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The Effect of Aphantasia on Visual Memory Retention

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by

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This thesis has been read and approved by the following supervisory committee and submitted in its final draft to the Longwood Senior Thesis Committee.

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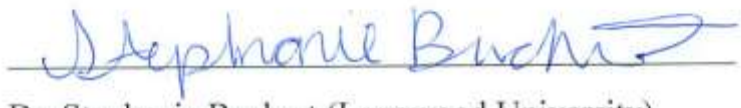

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Abstract

Aphantasia is the inability to create mental imagery which affects approximately 2% of people in the world (Zeman et al., 2015). The vividness of visual imagery questionnaire (VVIQ) was used to sort participants into four groups (aphantasia, low, medium, and high vividness) based on their vividness score with aphantasia participants scoring a 16 (the minimum). I tested the effect of aphantasia on scores of a visual memory recall test. Participants saw two of six possible images and answered five questions per image. Analysis of the results did not show any significant difference between aphantasia and non-aphantasia scores on the recall test however there was a significant difference between the image type (clipart or real-world scenes) and recall score. Future directions should examine the subconscious' role in mental imagery as a possible explanation as to why there was no significant difference between VVIQ groups on recall score.

Dedication

This thesis is dedicated to my parents, Michael and Kathy Bain, for always being there for me and pushing me to find something that I love working on and to my roommates for giving me the motivation I needed to continue working when I needed it the most.

The Effect of Aphantasia on Visual Memory Retention

Imageless thought is the phenomenon of being able to have a thought but no accompanying perceptual sensory aid (such as a mental picture of an object one is imagining). The inability to create these mental images during thought is currently known as aphantasia. Approximately 1% of people have aphantasia and cannot create these mental images according to self-report data from several thousand participants (Milton et al., 2021). More recently there has been research conducted with surgery patients finding that afterword people experience aphantasia (Farah et al., 1988; Zeman et al., 2015). Including aphantasia from surgery, injury, or diseases that may cause aphantasia the number could be closer to 2% of the population (Zeman et al., 2015). These self-reports come mostly from the Vividness of Visual Imagery Questionnaire (VVIQ). The definition of an aphantasia participant using the VVIQ is having the minimum score of 16. There is a long history about whether imageless thought can even exist or if people are simply communicating their vividness differently (Crowder, 2018).

History of Imageless Thought

Imageless thought is a concept that has had many cycles over the years and initiated one of the first controversies in psychology. This debate began when Oswald Kulpe and his colleagues started to investigate the psychology of thought through the means of Wundtian introspection (Kazdin, 2000). Wundtian introspection involved rigorous training to self-reflect in a replicable way to examine the changes that stimuli had on their mental state. Participants reported their sensations and emotions including pain, relaxation, and excitation. Wundt did not have the participants report surface level sensations such as tactile feeling (roughness) or sound (pitch or loudness) as these did not give any insight into one's processing of the stimuli. Using this thorough form of introspection in experiments with word association, the participants

attempted to explain what led them to choosing the specific word. The researchers believed that the inability of the participants to explain why they connected the word presented with their response was proof that some knowledge was unknowable through introspection. Narziss Ach's studies on determining tendency (originally *Einstellung* in German) supported the existence of these unknowable thoughts, now called imageless thoughts. Now known as a mental set in psychology, this is a tendency to approach situations in ways that worked in the past such as solving a new problem with a previously successful technique (Kazdin, 2000). All of these studies were meant to demonstrate thinking without any sensory properties and not being able to explain where the thoughts began using introspection.

The opponents of imageless thought at the time had issues with varying parts of the process. Titchener believed that Kulpe was coming to these results because of a stimulus error, focusing on the stimuli rather than on the resulting sensations. He believed that all ideas are linked with images as he had not yet found any case of imageless thought within his research (Calkins, 1910; Pylyshyn, 2006). Another opponent, James Angell, questioned whether introspection could analyze the contents of the mind. In his critique on imageless thought, he posits that the method for testing imageless thought is not satisfactory and only describable in negative terms (Angell, 1911). In other words, the participant's descriptions of imageless thought only described what is not there, rather than what is there. After Angell's paper the controversy faded out, waiting for another measurement tool, along with the phasing out of introspection.

