THE MENDEL SCIENCE EXPERIENCE – COURSE PROPOSAL
(for courses that will be taught without Mendel Post-docs or with Mendel post-docs who are currently employed by Villanova)

1. Course Title:

The Sounds of Human Language

2. Instructor(s):

Dr. Joe Toscano (Psychology)

3. Preferred class meeting schedule for lecture (3 meetings per week for 50 minutes vs. 2 meetings per week for 75 minutes):

2 meetings per week for 75 minutes

4. Preferred lab meeting schedule:

12 meetings during the semester for 2 hours 40 minutes each.

5. Course Description for NOVASIS (100 word maximum):

This course will explore the sounds used in spoken language and investigate how humans use speech to communicate. Students will learn basic principles of acoustics, the mechanics of hearing and auditory perception, mechanisms of human speech recognition and speech production, the anatomy and physiology of the articulatory system, and the brain mechanisms that support language processing. Laboratory meetings will provide students with first-hand experience using techniques involved in the acoustic analysis of speech, speech synthesis, and techniques used to study human speech perception.

6. Course Description for College website of Core Curriculum courses (250 word maximum):

This course explores questions about the sounds used in spoken language and provides an introduction to phonetics and speech science, the study of how humans communicate using spoken language. Language comprehension is a complex behavior, and the use of language to communicate distinguishes humans from other animals. A wide range of speech sounds are used across different languages, ranging from the familiar consonants and vowels used in English, to differences in pitch used by tone languages like Chinese, to click consonants used in languages like Xhosa. This course will explore the scientific study of the sounds used in human speech, including how they are produced, learned, and perceived. This includes questions about the origin of human language, language acquisition, and the neural basis of language processing. Students will gain first-hand experience with the techniques used by scientists to study human speech through laboratory exercises designed to illustrate principles of acoustic analysis (Fourier

analysis, measurement of acoustic cues), speech synthesis (source-filter models, cascade synthesizers), and methods used to study human speech perception (psychophysical experiments examining speech sound discrimination and recognition).

7. Although MSE courses are intended to be topically diverse, they all share a common approach, incorporating each of four critical components listed below. Since these four elements embody the spirit of an MSE course, the Subcommittee on the Core Science Requirement considers this section of the course proposal of utmost importance. Keeping this in mind, **please articulate fully and explicitly how you will incorporate, in a meaningful way, each of the following:**

a. Problem Solving

Studying spoken language is challenging, both because the systems under investigation are complex, and because speech is highly variable across different talkers. Students will learn how these issues are addressed in practice, by applying concepts used to study behavior in a controlled and empirically rigorous way. Issues related to experimental design, random assignment of subjects to conditions, and careful hypothesis testing will be discussed. For example, students will learn how experiments should be designed to avoid potential confounds and to ensure that the models we are using are well defined. In addition, there will be several readings that involve original research articles, which will be discussed in detail in lecture. Students will be encouraged to think carefully about the findings and implications of these studies. This will allow them to improve their critical thinking skills, and it will help them to become better "consumers" of scientific information, an important skill even if they pursue careers outside of STEM fields.

b. Laboratory/Field Experience

The methods used to study speech production and perception are very broad. Laboratory sections will focus on three general approaches: (1) acoustic analysis, (2) speech synthesis and manipulation of natural speech sounds, and (3) experimental approaches used to study speech perception. Within each of these areas, laboratory sections will be focused on the tools used by researchers to study the acoustic characteristics of speech (in order to describe a particular sound system used in a language), speech synthesis (in order to use what we learned from acoustic analyses to create stimuli for experiments), and speech perception experiments (using the stimuli to test listeners' ability to recognize different speech sounds). This structure introduces students to the techniques used within each of these areas, and it allows them to build on what they learn as we progress through the semester. In addition, students will complete a project in which they measure the sound system of a native speaker of a different language (providing them with exposure to fieldwork methods used in phonetics) or investigate a question about speech recognition in a perceptual experiment (further applying the skills they learned in the lab sections).

c. Use of Technology and Quantitative Tools

The use of computers and quantitative analyses are central to the study of human speech recognition. As such, technology will be incorporated throughout the course, particularly in the lab sections. Laboratory sections will be held in a computer lab, where students will use the same software used by researchers to analyze speech sounds, generate stimuli for experiments, and carry out experiments examining speech perception. In addition, students will learn how to describe the data collected in lab exercises (e.g., by computing the mean and standard deviation of their datasets) and use simple statistical tests (e.g., t-tests) to analyze data from experiments. In all of the lab exercises, the importance of careful measurements and accurate data recording will be emphasized.

