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Pupillometry as a test of infant word recognition

Kierra Lynch
James Madison University

Pupillometry as a Test of Infant Word Recognition

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by Kierra Alexis Lynch

Accepted by the faculty of the Department of Communication Sciences and Disorders, James Madison University, in partial fulfillment of the requirements for the Honors College.

FACULTY COMMITTEE:

Project Advisor: Rory A. DePaolis, Ph.D.,
Professor, Department of Communication Sciences and Disorders

Reader: Jaime B. Lee, Ph.D.,
Assistant Professor, Department of Communication Sciences and Disorders

Reader: Geralyn R. Timler, Ph.D.,
Associate Professor, Department of Communication Sciences and Disorders

HONORS COLLEGE APPROVAL:

Bradley R. Newcomer, Ph.D.,
Dean, Honors College

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Pupillometry as a Test of Infant Word Recognition

Kierra A. Lynch

James Madison University

Abstract

By 11 months of age, infants recognize commonly occurring word forms in their environment. The Head Turn Preference Paradigm (HTPP) is the one method of measuring infant word form recognition. The HTPP uses looking times as judged by a head turn of the infant towards or away from a speaker. This method is thus subject to infant attention, which can make it difficult to get accurate results when infants are not paying attention due to external factors (for example, teething). Pupillometry is a non-invasive, physiological measurement that uses pupil dilation to assess cognitive processes. Pupil dilations have been found to be an accurate measurement of cognitive load in infants because pupil dilations reflect involuntary activity in the nervous system. Therefore, pupillometry is a non-behavioral assessment of infant word form recognition that may provide richer data than the HTPP. This Honors project was a pilot study for a larger study. The larger study assesses infant word form recognition through pupil dilations and head turns using a common form of the HTPP called the One Screen Head Turn Preference Test. This Honors project compares the results of pupillometry and the One Screen Head Turn Preference Test in one infant from the larger study. It makes a direct comparison of the two methodologies to determine if they can be used side by side to assess infant behavior.

Pupillometry as a Test of Infant Word Recognition

The process of developing language is very complex because of the different components of language such as form (sounds, words, and word order), content (meaning of words), and use (social communication). One of the ways researchers understand language acquisition during the first few years of life is by studying infants' word form recognition at various ages (Halle & Boysson-Bardies, 1994). Word form recognition differs from word recognition since it does not imply meaning, only recognition of the sounds forming the words. When infants recognize word forms they do so without any context clues. For example, infants do not need to be looking at a ball or playing with a ball to recognize the word form of ball (DePaolis, Keren-Portnoy, & Vihman, 2016).

Once researchers know how infants recognize word forms they can explore other aspects of language, such as how words are stored in infants' brains and what aspects of stress are necessary for infants to recognize words (Halle & Boysson-Bardies, 1996; Swingley, 2005; Vihman, Nakai, DePaolis, & Halle, 2004). By developing an understanding of infant language acquisition, researchers also become aware of the typical pattern of language development. This then allows researchers to pay particular attention to infants whose language does not seem to be following the typical language development pattern (Owens, 2013). It is important to identify infants who show atypical language development because infants who receive early intervention for a language disorder have better chances of acquiring language skills similar to typically developing infants (Owens, 2013).

In order to test infants' word form recognition, simple, non-invasive measures must be used because infants are a fragile population (Sirois & Brisson, 2014). Since the 1980s, the most common and successful method of measuring the cognitive process of word form recognition in infants has been the Head Turn Preference Paradigm (HTPP). The HTPP is a non-invasive, behavioral assessment that uses the length of time infants look toward a sound source to determine infants' word form recognition (DePaolis et al., 2016). There are a few detractors to using the HTPP though. For example, the HTPP is subject to human error and it is reliant on infants' behavior, which can be influenced by outside factors (DePaolis et al., 2016; Jusczyk & Aslin, 1995).

Pupillometry is a non-invasive, physiological assessment of pupil dilation that may be able to resolve some of the problems associated with the HTPP (Hepach & Westermann, 2016; Sirois & Brisson, 2014; Sirois & Jackson, 2012; Yeung, Denison, & Johnson, 2016). For the past 50 years, pupillometry has shown that adults' pupils dilate in response to their processing of information (Beatty, 1982; Sirois & Brisson, 2014). So far, only a few studies have used pupillometry to study language processing skills in infants (Hochmann & Papeo, 2014).

This Honors project is a part of a larger study that investigated infants' pupil dilation as a measure of recognizing familiar word forms. There is evidence for a connection between word form recognition and pupil dilation from the results of many studies that show pupil dilation reflects cognitive load in adults and infants (Beatty, 1982; Hepach & Westermann, 2016; Jackson & Sirois, 2009; Sirois & Jackson, 2012). The larger study used a common form of the HTPP called the One Screen Head Turn Preference Test. This served as a parallel measure to pupillometry that assessed concurrent validity (data from one test matches that of a previously established measurement of the same construct). This Honors project was a pilot study that compared the use of pupillometry and the One Screen Head Turn Preference Test in one 13-month-old infant from the larger study. It makes a direct comparison of the two methodologies being explored to provide insight into whether these two methods can be used simultaneously to reflect the onset of word form recognition.

Background

Familiarity vs. Novelty Preference

The foundation upon which many experimental techniques for assessing infant development is infants' preference for both novel and familiar stimuli. It was originally proposed that infants older than two months of age preferred novel stimuli (Hunter & Ames, 1988). However, it was realized that preferences are not linked to age but are linked to task difficulty and familiarization time. As familiarization time increases, infants shift from no preference to a familiarity preference to a novelty preference (Hunter & Ames, 1988). Thus, infants prefer both familiar and novel stimuli.

The model developed by Hunter & Ames (1988) has been adapted for use in many different studies. One such study examined infant familiarly and novelty responses to words at lexical onset (DePaolis et al., 2016). It found that infants who had no preference for stimuli were less phonetically advanced than infants who showed a familiarity or novelty preference. The study also concluded that infants who had a novelty preference had a better understanding of the words presented than infants who had a familiarity or no preference. Thus, familiarity, novelty, and no preference reveal different aspects of development in infants' expression and comprehension (DePaolis et al., 2016).

Head Turn Preference Paradigm (HTPP)

For the past 21 years, infant word form recognition has been primarily measured using the Head Turn Preference Paradigm (HTPP; Halle & Boysson-Bardies, 1996). The HTPP is a suitable method for testing infants' word form recognition because of their tendency to turn towards a sound source, especially when motivating stimulation depends on their head turns (Nelson, Jusczyk, Mandel, Myers, Turk, & Gerken, 1995).

