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The Outer Limits of Cognitive Processing: A Closer Look at What Is Desirable

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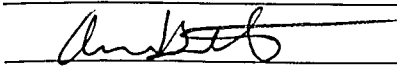
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The Outer Limits of Cognitive Processing: A Closer Look at What is Desirable

A Thesis

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Zachary K. Walter

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Abstract

Cognitive tasks are most satisfying when they include the right balance between ease and difficulty (Labroo & Kim, 2008). This balance is viewed as optimal for high quality and progressive learning in school and societal contexts (Bjork & Bjork, 1992). This idea is the basis of the concept of desirable difficulties, which are defined as certain difficulties in the learning process that can greatly improve long-term retention of learned material (Bjork & Bjork, 1992). Having received a lot of attention in recent research, they allow for one to develop questions about how we, as humans, approach certain tasks and where the cognitive difficulty threshold lies for maximum personal satisfaction. This study examines participants' ability to accurately recognize word and picture stimuli presented in one of five angles of rotation to determine whether a universal "desirably difficult" mental threshold exists or whether there are different mental thresholds based on the particular stimuli that are presented. Results show that there seem to be different mental thresholds depending on the type of stimulus that is presented. In addition, the threshold of what is considered to be desirably difficult does not act on a linear continuum; rather, it appears to fluctuate based solely on the difficulty of the task in a cubic-fashion.

The Outer Limits of Cognitive Processing: A Closer Look at What is Desirable

Neuronal interplay within the human brain has been shown to play a major role in how we perceive, understand, learn, and encode pieces of information we obtain in our everyday lives (Driver & Noesselt, 2008). Recent advances in cellular and molecular neurobiology techniques such as organelle and membrane staining have made it possible to see how individual cells facilitate neurotransmitter and ion release across a multitude of synapses. In combination with the also recently created structural and functional neuroimaging techniques, such as the CT, fMRI, and PET scans, it has become common knowledge that neuronal interplay in various regions and pathways within the human brain govern most, if not all, of our ability to engage in higher level processes. One of the most heavily researched topics related to higher-level processes is the role of cognition in learning. In order to study higher-level learning, one must acknowledge that there is a particular mechanism controlling the capacity for individuals to learn. One of these higher level processes that has recently come into the forefront of psychological research is the facilitation of optimal learning through the concept of desirable difficulties. Desirable difficulties help to explain how individuals are able to learn when there is a certain level of difficulty associated with a task. In addition, desirable difficulties may impact other cognitive factors such as attention and encoding processes that play a significant role in higher-level learning. Although there is not a lack of literature on desirable difficulties, it is still unclear as to what cognitive factors are responsible for the production of desirable difficulties (Bjork & Bjork, 1992).

The concept of desirable difficulties has gained a lot of popularity in recent years due to the limited knowledge we have about complex cognitive processes. Desirable

difficulties are defined as certain difficulties in the learning process that can greatly improve long-term retention of learned material (Bjork & Bjork, 1992). In other words, desirable difficulties are the difficult mental tasks that we may not enjoy performing, but that are important in achieving the appropriate level of difficulty for optimal learning. These difficulties are seen as being not too cognitively difficult yet not too cognitively easy.

Over time, the literature on desirable difficulties has become much more focused. In the beginning of higher-level learning research, desirable difficulties were shown to simply exist by Bjork and Bjork (1992), which is no real surprise given that we are able to directly experience different difficulties based on certain tasks that we perform in our everyday lives. For example, an individual may find typing a paper on a computer to be relatively difficult and typing a text message on a phone to be relatively easy. These are different levels of difficulties that are directly observable and commonly seen throughout our everyday lives. Therefore, it has been a foregone conclusion that a certain threshold of desirable learning exists. However, more research has verified the notion that desirable learning exists in a multitude of settings. Vlach and Sandhofer (2010) showed that the memories for certain words were greater in the long-term rather than the short-term. This implies that length of time between testing periods greatly impacts one's ability to learn. As for desirable difficulties, this suggests that as time progresses there is a certain level of difficulty associated with having to retrieve encoded information that was previously learned. Common knowledge would suggest that individuals would be more likely to retrieve information that was recently presented. However, Vlach and Sandhofer (2010) showed that this is not necessarily the case, providing evidence for the desirable difficulty