d. Interdisciplinary Understanding (Please refer to the rationale for our definition of "Interdisciplinary")

Work in speech science makes a number of connections to the social sciences and to the study of human behavior more broadly. Lectures will discuss questions about the nature of human language, bilingualism and second language learning, and the way that language shapes human thought and behavior. Students will examine how the basic mechanisms that give rise to the acoustic patterns we see in speech might influence the way humans use language more generally in the context of communication and literature. A guest lecture from a faculty member in Romance Languages and Literatures, or another relevant department, would be incorporated in order to provide students with exposure to the study of language from a humanities or social science perspective.

8. Provide an overview of how student performance will be assessed (exams, lab reports, written and/or oral assignments).

Performance will be addressed by means of exams, lab reports, and a final project (which consists of a written paper and a class presentation).

9. Attach a proposed syllabus limited to five pages, which must include a general overview of the progression of the topics to be explored and a tentative topic for each laboratory session. Note that laboratory components of MSE courses are expected to include about 12 lab periods per semester.

Attached.

MSE XXXX — The Sounds of Human Language

General information

Instructor: Dr. Joe Toscano
Office: Tolentine 344
Office hours: Mon. 1-3pm, Wed. 4:30-5:30pm, or by appointment
Phone: (610) 519-4755
Email: joseph.toscano@villanova.edu
Course website on Blackboard: https://elearning.villanova.edu

Course description and objectives

This course explores the sounds used in human language and provides an overview of speech science and phonetics, the study of how humans communicate using spoken language. Language comprehension is one of the most complex human behaviors, and the use of language distinguishes humans from other animals. How does spoken language vary across languages, or across different speakers of the same language? Human speech uses a wide variety of sounds, ranging from the consonants and vowels used in English, to differences in pitch used by tone languages like Chinese, to click consonants used in languages like Xhosa. Understanding the sounds used in spoken language is also of practical significance: it can help us improve computer systems designed to recognize speech, it can help us develop better treatments for language disorders, and it can help us improve assistive devices like hearing aids and cochlear implants.

Throughout the course, we will explore basic concepts used in the scientific study of human speech, including how speech sounds are produced, learned, and perceived. We will examine questions about the origin of human language, language acquisition, and the neural basis of language processing. You will gain first-hand experience with the techniques used by scientists to study speech through laboratory exercises designed to illustrate principles of acoustic analysis, speech synthesis, and methods used to study human speech perception. This provides both an introduction to basic concepts in the natural sciences (such as experimental design and hypothesis testing), as well as experience with the specific tools used by scientists who study hearing, speech perception, and language comprehension. We will also examine how this work intersects with research on language in the humanities and social sciences, and how our understanding of the sounds used in human language influences the way we think about and use language in general.

Course materials

Required textbook: Ladefoged, P., & Johnson, K. (2014). *A Course in Phonetics*. Cengage Learning. *Note: there are many editions of this book (the current one is the 7th).* ***Any edition*** *is acceptable for this course.*

Prerequisites

Must be enrolled in Arts. Must *not* be enrolled in Continuing Studies.

Course requirements

Grades will be based on the percentage of points on lab reports, written assignments, and a term project using the following distribution (grades will ***not*** be determined on the basis of a curve):

A … 187-200 pts (>93%)
A- … 179-184 pts (90-92%)
B+ … 172-178 pts (87-89%)
B … 165-171 pts (83-86%)
B- … 159-164 pts (80-82%)
C+ … 153-158 pts (77-79%)
C … 147-152 pts (73-76%)
C- … 139-144 pts (70-72%)
D+ … 133-138 pts (67-69%)
D … 127-132 pts (63-66%)
D- … 119-124 pts (60-62%)
F … 118 pts or less (<59%)

Course requirements (continued)

Exams (45% total):
- Exam 1: 30 pts (15%)
- Exam 2: 30 pts (15%)
- Final exam (non-cumulative): 30 pts (15%)

Final project (20% total)
- Final project write-up: 30 pts (15%)
- Class presentation: 10 pts (5%)

Lab reports (35% total):
- Lab 1—Acoustic Analysis: 14 pts (7%)
- Lab 2—Speech Synthesis: 14 pts (7%)
- Lab 3—Sound Splicing: 14 pts (7%)
- Lab 4—Psychoacoustics: 14 pts (7%)
- Lab 5—Speech Perception: 14 pts (7%)

Additional details

Readings

Pleas see the course schedule on page 4 for a list of **textbook readings** associated with each topic. The textbook covers the material presented in the first half of the course. In addition, it will serve as a guide for the laboratory exercises. Readings for the second half of the course will be posted on Blackboard.