In the HTPP, infants are seated on a parent's lap in a testing booth (Nelson et al., 1995). One loudspeaker hangs from each of the two side walls with an attached blinking red light. A blinking green light is placed in the center panel and used to orient the infants' attention to the center. Once the infants' attention is centered, the green light is shut off and one of the red lights on the side wall is initiated. When the infants' attention is perceived to be on the red light, a pre-recorded, randomized list of familiar or rare words is presented through the speaker. Researchers stop playing the stimulus when the infants look away for at least two consecutive seconds (DePaolis et al., 2016; Halle & Boysson-Bardies, 1994; Halle & Boysson-Bardies, 1996; Jusczyk & Aslin, 1995; Nelson et al., 1995; Swingley, 2005; Vihman et al., 2004).

Researchers use two buttons to indicate where infants are looking during the HTPP. To begin trials, one button is pressed to indicate that infants are looking toward the center. The other button is pressed when infants turn their heads at least 30° toward the sound source until they look away (Nelson et al., 1995; Vihman et al., 2004). It is important that researchers are unaware of the stimulus being played to avoid any bias in determining looks towards the center or away. Thus, researchers wear earplugs or headphones to prevent them from hearing stimuli. Often a video camera is used to record test sessions so that reliability checks can be performed (Nelson et al., 1995). The results of the HTPP consistently reveal that 11-month-old infants turn their heads for a longer amount of time when familiar words are presented (DePaolis et al., 2016; Halle & Boysson-Bardies, 1994; Halle & Boysson-Bardies, 1996; Jusczyk & Aslin, 1995; Swingley, 2005).

Many labs have made modifications to the HTPP to assess word form recognition in different ways. One such modification is the One Screen Head Turn Preference Test (Cooper & Aslin, 1990). In this method, one screen is placed in front of the infants. Then, either one large speaker is placed in front of the screen or speakers are placed on the right and left sides of the screen. Researchers record the length of the infants' looks toward the screen to assess their word form recognition (Cooper & Aslin, 1990; Houston, Pisoni, Kirk, Ying, & Miyamoto, 2003; Segal, Keren-Portnoy, & Vihman, 2015).

Researchers have used the different forms of the HTPP to determine the age range for when infants begin to recognize familiar word forms in French, British English, and American English (DePaolis, personal communication, September 18, 2017; Halle & Boysson-Bardies, 1994; Vihman et al., 2004). It has been found that nine-month-old infants are too young to recognize familiar word forms from their environment because they have not had enough exposure to language (Vihman et al., 2004). By 11-months-old, infants start to show the onset of a lexicon (mental dictionary) for familiar word forms and therefore, consistently look longer toward familiar words (Halle & Boysson-Bardies, 1996; Swingley, 2005; Vihman et al., 2004).

There are a few factors that affect the accuracy of the HTPP results. For example, researchers are responsible for pressing different keys on a keyboard to indicate the length of time infants look toward a sound source. Therefore, there is the possibility of human error because it is difficult to record the length of infants' head turns with precision and accuracy (Oakes, 2012). Also, since the HTPP relies on infants' physically turning their heads, results can be affected by external factors such as infants' attention (DePaolis et al., 2016; Jusczyk & Aslin, 1995). For example, when infants are teething, the HTPP is competing against interfering factors. Therefore, infants may not consistently look when a familiar word is presented.

Pupillometry

Recently, researchers have started using pupillometry to explore infants' cognitive processes. These cognitive processes include infants' object permanence, social cognition, and emotions (Hepach, Vaish & Tomasello, 2015; Hepach & Westermann, 2016; Sirois & Jackson, 2012). It has been found in multiple experiments that infants' pupil dilation reflects their cognitive load (Hepach & Westermann, 2016; Jackson & Sirois, 2009; Sirois & Jackson, 2012). This is the same result that researchers have found from studying adults' pupil dilation in response to cognitive processes like memory, perception, and language processing (Beatty, 1982; Hepach & Westermann, 2016; Sirois, & Brisson, 2014).

There is emerging consensus that pupillometry is a useful way to study cognitive processes in infants (Hepach & Westermann, 2016; Sirois & Brisson, 2014; Sirois & Jackson, 2012; Yeung et al., 2016). One of the main reasons that pupillometry is effective for testing infants is because pupil dilations are independent of infants' behaviors and can be precisely and automatically captured by an eye tracker. Therefore, pupillometry is not affected by researcher input and is less affected by lack of attention. Even if infants are teething or bored during pupillometry testing, their pupils will still dilate in response to their cognitive load. It is only if infants look away from the eye tracker that results would be compromised (Hepach & Westermann, 2016). When using pupillometry, researchers can also focus on infants' responses at fixed moments in time by studying pupil diameter rather than just the overall length of time infants' look toward a sound source (Hepach & Westermann, 2016; Yeung et al., 2016). Studying responses at fixed moments allows researchers to better understand the time frame of when information processing is occurring in pre-verbal infants and to detect small changes in cognitive processes during infant development (Hepach & Westermann, 2016).

At the time of the experiment, there was no research that used pupillometry to assess infant word form recognition. The goal of the larger study was to address the gap in knowledge as to whether pupil dilation is a reliable measure of word form recognition in infants. The larger study measured both pupil dilations and looking times (length of time infants look toward the sound source). This Honors project used data from the larger study to assess whether pupillometry and the One Screen Head Turn Preference Test could be conducted simultaneously to yield more detailed information about early word learning.

Design and Methods

This project used a quasi-experimental design to compare pupil dilations and looking times in relation to infants' word form recognition (See Appendix A for the approved IRB protocol). Looking times were measured using the One Screen Head Turn Preference Test as implemented by the Habit program (Oaks, Sperka, & Cantrell, 2015).

Stimuli

This study tested infant word form recognition using one list of familiar words and one list of rare words. Familiar words, such as "mummy" and "baby," commonly occur in infants' environments (Vihman et al., 2004). Rare words, such as "cycle" and "disturb," occur in low frequency in infants' environments (Vihman et al., 2004). The words used in this study were a combination of trochees (stressed syllable followed by unstressed syllable) and iambs (unstressed syllable followed by stressed syllable). Table 1 contains the complete list of stimuli. These word lists were recorded by a female speaker with general American dialect. The volume at which the lists were played was predetermined using a Sound Level Meter (SLM). All stimuli were presented at an average level of 60dB SPL.