mechanism. In addition, Dobson (2011) examined how participants were able to improve their learning capabilities through an expanded learning technique rather than a uniform learning technique. Specifically, Dobson (2011) showed that uniform learning (i.e., learning the same facts in equal intervals of time) is inadequate for optimal learning. This result shows that there is a certain level of difficulty related to learning information in sporadic intervals as opposed to equal intervals when the total amount of study time for both groups is the same. Similar to the Vlach and Sandhofer (2010) study, common knowledge would typically favor the opposite result. That is, given the consistent nature of learning new material in equal intervals, it would generally be expected for individuals to learn more when their study times were regimented as opposed to sporadic. With Dobson's (2011) findings, there is even more compelling evidence suggesting that desirable difficulties are playing a vital role in higher-level learning by way of impacting the effortful processing individuals must put forth in challenging situations. Both of these recent studies exhibit the narrower focus in which researchers are approaching the concept of desirable difficulties in the current literature.

Despite what the current literature says about the mechanisms behind the learning process, there is still a somewhat limited scope of knowledge about how we study the mental thresholds that determine what is considered to be desirably difficult. However, there is compelling evidence that we are able to study what cognitive factors desirable difficulties are affected by through certain cognitive tasks. One experimental approach to studying desirable difficulties is by looking at recognition of stimuli presented in different rotations. Recent research by Barnhart and Goldinger (2013) suggests that word rotation illustrates the importance of word identification by showing that words written in

cursive are much harder to identify when they are tilted compared to when they stand upright. A closely related study by Sungkhasettee and Friedman (2011) showed that fully inverted words (i.e., words rotated 180 degrees so that they are completely upside-down) were also much more cognitively difficult to identify than words standing upright; yet, they also found that participants scored much higher on a recognition test over time when they had been exposed to fully inverted words as opposed to upright words. In fact, results indicate that participants not only did significantly better in the "inverted words" condition, but that participants in the "upright words" condition did not do much better than chance (as if they were guessing on every word in the recognition task). This study by Sungkhasettee and Friedman (2011) verified the previous notion by Bjork and Bjork (1992) that desirable difficulties are beneficial for learning and memory improvement.

Furthermore, Labroo and Kim (2008) found that people are much more satisfied and invested in goals that require some sort of physical or mental effort as opposed to goals that are easy. This finding suggests that desirable difficulties are not just critical for learning, but play an important role in individual enjoyment. However, determining what is "desirably difficult" is challenging because beliefs about what is desirably difficult are often skewed by faulty perceptions. For instance, the concept of unrealistic optimism, or the optimistic attitudes people display when facing adversity, can play a major role in distorting the difficulty of a task. Research has shown that people who portray unrealistic optimism actually show a diminished neural coding of undesirable information when they face adversity (Sharot, Korn, & Dolan, 2011). This implies that there is a biological basis for faulty perceptions, such as unrealistic optimism, which can misguide people into believing a task is easy or desirably difficult when it is actually too difficult to perform.

The basis of my research builds upon the methodologies and findings of Sungkhasette and Friedman (2011) as well as Labroo and Kim (2008) to further examine where the cognitive threshold lies between what is cognitively easy, desirably difficult, and too cognitively difficult. Up to this point, research has been conducted relating desirable difficulties to verbal tasks in discrete, isolated trials, however, no studies have been conducted to evaluate the universality of mental thresholds and whether or not they act on a linear continuum. The current study looks to address the fundamental research questions of whether mental thresholds lie on a linear continuum and whether or not there is a specific threshold that separates what is considered to be too cognitively difficult from what is considered to be desirably difficult. If results suggest that desirable difficulties do act in a linear fashion, then there would be a clear drop off of cognitive abilities as tasks appear to be getting more difficult. However, if desirable difficulties do not operate on a linear continuum, then I would expect measures of cognitive ability to fluctuate based on the perceived difficulty of the task instead of the appeared difficulty of the task. In this study, I assessed participants' learning, perceived learning, and task enjoyment in continuous trials with different stimulus rotations (0°, 45°, 90°, 135°, 180°) to approximate where the cognitive thresholds lie. I hypothesized that word and picture rotations that must be mentally flipped upside down and rotated slightly (135° condition), as opposed to only mentally flipped (180° condition) or only rotated slightly (45° condition; 90° condition), would be too cognitively difficult for participants to encode. If this is the case, I do believe that there exists a universal mental threshold in which recognition for the 135° condition will be significantly lower than all other degrees of rotation. However, the capacity for higher-level learning will not operate on a linear

continuum, as the previous literature would suggest, due to inconsistencies in recognition between each of the conditions. That is, recognition scores should not increase as the stimuli get progressively more inverted. Instead, recognition should be directly affected by the individual's perceived difficulty of the degree of rotation. .