Sir Francis Galton's article on the differences in vividness between individuals (Statistics of Mental Imagery, 1880) made the resurgence of the imageless thought debate possible. In the paper, Galton created a visualization questionnaire intending to measure vividness, definition, illumination, color, and various other features. He then categorized the responses from the

questionnaire into groups of low, mediocre, and high faculty (or ability) based on illumination (dim or clear image), definition (well defined or only sharp where focusing), and coloring (vast array of colors or closer to grayscale). Galton believed that these three qualities would be able to delineate someone's ability for vividness. Betts (1909) used Galton's work on voluntary visualization along with work conducted by Titchener (1909) to create an instrument to study spontaneous imagery, the automatic imagery during mental processes. Sheehan (1967) then created a shorter version of Betts' instrument and validated it. This led to Marks (1973) creating the Vividness of Visual Imagery Questionnaire (VVIQ) which is still in use today (Campos, 1995; Crowder, 2018; Zeman et al., 2015).

Measurements of Vividness

Researchers use the aforementioned VVIQ to measure the vividness of mental imagery and as a test for aphantasia (Blazhenkova, 2016; Crowder, 2018; Campos, 1995; McKelvie, 1995; Milton et al., 2021; Zeman et al., 2015). This self-report questionnaire has participants describe their vividness of scenes based on a Likert-type scale. The top of the questionnaire has instructions for each scene, such as "Visualize a rising sun" with each of the four following questions having specifics about the scene to imagine such as "The sun is rising above the horizon into a hazy sky" (Marks, 2020). The participants chose one of the options from 1-5 depending on their vividness. Marks (1973 pg. 18, 2020) defined the options as the following:

> 1. Perfectly clear and as vivid as normal vision; 2. Clear and reasonably vivid; 3. Moderately clear and vivid; 4. Vague and dim; 5. No image at all, you only "know" that you are thinking of the object.

In the 2020 post on his website, Marks has the numerical values reversed with 5 being no image at all (Marks, 2020). Marks believed this would help reduce social bias of selecting the lowest option which is also the lack of something (vividness).

Although researchers commonly use the VVIQ it is not the only method of testing vividness. Researchers also use the Object-Spatial Imagery Questionnaire (OSIQ) developed by Blazhenkova et al. (2006) for object and spatial visualization abilities. Object visualization is what the VVIQ is measuring with one imagining shapes, colors, and textures in pictures or scenes. Spatial visualization is associated with object relationships in three-dimensional space such as structure, location, and motion. Another method of measurement, the Vividness of Object-Spatial Imagery Questionnaire (VOSIQ), measures the vividness of object and spatial imagery; this was in response to object and spatial imagery abilities testing with the OSIQ (Blazhenkova, 2016). The validation of the VOSIQ showed that the VVIQ was only measuring object imagery and that there is a difference in that ability for most people (Blazhenkova, 2016). A later study showed that people have a tendency to be better at either object or spatial visualization rather than equal in both (Kosslyn & Thompson, 2012). Depending on the desired use these different tests have efficacies predicting outcomes. For example, a mental rotation task uses mostly spatial visualization, because of this the OSIQ (for ability) or VOSIQ (for vividness) would be better than the VVIQ. Previous studies examined the relationship between types of visualization and education such as the effect of aphantasia on STEM/Arts self-efficacy and found that people reporting lower on the VVIQ had lower arts self-efficacy (Crowder, 2018).

