THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF PSYCHOLOGICAL AND SOCIAL SCIENCES

HEARING THE VISION: CREATING VISUAL PERCEPTIONS THROUGH AUDITORY STIMULI

ZELNNETTA CLARK
SPRING 2019

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Psychological and Social Science
with honors in Letters, Arts, and Science (BA)

Reviewed and approved* by the following:

Jacob Benfield
Professor of Psychology
Thesis Supervisor

David Ruth
Professor of History and American Studies
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

Centering around visual impairments, this baseline study seeks to aim as a tool that will further develop into a rehabilitation method for this population. Our abstract device serves as a future potential navigation device for those with visual impairments. In which generating sound files to represent visual cues that are easily identifiable and disguisable. In my research, I hypothesized that participants who are blindfolded will rely on their other senses, in particular, their auditory sense and are able to overall accurately discriminate between sounds of shapes while interconnecting them with the correct shape visuals in comparison to those who are not blindfolded. A survey was conducted to thirty-nine participants between the ages of eighteen to twenty-five. The survey was based on sound files that were generated from a LIDAR device and participants were asked to identify the sounds with the respective shape. An independent samples t-test showed insignificant results in accuracy between conditions. Replication and further development of this research should be considered to continue developing this abstractive rehabilitation tool.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

A special thank you to:

Dr. Yi Yang and his ACURA team

Dr. Jacob Benfield

Dr. Meghan Gillen

This project wouldn’t be possible without you all.

Chapter 1

Introduction

Perception is defined as:

"The acquisition and processing of sensory information in order to see, hear, taste, smell or feel objects in the world; [which] also guides an organism's actions with respect to those objects. Perception may involve conscious awareness of objects and events; this awareness is termed a percept" (Blake & Sekuler, 2006, p. 578).

In other words, perception shapes the way we view and comprehend the world around us. In order for perception to be initiated, there must be a presence of a stimulus or stimuli. The stimulus/stimuli are the actions that cause the reaction. By definition stimuli are, "The pattern of physical energy set up by an object or event in the environment" (Blake & Sekuler, 2006, p. 580). In order to understand what our senses are detecting we need to recognize the stimulus. But what happens to our perceptions of a particular stimulus with the presence of some sort of sensory impairment(s)?

According to the 2015 consensus from the American Foundation for the Blind, 23.7 million American adults reported vision loss in 2015. Blindness is considered the loss of sight, which can be either temporary or permanent. Cerebral Visual Impairment is the most common cause of visual impairment in the developed nations. Cerebral Visual Impairment (CVI) is a disorder that stems from neurological damage to the visual pathways that interfere with the communication between the brain and vision centers; thus creating a deficiency in detecting stimuli (Lueck & Dutton, 2005). Deficiencies in an individual's visual perception often times results in necessary additional assistance and resources to rehabilitate the issue, such as visual perception rehabilitation. Such rehabilitation includes devices that are designed to help the visually impaired. One example of a device used on veterans with visual impairments are low-technological devices that assist veterans in their everyday visual functionalities (Williams, 2007).

In Israel, researchers have also created a similar device to assist those with visual impairments. EyeMusic is a music device that creates sounds based on visual objects to assist in object identification (Reddy, 2017). This is a newly innovated device with a lot more development necessary for it to be widely distributed because of its difficulties in fitting the majority of the accommodations for those who were born blind; the device was composed for those who had lost their vision at some point in their life.

("Blind People 'See' Sound", 2005) designed a study that would show that those with visual impairments have a much better sense of auditory perceptions. Sighted subjects were blindfolded and asked to identify the location of a sound that was played and their accuracy was compared to those who were visually impaired. Results shows that those with visual impairments were much better in pinpointing the location of the sounds. Additionally PET scans showed that areas of the brain connected to vision showed activity on the PET scan in blind participants while locating the sound cues. Blind participants were able to use the visual regions of their brain while processing and identifying the sounds they heard ("Blind People 'See' Sound", 2005).

It is also said that people can create visual artwork based on sounds or seeing sounds. Music legend Ray Charles was able to create famous musical compositions and hit records, while also promoting his piano talent with a visual impairment. Artists have found a way to create visual imagery from sounds. For example, some paint what they hear and create a visual convention (Sauro, 2013).

