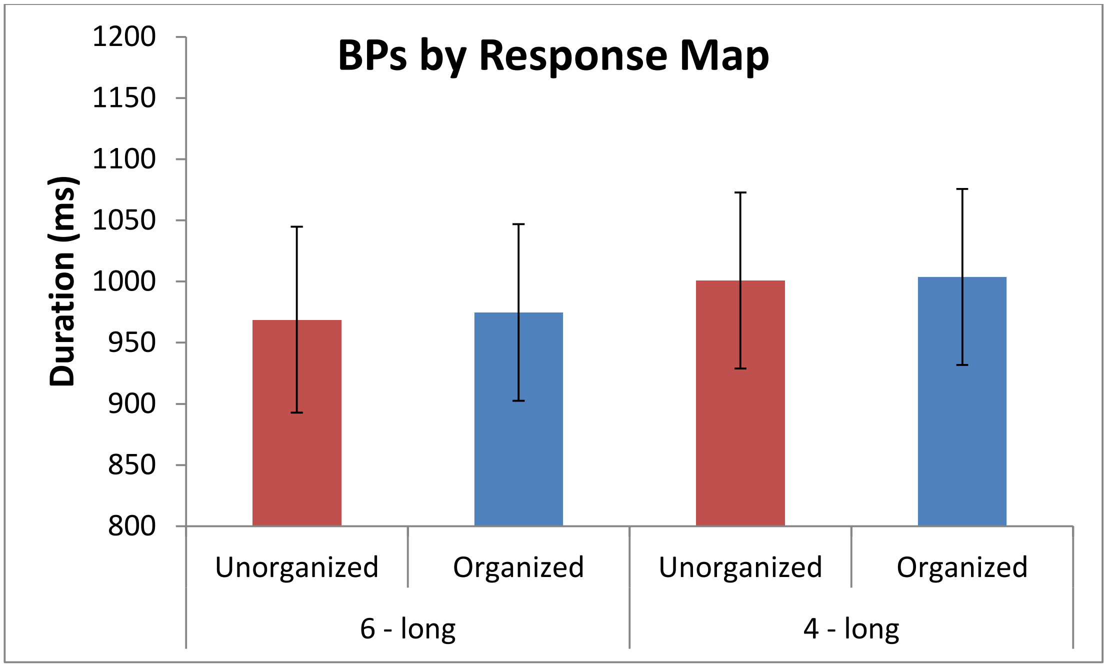

Figure 4. Mean Bisection Points by Response Map.

Note(s): This shows the average bisection points for each type of organization across the response map conditions. The interaction between the response map condition and the organization was insignificant.