Context for my Study

Previous research in vividness has linked mental imagery to mathematical learning using spatial and object vividness. People with a high score on object vividness tests (like the VVIQ)

were more likely to have arts careers than people with higher spatial ability, who were more likely to choose a STEM field (Crowder, 2018; Milton, 2021). This was based on the theory that mental rotation tasks are easier with better spatial ability and tasks which involved the creation of new images easier with object ability. Researchers found that spatial and object ability were inversely correlated, when one increases the other decreases (Blazhenkova, 2016). Crowder's (2018) results showed that aphantasia participants (having a score of 16 on the VVIQ) had significantly lower spatial imagery when compared to non-aphantasia participants, meaning that both imagery abilities were lower and would not follow the aforementioned inverse relationship between object and spatial vividness.

I examined how well aphantasia participants are able to recall images of assorted items and scenes. The images were similar to those used in Marks' (1973) study creating the VVIQ. The goal of using a similar design was to examine any differences between aphantasia and non-aphantasia participant groups in terms of correctly answered image recall questions. If my study shows there to be no relationship between VVIQ score and recall test score then the processing of visual information would be involuntary; thereby opposing Galton's (1880) research on voluntary object vividness. This would mean that people without spontaneous imagery ability, aphantasia (tested during the VVIQ), are either processing the information differently than other participants or all participants are accessing subconscious images rather than only recreating the image consciously. Faw (2009) theorized that non-imagers (aphantasia participants) have a possible subliminal, or unconscious, imaging ability that allows perception similar to imagers (non-aphantasia participants) but with an inability to transfer the imaging into conscious, supraliminal, imaging. I aim to examine the hypotheses in an effort to find if aphantasia

participants are able to use a subliminal imaging ability to recall recently seen images and if there is any difference between gender and age on visual recall ability:

- If VVIQ scores are higher then recall test scores will also be higher
- Aphantasia participants will score significantly lower than non-aphantasia participants on the recall test
- As age increases VVIQ score will decrease
- Gender will not have a significant effect on VVIQ score

Method

Sample

I recruited participants through three methods. The primary method was using word of mouth from friends, family, psychology students and professors, campus staff, and various acquaintances that volunteered to participate in the study. Method two was using flyers (Appendix A) posted around the Longwood University Center and Student Activities Office which included a QR code to be directly linked to the study, an approximate time of participation, and brief details with a link to learn more. Method three was using the Psychology research management system at Longwood University, Sona Systems, to recruit students in the department and make it easier for professors in the department to refer students. I did not pay participants to participate in this study however students in the psychology department received class credit for participating in studies. Two hundred and forty-five people participated in the study with two excluded because of a system error on the website. Two additional participants had an issue with their gender demographics not saving so I excluded their data only from the related analyses. For participant demographics reference Table 1 and 2.

Materials and Procedure

I used an online testing format to perform the study in an easily replicable way across all participants. A professional developer created a website to host the study and collect data including all of the features required for the study. The webpage began with a preface including general instructions and an option to start the study. This also included a statement that there are no wrong answers to reduce confounding variables from social desirability in response (McKelvie, 1995). Next, participants saw and completed a short demographics survey. After the demographics survey, participants completed the VVIQ test with 16 questions, developed by Marks (1973) and found in Appendix B. The VVIQ questions were all Likert-scale questions with options ranging from 1 (*No image at all, you only "know" that you are thinking of the object'*) to 5 (*'Perfectly clear and as vivid as normal vision*').

Following the demographic survey, participants completed a practice recall test to become familiar with the memorization format and distraction task. Participants had 30 seconds to view the image before the website automatically switched to the distraction task. For the distraction task participants counted down by three from a randomly generated three-digit number. After the 15 seconds participants entered the number they had calculated into a text box and press continue. The practice quiz had two questions with one asking about a barn and the other asking about the number of ducklings in a clipart farm scene photo. I chose a clipart barn for the practice image as a mixture between the assorted image clipart and real-world scene images.