Interconnectivity, which is the connection of senses or when the senses are working simultaneously, can also play a role into a rare developmental disorder called synesthesia. By Oxford Dictionary definition, synaesthesia is "The production of a sense impression relating to one sense or part stimulation of another sense of the body." (Synaesthesia, n.d.). Research done with people with synaesthesia, especially those who experience sound and shape interconnectivity, is significant to the current study because we would like to understand how we get participants to rely on their auditory senses in the absence of visual perception—generally, we would like to know how can researchers represent a visual/physical object through sound.

Previous research indicates that in the absence of individuals' visual sense, we are able to increase one's hearing abilities (Kim, 2014). Temporary blindness coerces individuals to rely on their other senses, in particular the one they are most proficient in after their vision. This phenomenon is possible because of the brain's plasticity and its ability to learn new techniques to improve hearing in the absence of vision (Kolarik & Scarfe, 2007).

The purpose of the present study is to further our comprehension between the interconnectivity between auditory and visual sensation and perception. We hypothesized that in the absence of vision (i.e., blindness) participants will rely on their other senses, in particular, their auditory sense and are able to accurately discriminate between sounds of shapes while interconnecting them with the correct shape visuals in comparison to those who are not blindfolded. Synethesia is a disorder that allows the brain to associate certain stimuli with varying perceptions of sensation thus generating interconnected sensations of senses. We sought to create a device that represents different physical characteristics such as variance in shape, size, proximity, and location of objects by producing auditory stimuli that effectively distinguishes these objects as recognizable to what they look like physically. This baseline information will serve as a pilot test in order to understand the ability that people with normal vision have with recognizing shapes based on the sound of the shape and if they can connect the shape audio with the visual shape.

Chapter 2

Methodology

Participants

Participants consisted of 39 participants in total—14 identified as female and 25 identified as male. 19 of our participants were randomly assigned to a control group (able to use their vision to answer questions) and the other 20 were randomly assigned to a manipulation group (absence of vision to answer questions). All participants were located in the northeastern region of the United States. 15% of participants indicated they were international students. Participants' ages ranged from 18-25 years old. Approximately 8% of students reported that they suspect that they may have hearing issues. All participants were recruited through a research pool called SONA at Penn State Abington. Participants were granted class credit as an incentive for participating in the research.

Measures

As a baseline, we must understand and figure out how to represent the physical characteristics of objects in the way of sounds. What does a circle sound like? How would we represent an object that is shaped like a square, large, and to the left of a person? Undergraduate engineering majors from PSU Abington created a LIDAR device based in frequency and sound waves that psychology researchers could use to test out the sounds. The LIDAR machine ran on an abstract program that was created by the engineers. Based on the sound files the engineers established, psychology researchers generated a survey that would test out participants' ability to accurately recognize the established sounds after being trained on them. Demographic questions were also incorporated into our questionnaire because perception may vary dependent on characteristics such as being an international or domestic student. The survey also asked participants about any possible hearing impairments which in turn could affect their responses and the data. Researchers also created a shape booklet that would serve as a visual cue for participants in condition 1 to look at while they were listening to the shapes. The booklet served as a way to see if participants would rely on their vision—the visualization of the shape indicated in the booklet—or to their auditory capabilities. For example, researchers would show the participants a image of a large circle but would play the small line sound file and then ask them questions based on what they think they're hearing.

Chapter 3

Protocol

Procedure

A brief survey was administered to participants to collect their responses based on demographics. After this survey was completed and handed in to the researcher, the researcher would record the responses of the participants on the paper survey after verbally relaying the survey question. Researchers would type in specific codes in the LIDAR device that would play back the indicated shape. Once the shape was played, we had participants put on headphones to listen to the sounds. While listening to the sounds, we handed participants a booklet that had images of the physical shapes they were being trained to listen to, as well as an external keyboard that would serve to have participants adjust the sound of the shape. Participants were instructed to listen to the sounds during a 10 second period while viewing the image in the booklet. After that 10-second period, we asked participants to use the external keyboard to adjust the pitch and delay of the sound to what they subjectively thought the shape should sound like. After the adjusting period, researchers would either blindfold participants (manipulation group) or had them continue without the blindfold (control group). Those who were in the control group continued to look at the images through the booklet as a way to rely on their vision while listening to the sounds. We did this because people tend to rely heavily on their vision and will sometimes neglect other senses because their vision is much more dominant than the other senses. We used this theory to our advantage and used deception techniques for condition 1 participants—such as having condition 1 participants viewing a picture of a large square image in the booklet while having the researcher also tell them that the image is corresponding to the sound file; however, the sound file being administered is a completely different shape and or size. Researchers wanted to see if participants would solely rely on their visual cues when seeing a specific shape image on the booklet and hearing a dissonant shape sound through the headphones. Those who were in the manipulation group where unable to utilize their sense of vision to answer the true or false questions. In the absence of vision participants were asked to solely rely on their auditory sense (Kolarik & Scarfe, 2007). The survey consisted of a learning period (shape objectivity), adjustment of sound (shape subjectivity), a true or false portion, and a multiple choice portion.