Method

Participants

Thirty-four individuals (8 men and 26 women) from Butler University and the surrounding Indianapolis area willingly participated in this study. Individuals either received extra credit in a psychology course or a $5 Starbucks gift card. Participants who had been previously diagnosed with dyslexia were asked not to participate.

Design

I used a 3 x 5 mixed-factorial experimental design with degree of rotation ($0°$ vs. $45°$ vs. $90°$ vs. $135°$ vs. $180°$) as the between-subjects independent variable, such that each participant was assigned to one degree of rotation condition. In addition, stimulus type (low-frequency words vs. high-frequency words vs. pictures) was used as a within-subjects independent variable, such that all participants received all types of stimuli. Corrected recognition scores, enjoyment questionnaire scores, and "judgments of learning" were all dependent measures of this study.

Materials

Thirty high-frequency words, 30 low-frequency words, and 30 black and white two-dimensional and three-dimensional images of common, easily recognizable objects (see Appendix A) were chosen for a total of 90 visual stimuli. The high-frequency and low-frequency words were chosen from the word list from Brysbaert, Keuleers and New

(2011). Each word was five letters in length and chosen using a pseudorandom method. That is, a random number generator was used to choose the words from the word list; however, I replaced words with other words if the chosen word was too semantically related to another word that was already chosen (for example, I replaced "salad" with a different word because it was too semantically similar to the word, "lunch"). An internet search of common black and white pictures provided me with the appropriate pictures I needed. Due to the inability to find 30 common two-dimensional black and white pictures, I incorporated both three-dimensional and two-dimensional pictures into the study. These 90 visual items were then separated into three blocks. Each block contained 10 low-frequency words, 10 high-frequency words, and 10 black and white pictures. The order in which stimuli appeared in these blocks was randomized using the "rand" feature in Microsoft Excel. For the sake of consistency, every participant received the same randomized order of each block. Each of these blocks was presented in succession to one another. In addition to the visual stimuli, six low-frequency word distractor items, six high-frequency word distractor items, and six picture distractor items were chosen for the recognition test. I obtained the high-frequency and low-frequency distractor items from Bysbaerta, Keuleers, and New (2011). The picture distractor items were simply words that were semantically similar to the picture stimuli that were presented to the participants. A challenging maze from Krazydad.com (see Appendix B) was obtained in order to act as a distractor task between the stimuli presentation and the recognition test.

The recognition test contained six high-frequency words from each of the three blocks, six low-frequency words from each of the three blocks, and six pictures from each of the three blocks, totaling 54 items that were previously presented. All six of the

high-frequency, low-frequency, and picture distractors were also used on the recognition test to account for participants simply answering "yes" to all questions.

The stimuli were oriented in one of the five previously-mentioned rotations resembling a continuum (0°, 45°, 90°, 135°, 180°). Each of these degrees of rotation acted as a separate condition and each participant was assigned to view all stimuli in one of these five conditions.

A 10-item enjoyment questionnaire (see Appendix C) was administered to all participants in the middle of the experiment. Although the questionnaire contained 10 items, only five were scored. The other five questions were distractor catch-trial type questions.

MediaLab was utilized in order to present the visual stimuli as well as the recognition test. The challenging maze was administered on paper at the participant's workbench beside the computer. Due to the nature of the study (using specific word and picture rotations to achieve a particular orientation) participants had to place their head in a head-chin-rest apparatus before the experiment began.

Procedure

Participants were first greeted and given an informed consent form. They were then escorted into a separate room with the head-chin-rest situated in front of a computer containing all components of the experiment. Instructions were given to the participant to begin at any time and to ask the experimenter if they had any further questions about the study. Participants viewed each of the visual stimuli in one specific orientation. Participants viewed each stimulus for 4 seconds with a 1 second inter-stimulus interval. At the end of each stimulus presentation, participants rated whether or not they believed

they would recognize the given stimulus on a recognition test later (these are referred to as 'judgments of learning' or JOLs). Participants rated their JOLs on a scale from 50-100 with 50 being "I will definitely not remember this word or picture on a later recognition test" and 100 being "I will definitely remember this word or picture on a later recognition test." At the beginning of the study, I utilized a practice trial so that participants could understand how to properly rate their JOLs in relation to the stimuli that were presented. The word, "drain," was designated as the practice trial for all participants. After participants viewed and made JOLs for all 90 stimuli, they were administered a 10-item questionnaire that gauged their enjoyment of the first part of the experiment. Directly following the questionnaire, participants were given a maze to work on for approximately one minute. The maze acted as a distractor task to eliminate recency effects.

