This is provided as an example proposal.
It is important that you follow the current guidelines.

The mentor letter has been removed.
TITLE OF PROJECT: Examining Pupillometric Measures of Cognitive Effort Associated with Speaker Variability During Spoken Word Recognition

NAME OF APPLICANT: Lillian Douds
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DEPARTMENT: Communication Sciences and Disorders

BUDGET: Total Request

CLASS RANK: (circle one) Freshman Sophomore Junior Senior
GPA: 3.95
EXPECTED DATE OF GRADUATION: April 29, 2016 *

* Note: Students must be enrolled and maintain undergraduate student status during the proposed project period.

FACULTY MENTOR INFORMATION:
NAME: Dr. Brooke Hallowell
E-MAIL ADDRESS: hallowel@ohio.edu
CAMPUS ADDRESS: W237 Grover Center
DEPARTMENT: Communication Sciences and Disorders
DEPARTMENT ADMIN/EMAIL: thyson-dr@ohio.edu

We the undersigned have read the PURF Guidelines and understand the responsibilities we undertake should funding be granted. We certify that the application has been conceived, written and completed by the student.

Student signature: ___________________________ Date: 9/19/2016
Faculty signature: ___________________________ Date: 9/19/2016
Faculty Advisor’s Dept. Chair signature: ___________________________ Date: 9/19/2016

IRB AND IACUC APPROVAL:
To ensure that the University is in compliance with all federal regulations, complete the checklist below. Note: your proposal can be approved prior to IRB or IACUC approval (put “pending” or “to be submitted” instead of approval number), but funding will be withheld until notification of approval or exemption.

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Office of Research Compliance</th>
<th>Policy #</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td>Human Subjects in Research (including surveys, interviews, educational interventions): 60 Institutional Review Board (IRB) Approval #: pending Expiration Date: N/A</td>
<td>19.052</td>
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<tr>
<td>X</td>
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<td>Animal Species: Institutional Animal Care &amp; Use Committee (IACUC) Approval #: Expiration Date:</td>
<td>19.049</td>
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☒ Optional:
If selected for funding, I give permission to the Research Division to use my proposal as an example during training and workshop exercises. (Sign below)
Signature: ___________________________ Date: 9/20/2016
ABSTRACT

Speaker variability, changes in which speaker is talking, is an important aspect of everyday speech processing. Humans have the remarkable ability to process speech regardless of who is speaking, as long as the speech is clear and its phonetic properties are consistent with the listener’s experience with the language spoken. There is no research to date examining the role of cognitive effort (the degree of mental energy required) associated with speaker variability during spoken word recognition. This study is designed to examine the influence of speaker variability on cognitive effort, as indexed via pupillometry (measurement of pupil size).
Project Description:

The aim of this research is to examine pupillometric indices of changes in cognitive effort associated with controlled speaker variability conditions during spoken word recognition. Speaker variability refers to differences in individuals’ voices and is defined as “acoustical variability generated as a consequence of the speaker’s idiosyncratic features” (Lee & Zhang, 2015, p. 238). Results from the substantial literature on the effects of speaker variability on spoken word recognition have been inconsistent. Some researchers concluded that speaker variability does not impact spoken word recognition (Kittredge, Davis, & Blumstein, 2006; Schacter & Church, 1992), while others, such as Lee and Zhang (2015), conclude that speaker variability does impact spoken word recognition.

Lee and Zhang (2015) explored the effect of speaker variability on spoken word recognition using short-term priming. Short-term priming is when there is a short delay (a fraction of a second) between a prime (e.g., an initial spoken word) and a target (e.g., a word spoken after the prime). Through the use of repetition priming, which entails the processing of a target word when preceded by the same word, researchers found that speaker variability effects were more evident in processing word form (phonological information) than word meaning (semantic information). Lee and Zhang’s results were similar to those reported in previous studies (Goldinger, 1996; Luce & Lyons, 1998). They found greater priming facilitation when primes and targets are spoken by the same speaker compared to conditions in which the prime and target are spoken by different speakers. It may be that the priming facilitation associated with same-speaker conditions is related to a decrease in cognitive effort (the degree of mental
energy required) to process prime-target pairs spoken by the same speaker as compared to different speakers.