Table 1. Word Stimuli

	Familiar word	Phonetic transcription	Rare word (unfamiliar to infants)	Phonetic transcription
Trochaic	apple	/æpəl/	bridle	/braɪdəl/
	baby	/beɪbi/	cycle	/saɪkəl/
	button	/bʌtən/	fog light	/fɔglaɪt/
	mummy	/mʌmi/	maiden	/meɪdən/
	nappy	/næpi/	manna	/mænə/
	sleepy	/slipi/	mortar	/mɔtə/
	thank you	/ɵæŋkju/	thorough	/ɵʌrə/
Iambic	a ball	/əbɔl/	a bine	/əbaɪn/
	away	/əwėɪ/	a noose	/ənus/
	balloon	/bəlun/	compare	/kəmpɛə/
	fall down	/fɔldaʊn/	disturb	/dɪstɜb/
	tonight	/tənaɪt/	taboo	/təbu/

Note. Nappy was replaced with cookie because it is more familiar to American infants.

Participant

The participant was a 13-month-old bilingual infant. The parent questionnaire stated that the participant learned Spanish at home where the subject lived with parents, both grandparents, and multiple aunts and uncles. The participant attended daycare 4 times a week and spent two days a week in the care of his father (see Appendix B for the parent questionnaire form). The participant was recruited through flyers placed throughout the community. Before testing began, the participant's mother completed the informed consent form (see Appendix C).

Procedure

This Honors project followed the same procedure as the larger study. The larger study began by having the infant seated on the parent's lap in the testing booth. The main light in the testing booth was left on and the door to the testing booth was closed during the experiment. The testing booth was separated from the researcher's room by a one-way mirror and black curtain. The parent wore earplugs with headphones on top, which played a constant masking noise, so that they were unaware of the words being presented to the infant. A Behringer headphone amplifier was used to increase the volume of the masking noise. The masking level was set using two college-aged volunteers, who interpreted some babble as real words, but reported hearing none of the words from the experimental list. Researchers wore earplugs as well, so that they were unaware of which words were playing.

To record the infant's pupil dilations during testing, a Tobii T60 XL Eye Tracker was placed on a table in front of the infants. The table was 22 inches tall. The eye tracker was adjusted up or down once the infant and parent were seated in order for the eye tracker to catch the infant's eyes. The chair in which the infant and parent were sitting was placed 27 inches from the Tobii eye tracker screen (see Figure 1). The Tobii eye tracker operated by using infrared light waves to record the infant's pupil dilations. Eye tracking data was recorded with TobiiStudio software that was run on a Dell computer. See Figure 2 for a block diagram of the equipment setup.

The testing of the infant began with a five-point calibration. Then, the experimental phase began. Each trial was preceded by a short (approximately three second) attention grabbing black and white checkboard screen that moved but caused no change in luminance. The experimental phase consisted of 12 trials, six each of the two test conditions (familiar and rare). The words in each trial were pseudo-randomized so that each word appeared either first or second in one trial. Each list order was blocked into three sections of four with two rare and two familiar word lists in each block. While each word list was playing, a still black and white checkerboard screen was presented on the Tobii eye tracker screen. Pupil dilation was measured by the Tobii eye tracker from the moment the word was presented until the infant looked away from the screen. Also, the Tobii eye tracker measured where the infant was looking during the presentation of each word. Altogether the experimental phase took a total of five to six minutes.

During testing, one researcher in the researcher's room controlled the Tobii eye tracker by clicking the mouse to change the screen from the still checkerboard to the attention getter checkerboard. The other researcher in the researcher's room used Habit software to record the length of time the infant looked towards the center and away from the sound source. Habit required the researcher to press one key for when the infant looked towards the screen and a separate key for when the infant looked away from the screen.

Figure 1. Testing Booth Setup

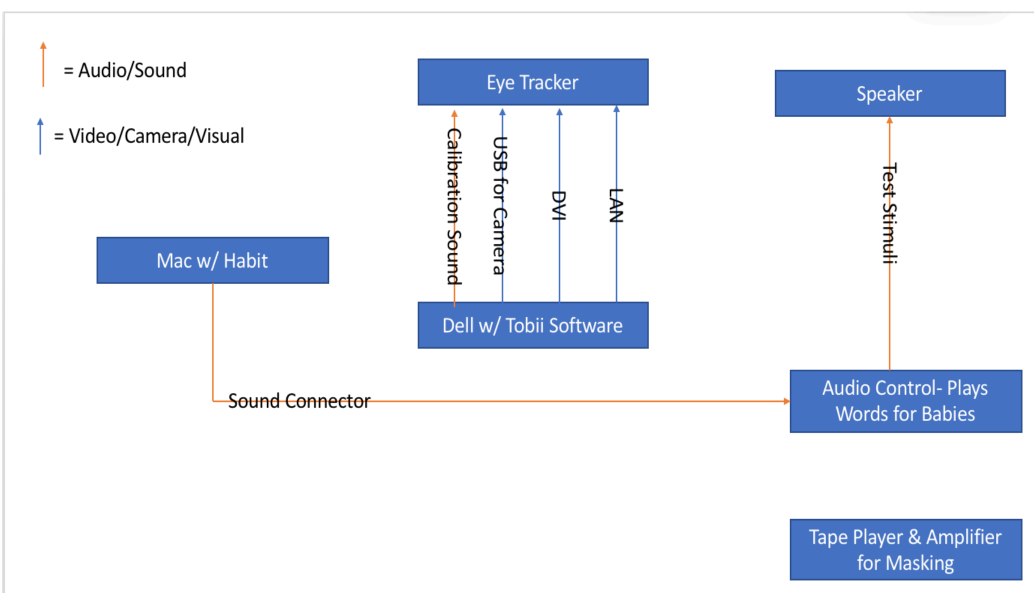

Figure 2. Block Diagram of Equipment Setup

Results

The participant was able to complete 11 of the 12 trials. The video recording captured by the Tobii eye tracker was used to place a marker at the start of each word in the data recording. After the markers were placed, the right and left pupil size data taken 60 times a second during the entire test was exported into an excel spreadsheet. The data showed that the infant intermittently looked towards the eye tracker for about eight out of the twelve words in each trial, which made the eye tracker unable to collect the right and left pupil size for many of the words. Thus, only the familiar and rare words that had the most complete pupil dilation data were analyzed. The familiar words that showed the most pupil data included baby, mummy, and a ball. All of these words were reported on the parent questionnaire as the most familiar to the subject. The rare words that showed the most pupil data included compare, cycle, manna, a bine, thorough, mortar, manna, and taboo.