Lastly, researchers played an audio file and asked participants to identify the shape solely based on the physical property of the shape while ignoring the shape’s size. As previously mentioned, these means of ‘testing’ were used to measure the ability of participants to discriminate and identify the audio sounds of the shapes matching them up with their visual cue. Some of the questions in the survey served as deception questions to see if the shapes were recognizable. We also utilized deception in our study to test if participants would rely on their auditory sense when vision was temporarily impaired.

Chapter 4

Analysis

Results

It was hypothesized that participants who are blindfolded will rely on their other senses, in particular, their auditory sense and are able to accurately discriminate between sounds of shapes while interconnecting them with the correct shape visuals in comparison to those who are not blindfolded. To test this hypothesis, an independent samples *t*-test was conducted. Results showed no significant difference on accuracy between the control group (M=6.95, SD=1.78) and the manipulation group (M=7.15, SD=2.43), $t(39)$=.769, $p < .05$.

Additionally, results showed that both groups, manipulation and controlled, answered all questions at a rate little to no better than chance. An one samples t-test was administered to determine the mean. **Figure 1** displays participant's responses scored on accuracy for the true or false portion of the survey. For the true or false portion, each participant had a 50% chance to get the correct answer, therefore $M \leq 0.50$ represents accuracy based on chance. While, **Figure 2** displays responses of participants based on accuracy for the multiple choice question portion of the survey. For the multiple choice portion, each participant had a 25% chance to answer correctly (4 choices total), therefore, $M \leq 0.25$ represents accuracy based on chance.

Mean Score of Figures

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
#1: This is a large circle.	39	.51	.506	.081
#2: This is a short line.	39	.62	.493	.079
#3: This is a large circle	39	.54	.505	.081
#4: This a large rectangle	39	.79	.409	.066
#5: This a small circle	39	.62	.493	.079
#6: This a large rectangle	39	.51	.506	.081
#7: This a large square	39	.51	.506	.081
#8: This a small rectangle	39	.44	.502	.080
#9: This a large square	39	.51	.506	.081
#10: This a long line	39	.92	.270	.043
#11: This a small square	39	.36	.486	.078
#12: This a long line	39	.72	.456	.073

Figure 1: M≤ 0.50 represents accuracy based on chance. M=Mean score

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
#1: What shape is this?	39	.31	.468	.075
#2: What shape is this?	39	.18	.389	.062
#3: What shape is this?	39	.49	.506	.081
#4: What shape is this?	39	.38	.493	.079
#5: What shape is this?	39	.26	.442	.071
#6: What shape is this?	39	.36	.486	.078
#7: What shape is this?	39	.31	.468	.075
#8: What shape is this?	39	.49	.506	.081

Figure 2: M≤ 0.25 represents accuracy based on chance. M=Mean score

Chapter 5

Conclusory Remarks

Discussion

This study will serve as an idea of what sounds fit best for which physical property of the shapes. Researchers found there was no significance in results after hypothesizing that participants who are blindfolded will rely on their auditory sense. Researchers hypothesized that those blindfolded will accurately discriminate between sounds of shapes while interconnecting them with the correct shape visuals better than those who are not blindfolded. There was no level of significance in results between the accuracy of those who were blindfolded in comparison to those who were sighted throughout the whole procedure and groups of items (aggregates). Both groups were not able to accurately discriminate the sounds of the shapes and match them with the visual cue. Overwhelmingly, results suggest that participants had almost never correctly identified shapes at a rate better than chance—for both multiple choice and true or false portions of the study. Results show that participants were able to associate the visualization of a line with the appropriate sound file for the true or false section. Moreover, only by a rate a bit better than chance

Limitations

Although, this research does refute the phenomenon that temporary blindness increases hearing abilities (Kolarik & Scarfe, 2007) and does not replicate the significant results of Kim's 2014 study; there are certain conditions that may explain the results. Initially stating, visual information with auditory signal is difficult to represent due to subjectivity. With a abstractive viewpoint, generating the 'standard' sound of the shapes creates researcher's bias. The LIDAR sound machine that was created to generate the sounds became the standard sounds that participants would learn and then be tested on during the study. This control was based on the set input of the pitch and delay, for each shape. In spite of originally asking participants to adjust the sound of the shape to represent its' visual cue; we expected participants to answer questions and discriminate shapes solely based on the established standard negating their adjustments. We did this because we wanted to control the sounds of the shapes. This control may be a possible explanation for the insignificant results. Having the shapes all have the standard pitch and delay established a control that may have been indistinguishable for participants because they did not objectively represent the visual and auditory characteristics of each unique shape and or size. Results showed that overall participants were able to identify the line shape (negating size of shape) at a rate a little better than chance. All other shapes were undisguisable. Lines were the only statistical difference from chance.