After the practice test participants observed the first recall test image (refer to Appendix C) for 30 seconds followed by the distraction task automatically displayed. The distraction task was a subtraction task lasting for 45 seconds following the same method as the practice distraction task. After the distraction task the participants answered five questions related to the

first image. The second image used the same protocol. All three images (practice, test image one, and test image two) were distinctly different from each other, one using clipart and the other real-world photos, to eliminate confusion between images. The test images had its images randomly selected from six total options with three options for each test image (See Appendix C for the options). Test image one was selected from randomly ordered, unrelated clipart items (all the same items, but in different orders for each image). Test image two was select from a full scene, like a marketplace or a city street scene. There was a total of six images, three randomly ordered object images and three stock photo scenes, used in the study (reference Appendix C for all the photos). Both of these follow Marks' (1973) procedure with variations in the specific scene's contents. The test questions were also similar to Marks' (1973) procedure with there being four total answers for the multiple choice and variations of the questions to pertain to each scene. An example would be, *what was above the button?* with four options consisting of other objects in the image or *what color was not present in the set of markers?* with four color options. Following the last test image, participants saw a screen that told them they have completed the study and thanked them for their participation. On this page there was also a form to submit an email address to receive this paper noting that all emails would be separate from all test information.

Specifications of the Survey Website

I opted to create a website rather than use premade services, such as QuestionPro, due to the specific requirements for the study being unavailable in existing systems. The website requirements were to be able to display random images from a finite set of options, allow forward-only flow through multiple screens, allow multiple questionnaires, have timer functionality, automatically move participants past the images when the timer expired, and

disallow participants from going back to the images. I commissioned a website to fulfill these requirements and save the testing data into an easily accessible CSV file. Amazon Webs Services (AWS) was used to host the website and ran the framework while a web address from GoDaddy.com allowed participants to access the website easily. With the study being associated with Longwood University, I used the official Longwood digital marketing manual for a color pallet.

Results

The main goal of this study was to examine the relationship between aphantasia and scores on a visual recall test. There were four participant categories based on their VVIQ score. A VVIQ score of 16 placed participants into the aphantasia group while all other scores would place them into the non-aphantasia group. The non-aphantasia group had three subdivisions based on VVIQ score: low (17-37), medium (38-59), and high (60-80) visual ability.

Recall Scores

I performed a 2x4 Mixed Model Analysis of Variance (ANOVA) to determine if there was any significant difference between the type of image shown (clipart or real-world scene) as a within-subjects factor and VVIQ group (aphantasia, low, medium, and high) as a between-subjects factor, on recall test score. The analysis indicated that there was no significant difference between any of the VVIQ group's recall scores, $F(3, 237) = .440$, $p = .725$, $\eta p^2 = .006$. The analysis, however, did find a significant difference between the image type and recall score, $F(1, 237) = 23.656$, $p < .001$, $\eta p^2 = .091$. There was no significant interaction between image type and VVIQ group, $F(3, 237) = 1.142$, $p = .333$, $\eta p^2 = .014$. Refer to Figure 1 for a graphical representation. A Pearson's r correlation between recall score and VVIQ score did not find any significant correlation between the two, $r(241) = .094$, $p = .144$. See Figure 2 for the scatterplot

of VVIQ scores and recall test scores. The analysis was underpowered based on estimate by Cohen (1992), requiring 18 participants per group assuming a large effect and 45 participants per group assuming a medium effect to avoid a type I error.

Gender and Age Differences

Participants chose one of seven age groups during the demographic survey (18-25, 26-35, 36-45, 46-55, 56-65, 66-75, 75+). I performed a Spearman's rho correlation to examine if there were any correlations between age and VVIQ score which indicated a significant positive correlation $r(241) = .136$, $p = .035$. The age groups 26-35 and 66-75 had few participants with only 5 and 4 respectively. More research is necessary to determine if this significance is accurate or due to the small sample size. Participants also chose one of four options for gender identity (male, female, transgender/non-binary, or other). I performed a One-Way ANOVA to find if there was a significant difference between genders on imagery vividness. I excluded the 'other' category from the analysis as there was only one participant. The analysis found a significant difference $F(2, 237) = 10.66$, $p < .001$. A Tukey post-hoc test showed the significant difference was between the Transgender/Non-Binary group and both the male and female groups at $p < .001$. There was no significant difference between the male and female groups $p = .935$.