The pre- and post- period for each word indicated above were analyzed. The pre-period consisted of 10 milliseconds before the onset of the word. The post-period consisted of 10 milliseconds taken 60 milliseconds after the onset of the word. The right and left pupil dilations were averaged for each word in the pre- and post-period. The pre-and post-period pupil change averages were compared for each word using an independent sample t-test. There were significant pupil changes for four out of six familiar words and seven out of nine rare words. See Figure 3. The only familiar word that showed significant dilation was mummy. See Figure 4. The familiar words that showed significant constriction included baby and a ball. The rare words that showed significant dilation included compare, manna, and taboo. The rare words that showed significant constriction included cycle, a bine, and mortar. See Figure 5 and 6.

The looking time data from Habit captured the total look time toward the center for each word list presented to the infant. See Figure 7. It is important to note that there is no total looking time towards the center for trial 12, a rare list of words, since the pilot subject was unable to complete the final trial. The average total look time towards the center for the familiar word lists was 9296.833ms and the average total look time towards the center for the rare word lists was 11182.4ms. Thus, on average, the infant looked for a longer amount of time towards the center screen when the rare word lists were presented. The difference was noticeable, but not statistically significant. Since these looks were coded by a human, coding errors are a possibility.

Familiar Word	P-value (2 Tail)	Pre Mean	Post Mean	Significant?
Baby	0.00050613	3.57	3.4065	Yes
Mummy	0.40958807	3.696	3.7195	No
A ball	1.90189E-05	3.6675	3.47	Yes
Mummy	1.06441E-05	3.3675	3.552	Yes
Baby	0.078273162	3.829	3.7955	No
Mummy	0.651293918	3.5805	3.574	No

Rare Word	P-value (p<.05)	Pre Mean	Post Mean	Significant?
compare	6.22329E-09	3.206	3.3425	Yes
cycle	0.000975195	3.498	3.4425	Yes
manna	2.38696E-08	3.4265	3.5925	Yes
a bine	1.7042E-12	3.69	3.4335	Yes
thorough	0.08056803	3.459	2.643	No
mortar	8.09012E-10	3.5915	3.492	Yes
manna	3.74709E-07	3.6255	3.7565	Yes
mortar	0.753727901	3.6985	3.715	No
taboo	0.009967301	3.169	3.4355	Yes

Figure 3. Independent Sample T-Test Results

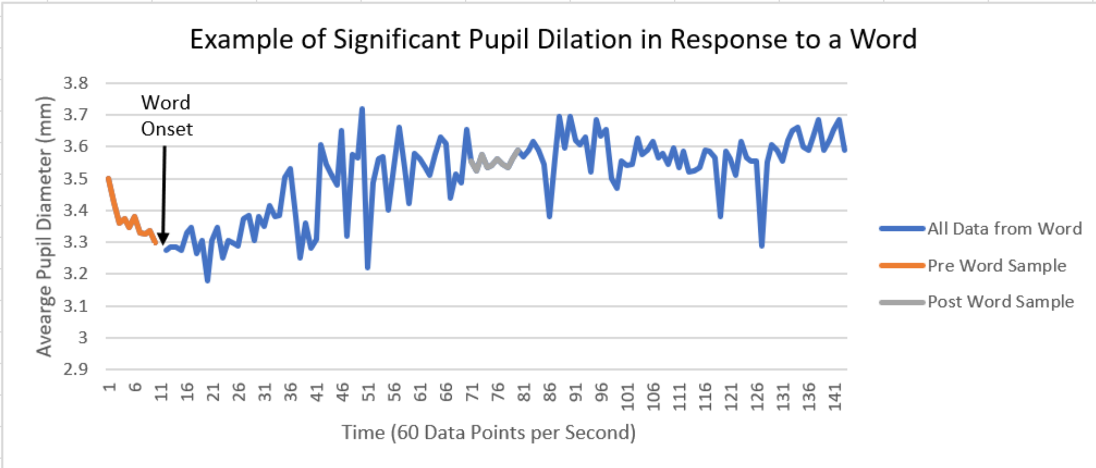

Figure 4. Example of Significant Pupil Dilation in Response to "Mummy"

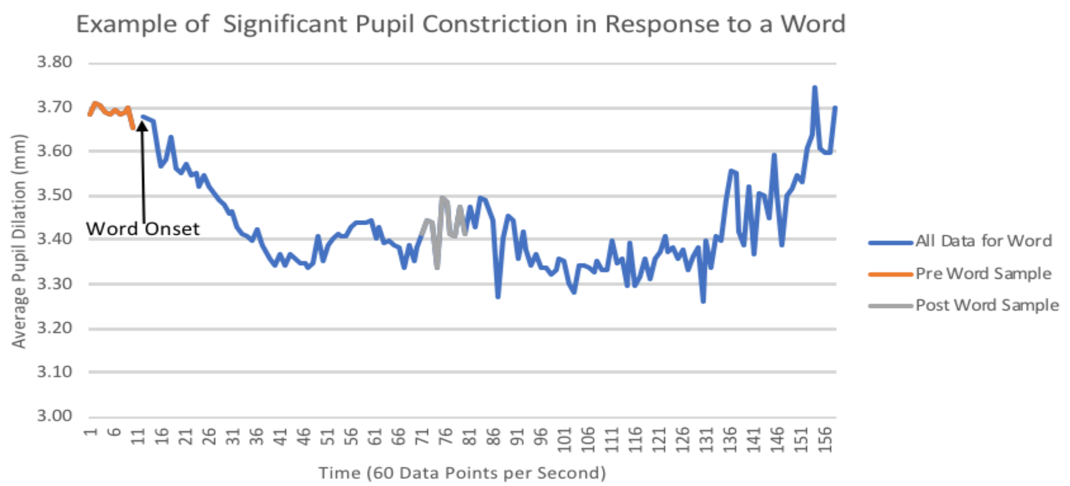

Figure 5. Example of Significant Pupil Constriction in Response to "A Bine"