Thus, the conditions (control and manipulation groups) did not variate how participants accurately identify sounds with the visualization of the shape. Conditions dis not impact accuracy. Blindfolded and sighted participants responses were equally at a rate no better than chance. Another possible explanation for this is that all participants do not have or have had a visual impairment. All participants have all at some point engaged with shape visuals and their physicality, so they have that visual bias. Those with visual impairments, who have never viewed the physicality of shapes, may be able to distinguish between the sounds effectively. In comparison to the study done by Lepore, all participants were diagnosed with some sort of blindness. Thus, the results for Lepore's study verified how auditory abilities are heightened in the absence of vision ("Blind People 'See' Sound", 2005).

Lastly, an additional condition that may have influenced the insignificant results were lack of learning styles. In essence, this study does ask researchers to teach participants the sounds of the shapes before they are able to match them with the appropriate visual cue. Participants have to learn what the shape sounds like and then apply the sound to the physical characteristics of the shape. The three prominent styles of learning are visual, auditory, and tactile. In this study however, there were only two types of learning styles present, which were auditory and visual. There was no part of the study where participants were able to physically interact with the associated shape. Those who identify as tactile learners were possibly unable to learn the shapes effectively because of the absence of their learning style preference. Not to mention, we put participants in random assigned groups, regardless of their learning style. Those who were in condition 1 were able to use the images in the shape booklet as a guide throughout the study. They were able to look at the booklet and associate the physical shape with its' audio file. Those in condition 2 could only rely on auditory learning. Needless to say, if participants were assigned to a condition that differentiates from their normal learning style, they may have not learned how to identify the shapes appropriately or effectively.

Implications

In the future, researchers should do a bit more research on generating sounds that are appropriate for each shape. Thus, seeking possible assistance from music professionals, artists, therapists, etc. may emphasize how music/sounds influence what we see and how we can portray visual cues based on auditory stimuli. Using this guide may assist researchers in generating a more effective pilot test. Therefore, this pilot test should be used on both participants who have or had visual impairments and those who have never experienced any visual impairments. A consensus on generating sound files that objectively represent the physicality of shapes and sounds that make the shapes distinguishable is what we aim to do in future reference. This study served as a baseline study. Based on the results from this study, it shows that researchers have to take a step back and learn from their own biases and subjectivity in order to develop this project objectively and in hopes of generating future rehabilitation tool.

Bibliography

Blake, R., & Sekuler, R. (2006). *Perception*. Boston, MA: McGraw-Hill.

BLIND PEOPLE 'SEE' SOUND. (2005, May 06). *Current Science, 90*, 12-13. Retrieved from http://ezaccess.libraries.psu.edu/login?url=https://search-proquest-com.ezaccess.libraries.psu.edu/docview/195880909?accountid=13158

Kim, M. (2014, Feb 09). Simulating blindness may boost hearing. *The Washington Post* Retrieved from http://ezaccess.libraries.psu.edu/login?url=https://search-proquest-com.ezaccess.libraries.psu.edu/docview/1496562009?accountid=13158

Kolarik, A. J., Scarfe, A. C., Brian C J Moore, & Pardhan, S. (2017). Blindness enhances auditory obstacle circumvention: Assessing echolocation, sensory substitution, and visual-based navigation. *PLoS One, 12*(4), e0175750. 10.1371/journal.pone.0175750

Sauro, T. (2013, Jan 31). Experience the sound of art. *McClatchy - Tribune Business News*. Retrieved from http://ezaccess.libraries.psu.edu/login?url=https://search-proquest-com.ezaccess.libraries.psu.edu/docview/1282974387?accountid=13158

Spector, F., & Maurer, D. (2009). Synesthesia: A new approach to understanding the development of perception. *Developmental Psychology*, *45*(1), 175-189. doi:10.1037/a0014171

