The Horizontal Vertical Illusion (HVI) refers to the perceptual overestimation of vertical distances over horizontal distances of the same actual value. In the present studies we seek to explore the HVI in varying contexts and in the environment. We conducted two experiments to investigate these variables. Our first study took place on computers, and we had participants make distance estimations on images containing varying amounts of contextual information (scene detail). In our second study we took participants outside into the environment and had them make distance estimations on the real life objects used in the images for our first study. We found that the amount of scene detail available to participants affected the magnitude of the HVI depending upon what type of object was pictured in the scene. When viewing walls, the amount of scene detail increased people’s exaggeration of vertical distances, but when viewing more complex objects, the amount of scene detail decreased people’s exaggeration of vertical distances. These findings provide an exciting new insight into the current body of knowledge about the HVI and may be explained well by the presence or lack of context in the visual scene.

M E N T O R S

Faculty Mentor: Lawrence Rosenblum
Department of Psychology
Graduate Student Mentor: Theresa C. Cook
National Science Foundation Graduate Research Fellow
Doctoral Program in Cognitive Psychology

Our research goal this past year, funded by a National Science Foundation Graduate Research Fellowship, was to explore the processing levels at which visual perception of distances takes place. Specifically, we explored which types of contextual (environmental) stimuli elicit vertical surface illusions. These findings hold important implications for designing training programs for people whose activities demand high perceptual accuracy of vertical extents (e.g. pilots, construction workers, etc.). Amanda was involved in these experiments from the day they began. Amanda’s work on these experiments is of exceptional merit; her scientific writing ability is remarkable in all aspects. Amanda easily locates and synthesizes information from primary research sources, readily applies the information to her own ideas, and produces papers of superior quality. In addition, Amanda is unwaveringly conscientious, reliable, and capable in all of her many duties associated with her research responsibilities. She is viewed as a leader in our lab, and I trust her with every aspect of our research. I am especially indebted to her for her abilities to train new RAs in the complex duties and meticulousness required in our studies.

A U T H O R

Amanda Roos
Psychology

Amanda Roos is a graduating senior in Psychology. She has worked as an undergraduate research assistant in Dr. Rosenblum’s Riverside Audiovisual Speech and Audition Lab (RASAL) for nearly a year. Amanda’s research interests include psychopharmacology and cognition and she plans to further these interests in the graduate program in Psychology at CSU San Marcos in the fall. Her experience at RASAL has been wonderful and cherished both personally and professionally, and has provided invaluable preparation for graduate studies. The author would like to thank Theresa Cook for her excellent mentorship and guidance, as well as Dr. Rosenblum for the opportunity to gain such fantastic experience in his lab. The author would also to acknowledge all of the other undergraduates at RASAL for their assistance in data collection and entry.
INTRODUCTION

When sizing up vertical distances, whether when driving, walking or simply trying to redecorate a large wall, the surface at hand can seem daunting. A long road across a flat desert is much less imposing than a steep road up a mountain, even if they are in reality the same distance. In the same way, staring up at a large wall can make anyone feel like a tiny ant, but looking out at a stretch of sidewalk rarely has the same impact. These perceptual phenomena are a result of the Horizontal Vertical Illusion (HVI). The HVI occurs when vertical distances are overestimated in comparison to horizontal distances of the same actual size (Wolfe & Tam, 2005). The HVI is often demonstrated using simple inverted “T” images but is present in the everyday viewing of images and real life interactions. Previous findings have demonstrated that the HVI can be influenced by many factors including context, visual cues, and the environment. In the present studies, we will explore and discuss the influence of image context and the environment on the Horizontal Vertical Illusion and how our findings may be explained by the presence or lack of context in the visual scene.

Searleman, Porac, Alvin and Peaslee (2009) found that placing nontarget dots on line images demonstrating the HVI had a significant impact on the degree of the illusion subjects perceived. Subjects overestimated the vertical distance when maximizing distractor dots (i.e. dots outside the endpoints of the line) were present and underestimated the horizontal distances accordingly. However, vertical distances were not underestimated when minimizing dots (i.e. dots inside the endpoints of the lines) were present on the vertical axis (Searleman et al, 2009). Other research has demonstrated that different configurations of the traditional HVI inverted “T” can impact the amount of illusion perceived by the viewer. Wolfe and Tam (2005) found that the illusion increased when the angle between two lines went from acute to more obtuse and that asymmetry in the inverted T configuration decreases the amount of illusion perceived. The relationships between the lengths of lines also effects how the HVI is perceived. Armstrong and Marks (1997) found that an increase in the length of a vertical line increases the perceived length of the horizontal and vice versa. All of these findings help demonstrate that the HVI is influenced by image context, but are limited to configurations which may not be strong indicators of how the illusion might be perceived in real life scenarios. It is important to explore previous research that investigates how the HVI manifests in a variety of environmental conditions.