Exams

Exams are non-cumulative and will consist of multiple choice and short answer questions. The goal of the exams is to evaluate your ability to understand the basic concepts covered in the course and apply the scientific principles you have learned. As such, the exam questions will focus more on broad concepts than on specific facts. Questions will be drawn primarily from the material presented in lecture, as well as from material presented in the textbook and other readings (see last page for the topics covered in each exam and the exam schedule). *Exams will not be administered prior to the scheduled date. Do not miss an exam unless it is absolutely necessary*.

You may request to take a **make-up exam** if you have an *authorized university absence*. The University's official Attendance Policy lists the following excused absences: "approved athletic participation or participation in approved academic events; official university business; approved field trips; certified serious illness; death in the immediate family; or approved placement activities" (http://www1.villanova.edu/villanova/vpaa/studentservices/policies/attendance.html). Please speak to me *in person* if you have an authorized absence that requires you to make-up a scheduled exam.

Lab reports

There will be 12 laboratory meetings during the semester. These meetings are designed to put the concepts we discuss in lecture into practice, and to give you hands-on experience with the tools used by scientists to study speech. There will be a total of five **exercises** and **lab reports** associated with each of them. Details for each exercise will be given in laboratory meetings. The exercises are designed to build on each other, so that the techniques you learn from the first exercise will be useful for the second one, and so on. Ultimately, the skills you learn in the lab will be useful to you when working on your final project.

Final project

You will also complete a **final project** that will combine what have learned in lecture with the skills covered in laboratory meetings throughout the semester. This project is designed to put what you have learned into practice to investigate a question about speech perception, or to investigate how speech sounds are produced in a different language by conducting a field study. The project will consist of a **write-up** and **class presentation**. Additional details about the project will be given in class.

Additional details (continued)

Class participation and attendance

You are expected to attend all lectures and laboratory sections. It is important that you actively participate in class discussions, and you are highly encouraged to ask questions and offer your thoughts on a topic we are discussing. In addition, the majority of the exam material will be based on content covered in lectures. I am happy to make my lecture slides available on Blackboard, but you may not find them sufficient as study guides by themselves. If you must miss class, I will be happy to meet with you to go over any material you would like. Please review Villanova's official Attendance Policy (see URL above under "make-up exams").

Office hours and class communication

My office hours are listed at the top of the syllabus. I am more than happy to meet with you during those times (just stop by), and if they do not work with your schedule, we will find another time that works for both of us. I encourage you to take advantage of office hours to ask any questions you have about the course. If you need help with anything in the course, please let me know; that's why I'm here. The best way to reach me is by email, but note that I may not respond immediately. If you need a response right away, please call me (610-519-4755), or stop by my office (Tolentine 344) or lab (Tolentine 231).

All class communications will occur via Blackboard and/or Villanova email. *Be sure to check your Villanova email for any class-related news.* Lecture slides, handouts, etc., will be posted on Blackboard.

Other Policies

Academic integrity: Students are bound by Villanova's Code of Academic Integrity, available at https://www1.villanova.edu/villanova/vpaa/studentservices/policies/integrity/code.html. It is extremely important that you familiarize yourself with this code. Students must do their own work in the course, unless an assignment specifically calls for group work. Cheating, plagiarism, and other types of dishonest behavior negatively affect our academic community and undermine your own learning goals. Please be sure to familiarize yourself with the Code of Academic Integrity. Note that, according to University policy, I am required to report academic integrity violations to the Department Chair, who will notify the Dean.

Disability policy and Office of Learning Support Services: Reasonable accommodations will be made for individuals with disabilities. Please inform me of any needs as soon as possible. Students seeking accommodations for learning disabilities must first register with Learning Support Services (http://www1.villanova.edu/villanova/learningsupport.html). In addition, note that the Office of Learning Support Services also has resources available for students that do not have a documented disability. Call (610-519-5176) or email (learning.support.services@villanova.edu) for more information.

Snow days and emergency closings: Please check the Villanova website for information about campus-wide class cancellations. If class is cancelled on an exam day, the exam will take place on the *next class day*.