Discussion

Although there was a significant correlation between age and VVIQ score there is not enough data to give a strong indication that this was accurate to the population as the correlation had a low confidence. The 26-35 and 66-75 groups having only nine total participants (Table 2) makes the data incomplete for such an analysis and more information would be needed to form any conclusions. The difference between gender and imagery vividness was also underpowered with nine total participants between the transgender/non-binary and other groups (Table 1).

There is also not enough data to be confident that the significant difference was accurate to the population and further research should examine both of these factors.

VVIQ and Recall Test Scores

The results of the 2x4 Mixed Model ANOVA testing image type and VVIQ group on visual recall test scores showed no significant difference between VVIQ groups in recall test score. This result led me to believe that there is no link between aphantasia and visual recall test scores. If there is a large effect between aphantasia and this recall test score then I would have expected to see the beginnings of a trend as the estimated required participants per group for analysis would be 18 participants according to Cohen (1992). It is also possible that VVIQ score has a small effect on recall test score and that I did not have enough power to detect such an effect. My hypothesis assumed that VVIQ score would play a large effect on visual recall ability since the test requires participants to remember specifics about the photo. I believed these specifics to be varied enough as to not allow for rehearsal of the images and I used a distraction task for the same reason. The study being online was beneficial as many more people had the opportunity to participate and in a more replicable way; however, there are limitations that come with this format. The second part of the ANOVA did show a significant difference in recall scores based on the type of image shown (clipart or real-world scenes). Although I attempted to keep the difficulty of questions consistent throughout could be the reason there is a significant difference, if participants found the clipart questions easier. Another possible reason for the significance could be that assorted object clipart images are easier to remember parts of because of the very distinct items present when compared to the more chaotic real-world scenes. More testing would need to be done on the difference between clipart and real-world scenes to determine the reason behind this significance.

A major concern with the online format is how attentive people were to the study as not focusing on the pictures can have a significant impact on recall test scores. People may have also taken a picture, using a phone or other similar device, of the stimulus image and referenced that for the following questions. Although I hope that participants gave this study the time and attention necessary to complete it properly, there is a possibility that some participants did not. There is no way of determining whether participants did not give their full attention in order to exclude their data with the information given from the website, future studies should include a manipulated check to help with this issue. Another limitation was that the VVIQ questions themselves had a Likert-scale selection option using bubbles to select the appropriate answer. These bubbles were setup horizontally with 1 (no image) being on the left and 5 (fully vivid image) being on the right which could have led participants to believe that selecting 5 was better than 1. These biases may explain why the number of high (N = 115) and medium (N = 93) scores on the VVIQ were more frequent than low (N = 20). Participants in the aphantasia group were more frequent than estimated from previous literature (about 1-2%) with 6.2 percent of the sample assigned to this group (N = 15) (Farah et al., 1988; Zeman et al., 2015).

Future research could examine the likelihood of people misunderstanding the questions on the VVIQ as many times people with aphantasia assume the phrase “picture this” to be just the sentiment and assume others also cannot form mental images. This data would be valuable to obtain as if people are commonly misunderstanding then statistics about how common aphantasia is could be off. If the studies examine how participants would interpret the VVIQ’s instructions then this could inform previous findings to either validate the scale further as an accurate measure or call into question a number of scores that change analysis results. The wording of the VVIQ’s scale attempts to avoid confusion like this however it would be