At the end of the experiment, participants were given a recognition test containing 54 of the previously presented stimuli and 18 distractor items. Each question asked "Was this item presented as either a word or a picture?" The participant had to either answer "yes" or "no." After completion of the recognition task, participants were verbally debriefed and escorted out of the testing room.

Results

Presented Stimuli Recognition

Participants' total scores were evaluated with corrected recognition. Corrected recognition was scored by taking the percentage of correctly recognized stimuli minus the percentage of falsely recognized stimuli (% correctly recognized - % falsely recognized). This was to account for any participant who gave the same answer for all stimuli on the recognition test. Results indicate that there was no statistical difference of overall corrected accuracy $F(4, 25) = 1.31, p > .05$, partial $\eta^2 = .17$. A two-way analysis of

variance with stimulus type as a within-participants factor and degree of rotation as a between-participants factor indicated no significant main effect of degree of rotation on corrected recognition, Wilks' λ = .69, F (4, 25) = 0.84, p > .05, partial η^2 = .13. Post-hoc analyses indicate that there is no significance between the 135° condition and all other conditions, p > .05. That is, individuals in the 0° condition (M = 75.61, SD = 15.95), 45° condition (M = 79.62, SD = 12.78), 90° condition (M = 72.22, SD = 15.11) and 180° condition (M = 72.59, SD = 23.89) were not statistically significantly different than the 135° condition (M = 67.90, SD = 15.07). In addition, there were no significant differences between any of the other degrees of rotation. However, the two-way ANOVA revealed a significant main effect of stimulus type, Wilks' λ = .77, F (2, 24) = 3.63, p < .05, partial η^2 = .23. Post-hoc analyses indicate that pictures (M = 79.44, SD = 11.68) were recognized more frequently than high-frequency words (M = 69.62, SD = 17.55), p < .05. In addition, post-hoc analyses indicate marginal significance between picture stimuli and low-frequency words. That is, pictures (M = 79.44, SD = 11.68) were recognized marginally more than low-frequency words (M = 71.66, SD = 18.93), p = .059. Although the total corrected accuracy varied as a function of degree of rotation and stimulus type (see Table 1), these differences were not statistically significant, all ps > .05. Also, the interaction between stimulus type and degree of rotation was not significant, Wilks' λ = .81, F (8, 48) = 0.69, p = .70, partial η^2 = .10. Although the interaction is nonsignificant, recognition scores for presented stimuli only (i.e., not distractors) (see Table 2) reveal similarities across all stimuli regardless of degree of rotation.

Distractor Stimuli Recognition

Figure 1 displays percentage of distractor items falsely recognized as a function of stimulus type and degree of rotation. A two-way ANOVA on these two factors revealed a significant main effect of stimulus type, F (2, 75) = 5.71, MSE = 171.78, p = .005, partial η^2 = .13. Post-hoc analyses revealed that significant differences exist between picture distractors (M = 3.89, SD = 8.40) and high-frequency distractors (M = 13.89, SD = 16.99), HSD = 10.00, p = .011, and between picture distractors and low-frequency distractors (M = 12.78, SD = 14.31), HSD = 8.89, p = .028. There was also a main effect of degree of rotation regarding falsely recognized stimuli, F (4, 75) = 3.08, MSE = 171.78, p = .021, η^2 = .14. Post-hoc analyses revealed no statistically significant differences between degrees of rotation, although the differences between 45° and 135° and between 45° and 180° approached statistical significance (p = .055 and .051, respectively). The stimulus type x degree of rotation interaction was not significant, F (8, 75) = 0.99, MSE = 171.78, p = .450, η^2 = .10.