Pupillometry (measurement of pupil size) has been shown to be valid for quantifying cognitive effort through task-evoked responses of the pupil (TERPs; Chapman & Hallowell, 2015; Hess & Polt, 1964). According to Just and Carpenter (1993), cognitive effort refers to the mental work associated with completing a task. TERPs reflect subtle changes of dilation and constriction during a task. In general, as task difficulty increases, so does cognitive effort. This change in effort is characterized by increased pupil dilation.

Many authors of studies using pupillometry have not provided sufficient detail regarding the dependent measures they are use. Most fail to justify their selection of dependent measures. Thus, there is a need to study not only the construct of effort associated with speaker variability, but also the indices and analytic methods that best characterize the construct of effort. There are three types of measures of TERPs: mean pupil dilation, peak dilation, and latency to peak dilation. Mean pupil dilation is “obtained by averaging the relevant number of data points in the measurement interval and subtracting the mean diameter obtained in the baseline period” (Beatty & Lucero-Wagoner, 2000, p. 148). Peak dilation is “the maximal dilation obtained in the measurement interval of interest” (p. 148). Latency to peak dilation “reflects the amount of time elapsed between start of the measurement interval and emergence of the peak dilation” (p. 148). The purpose of this research is to analyze the data using all three types of dependent measures, examine the relationships among them, and quantify the degree to which each may capture expected differences in cognitive effort associated with processing speaker variability during spoken word recognition.
Methods:

Hypotheses: There will be greater cognitive effort, indexed via TERPs, when speakers differ than when they are the same. There will be a correlation between TERPs and behavioral measures. There will be a relationship between the three types of TERPs.

Participants: Sixty young adults (age 18-26), all native speakers of American English without any history of cognitive, speech, language, or hearing impairments, and who have normal eye movements and pupillary reaction to light, will participate.

Materials: Instrumentation includes an audiometer for a hearing screening, headphones for auditory stimuli presentation, and the Eyefollower 2.0 Eyegaze System (LC Technologies) to record pupillary changes.

The verbal stimuli used in the current study will be the same as those from Lee and Zhang (2015). These consist of 26 English words that serve as real-word targets, each of which is paired with four types of real-word primes: (a) a repetition prime produced by the same speaker, (b) a repetition prime produced by a different speaker of the same gender, (c) an unrelated prime produced by the same speaker, and (d) an unrelated prime produced by a different speaker of the same gender. The stimuli also include 26 pronounceable non-word targets. Each non-word target was paired with the same set of primes as the real-word targets. Two different male speakers of American English from the same town in central Ohio recorded the stimuli, serving as the two different types of voices heard by participants. There will be four stimulus lists based on target speaker (male 1 and male 2). Each participant will be randomly assigned one of the stimulus lists to lessen the chance of participants hearing target words or non-words twice. An inter-stimulus interval (ISI) of 250ms will be used, based on Lee and Zhang’s (2015) design.
**Procedure:** Baseline pupil diameter will be recorded prior to every experimental trial to compare the increase in pupil diameters between each trial. A blank screen will be displayed for three seconds; the last 500 milliseconds of the pupil diameter data will be used as a baseline measure. Participants will sit comfortably in front of a computer screen. An asterisk will be presented in the center of the screen during experimental trials. Each trial consists of a prime and target word presented via headphones. Participants will be asked to listen to the words and pay attention to the meaning of each word while looking at the screen.

**Data Analysis:** During the trials, pupil size will be recorded at a rate of 120 Hz. Three measures will be used to analyze pupil data: mean pupil dilation, peak dilation, and latency to peak dilation. Analysis of variance (ANOVAs) will be conducted on word relation (repetition or no repetition) and speaker relation (same or different) as within-participant factors, and target speaker (male 1 or male 2) as a between-participant factor. Non-parametric correlation coefficients will be calculated to determine the degree of relationship among the three TERPs, as well as among TERPs and the behavioral measures (speed and accuracy of priming responses).