interesting to see if the number of people with aphantasia would increase as more information increases about mental imagery and vividness. Future directions should also examine involuntary, or subconscious, mental imagery as aphantasia participants may be more accustomed to utilizing this type of unconscious mental imagery possibly explaining why the results were not significantly different (Faw, 2009). Faw (2009) also theorized that people with aphantasia may also recall images in the same way but not be able to consciously detect the generated image. Further research, likely with brain imaging, could be done to explore the way people in various VVIQ groups recall images to come closer to understanding the underlying mechanisms behind forming a mental image. An extension of this could also utilize people dreaming as some people with aphantasia are able to vividly dream (like me). This type of study should also include, if possible, lucid dreaming as aphantasia has not been correlated with any drop in frequency of lucid dreams. Lucid dreams could also be a way to explore the conscious imagery connecting with subconscious imagery, I would expect that people with aphantasia would be unable to conscious make changes to their dreams even when lucid since that would take conscious processing. Lastly, future research examining whether the pictures of sorted clipart objects or the pictures of real-world scenes was significant due to the questions present in this study or another difference in processing ability. The research should include various types of clipart images (like full scenes, different clipart styles, and overlapping images) to determine if the difference was in the way the image was formatted or the medium itself. This research could help inform the way diagrams are made for students (or papers) as if clipart is more easily remembered it would be more beneficial to use it over other similar mediums. Future online testing should also be wary of the limitations and include countermeasures where possible to offset these limitations.

I conducted this study to determine if there is a connection between aphantasia and visual memory. Although there was no significant difference between aphantasia and non-aphantasia participants in recall test scores the significant difference between image types was interesting to see. The lack of difference between aphantasia and non-aphantasia participants also creates a stronger case for another way of forming mental images that can be explored in the future. While we cannot look into someone's mind and determine how they perceive and interact with the world differently, I hope that by studying these differences (like aphantasia) we can come closer to understanding the mind as a whole. Memory, in particular, is a very complex part of the brain that not a lot is known about, I hope that this and future research can slowly make steps toward understanding memory and how memory differs between people.

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Figures

Table 1

Gender Demographics

		N	%
Male		58	23.9%
Female		174	71.6%
Transgender/Non-Binary		8	3.3%
Other		1	0.4%
Missing	System	2	0.8%

Note. The two missing values came from a system error where parts of their demographic data did not save.