JOLs

A one-way analysis of variance revealed no significant differences in judgments of learning between rotation conditions, p > .05. However, a one-way analysis of variance revealed a significant difference in judgments of learning between stimulus type, F (2, 87) = 18.29, p <.0001, η^2 = .296. Post-hoc analyses indicate a significant difference between judgments of learning for pictures (M = 79.10, SD = 9.99) and high-frequency words (M = 67.10, SD = 8.90), p < .001, such that individuals indicated that they would remember pictures much more frequently than high-frequency words. In addition, there was a significant difference between judgments of learning for pictures (M = 79.10, SD =

9.99) and low-frequency words ($M = 65.97$, $SD = 9.02$), $p < .001$. There was no statistical difference between high-frequency and low-frequency words, $p > .05$.

Enjoyment

A one-way analysis of variance revealed no significant difference in enjoyment ratings between conditions, $F (4, 25) = 1.085$, $p > .05$, $\eta^2 = .15$.

Discussion

The overall goal of this study was to examine whether there exists a mental threshold that divides what is desirably difficult from what is too cognitively challenging. I also wanted to examine whether or not higher-level learning operated more on a linear continuum or whether higher-level learning was solely dependent on task difficulty. Results show that I cannot definitively say that there is a mental threshold that divides what is considered to be too cognitively difficult from what is desirably difficult. Although statistically nonsignificant, unexpected patterns emerged from the results. The accuracy for low-frequency words, high-frequency words, and pictures without distractor items included were all relatively similar (see Table 2). This suggests that the participants were able to encode the stimuli at a fairly consistent rate. Therefore, any differences seen between degree of rotation conditions can be attributed to falsely recognized stimuli suggesting that the difficulty of the task elicits more false recognition which can greatly impact the encoding process or the ability to retrieve information. . Although there was no significant main effect of degree of rotation, results indicated that participants were significantly better at recognizing picture stimuli than low-frequency or high-frequency words. This resembles the picture superiority effect in which individuals remember

picture stimuli better than words (Mintzer & Snodgrass, 1999). Therefore, this was an expected result of the study.

In addition to participants recognizing pictures more than words, false recognition was shown to play a vital part in the higher-learning process. Participants who observed upright degrees of rotation (0°, 45°, and 90°) falsely recognized words at a much higher rate than pictures, whereas participants who observed inverted degrees of rotation (135°, 180°) did not make as many false recognitions of word stimuli. This finding suggests that as task difficulty increased, participants did not falsely recognize word stimuli indicating desirable learning was taking place. This is consistent with work done by Bjork and Bjork (1992) and Sungkhasette and Friedman (2011). Therefore, I am able to conclude that desirable difficulties do not act in a linear fashion, but instead are solely dependent on task difficulty. Based on these results, I believe there is evidence to suggest that desirable difficulties do exist and play a vital role in how individuals learn. Also, these results may be directly related to the distinctiveness heuristic, which is a retrieval strategy used to know that something did not happen or some stimulus did not appear. Specifically, the distinctiveness states that we have an expectation that we would remember seeing a picture compared to a word. That is, when we do not remember seeing a picture, we correctly infer it was not there (Dodson & Schacter, 2001). This furthers the point that stimulus type is a determining factor in the learning process. Based on the prior research and these results, there is evidence to believe that individuals with semantically unrelated knowledge may falsely recognize outside information in their surroundings. This can have detrimental effects such as an individual's inability to correctly recognize a crucial piece of information while performing a task. In addition,

these results show how eyewitness testimony can be brought about in a court of law. For example, through the presentation of outside stimuli that is semantically unrelated to other evidence in the case, individuals may falsely recognize "seeing" evidence that is not related to the case.

Participants' judgments of learning only differed significantly in relation to the stimulus type. This suggests that participants perceived that they would recognize pictures more than the high-frequency and low-frequency words. This may relate to the previous work of Dodson and Schacter (2001) who described the distinctiveness heuristic that was mentioned previously. Interestingly, participants did not perceive that they would recognize stimuli more in the upright degree of rotation conditions as previous work has suggested (Sungkhasettee & Friedman, 2011).

Participants did not differ significantly in their ratings of task enjoyment. Due to the participants' lack of difference in their perceived learning (JOLs), this result is not surprising. According to Labroo and Kim (2008), not only is there a difficulty level associated with optimal learning, but there is a difficulty level associated with optimal enjoyment. Because there was no statistical difference between any of the degree of rotation conditions signifying that there was no real difficulty level for optimal learning, it is to be expected that there would not be optimal enjoyment either.