**Timeline:**

- October 2016-December 2016: Initiate data collection.
- January 2017-February 2017: Complete data collection; complete data analysis.
- February 2017-March 2017: Prepare materials and present results at Ohio University Student Research and Creative Activity Expo.
March 2017-April 2017: Prepare manuscript for publication and for presentation at a professional conference.

Estimated Hours: 200

Student’s Role:

The plan for this research arose from collaborative efforts among members of the Neurolinguistics Laboratory, led by Dr. Hallowell. I assisted in literature reviews of speaker variability and pupillometry research. I will be the lead investigator studying the three pupillometric measures described in this proposal. My role in this study, and in the larger overall study, will be to aid the graduate students and Dr. Hallowell in preparing stimuli, recruiting participants, and running experiments. I will analyze the three TERPs to investigate the relationship among them and the degree to which each reflects differences in cognitive effort. I will co-author material for publication and dissemination at expos and/or conferences.

Significance:

The significance of this research is to examine cognitive effort associated with speaker variability in order to enhance knowledge about linguistic processing, which is important across several disciplines. Considering cognitive effort in linguistic processing is important in all populations, because assessing cognitive exertion in addition to behavioral measures, such as speed and accuracy, will yield more comprehensive understanding of language and communication abilities. Results from this research will inform future research applied to populations with cognitive-linguistic impairments, to better understand the nature of their linguistic processing challenges.
BIBLIOGRAPHY


BIOGRAPHICAL INFORMATION

The idea of this study was developed by Dr. Hallowell and other members of the Ohio University Neurolinguistics Laboratory. I assisted in an extensive literature review in pupillometry and speaker variability. The next step in researching speaker variability became apparent from noting the existence of equivocal results. In reviewing pupillometric research, we noticed that the rationale for specific measures used in data analysis is often not clearly stated. I hope to improve upon this by clearly delineating specific measures for analysis and considering how means of calculating each may influence results. I have taken speech science and introduction to research courses to prepare for this research. I have discussed cognition and pupillary responses in classes on physiological psychology, and anatomy and physiology of speech, language, and hearing. I also have experience working with other members of the Neurolinguistics Laboratory, such as being an experimental facilitator for a different project of a PhD student and co-authoring a presentation for the American Speech-Language-Hearing Association (ASHA) convention. From these experiences, I understand what is necessary to complete this project. I will continue to work with my mentor, Dr. Hallowell, and learn how to complete the proper data and statistical analysis for pupillometric measurements.
# BUDGET

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<th>Item</th>
<th>Amount</th>
<th>Source</th>
<th>Justification</th>
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<tr>
<td>Participant reimbursement</td>
<td>$10 x 60 participants = $600.00</td>
<td>PURF</td>
<td>Reimbursement is provided to participants in recognition of their important contributions to the research.</td>
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<td>Pupillometry analysis software package</td>
<td>$600</td>
<td>PURF</td>
<td>A new software package is required to complete the analysis of the types of measures I propose to analyze.</td>
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<td>External hard drive for secure data back-up</td>
<td>$60.00</td>
<td>PURF</td>
<td>A hard drive is required to back up and store IRB-protected data.</td>
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<td>Printing costs</td>
<td>$90</td>
<td>PURF</td>
<td>Flyers and other materials will be printed to recruit participants; a research poster will be printed to disseminate results.</td>
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<td>Pupillometric equipment, experimental deliver software, and all other materials</td>
<td>Neurolinguistics Laboratory</td>
<td>All other materials, software, and equipment required for the project are in place, previously funded through grants to Dr. Hallowell</td>
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<td><strong>Total</strong></td>
<td><strong>$1350</strong></td>
<td><strong>PURF</strong></td>
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**MENTOR’S ENDORSEMENT**

My mentor will email the letter separately from this application.