Table 2

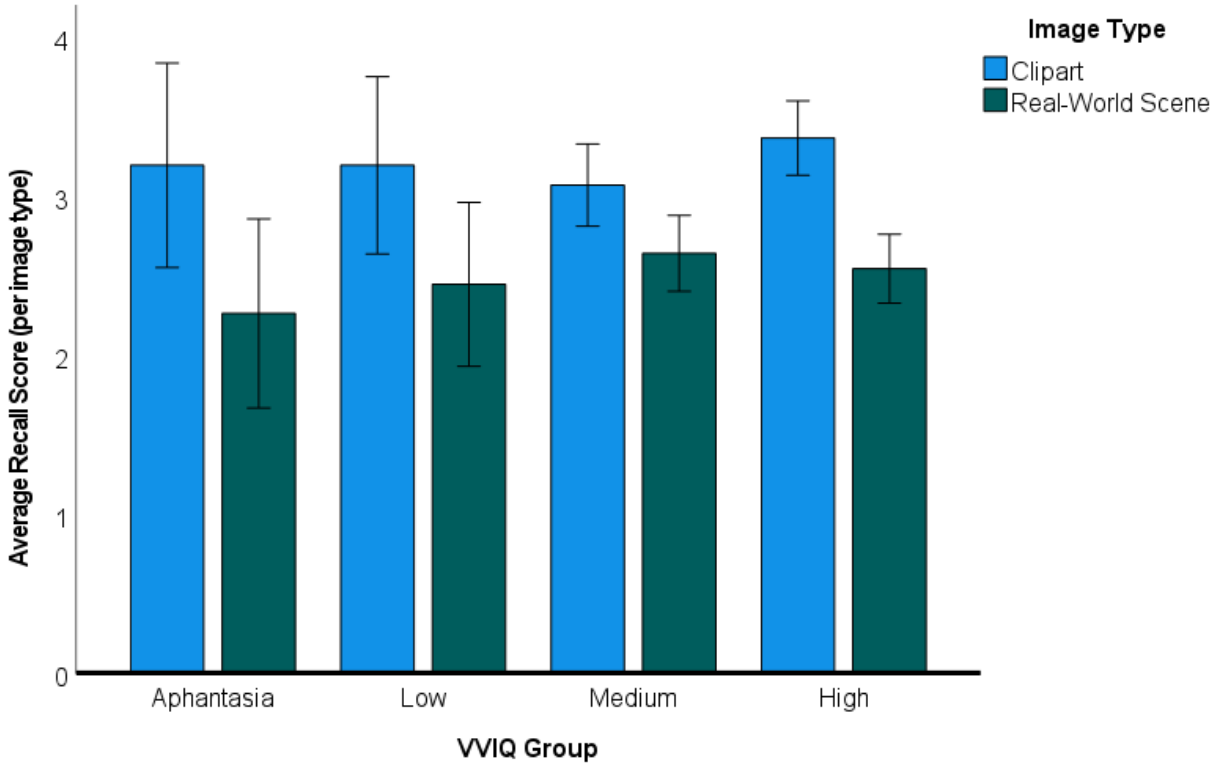
Age Demographics

		Frequency	Percent
Valid	18-25	106	43.6
	26-35	5	2.1
	36-45	23	9.5
	46-55	79	32.5
	56-65	24	9.9
	66-75	4	1.6
	75+	0	0
	Total	241	99.2
Missing	System	2	.8

Note. The two missing values came from a system error where parts of their demographic data did not save.

Figure 1

Recall Test Scores Based on VVIQ Group



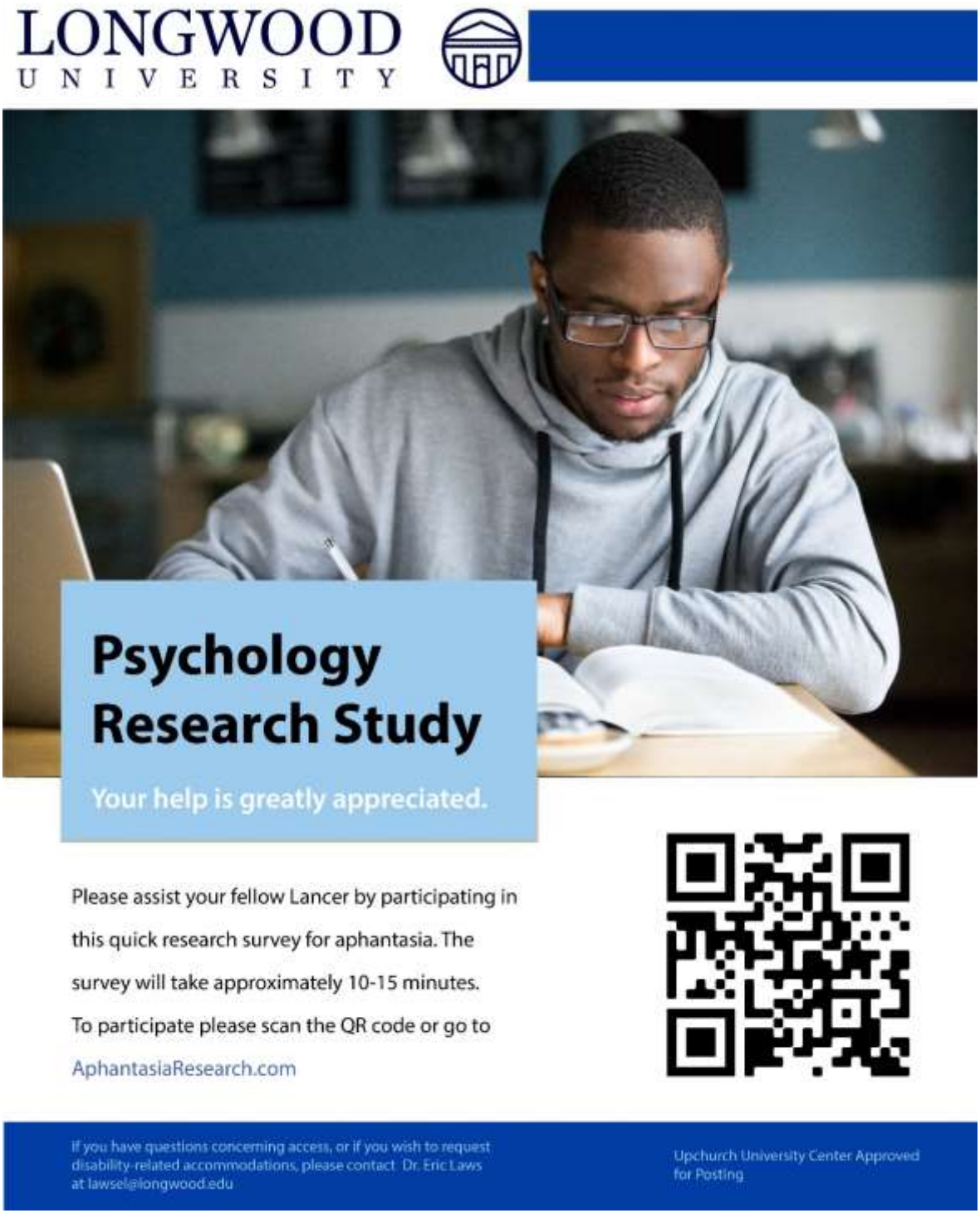
Note. Only the within-subjects factor of image type was found to be significant through a 2x4 mixed model ANOVA, there was no significant difference in scores based on the between-subjects VVIQ group.