Jackson and Cormack (2008) explored distance estimation in environmental settings by having participants estimate a variety of heights and horizontal surfaces, including buildings and parking garages, from a range of heights and positions. They found that participants had large overestimations of vertical environmental distances and slight underestimations of horizontal distances (Jackson & Cormack, 2008). Higashimaya (1996) investigated the HVI in the environment in a variety of conditions including different subject positions (e.g. lying on side, lying on belly, and upright) and visual configurations (e.g one eye occluded, looking through a cylinder, and looking through a prism). The findings of these environmental HVI studies demonstrate the importance of the natural setting in influencing the perception of the illusion. Most importantly, the HVI in the environment seems to be of a much larger magnitude than the HVI in the laboratory setting. Typical exaggerations of vertical distances on computer or paper are about 5-15% above accuracy, whereas environmental overestimations can be 30% or more (Armstrong & Marks, 1997; Higashimaya, 1996; Jackson & Cormack, 2008; Searleman et al, 2009; Wolfe & Tam, 2005).

In the present studies we sought to explore context and environmental effects on the HVI. We wanted to determine if various visual cues in images presented on a computer screen might be similar to the visual cues found in the environment such that the images on the computer would create a perception of HVI magnitude similar to that found in the environment. In Experiment 1, we predicted that there will be main effects for context and image on the amount of HVI perceived. In Experiment 2, we predicted that the HVI magnitudes found for the objects in the images in Experiment 1 will correlate with the HVI magnitudes found for the objects in real life.
METHODS AND MEASURES

Experiment 1

An ethnically diverse sample of 70 introductory psychology students from the University of California, Riverside signed up to participate in the experiment through a website as instructed by their courses. All participants received one unit of credit for their participation. All participants signed informed consent documents and had normal or corrected to normal vision. Ten photos were taken of vertical objects: a brick wall (from three angles), a fire hydrant (from three distances), a lamppost, a tree, a glass wall, and a rock. In our analyses, we refer to these ten vertical objects as “objects.” The photograph of each object was presented in four contexts: full context, reduced texture, edge only and no context. All manipulations were made in Photoshop. Full context images were ordinary, full detail black and white photographs. Reduced texture images were achieved by using the “photocopy” filter in Photoshop, which reduced the surface texture of the objects in the photographs, but left all other scene details in tact. Edge only images were manually generated using erase in Photoshop to remove all scene detail information except for the edge of the object being estimated. No context images only contained two black dots. In our analyses, we refer to these four manipulations of the photographs of objects as “context.” Through these manipulations, we created a total of 40 images: ten photographs of objects presented in four contexts. All images presented contained two black dots to specify the vertical distance to be estimated and a number line superimposed on the bottom of the photo (see Figure 1 for examples of stimuli). This experiment ran on Psyscope, and the order of the images presented was completely randomized.

A research assistant (RA) welcomed participants and instructed them in their task for the experiment. The RA asked participants to estimate the distance between the two black dots on the images presented to them on the computer screen by imagining that distance placed horizontally on the number line at the bottom of the image. The participant would then enter the positive number value for the distance on the computer. The RA would aid the participant in a practice estimate until the task was understood clearly, and would sit in the room to ensure that participants did not use hands or any other objects to measure or aid in their estimations. An RA would administer a survey, debrief participants and assign credit following the experiment. The experiment took approximately 30 minutes.

<table>
<thead>
<tr>
<th>Brick Wall (0')</th>
<th>Fire Hydrant (mid)</th>
<th>Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Context</td>
<td>Reduced Texture</td>
<td>Edge Only</td>
</tr>
<tr>
<td></td>
<td>No Context</td>
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Figure 1: Twelve examples of the 40 stimuli presented to participants, grouped by object (x axis) and context (y axis).

Experiment 2

An ethnically diverse sample of 48 introductory psychology students from the University of California, Riverside signed up to participate through a website as instructed by their courses. All participants received one unit of credit for their participation. All participants signed informed consent documents and had normal or corrected to normal vision. We selected five objects on campus to be viewed by participants: a brick wall, a glass wall, a tree, a fire hydrant (from three distances) and a lamppost. These were the same objects whose images were used in Experiment 1. The only object not used was the rock because it’s physical location was too far to walk to in time for the experiment. Three research assistants (RAs) were required for this experiment, one “instructor” and two “measurers”.


