IPRO 343

Improving Communication Quality

of the Drive-thru Experience

Instructors:

Matthew Bauer (HUM) in consultation with Kathryn Riley (HUM) and Thomas Wong (ECE)

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1. Abstract

IPRO 343 addressed the problem of low quality communication in the drive-thru environment of the quick-service restaurant (QSR) industry. The IPRO team initially investigated four aspects of communication that had relevance in the drive-thru setting: intercultural issues related to comprehensibility of native and non-native speakers, cognition issues related to the presence or absence of multiple modalities (that is, how language perception is affected by the presence or absence of certain cues or by conflicting cues), human technology interaction issues related to customer interfaces used for ordering, and acoustics related to inbound and outbound speech signals. The focus of IPRO 343 was subsequently narrowed to acoustics, and culture/cognition issues, following a meeting with industry executives. After some preliminary research, the team hypothesized that masking background chatter with white noise (broadband noise between 100Hz and 10,000Hz, in essence, TV static) might contribute to order accuracy, perhaps as effectively as more expensive alternatives such as higher-quality microphones, headsets, and other hardware options. In order to test this hypothesis, IPRO 343 team members conducted an experiment in which multiple streams of background noise were masked with white noise. The results showed that the addition of white noise to babble improves intelligibility, as indicated by order accuracy for both native and non-native speakers of English who participated in the experiment. It is therefore recommended that some form of white noise generation be adopted by the QSR industry to address the problem of low quality communication in the drive-thru setting.

The findings of IPRO 343 have wider applications for use in noisy and distracting environments other than the drive-thru environment of QSRs, including use in mass-transit kiosks serving patrons with limited sight, public address systems, and automated teller machines.

2. Background

a. Problem addressed in the IPRO

In the quick-service restaurant (QSR) industry, a 2007 QSR Consumer Drive-Thru Preference Survey found that “speaker communication” was ranked as “important” by 69% of those surveyed. However, “communications via speaker” received only a 62% satisfaction rate from those surveyed. Thus, in the area of communication, a 7+point spread exists between consumer ratings of importance and satisfaction, indicating a critical need (by industry standards) for improvement.

Research at the McDonald’s Innovation Center in Romeoville, Illinois reveals that 57% of errors made during transactions in this area occur during the “capture order phase." Little systematic research has been conducted into the source of these communication issues.

IPRO 343 team members initially identified four areas in which to investigate multiple stream communication problems:

a. Acoustic issues related to in-bound and out-bound speech signals at the drive-thru;

b. Cognition issues related to multiple modalities (that is, how language perception is affected by the presence or absence of certain cues or by conflicting cues) for the speech signal;

c. Intercultural communication issues related to comprehensibility problems of native and non-native speakers, including speech-in-noise effects and language attitudes; and

d. Human-technology interaction issues related to customer interfaces used for ordering, including findings on customer rejection/approval of technology, and multi-modal/speech recognition systems.

After a consultation with industry executives, IPRO team 343 was tasked with narrowing the focus to conducting research on in-bound speech signals—those coming in to the order-taker from the customer in the drive-thru. The team therefore limited the scope of their research to focus on acoustic issues, specifically trying to limit the impact of multiple speech streams heard by order-takers in the drive-thru setting.

b. Ethical Issues – Institution Review Board

The Institution Review Board (IRB) reviews research proposals that involve human participants. The IPRO 343 ethics sub-committee, in consultation with faculty advisor Matt Bauer, prepared and submitted an application to the IRB for review. The team was required to indicate the purpose and scope of the experiment, the type of testing that would be involved, and the ethical implications of the study. The ethical issues indicated were:

1. a possibility of slight discomfort from wearing headphones for an extended period of time, as well as possible discomfort from sitting in a chair for an extended period of time, and

2. a possibility that participants could experience increased stress from being asked to make decisions quickly.

See Appendix 1 for IRB Application and Participant Consent Form.

3. Objectives

The primary objective of IPRO 343 was to find a method to improve inbound communication to order-takers so as to improve accuracy of order capture in the drive-thru setting at quick-service restaurants. Secondary objectives were:

a. to minimize the impact of multiple streams of speech heard by the order taker;

b. to develop and conduct an experiment in order to test a pre-established hypothesis (that white noise would improve order-capture accuracy);

c. to analyze results and draw conclusions based on the data from the experiment; and

d. to make recommendations on possible solutions or further studies for future IPROs to investigate.