Cell phone use and punctuality: Just like at the movies, please put your cell phones on **silent** during lecture. Please do not talk on the phone or text during class. It disrupts other students, as well as your ability to attend to the lecture and discussion. Of course, if you must take an emergency phone call, please exit the classroom and talk in the corridor. Please avoid being late to class and do not pack up early; this is very disruptive to everyone else. I will endeavor to finish class on time, so there is no need to pack up before the end of class.

Modifications to syllabus: If any information in the syllabus changes during the course of the semester, the latest version will be available on Blackboard.

Schedule

Note: Specific dates will be adjusted depending on class and lab meeting times for the fall semester.

Week	Dates	Lecture Topic	Reading*	Lab Exercise
1	8/24-8/28	Introduction to Phonetics and Speech Science	Chapter 1	Lab 1: Acoustic Analysis
2	8/31-9/4	Phonology; Sound Systems Used in Language; Origin of Human Language	Chapter 2-4	
3	9/7-9/11			Lab 2: Speech synthesis
4	9/14-9/18	Articulatory Phonetics; Anatomy and Physiology of the Speech Motor System; **Exam 1—week of 9/25 (topics covered in Weeks 1-5)**	Chapter 6-7	
5	9/21-9/25			Lab 3: Splicing sounds
6	9/28-10/2	Principles of Acoustics; Acoustic Analysis of Speech	Chapter 8	
7	10/5-10/9			Lab 4: Psychoacoustics
8	10/12-10/16	No class—Fall break		
9	10/19-10/23	Hearing; Anatomy and Physiology of the Auditory System; Psychoacoustics; **Exam 2—week of 10/26 (topics covered in Weeks 6-10)**	*see Blackboard	Lab 4 (continued)
10	10/26-10/30			Lab 5: Speech Perception
11	11/2-11/6	Speech Perception; Neural Mechanisms of Speech Processing	*see Blackboard	
12	11/9-11/13			Student Research Projects
13	11/16-11/20	Speech Development	*see Blackboard	
14	11/23-11/27	Guest Lecture: Language Research in the Humanities and Social Sciences		Thanksgiving—Partial week
15	11/30-12/4	Language Disorders	*see Blackboard	Student Research Projects (continued)
16	12/7-12/11	Class presentations	N/A	
17	12/14-12/18	**Final Exam—date/time TBA (topics covered in Weeks 11-15)**	N/A	

* The textbook covers the material presented in the first half of the course and serves as a guidebook for laboratory meetings. Additional readings will be posted on Blackboard for the second half of the semester.

Toscano Example MSE Lab — *Categorical Perception*

Note: Prior to this lab, students will have covered many of the basic concepts involved in the lecture. This would also be an exercise done later in the semester after the students are familiar with the computer programs used to create the stimuli.

The lab is designed to illustrate principles of hypothesis testing, experimental design, data analysis and problem solving. The expected outcome is that students will be able to clearly demonstrate their understanding of these ideas and present the results of the experiment.

This lab is designed to replicate a classic experiment in speech perception by Liberman, Harris, Hoffman, & Griffiths (1957). Liberman et al. were interested in whether the auditory system is sensitive to acoustic differences in speech for stimuli that belong to the same phoneme category. For example, as we discussed in lecture, *voice onset-time* (VOT) is an acoustic cue that signals the phonological feature *voicing* in many spoken languages.

In English, VOT is one cue that distinguishes the phonemes /b/ and /p/ at the onset of words. In a previous lab exercise, you created VOT continua from recordings of natural speech using the cross-splicing technique (you will use those sounds as stimuli in the current experiment). Recall that sounds with a VOT near 0 ms are perceived as /b/ and sounds with a VOT near 50 ms are perceived as /p/. This is called a **between-category difference**.

These correspond to the VOT values that a talker would typically produce. However, because VOT is a *continuous* acoustic cue, it can take on any value between 0 and 50 ms (and beyond). This means that we can have two sounds (e.g., one with a VOT of 0 ms, and one with a VOT of 5 ms) that both signal the same phoneme (/b/). These are called **within-category differences**.

Can the auditory system distinguish within-category differences even though they do not provide a meaningful distinction in the language (that is, they are both instances of the same phoneme)? This is the question Liberman et al. sought to answer. If listeners cannot distinguish within-category differences, this is called **categorical perception**, since it suggests that perception is based on phoneme categories instead of acoustic cues.