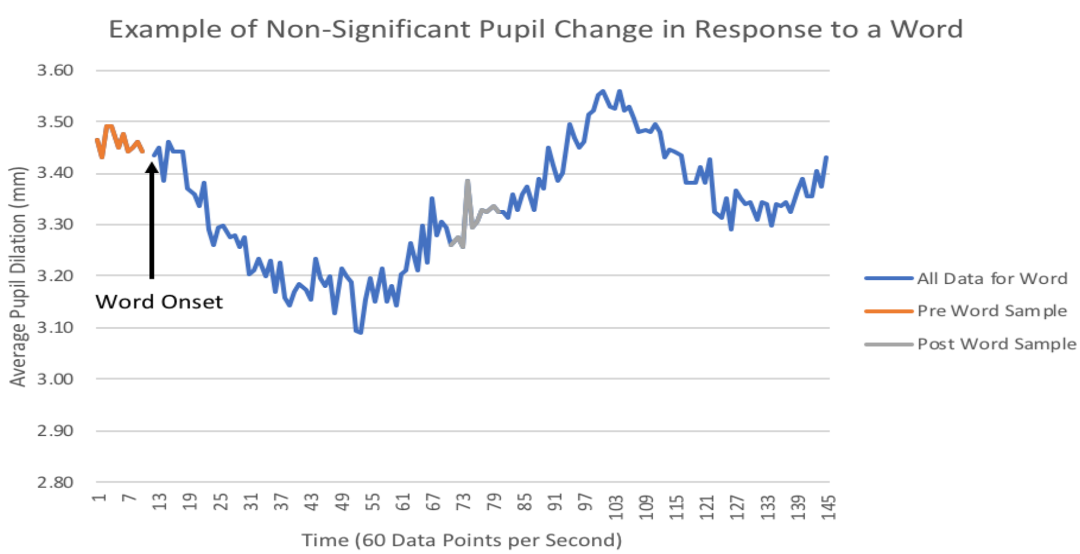

Figure 6. Example of Non-Significant Pupil Change in Response to "Thorough"

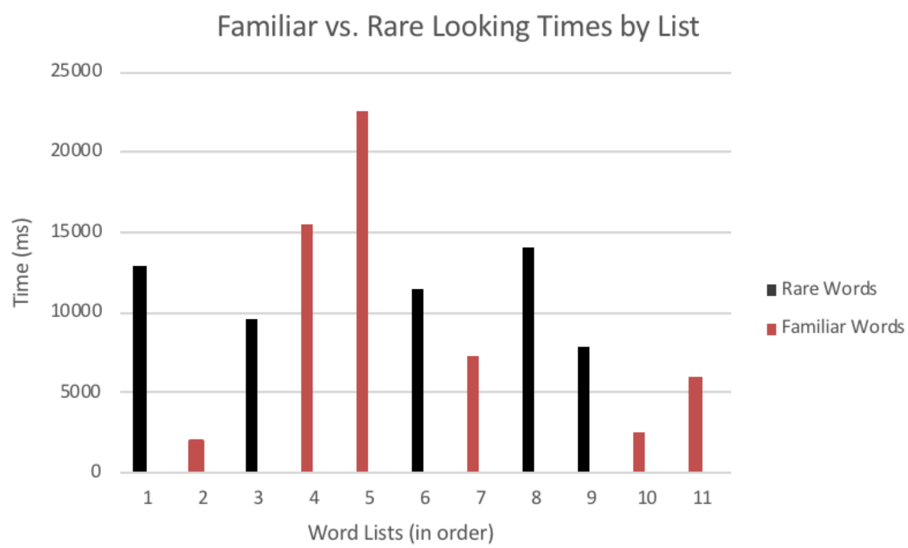

Figure 7. Looking Times by Trial for Familiar vs. Rare Word Lists

Discussion and Conclusion

The purpose of this study was to explore the simultaneous use of HTPP and pupillometry as a measure of infant word form recognition. This pilot study showed that the HTPP and pupillometry can successfully be used side by side. Based on the t-tests, the infant's pupils revealed dilation for rare words when compared to familiar words. It is possible that when the infant was presented with rare words, the infant's pupils dilated because it was a cognitively demanding task, which is consistent with adult pupil dilation data. The cause of constriction for some of the rare words is unknown at this time. The infant's pupillometry results were consistent with the One Screen Head Turn Preference Test results, which showed that on average the infant looked towards the center for a longer amount of time when rare words were presented.

The scope of this research was to investigate support for or against the simultaneous use of pupillometry and HTPP in a single study. Future research will need to test a larger sample size to determine if pupillometry can be a successful measure of infant word form recognition, but the preliminary results presented here suggest that pupillometry and the HTPP can be used simultaneously to assess infant word recognition.

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Appendix A

James Madison University
Human Research Review Request

FOR IRB USE ONLY:

Exempt: ☐	**Protocol Number:**	**1st Review:** _____	**Reviewer:** ____________________
Expedited: ☐	**IRB:** 17-0541	**2nd Review:** _____	**Reviewer:** ____________________
Full Board: ☒	**Received:** 04/07/17	**3rd Review:** _____	

Project Title:	Assessing Infant Word Recognition Through Head Turn Preference and Pupil Dilation
Project Dates: (Not to exceed 1 year minus 1 day)	From: 4/27/17 MM/DD/YY To: 4/26/18 MM/DD/YY
Responsible Researcher(s):	Amy Vinyard, Kierra Lynch
E-mail Address:	vinyaram@dukes.jmu.edu
Telephone:	(573) 823-2256
Department:	Communication Sciences and Disorders
Address (MSC):	4303
Please Select:	☐ Faculty ☐ Administrator/Staff Member ☒ Undergraduate Student (Kierra Lynch) ☒ Graduate Student (Amy Vinyard)
(if Applicable):	
Research Advisor:	Rory DePaolis
E-mail Address:	depaolra@jmu.edu
Telephone:	540-568-3869
Department:	Communication Sciences and Disorders
Address (MSC):	MSC 4303
Minimum # of Participants:	10
Maximum # of Participants:	20
Funding:	**External Funding:** Yes: ☐ No: ☒ **If yes, Sponsor:** _____ **Internal Funding:** Yes: ☒ No: ☐ **If yes, Sponsor: CSD Department** **Independently:** Yes: ☐ No: ☒
Incentives:	**Will monetary incentives be offered? Yes: ☒ No: ☐** **If yes: How much per recipient?** $20 **In what form? Gift card**
Must follow JMU Financial Policy:	http://www.jmu.edu/financemanual/procedures/4205.shtml#.394IRBApprovedResearchSubjects

Institutional Biosafety Committee Review/Approval:	**Use of recombinant DNA and synthetic nucleic acid molecule research:** ☐ Yes ☒ No **If "Yes," approval received:** ☐ Yes ☐ No ☐ Pending **IBC Protocol Number(s):** **Biosafety Level(s):**
Will research be conducted outside of the United States?	☐ Yes ☒ No **If "Yes," please complete and submit the International Research Form along with this review application:** **http://www.jmu.edu/researchintegrity/irb/forms/irbinternationalresearch.docx.**
Certain vulnerable populations are afforded additional protections under the federal regulations. Do human participants who are involved in the proposed study include any of the following special populations?	☒ Minors ☐ Pregnant women *(Do not check unless you are specifically recruiting)* ☐ Prisoners ☐ Fetuses ☐ My research does not involve any of these populations
Some populations may be vulnerable to coercion or undue influence. Does your research involve any of the following populations?	☐ Elderly ☐ Diminished capacity/Impaired decision-making ability ☐ Economically disadvantaged ☐ Other protected or potentially vulnerable population *(e.g. homeless, HIV-positive participants, terminally or seriously ill, etc.)* ☒ My research does not involve any of these populations

Investigator: Please respond to the questions below. The IRB will utilize your responses to evaluate your protocol submission.