4. Methodology

a. Gantt Chart

The original schedule of activities, with key milestones is presented below in Table 1.

Table 1: IPRO 343 Schedule - 1st iteration

Milestones/Activities	Duration	Start Date	Completion Date
Project Plan Due	0 days*	19-Sep-08	19-Sep-08
Ethics Module Completed	13 days	19-Sep-08	7-Oct-08
Research Design Completed	**19 days**	**22-Sep-08**	**16-Oct-08**
Midterm Presentation to Group	0 days	2-Oct-08	2-Oct-08
Midterm Presentation	0 days	6-Oct-08	6-Oct-08
Ethics Review	0 days	20-Oct-08	20-Oct-08
Participant Recruitment	**8 days**	**23-Oct-08**	**3-Nov-08**
Exhibit/Poster/Abstract Due	0 days	26-Nov-08	26-Nov-08
Experiments Conducted	**7 days**	**13-Nov-08**	**21-Nov-08**
IPRO Day Preparation Seminar	0 days	20-Nov-08	20-Nov-08
Analysis Completed	**7 days**	**24-Nov-08**	**2-Dec-08**
Presentation Uploaded	0 days	3-Dec-08	3-Dec-08
Final Report Due	0 days	8-Dec-08	8-Dec-08
IPRO Day/CD Due	0 days	5-Dec-08	5-Dec-08

b. Changes to the Gantt Chart and Justifications

The schedule presented in the mid-term report did not reflect all of the final phases of the project. The final four phases were: research design, experiment, analysis, and IPRO Day preparation. While all these phases were implied in our original plan (see Table 1), our revised schedule and Gantt chart (see Appendix 2) now explicitly identify these stages and related tasks.

Some significant changes in the duration of the tasks, and their justification are:

1. **The research design deadline date was delayed for one week**. Once the objectives were redefined, the team needed additional time to modify the research design.

2. **The participant recruitment period was extended throughout the experiment period.** This was to ensure that sufficient numbers of participants were available for the experiment.

3. **The experiment phase extended for an additional 5 days**. This change accommodated the sub-phases which now included creating the materials for the experiment.

4. **The analysis phase was extended for two days.** This was done to accommodate the increased number of questions which would have to be coded, based on the new experiment design.

c. Experiment Methodology

One deliverable which the team developed was an Experiment Methodology Report which could be delivered to a potential sponsor or presented at a conference. The paper is entitled "Using White Noise to Improve Order Accuracy in Noisy and Distracting Environments." The report is presented in Appendix 3 and details the method, procedures, results, and discussion of the experiment conducted by IPRO 343 team members.

5. Team Structure and Assignments

a. Team Members

IPRO 343 was led by instructor Dr. Matthew Bauer in consultation with Dr. Kathryn Riley and assisted by Yu Zhang. There are ten student members. Their background, skills and team roles are listed below.

Kevin Arnold

- **Background**: 4th-year student majoring in political science with minors in professional and technical communication and art history; taking first IPRO
- **Skills**: Experience with Microsoft Office, especially Excel; courses in linguistics, research methods and design experience
- **Team Roles**: Co-Team Leader, Acoustics Team Member, Mid-Term Presentation Team Member, Experiment Team Member

Matthew Campen

- **Background**: 3rd-year student majoring in computer engineering; taking first IPRO
- **Skills:** Circuit design, Java, C, Unix, Microsoft Office
- **Team Roles:** Ethics Team Leader, Acoustics Team Member, Experiment Team Member, Data Analysis Team Member, Recruitment Team Member

Shaun Doran

- **Background**: 3rd-year student majoring in electrical engineering; taking first IPRO
- **Skills**: problem solving, computer skills, experiment design
- **Team Roles**: Budget and Facility Management, Acoustics Team Member, Experiment Team Member, Reading Team Member, Data Analysis Team Member

Karen Hong

- **Background:** 5th year student majoring in architecture, digital design specialization; taking first IPRO
- **Skills:** AutoCAD, 3d Studio Max, Adobe Photoshop/Illustrator, Korean language skills
- **Team Roles:** Documentation and Reminder Manager, Ethics Team Member, Acoustics Team Member, Experiment Team Member, Data