Apart from small sample size, there were many aspects upon which this study could improve. The major experimental issue I faced was the lack of consistent modality for the picture stimuli. Some pictures appeared to be two-dimensional whereas others appeared to be three-dimensional. Although any differences between the two types of pictures should theoretically be spread evenly throughout all participants, it may have had

an all-encompassing effect due to the fact that a rotated three-dimensional object appears to be rotated differently than a two-dimensional object. For instance, a 45° three-dimensional picture of an airplane appears to be in a different orientation than a two-dimensional airplane rotated 45°. Although they are the same rotation, they may differ in the individual's perception. Also, I took no preventative measures to account for individuals who are able to process words from right to left as opposed from just left to right. This could be a problem due to those individuals possibly perceiving certain pictures rotated in the opposite direction. If I had controlled for this, then I would have assured that all participants were processing the high-frequency and low-frequency words in the same way. Because it is commonly known that people process faces holistically, if I were to control for people who read languages from right to left, I would ensure that all participants were processing all stimuli in the same way. Finally, because I made "degree of rotation" a between-subjects factor, every participant only received one degree of rotation throughout the entire experiment. There is the possibility that the participants became habituated to the rotated stimuli and started using other mental strategies to rotate the stimuli. Although there is no current research on mental strategies utilized in cognitive tasks assessing desirable difficulties, Mohring and Frick (2013) found that people, even infants, are able to habituate to mentally rotated objects and correctly recognize what the objects are with repeated exposure. It is not farfetched to say that the same phenomenon may have happened in this experiment.

The concept of desirable difficulties is still relatively new such that it has only been studied over the past 20 years. Further research should still be conducted in order to better understand how the process of learning is common to all healthy individuals. The

next step would be to design a study in which participants are only exposed to one type of stimulus (high frequency vs. low frequency vs. picture) with multiple degrees of rotation. If a mental threshold exists, this experimental design should be able to capture it. In addition, this would correct for the habituation problem that the current study faced and would allow for a much better understanding of how desirable difficulties and mental thresholds work.

The concept of desirable difficulties allows for the indirect study of cognitive mechanisms and cognitive processes that govern the learning process. As mentioned previously, work conducted by Vlach and Sandhofer (2010) showed that people recognized information better when they were further removed (time-wise) from the presentation of the stimuli suggesting that the difficulty of retrieving information facilitated learning. Through the results of this study, I believe Vlach and Sandhofer's (2010) findings to represent a real effect. Also, just as Sungkhasettee and Friedman (2011) showed that individuals learn more and exhibit better recognition when words were inverted, I was able to take that finding one step further to show that there are different patterns exhibited for each degree of rotation. This further suggests the possibility of a desirably difficult threshold. Just as Bjork and Bjork (1992) showed that desirable difficulties exist, I believe it is imperative that it be studied in more detail. Insight into how humans learn and enjoy certain tasks allows for better teaching methods, increased student comprehension, and many other potentially beneficial factors.

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Appendix A.

High Frequency Words

court coast purse teeth earth thing phase train nurse horse plant

drill group storm track board brain birth light smoke slave glass

stick lunch grass night badge floor blade fence

Low Frequency Words

troop slope snail noose flask swamp globe quart broom spark links

pouch curve plank frost brass crumb cleat hedge chart flood stair

grove thorn fleet peach graph stump ridge wharf

Pictures

clock	leprechaun	frog	bike	sombrero	barn
drum	pumpkin	cake	airplane	umbrella	well
lamp	typewriter	candycane	strawberry	flower	piano
house	boots	desk	rollercoaster	shirt	balloon
apple	sailboat	bear	guitar	Christmas tree	
ice cream					

Examples:

Cake   Christmas Tree   Frog   Guitar   Ice Cream Cone

Appendix B
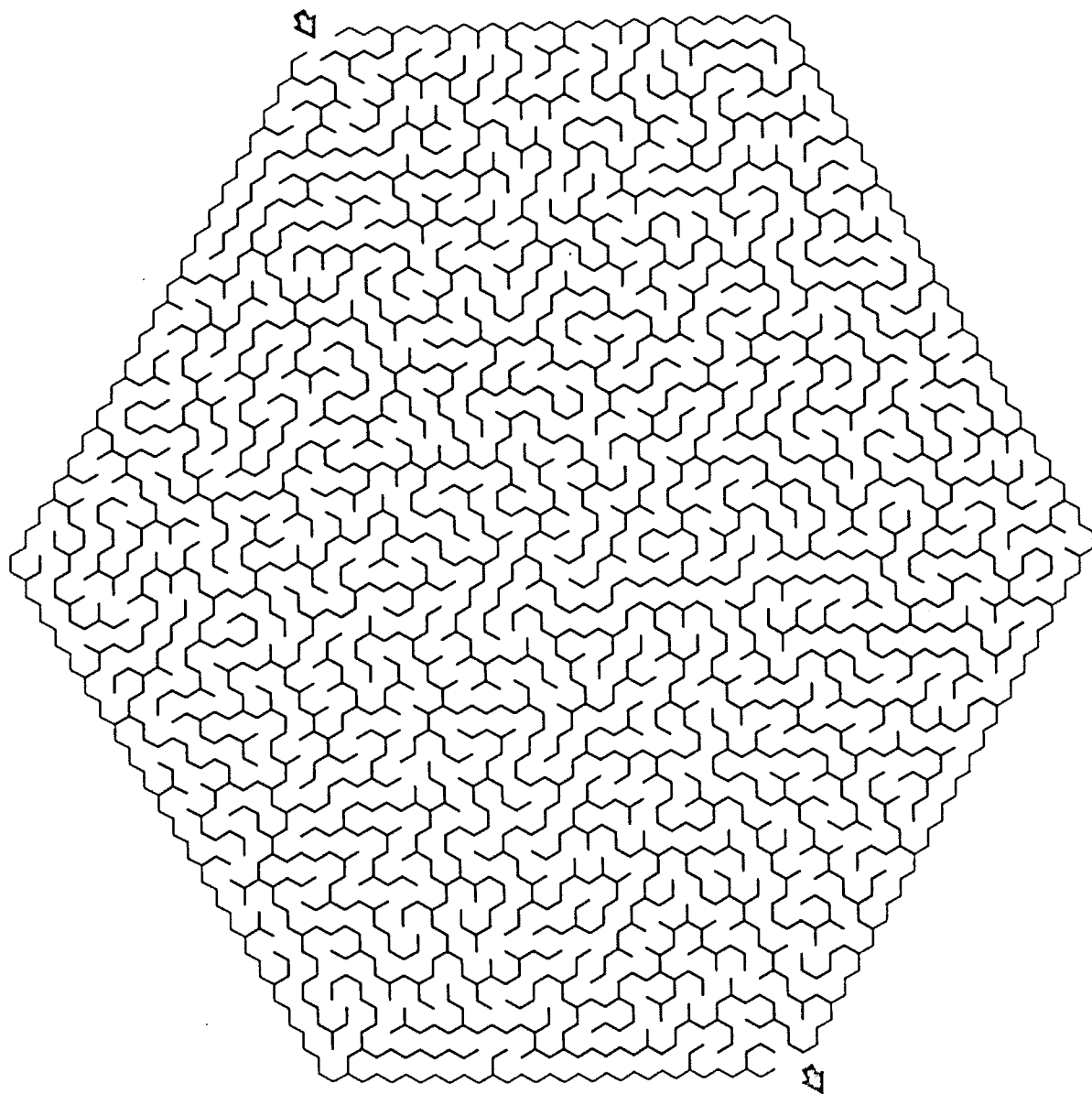
Appendix C
Task Enjoyment Questionnaire (questions of interest are bolded)

1.   I enjoyed participating in the task involved in this experiment.
Strongly Disagree   **Disagree**   **Neutral**   **Agree**   **Strongly Agree**

2.   I enjoy learning new skills.
Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

3.   If a similar experiment will be taking place in the future, I would be willing to participate.
Strongly Disagree   **Disagree**   **Neutral**   **Agree**   **Strongly Agree**

4.   My friends and I enjoy similar interests.
Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

5.   I had fun participating in this task.
Strongly Disagree   **Disagree**   **Neutral**   **Agree**   **Strongly Agree**

6.   I tend to enjoy tasks that most other students do not.
Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

7.   I would recommend this study to a friend based on how much I liked the task.
Strongly Disagree   **Disagree**   **Neutral**   **Agree**   **Strongly Agree**

8.   I dislike tasks that take a long time.
Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

9.   I make leisure time a priority in my everyday life.
Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

10.   I enjoy doing tasks similar to the one I just completed.
Strongly Disagree   **Disagree**   **Neutral**   **Agree**   **Strongly Agree**

Table 1

Corrected Accuracy as a Function of Stimulus Type and Degree of Rotation

		Stimulus Type	
		Word	Picture
	0	71.30	84.25
	45	80.09	78.70
Degree of Rotation	90	69.44	75.39
	135	64.81	74.07
	180	65.55	86.66