1. ☒ **YES** ☐ **NO** Does the James Madison University Institutional Review Board define the project as ***research?***

The James Madison University IRB defines "research" as a "*systematic* investigation designed to develop or contribute to *generalizable knowledge*." All research involving human participants conducted by James Madison University faculty and staff and students is subject to IRB review.

2. ☒ **YES** ☐ **NO** Are the human participants in your study ***living*** individuals?

"Individuals whose physiologic or behavioral characteristics and responses are the object of study in a research project. Under the federal regulations, human subjects are defined as: living individual(s) about whom an investigator conducting research obtains:
(1) data through intervention or interaction with the individual; or (2) identifiable private information."

3. ☒ **YES** ☐ **NO** Will you obtain data through ***intervention*** or ***interaction*** with these individuals?

"Intervention" includes both physical procedures by which data are gathered (*e.g.*, measurement of heart rate or venipuncture) and manipulations of the participant or the participant's environment that are performed for research purposes. "Interaction" includes communication or interpersonal contact between the investigator and participant (*e.g.*, surveying or interviewing).

4. ☒ **YES** ☐ **NO** Will you obtain ***identifiable private information*** about these individuals?

"Private information" includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, or information provided for specific purposes which the individual can reasonably expect will not be made public (*e.g.*, a medical record or student record). "Identifiable" means that the identity of the participant may be ascertained by the investigator or associated with the information (*e.g.*, by name, code number, pattern of answers, etc.).

5. ☐ **YES** ☒ **NO** Does the study present ***more than minimal risk*** to the participants?

"Minimal risk" means that the risks of harm or discomfort anticipated in the proposed research are not greater, considering probability and magnitude, than those ordinarily encountered in daily life or during performance of routine physical or psychological examinations or tests. Note that the concept of risk goes beyond physical risk and includes psychological, emotional, or behavioral risk as well as risks to employability, economic well being, social standing, and risks of civil and criminal liability.

CERTIFICATIONS:

For James Madison University to obtain a Federal Wide Assurance (FWA) with the Office of Human Research Protection (OHRP), U.S. Department of Health & Human Services, **all** research staff working with human participants must sign this form and receive training in ethical guidelines and regulations. "Research staff" is defined as persons who have direct and substantive involvement in proposing, performing, reviewing, or reporting research and includes students fulfilling these roles as well as their faculty advisors. The Office of Research Integrity maintains a roster of all researchers who have completed training within the past three years.

Test module at ORI website http://www.jmu.edu/researchintegrity/irb/irbtraining.shtml

Name of Researcher(s) and Research Advisor	Training Completion Date
Rory DePaolis	**2-23-15** Dr. DePaolis will complete the IRB Social/Behavioral Research Course – Refresher Course before the training expires
Amy Vinyard	**4-1-17**
Kierra Lynch	**1-28-17**

For additional training interests, or to access a Spanish version, visit the National Institutes of Health Protecting Human Research Participants (PHRP) Course at: http://phrp.nihtraining.com/users/login.php.

By signing below, the Responsible Researcher(s), and the Faculty Advisor (if applicable), certifies that he/she is familiar with the ethical guidelines and regulations regarding the protection of human research participants from research risks. In addition, he/she agrees to abide by all sponsor and university policies and procedures in conducting the research. He/she further certifies that he/she has completed training regarding human participant research ethics within the last three years.

Principal Investigator Signature Date

Principal Investigator Signature Date

Principal Investigator Signature Date

Faculty Advisor Signature Date

Submit an electronic version (in a Word document) of your **ENTIRE** protocol to researchintegrity@jmu.edu.
Provide a **SIGNED** hard copy of the Research Review Request Form to:
Office of Research Integrity, MSC 5738, 601 University Boulevard, Blue Ridge Hall, Third Floor, Room # 342

Purpose and Objectives

Please provide a lay summary of the study. Include the purpose, research questions, and hypotheses to be evaluated. (Limit to one page)

The purpose of this study is to assess whether pupil dilation is a reliable index of word recognition in infants. Previous studies have shown that 11-month-old infants recognize words independently of context (Halle et al 1994 and Vihman et al. 2004 and Swingley 2005). Traditionally, the head turn preference test has been used to assess word recognition in this population. However, this method relies on the infant's behavior and is influenced by lack of attention (due to teething for example). Pupil dilation is a physiological response that is independent of infant behavior. It's well-known that an adult's pupils dilate when they're working on a cognitively difficult task, and the same holds true for infants. However, no one has tested how word recognition influences an infant's pupil dilation. We hypothesize that infant's pupils will dilate in response to unfamiliar words, but not in response to familiar words. We will use the head turn preference paradigm as a parallel measure to assess concurrent validity.

Procedures/Research Design/Methodology/Timeframe

Describe your participants. From where and how will potential participants be identified (e.g. class list, JMU bulk email request, etc.)?

Participants will be monolingual English-learning 11-month-old infants from the Harrisonburg/valley area.

How will subjects be recruited once they are identified (e.g., mail, phone, classroom presentation)? Include copies of recruitment letters, flyers, or advertisements.

Recruitment will be through a bulk email to all JMU faculty, staff, and students and through flyers placed in the community (see attached).

Describe the design and methodology, including all statistics, IN DETAIL. What exactly will be done to the subjects? If applicable, please describe what will happen if a subject declines to be audio or video-taped.

The study will measure pupil dilation during the head-turn preference paradigm. Each method is described below.