Analysis Team Member

Sarah Johnson

- **Background:** 5th-year student majoring in architecture; taking second IPRO.
- **Skills:** Design, project organization, thinking outside of the box
- **Team Roles:** Acoustics Team Leader, Ethics Team Member, Experiment Team Member, Experimental Design Team Member

Scott Justus

- **Background:** 4th-year student majoring in biochemistry; taking first IPRO
- **Skills:** Good knowledge of human anatomy/physiology, basic understanding of various linguistic concepts, very computer savvy, good team player
- **Team Roles:** Experimental Design Team Leader, Data Analysis Team Member, Project Plan Development Team Member, Experiment Team Member

Halcyon Lawrence

- **Background:** Ph.D. technical communication candidate; taking first IPRO
- **Skills:** Certified MS Office Master Instructor, strong organizational and communication skills
- **Team Roles:** Co-Team Leader, Experimental Design Team Member, Recruitment Team Member

Susan Mallgrave

- **Background:** 4th year student majoring in technical communication; taking second IPRO
- **Skills:** writing, editing, web design, document design**,** communication skills

- **Team Roles:** Editor, Experiment Team Member, Recruitment Team Member

Shavanna Pinder

- **Background**: 5th-year student majoring in architecture; taking first IPRO
- **Skills**: Architecture: 3D Studio Max, AutoCAD, model making, hand drafting, freehand drawing, Adobe Photoshop/Illustrator, typing 50 wpm, basic Spanish
- **Team Roles**: Recruitment Team Leader, Ethics Team Member, Experimental Design Team Member

Russell Ucci

- **Background:** 4th-year student majoring in chemical engineering
- **Skills:** MS Word, Excel, Matlab, HYSIS, LABVIEW
- **Team Roles:** Experiments Team Leader, Ethics Team Member

b. Team Structure

IPRO 343 members were each allocated both team leader and team member roles. Individuals moved between these roles during the project. The project was divided into two main phases, given below in Figure 1. Four of the roles continued throughout the semester—team leaders, editing, document management, and budget and facilities.