Figure 2

Scatterplot of Recall Test Scores Based on VVIQ Score

Appendix A

Recruitment Flyer



Appendix B

VVIQ Questions

Item	Theme	Description
	Relative or friend †	For items 1 to 4, think of some relative or friend whom you frequently see (but who is not with you at present) and consider carefully the picture that comes before your mind's eye.
1	Relative or friend	The exact contour of face, head, shoulders, and body.
2	Relative or friend	Characteristic poses of head, attitudes of body, etc.
3	Relative or friend	The precise carriage, length of step, etc. in walking.
4	Relative or friend	The different colors worn in some familiar clothes.
	Natural scene: Rising sun	Visualize a rising sun. Consider carefully the picture that comes before your mind's eye.
5	Natural scene: Rising sun	The sun is rising above the horizon into a hazy sky.
6	Natural scene: Rising sun	The sky clears and surrounds the sun with blueness.

Item	Theme	Description
7	Natural scene: Rising sun	Clouds. A storm blows up, with flashes of lightening.
8	Natural scene: Rising sun	A rainbow appears.
	Shop	Think of the front of a shop which you often go to. Consider the picture that comes before your mind's eye.
9	Shop	The overall appearance of the shop from the opposite side of the road.
10	Shop	A window display including colors, shape, and details of individual items for sale.
11	Shop	You are near the entrance. The color, shape, and details of the door.
12	Shop	You enter the shop and go to the counter. The counter assistant serves you. Money changes hands.
	Natural scene: Lake	Finally, think of a country scene which involves trees, mountains, and a lake. Consider the picture that comes before your mind's eye.
13	Natural scene: Lake	The contours of the landscape.
14	Natural scene: Lake	The color and shape of the trees.
15	Natural scene: Lake	The color and shape of the lake.

Item	Theme	Description
16	Natural scene: Lake	A strong wind blows on the tree and on the lake causing waves.

Appendix C

Images used in the study

Practice Image	Test Image 1	Test Image 2
	  	  

Note. One image from each of the cells was selected at random for each participant. The test questions were different based on what image was selected.