Head Turn Preference Paradigm:

This will be a one screen head turn preference test. The infant sits on a parent's lap in a soundproof booth, facing out. The parent wears headphones that play a masking noise to prevent them from influencing the baby's responses. Directly across from the infant at their eye level is the Tobii screen. The screen displays a checkerboard pattern, which doesn't change throughout the experiment. The sound stimuli are presented at a comfortable level through a loudspeaker mounted under the computer. The infant is first habituated to the task, learning that a sound continues to be played as long as they look at the screen. The sound stops once they look away for two seconds or more, thus ending the trial. If the infant looks away for less than 2 seconds, the trial continues, but the looking-away time is not included in the length of look. Once this is established, the experimental phase begins. The infant is presented with two lists of words, one at a time and randomly ordered. One list contains words that the infant is likely to be familiar with, like “mommy” and “baby”. The other contains words that the infant has probably not heard often, like “maiden”. The process is the same for each of the 24 words (12 familiar and 12 unfamiliar). An attention-grabber animation is used to center the infant’s attention on the screen. Once the infant is centered, a word from one of the lists is played through a speaker. The word is repeated until the infant looks away from the screen for longer than two seconds. Throughout this process, the Tobii eye tracker is recording the size of the infant’s pupils in millimeters. A researcher watches through a two-way mirror to code the infant’s looks. The researcher codes the duration of the infant’s gaze towards the screen by pressing keys on a computer keyboard. The measurements are recorded using the Habit program. This process is repeated with each word list. All infant responses will be videotaped and checked for reliability by another researcher after testing is over.

Eye Tracker Method (concurrent with HPP):

Before the Head Turn Preference Paradigm begins, the Tobii will calibrate itself to the infant’s eyes. This is accomplished by having the infant look at a dot onscreen as it moves into various positions. This will take less than a minute. During all phases of the Head Turn Preference Paradigm, the Tobii will measure and record pupil size using an infrared beam of light (the same light that a TV remote control uses).

Emphasize possible risks and protection of subjects.
The main potential risk is the exposure of subject information (i.e. names and ages). This will be mitigated by keeping all identifying information in a locked drawer in the locked Infant and Toddler Language Laboratory. All electronic data will only contain subject codes without names. The lab is also behind a door that requires swipe access. Since the infant will be his/her mother at all times, any issues related to emotional distress (surprise at the changing computer screen for example) will be a non-issue.

The other potential risk is that the near infrared light used by the eye tracker could cause seizures in people with photosensitive epilepsy. About 3-5% of people with epilepsy have this type, and it may happen even in people without a history of seizures. A person with Photosensitive Epilepsy would also be likely to have problems with TV screens, some arcade games, and flickering fluorescent bulbs. To ensure that subjects are protected, the researchers will exclude any parent or infant with a diagnosis of epilepsy or a history of difficulties with TV screens or flickering lights from the study. This is explained in the consent form. We are also excluding anyone who uses a medical device that can be affected by infrared light.

What are the potential benefits to participation and the research as a whole?

Parents of participants will be engaged in a language task that emphasizes the parent role in word learning. Researchers in the field will potentially gain evidence that pupil dilation is a reliable index for infants' word recognition while acquiring a first language. In addition, the parent of each participant will receive a $20 gift card as compensation for their time.

Where will research be conducted? (Be specific; if research is being conducted off of JMU's campus a site letter of permission will be needed)

The research will take place in the Infant and Toddler Laboratory in room 5018 on the fifth floor of the Health and Behavioral Sciences Building.

Will deception be used? If yes, provide the rationale for the deception. Also, please provide an explanation of how you plan to debrief the subjects regarding the deception at the end of the study.

Deception will not be used.

What is the time frame of the study? (List the dates you plan on collecting data. This cannot be more than a year, and you cannot start conducting research until you get IRB approval)

The study will begin as soon as IRB approval is obtained, and will continue throughout the subsequent year.

Data Analysis

How will data be analyzed?

Pupil dilation data from the Tobii eye tracker will be analyzed using Matlab. Looking times will be collected from the Habit software and analyzed using SPSS. With both data t-tests will be run to determine if the dependent variables (pupil dilation and looking time respectively) are different between familiar and unfamiliar words.

How will you capture or create data? Physical (ex: paper or tape recording)? Electronic (ex: computer, mobile device, digital recording)?

Both previously mentioned computer programs capture data electronically. Tobi records the infants' eye movements on a screen as well as pupil dilation. It also takes a video of the parent and infant's faces, like a video from a video camera. Habit records when and how long the infants look towards a stimulus, in this case a word. We will also have a parent fill out a questionnaire regarding their infant's language development (see attached). The parent will also fill out another questionnaire, the MacArthur-Bates Communicative Development Inventories (CDIs), which assesses infant language. A copy of the MacArthur-Bates CDI is included at the end of the document.

Do you anticipate transferring your data from a physical/analog format to a digital format? If so, how? (e.g. paper that is scanned, data inputted into the computer from paper, digital photos of physical/analog data, digitizing audio or video recording?)

All pupil dilation and looking time data will be created digitally. The experiment will be videotaped for reliability using the Tobii software. Data from the questionnaire will be inputted into the computer from the paper questionnaires. Data from the MacArthur-Bates Communicative Development Inventories (CDIs) will also be inputted into the computer from paper questionnaires right away. All data entered into the computer will be de-identified.

How and where will data be secured/stored? (e.g. a single computer or laptop; across multiple computers; or computing devices of JMU faculty, staff or students; across multiple computers both at JMU and outside of JMU?) If subjects are being audio and/or video-taped, file encryption is highly recommended. If signed consent forms will be obtained, please describe how these forms will be stored separately and securely from study data.
The data will be stored on two computers in the CSD research labs on the fifth floor of the HBS building. The labs are behind a door that requires swipe access, and the labs themselves require another key. The computers are password protected. All digital data will only include participant codes. The video of the infants will be stored on an encrypted hard drive that is located in the Infant and Toddler Language Laboratory.

Who will have access to data? (e.g. just me; me and other JMU researchers (faculty, staff, or students); or me and other non-JMU researchers?)
Only the two principal investigators and the faculty advisor will have access to the participant names. De-identified data may be used for future student projects.

If others will have access to data, how will data be securely shared?
All data will be viewed in the Infant and Toddler Language Laboratory. Video will be stored on an encrypted hard drive.

Will you keep data after the project ends? (i.e. yes, all data; yes, but only de-identified data; or no) If data is being destroyed, when will it be destroyed, and how? Who will destroy the data?
All de-identified data will be kept on the same computers after the project ends. The paper surveys will be kept in locked cabinets in the Infant and Toddler Language Laboratory. The lab is behind a door that requires swipe access, and the lab itself requires another key. Video recordings will be kept in the same lab on encrypted hard drives. Participant information will be destroyed three years after the end of the project. This includes videos, which will be deleted from the encrypted hard drives three years after the end of the project. Paper data will be destroyed three years after the end of the project.

Reporting Procedures

Who is the audience to be reached in the report of the study?