Table 2

Recognition of Presented Stimuli as a Function of Stimulus Type and Degree of Rotation

		Stimulus Type		
		High-Frequency Words	Low-Frequency Words	Pictures
	0	77.78	78.70	89.81
	45	80.56	87.96	78.70
Degree of Rotation	90	84.13	88.09	80.15
	135	84.26	81.48	82.41
	180	92.22	85.55	86.66
	M	**83.79**	**84.36**	**83.55**

Table 3

Tukey Post-Hoc Significance as a Function of Degree of Rotation

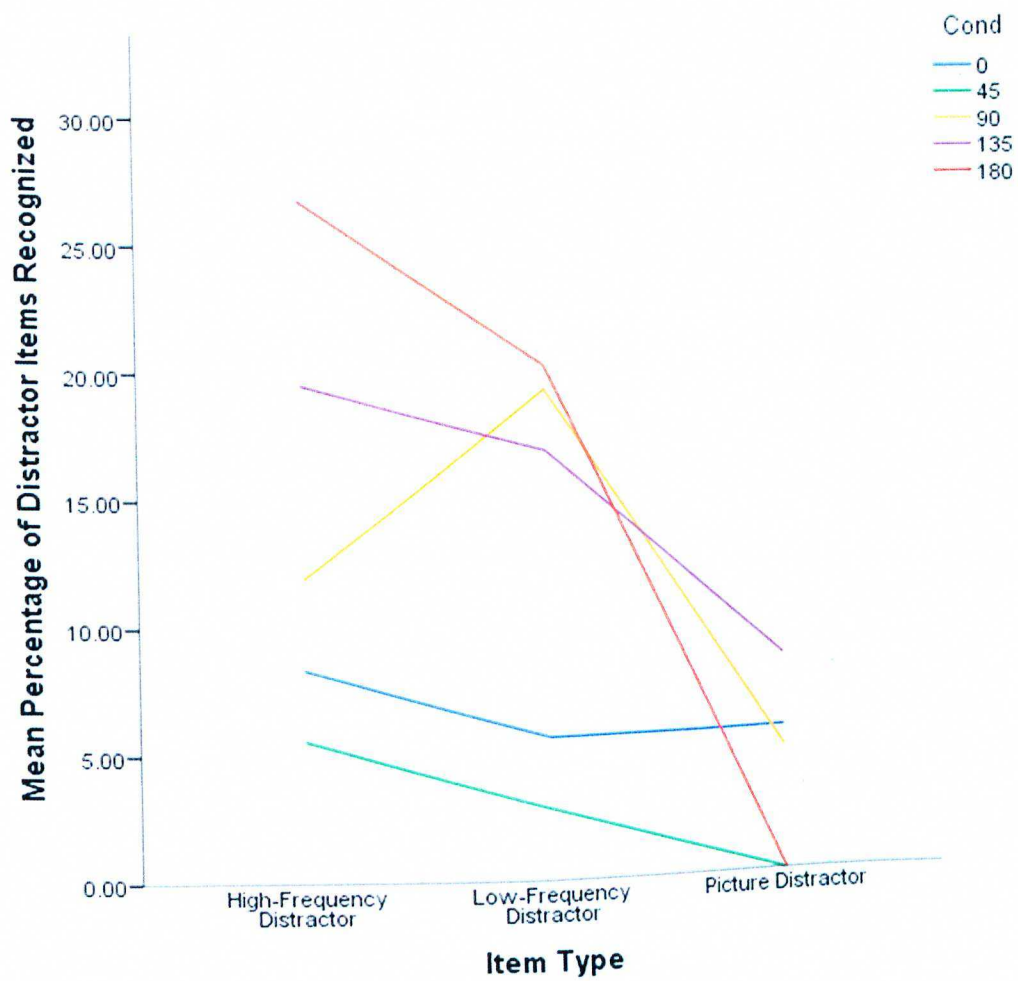| | | Degree of Rotation | | | | |
		0	45	90	135	180
Degree of Rotation	0	---	.950	.969	.635	.985
	45	.950	---	.638	.223	.746
	90	.969	.638	---	.927	1.000
	135	.635	.223	.927	---	.928
	180	.985	.746	1.000	.928	---

Figure 1. Mean percentage of distractor items recognized as a function of stimulus type and rotation condition.