Here is how they investigated whether speech is perceived categorically: they created sounds varying in equal-spaced steps along an acoustic cue continuum (like the VOT continuum you created) and they had listeners perform two tasks. The first task, called an **identification task**, asks listeners to label which sound the stimulus is heard as (e.g., a “b” or a “p”). The second task, called a **discrimination task**, asks listeners to discriminate pairs of sounds.

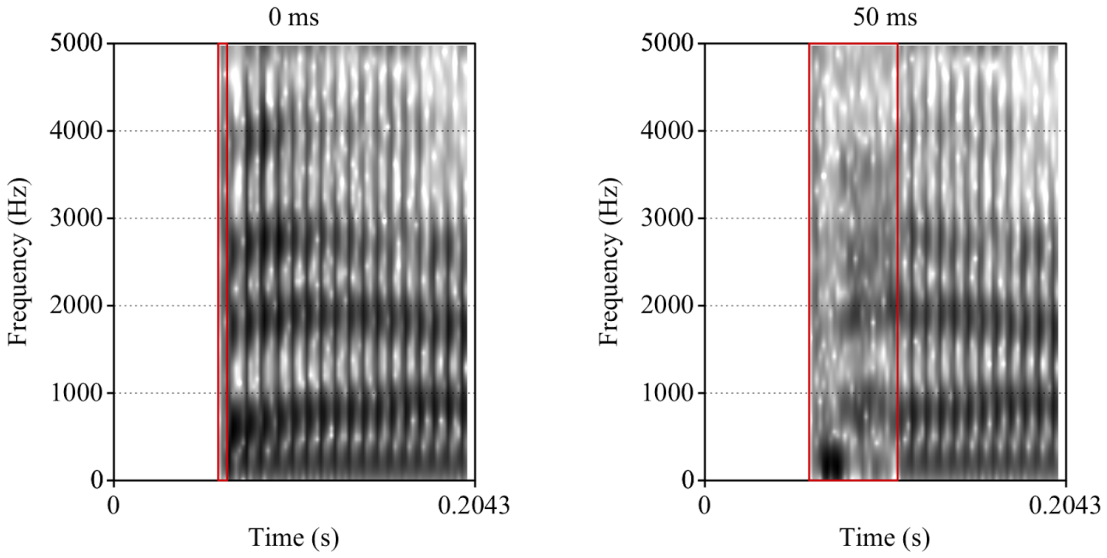
For this lab, you will recreate the ABX discrimination task used by Liberman et al. to test the hypothesis that speech is perceived categorically. In your lab report, be sure to clearly articulate your hypotheses for the experiment, the steps you did to carry out the experiment, and whether the data support your hypothesis. Details of the steps to follow for this lab are presented on the following pages.

I. Hypotheses

If the auditory system is not sensitive to *within-category differences* (that is, if speech perception is categorical), what do you predict will happen in the ABX task? Will listeners be more, less, or equally accurate at discriminating within- and between-category differences in VOT? What do you predict will happen if the auditory system *is* sensitive to these differences (that is, if speech perception is *not* categorical)?

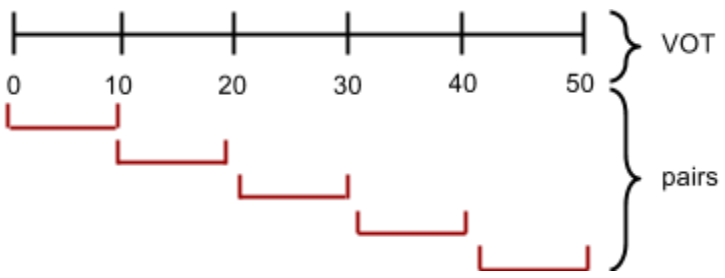
II. Stimuli

The stimuli for this experiment are the VOT continua you created in the previous lab. Select stimuli with VOTs varying in 10-ms steps from 0 ms (an unambiguous /b/ sound) to 50 ms (an unambiguous /p/). Here are sample spectrograms of the endpoint (0 and 50 ms) stimuli:



III. Design

For the ABX task, each stimulus will be a sequence of three sounds: a sound with one VOT (A), a sound with a different VOT (B), and a sound that matches either A or B (X). The participant's task is to indicate whether the third sound (X) matches the first (A) or second (B).