The audience will be other researchers interested in infant language acquisition, as well as clinicians who work with infants.

How will you present the results of the research? (If submitting as exempt, research cannot be published or publicly presented outside of the classroom. Also, the researcher cannot collect any identifiable information from the subjects to qualify as exempt.)

The results of the study will be written up as a master’s thesis and an honor’s thesis, as well as published in a peer-reviewed journal. De-identified data may be used for future classroom instruction.

How will feedback be provided to subjects?

Feedback will not be provided to subjects during or after the experiment. The results of the study will be posted on the Infant and Toddler Language Laboratory website

Experience of the Researcher (and advisor, *if student)*:

Please provide a paragraph describing the prior relevant experience of the researcher, advisor (if applicable), and/or consultants. If you are a student researcher, please state if this is your first study. Also, please confirm that your research advisor will be guiding you through this study.

This is the first study for Amy Vinyard and Kierra Lynch. Both are advised by Dr. DePaolis, who has been studying infant language development for 25 years. Rory DePaolis, PhD, has been conducting experiments with human participants for thirty years, including either running or supervising a half dozen studies that have collected observational data from over 100 families in Wales, England, and the US. He has also run and/or supervised at least a dozen studies that have collected experimental data using the head turn preference paradigm.

Appendix B

Parent Questionnaire: Head Turn & Eye Tracking

Family Profile

Child's Name____

Birth Date___________________ Birth Place________________________

	Mother	**Father**
Name		
Birthplace, date		
Accent		
How long have you lived in the valley?		
Occupation		
Highest level of education		

OTHER LANGUAGES to which child is exposed (indicate language, speaker and how often child is with speaker) ____

____

OTHERS living at home besides parents (indicate accent if relevant)

____

____

OTHER CARETAKERS (approx. amount of time per week spent with them; indicate accent)

____

____

Circle how well you think your baby recognizes these words/phrases. They may or may not have attached meaning to them yet, this just asks if they recognize the word if they hear it. **1 indicates they don't recognize the word at all, and 5 indicates that they always recognize the word.**

	1 (Never Recognizes)	**2**	**3**	**4**	**5** (Always Recognizes)
Away	1	2	3	4	5
Apple	1	2	3	4	5
Baby	1	2	3	4	5
Button	1	2	3	4	5
Mommy	1	2	3	4	5
Sleepy	1	2	3	4	5
Thank you	1	2	3	4	5
Cookie	1	2	3	4	5
A Ball	1	2	3	4	5
Balloon	1	2	3	4	5
Fall Down	1	2	3	4	5
Tonight	1	2	3	4	5

Appendix C

Parent Informed Consent: Head Turn & Eye Tracking

Identification of Investigators & Purpose of Study

Your child is being asked to participate in a research study conducted by Amy Vinyard and Kierra Lynch from James Madison University, under the advisement of Dr. Rory DePaolis. This study is designed to establish if pupil dilation is a reliable measure of word recognition in 11-month-old babies. We will be running all parts of the study at James Madison University, Harrisonburg, Virginia, USA. The experiment will be videotaped.

Research Procedures

Should you agree to allow your child to participate in this research study, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. You will also be asked to visit the James Madison University Infant and Toddler Language Laboratory. While your infant is seated on your lap, different types of speech will be presented through loudspeakers. Your child's response to this speech will be observed and videotaped, with your permission. An instrument called an eye tracker will use an invisible infrared light to measure the size of your baby's pupils. This is the same kind of light that TV remote controls use. The presentation level of the speech will be about that of normal conversational speech. You will be asked to wear headphones playing noise and to use insert earplugs to mask the speech your infant is hearing so that your response does not affect your infant's response.

This study also consists of a questionnaire that will be administered to individual participants in the Speech Laboratory at James Madison University. You will be asked to provide answers to a series of questions related to the language of your child.

Time Required

Participation in this study will require 30 minutes of you and your infant's time.

Risks

The investigators do not perceive more than minimal risks from you or your infant's involvement in this study (that is, no more risk than that encountered in everyday life). However, if you or your infant have photosensitive epilepsy, we don't recommend that you take part in the study. This is because the light from the eye tracker can cause seizures in people with this condition, like other computer screens. Also, we don't recommend that you take part in the study if you or your infant use a medical device that can be affected by infrared light, or are sensitive to flickering fluorescent lights or screens.

Benefits

Potential benefits from participation in this study include learning more about the way that infants begin to learn and remember their first words. Researchers in the field will potentially gain evidence that pupil dilation is a reliable index for infants' word recognition while acquiring a first language.

Incentives

You will be paid a $20 gift card for your participation.

Confidentiality

Confidentiality

The results of this research will be presented at conferences and in the classroom. The results of this project will be coded in such a way that the respondent's identity will not be attached to the final form of this study. The researchers retain the right to use and publish non-identifiable data. All data will be stored in a secure location accessible only to the researchers. Upon completion of the study the non-identifiable data will be archived on non-networked digital media and stored in a secure laboratory. All identifiable data, including videos, will be destroyed three years after the project ends.

There is one exception to confidentiality we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child abuse, child neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues.

Participation & Withdrawal

Your infant's participation is entirely voluntary. You may withdraw your infant from the study at any time. Should you choose to participate, you can withdraw at any time without consequences of any kind.

Questions about the Study

If you have questions or concerns during the time of your infant's participation in this study, or after its completion or you would like to receive a copy of the final aggregate results of this study, please contact:

Dr. Rory DePaolis

Communication Sciences and Disorders

James Madison University

depaolra@jmu.edu

(540) 568-3869

Amy Vinyard

Communication Sciences and Disorders Graduate Student

James Madison University

vinyaram@dukes.jmu.edu

Questions about Your Rights as a Research Subject

Dr. David Cockley

Chair, Institutional Review Board

James Madison University

(540) 568-2834

cocklede@jmu.edu

Giving of Consent

I have read this consent form and I understand what is being requested of my infant as a participant in this study. I freely consent for my infant to participate. I have been given satisfactory answers to my questions. The investigator provided me with a copy of this form. I certify that I am at least 18 years of age.

I give consent for my infant and myself to be videotaped during my participation. (*yes/no*) (parent's initial) __________

I give consent for use of my infant's video in classrooms and conferences. (*yes/no*) (parent's initial) _________

This is not necessary to participate in the study.

____

Name of Child (Printed)

____

Name of Parent/Guardian (Printed)

____________________________________ ______________

Name of Parent/Guardian (Signed) Date

____________________________________ ______________

Name of Researcher (Signed) Date