Synesthesia | Definition of synesthesia in English by Oxford Dictionaries. (n.d.). Retrieved from http://en.oxforddictionaries.com/definition/synaesthesia

Lueck, A. H., & Dutton, G. N. (Eds.). (2015). *Vision and the brain : understanding cerebral visual impairment in children*. Retrieved from https://ebookcentral.proquest.com

PRESSISRAEL21c, V. S. (2014, Month?). Israeli EyeMusic helps blind 'hear' colors and shapes.*Jerusalem Post*

ZATORRE, R. J. (2003). Music and the brain. *Annals of the New York Academy of Sciences, 999*(1), 4-14. 10.1196/annals.1284.001

ACADEMIC VITA

EDUCATION

The Pennsylvania State University
Schreyer Honors College, Abington, PA
JUNIOR ENTRY (FALL 2017)

B.S., Psychological and Social Sciences Expected Graduation: May 2019

COURSEWORK

Intro to Psychology
Writing in the Social Sciences
Intro to Sociology
Information and Research Methods
Elements of Statistical Psych.
Intro to Social Psychology
Organization Communication
Clinical Neuropsychology
Research Methods in Psychology
Program Evaluation Methods

Developmental Psychology

Effective Speech
Criminology
Adolescent Development
Intro to Chemistry
Basic Methods in Psychology
Intro to Biology
Qualitative Methods

RESEARCH & MEDICAL EXPERIENCE

Student Researcher
Abington Undergraduate Research Program 2017 - Present

• Conduct independent research projects with faculty oversight
• Submit research projects and results for review
• Conduct surveys, studies, and data collection for professors engaging in scientific research

Direct Support Professional
Maryhaven, West Babylon, NY 2017 - 2018

• Assist clients with intellectual disabilities with daily living • Coordinate home care needs with primary care team
• Maintain and monitor client health, and document any medical issues that may arise
• Provide exceptional and compassionate care to all patients

Call Center Coordinator
Language Service Associates 2015 - 2016

• Scheduled intake appointments for translation services to nearby hospitals
• Meticulously transcribed information for medical records purposes and court cases • Communicated any escalations and important information to relevant parties

Medical Scribe
Physassist Scribes, Langhorne, PA 2018

- Works diligently under the supervision of a provider in patient documentation
- Proficiency in medical terminology, describing procedures, and Physical exams
- Transcribes all procedures, symptoms, referrals, and physical exams during patient's duration of stay in the Emergency Department
- Typing skills and proficient speed in a high intensity environment

Peer Adviser
Pennsylvania State University, Abington, PA 2018 – Present

- Assist students with academic advising

- Providing referral information
- Assisting students with navigating online resources and programs
- Proficient in basic academic counseling
- Proficient in PSU's academic programs and resources

Personal Care Assistant
Potential Discoveries, Willow Grove, PA 2018 – Present

- Provide direct student support in a classroom setting
- Maintain confidentiality
- Assist Behavior Specialist with prescribed behavioral skill acquisition, protocols and behavior reduction assessments
- Providing a clean, safe and organized therapy environment
- Collaborate with therapy team
- Contributing to moderating client's individualized treatment and measuring progression
- Collect and record data on observable behavior

CHOLARSHIPS AND AWARDS

Abby A. Sutherland Scholarship	2018
Chancellor's Chair Abington Scholarship	2018
Schreyer Honors Scholar	2017
Superior Achievement Award	2016
Dean's List	2015 – 2018
Abington College Research Activities Blue Ribbon Winner for Social Sciences and Humanities	2018
Poster Presenter- American Educational Research Association	2019
Presenter- Pennsylvania Association of Environmental Educators	2019
Emerging Leader Award	2018
Outstanding Community Engagement Award	2019
Stand Out Leader Award	2019

ACADEMIC MEMBERSHIPS

PSI CHI Psychology Honor society	2017 – present
Treasurer, Secretary, and President- Community Outreach Workers	2017 – present

CUSTOMER SERVICE

Hostess - Ruby Tuesday, Warrington, PA	2018 - Present
Sales Associate - Express, Massepequa, NY	2016 – 2017
Peer Advisor – The Pennsylvania State University, PA	2018 – Present

SKILLS

Proficient in computer program SPSS, Google Docs, Qualtrics and Survey Monkey software, skilled in research, methodology, statistics, analysis, program evaluation and survey techniques, knowledge of research ethics, Fluent in Spanish, familiar with medical terminology, excellent email and phone etiquette, amiable customer service, and passionate interest in neuroscience and abnormal behavior.