The stimuli vary from 0 to 50 ms VOT in 10-ms steps, so there are 6 unique sounds (0 ms, 10 ms, 20 ms, 30 ms, 40 ms, 50 ms) that will be compared in 5 one-step pairs (0 and 10 ms, 10

and 20 ms, 20 and 30 ms, 30 and 40 ms, 40 and 50 ms). With this design, the acoustic distance between each stimulus pair (i.e., the VOT difference) is held constant. We will combine these sounds such that X matches either A or B (2 conditions), and either A or B is the shorter VOT (2 conditions). This produces a total of 20 conditions in the experiment.

As an example, lets look at the 0-10 pair. There are four conditions for this pair: X either matches A or B (2 conditions) and A or B is the shorter VOT (2 conditions).

#1	#2	#3	#4
A=0 B=10 X=0	A=10 B=0 X=0	A=0 B=10 X=10	A=10 B=0 X=10

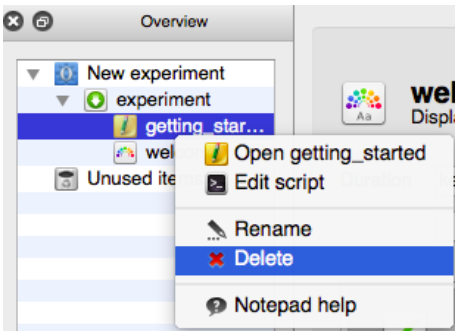
Create the 20 different ABX stimuli that will be used in the experiment using Praat.

IV. Experiment Procedure

To present the stimuli and collect our data, we will use an experiment presentation package called OpenSesame. The procedure below describes how to create the ABX task.

1. Run OpenSesame, and select *Default Experiment*. Use this as a template for your experiment. You will see that the interface is comprised of four main panels:
    a. **Main toolbar**, which contains icons that allow you to perform certain functions.
    b. **Item toolbar**, which contains the building blocks of your experiment.
    c. **Overview window**, which contains an outline of the structure of your experiment.
    d. **Tab window**, where you do the main work and editing of your experiment.

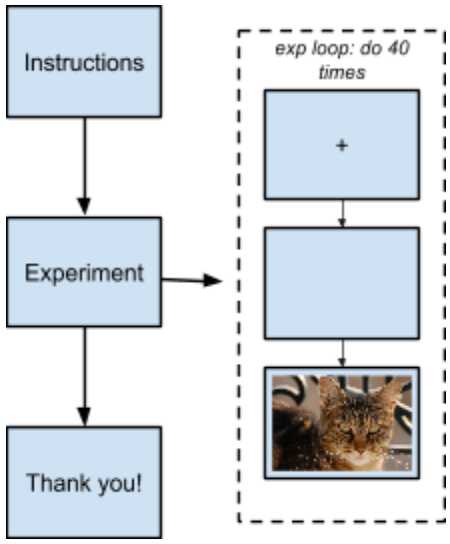
2. Run the demo experiment by clicking  in the Main toolbar. Enter “0” for the subject number and click “OK.” When it asks where you want to save your logfile, click “Cancel.”
    a. OpenSesame will display a message with the version number of the program.
    b. You will want to remove this default message for your experiment. Do this by right-clicking the objects in “experiment” in the Overview window and selecting “Delete”:



3. Click on the *New experiment* object in the Overview window. In the tab window, select the text that reads “New experiment” to give your experiment a meaningful name. You can also use this window to change the general settings of your experiment. Under Colors,

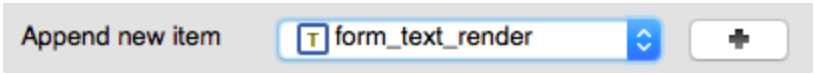
change the Foreground to “black” and background to “#808080.” Now click **File > Save as…** and save the experiment.

4. Before you begin to create your experiment, it’s useful to draw out what its structure will look like. For example, if we were to design an experiment that displayed a picture of a cat and asked participants to decide if it was male or female, repeating this process 40 times, the structure might look like this:

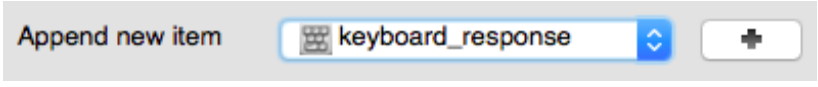


What should the structure of this experiment look like? Draw it in your lab report.