The instructor asked participants to view an object on campus and estimate its vertical height, then direct the measurers, who stood at the bottom center of the object, to move apart from one another until they felt the distance between the two measurers was the same as the height of the object. The RAs walked with participants to each object in counterbalanced order with the brick wall being either first or last because of its distance being farthest from the lab. The instructor timed the participants for each estimation, and the measurers recorded the distances participants had them move apart from the center of the object. After all the estimations were complete, the RA asked the participant to fill out a survey and assigned credit. The experiment lasted no more than one hour.

RESULTS

Experiment 1

A 10 x 4 Analysis of Variance (ANOVA) was performed on the data (10 objects, 4 contexts). This analysis looks for differences between the conditions in our experiment. It compares all of the objects (called a “main effect” of object), all of the contexts (called a “main effect” of context), and all of the objects within each context (called an “interaction” between object and context). No significant effect was found for context, $F(3, 67) = 1.481, p = 0.228$, which means that the amount of scene detail alone did not change people’s Horizontal Vertical Illusion exaggerations. A main effect for object was found, $F(9, 61) = 11.869, p < 0.001$, which means that the height of the vertical distance on the computer screen did affect people’s HVI exaggerations. A significant interaction of context and object on amount of HVI was observed, $F(27, 43) = 3.375, p < 0.001$, which means that the level of scene detail on the computer screen did affect people’s HVI exaggerations. A significant interaction of context and object on amount of HVI was observed, $F(27, 43) = 3.375, p < 0.001$, which means that the level of scene detail on the computer screen did affect people’s HVI exaggerations depending upon what type of object they were viewing (see Figure 2 for the context by object interaction). These results indicate that people’s perceptual exaggeration of vertical distances went up as scene detail increased when they were viewing walls, but people’s perceptual exaggeration of vertical distances went down as scene detail increased when they were viewing more complex objects.

Figure 2: Context by Object Interaction in Experiment 1

For wall-like objects (represented by the solid line), HVI magnitude increased as scene detail (i.e. context) increased. For more complex objects (represented by the dashed line), the magnitude of the HVI decreased as context increased. Full Context photographs contained the most scene detail, and are represented on the left side of the x axis, while No Context images had the least amount of scene detail, and are represented on the right side of the x axis. (Error bars represent the standard error of the mean.)

Experiment 2

We compared the HVI magnitudes found on the images on the computer with the HVI magnitudes found for the objects in the real environment, making a set of nine comparisons (because, as stated before, we could not get estimates for the rock in the real environment). Correlations between the amount of HVI in real life and images of reduced texture, $r = 0.592, p = 0.093 \ (N = 9)$, and edge only images, $r = 0.640, p = 0.063 \ (N= 9)$, were positive, large, and approaching significance. A large, positive, significant correlation was found between amount of HVI and full context images, $r$...
= 0.723, \( p = 0.028 \) (N= 9). This result means that as the HVI increased in full context photographs, the HVI also increased in real life, and when the HVI decreased in full context photographs, the HVI also decreased in real life. This result met statistical significance. As expected, we found no relationship between the no context images and the HVI in the live environment, as those images bore no similarity to the objects in the real environment, \( r = -0.373, p = 0.323 \).

**DISCUSSION**

These findings show that amount of visual information available in images influences the magnitude of the illusion an individual perceives. As amount of visual information increased, the magnitude of HVI elicited by the images approached the magnitude of HVI we found in the environment. In Experiment 2, we found that HVI magnitudes elicited by objects in the environment correlated strongly with, and often matched, HVI magnitudes found in full context photos. Reduced texture and edge only images also affected the HVI, indicating that HVI magnitudes found in the environment may rely on visual cues such as those manipulated in Experiment 1. What may be the most appropriate explanation for the findings of our present studies is that visual cues from the entire scene, not just the vertical distance or object in question, aid in determining estimations. Such factors could explain why walls were estimated in a completely opposite fashion as complex objects in our first experiment, because they block out a large part of the visual scene that would contain otherwise useful visual information. Differences in visual cues could also explain why when a more textured or a complete image was present for complex objects, the magnitude of HVI decreased.

Vision research will never be without merit because of its basic and necessary importance to everyday human functioning. The more that can be understood about human vision, distance estimation, and the Horizontal Vertical Illusion the better we can design vertical surfaces that must be navigated, like stairs, and aid those who take on tasks such as pilots where appropriate distance estimations are crucial. Fruitful future research may include the investigation into individuals who regularly navigate extreme vertical surfaces, such as rock climbers and free runners, which could provide a unique insight into the possible effects of learning on the HVI.

**REFERENCES**