5. Use the Overview window to recreate the global structure you just drew. All of the objects will be under the “experiment” object in the Overview window. To add each object, click on “experiment” and follow the instructions below:
    a. Add the **instructions**:
        i. Experiment > Append new item > form_text_render > **+**
        This causes text to be displayed on the screen:

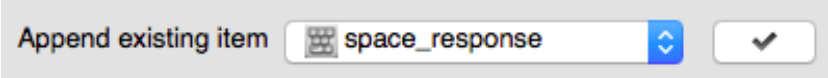


        ii. When it prompts for a name, type “instructions.”
        iii. You will now see this under “experiment” in the Overview window.
    b. Add a **keyboard response** that waits for the participant to read the instructions:
        i. Experiment > Append new item > keyboard_response > **+**
        This causes the experiment to proceed when a key is pressed:

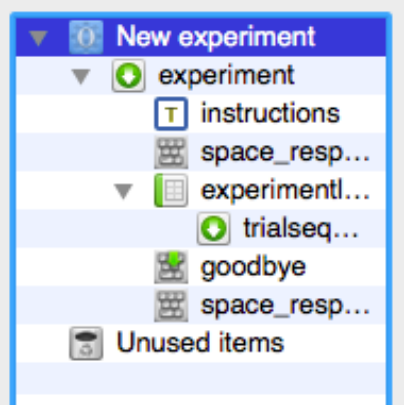


        ii. When it prompts for a name, type “space_response.”
        iii. This will now appear under “experiment” in the Overview window.
    c. Add an **experiment sequence**:
        i. Experiment > Append new item > loop > **+**
        ii. It will prompt you to also create a sequence. Click “Create”.
        iii. Name the loop “experimentloop.” Name the sequence “trialsequence.”

d. Add an **ending message**:
    i. Follow the same steps as with the instructions slide, adding a "form_text_render" object. This time, name it "ending_message."
e. Add a new **keyboard response**:
    i. Under the experiment tab, instead of selecting "Append new item" click "Append existing item" and then select the checkmark. This feature allows you to reuse an existing object, including all the settings you already selected. When you do this, it will change all other occurrences of the item. Since we want to reuse the same key response to end the experiment as we did to move to the next slide, this is a useful tool.

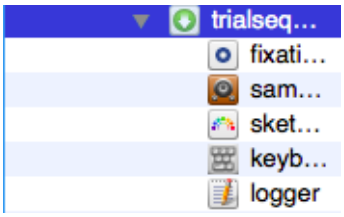


6. The structure of your experiment is now ready. The Overview window should look like this:

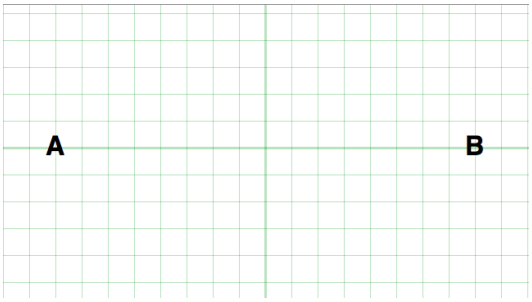


7. Next, adjust the settings of each of object so the experiment displays what you need:
    a. Click on the **instructions** object. In "Main form text," delete "Your message" and type the instructions for the experiment. You'll want to tell the participants what they'll see and what they should press to make a response.
    b. Click on the **space_response** object. We want the program to know to wait for the participant to press the spacebar before it moves to the next screen. In "Allowed Responses," type "SPACE." If you click on the second **space_response** object, you'll notice it will also have changed. (*Note:* you can try to run your experiment at any point. If you try to run now, you'll see that it will display the instructions and then wait for you to press the spacebar to continue.)
    c. Click on the **trialsequence** object. This is where you'll create the structure of the experiment sequence. The following sequence of things should happen: (1) a fixation cross appears, (2) a sound plays, (3) response options appear, (4) subject makes a response, and (5) the response is saved to a data file. To do this, add the following objects to the **trialsequence** object:
        i. **fixation_dot**: this displays a fixation dot/cross
        ii. **sampler**: this will play the sound
        iii. **sketchpad**: this will display the key press options
        iv. **keyboard_response**: this collects a participant's response
        v. **logger**: this saves the response to a file

d. Your **trialsequence** should now look like this in the Overview window:



e. Now, we need to set the properties for the items in the **trialsequence**:
   i. **fixation_dot**:
      1. Change the style to “cross.”
      2. Change the duration to “500” (the units are milliseconds).
   ii. **sampler**: This object is used to present the stimuli. It also opens the file library on the right side, which will allow you to tell OpenSesame where your stimulus files are:
      1. To add your sound files to the experiment, click “Browse,” then **+**.
      2. Add the files files you created in Praat.
      3. Leave the first file selected, and click “Select.” You should see the filename appear next to “Sound file” in the Sampler tab.
   iii. **sketchpad**: This displays text on the screen.
      1. Create a screen that shows the participant which options they can select. For this experiment, their task is to respond with whether sound X is the same as sound A or sound B. **A** will correspond to the “**z**” key and **B** will correspond to the “*/*” key. So, put **A** to be on the left side of the screen and **B** to on the right side:
         a. Click the “Ab” button
         b. Change the font size to 32 pt and Bold.
         c. Click on the left side of the screen and type “A.”
         d. Do the same for “B” on the right side.
         e. Your sketchpad should now look like this:

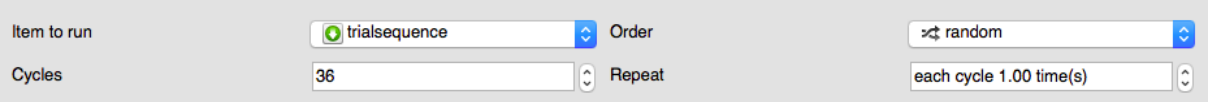


         f. *Note: if you make a mistake and want to delete one of the things you typed, you can scroll to the bottom of the screen and click the red “X” next to the code.
      2. The default duration for the sketchpad object is “*keypress*,” but this won’t actually collect a responses from the participant, so we want a **keyboard_response** to actually wait for the keypress. Change the Duration on the **sketchpad** to 0 ms, which will make it wait for a keyboard response object.

iv. **keyboard_response:**
    1. We want the program to only collect responses if the participant presses "**z**" or "*/*", so under *Allowed Responses*, enter "**z;/**"

v. **logger:**
    1. Leave everything checked. This sends the collected data to a file.

8. Now we need to set up our trials. This can be done inside the loop object, which was created earlier and named "experimentloop."
    a. There are four main settings here.



i. *Item to run*: This automatically selects "trialsequence" which means it will run that sequence.
ii. *Cycles*: Here, enter the number of stimuli you have. For example, if there are 36 sounds you want to play, you'll enter "36".
iii. *Order*: Leave this at the default, "random," so that the program presents the stimuli in a random order.
iv. *Repeat*: This is automatically set to 1, which means you'll hear each of the stimuli only 1 time. If you want each to present each one 2 times, you can change this to 2, and so forth.

    b. Now select "Add variable," and name it "fname" (for file name).
        i. Now, you need to populate the list with the filenames of your sound files. Type in the name of each sound file. This experiment will randomly select one of these files to present on each trial Once you've done that, you will have a list that will look something like this:

	fname
1	bath01.wav
2	bath03.wav
3	bath05.wav
4	bath07.wav
5	bath09.wav
6	bath11.wav
7	beach01.wav
8	beach03.wav
9	beach05.wav
10	beach07.wav

9. Your experiment is now ready to run! Collect your data by having you and your lab partner run through the experiment.

V. Data analysis

We want to determine whether participants are better than chance at discriminating each pair of stimuli, and whether this varies for the *between-category* and *within-category* stimulus pairs. To do this, we'll use a statistical technique called a t-test. In particular, we want to see whether the mean proportion of correct responses (e.g., an "A" response if X matches A) for each pair is significantly different from chance (50% correct).

Carry out the t-test using the Excel file prepared for this lab assignment. Load the data you collected and check whether listeners can discriminate the within-category pairs (e.g., 0-10 ms VOT) and between-category pairs (20-30 ms VOT) better than chance.

VI. Conclusions

Based on the results, what can you conclude from this experiment? Do the data support the hypothesis that speech perception is categorical, that is, that listeners' cannot detect within-category acoustic differences? What do these data this tell us about the mechanisms that underlie speech perception?

Categorical perception has been studied extensively in the field of speech perception in the decades following Liberman et al. (1957)'s original study. Many scientists have rejected the idea that speech is perceived categorically, while others have concluded that the auditory system uses phoneme categories rather than continuous acoustic cues.

What might account for these differences? Do you think the experiment may have measured something in addition to the listener's perception of the stimulus (e.g., effects of memory)? Does this task measure early stages of speech perception (e.g., how the brain initially represents the speech sounds)? Be sure to discuss other possible explanations and ways the experiment might be improved in your lab report.

VII. References

Liberman AM, Harris KS, Hoffman HS, Griffith BC (1957). The discrimination of speech sounds within and across phoneme boundaries. *Journal of Experimental Psychology, 54*, 358-368.