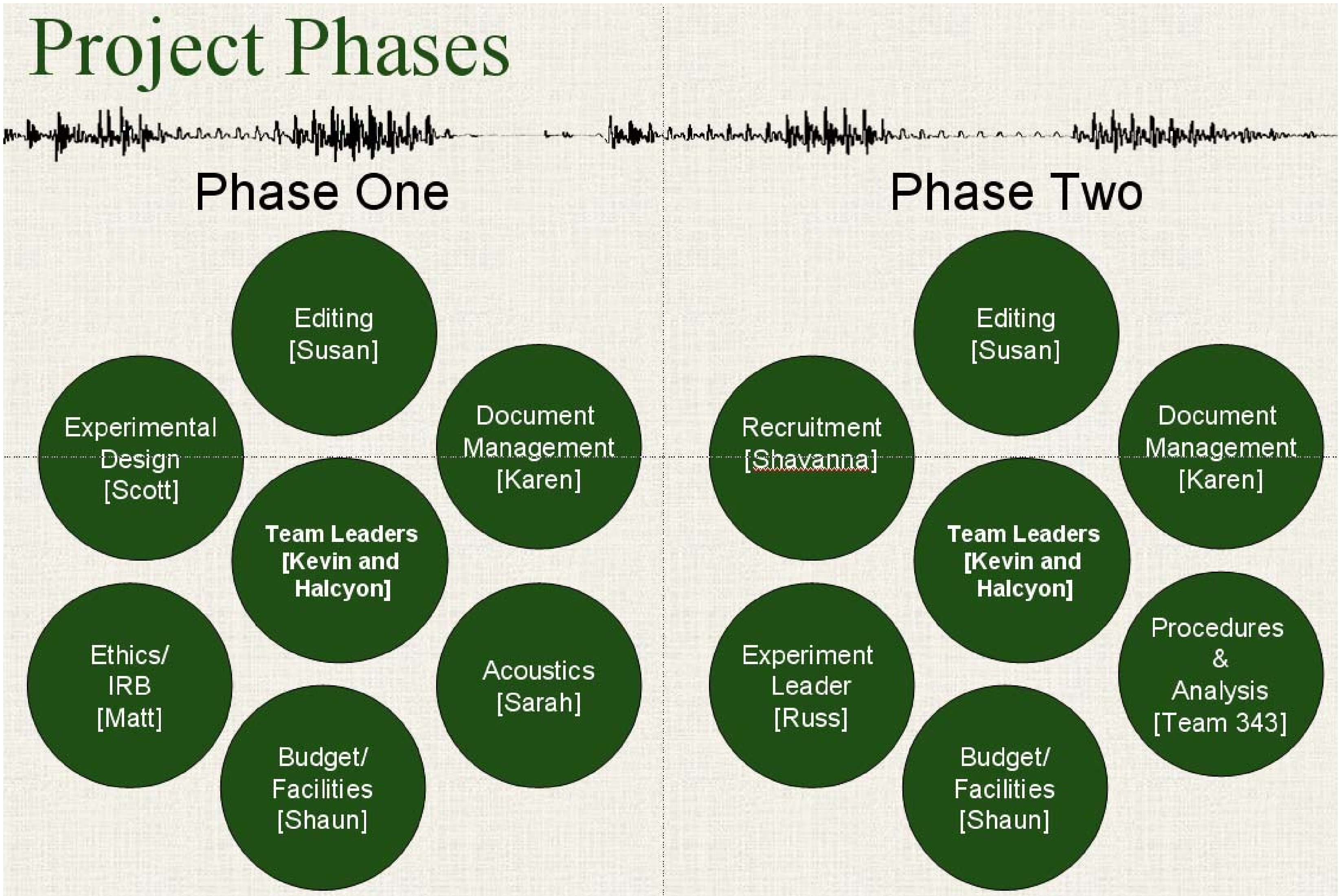


Figure 1: IPRO 343 Team Assignments

c. Team Assignments

The responsibilities given to each member are given in Table 2 below:

Table 2*:* Individual Responsibilities

Role	Person Responsible	Duties
Team Leaders	Kevin Arnold Halcyon Lawrence	Oversee all team activities; liaise with group leaders and academic staff members, oversee IPRO Day team, deliver final presentation
Culture Team Leader	Scott Justus	Manage culture/cognition group; design culture/cognition experiment; liaise with experiment and recruitment teams
Acoustics Team Leader	Sarah Johnson	Manage acoustics group; design acoustics experiment; liaise with experiment and recruitment teams
Budget/Facility Manager	Shaun Doran	Liaise with IPRO team to develop budget; manage expenditures; book facilities; procurements
Document Manager	Karen Hong	Manage all documents (hardcopy & softcopy) for IPRO 343 through iGROUPS; work with team leaders to design meeting agendas; take and distribute minutes for meetings
Editor	Susan Mallgrave	Edit all official IPRO 343 documents (project plans, brochures, abstracts, presentations etc.)
Ethics Team Leader	Matthew Campen	Work with team members to complete the ethics requirements for the Ethics Review Board (ERB); brief team members on the outcome of ERB requirements
Recruitment Team Leader	Shavanna Pinder	Manage recruitment of all participants; liaise with acoustics, culture/cognition, and recruitment team leaders
Experiment Team Leader	Russell Ucci	Manage all experiments; liaise with acoustics, culture/cognition, and recruitment team leaders

6. Budget

a. Initial budget

The initial budget is given in Table 3 below:

Table 3: IPRO 343 Budget

Item	Budgeted Cost
Equipment (headphones)	$100.00
Participant incentives	$200.00
Travel (fieldwork)	$100.00
IPRO Day	$100.00
Total	$500.00

b. Final Income and expense report

The final income and expense account for IPRO 343 is given in Table 4 below:

Table 4: IPRO 343 Income and Expenses

Income	Amt	Per Unit Cost	Total
Approved Budget			$ 500.00
IPRO Office catering allowance			$ 300.00
Humanities Department support			$ 291.00
Total Income			**$1,091.00**
Expenses			
Equipment - Headphones	$ 12.00	$ 15.83	$ 189.96
Participant Support - Sodexo Catering	$ 4.00	$ 125.00	$ 500.00
IPRO Day Expenses			
Polo Shirts	$ 12.00	$ 24.25	$ 291.00
Exhibit Materials			$ 80.46
Total Expenses			**$1,061.42**
Budget Surplus			**$ 29.58**

7. Results

a. Critical learning and discoveries

Having completed the project the team reflected on the process and indicated the following as being the most significant learning experiences:

i. None of the members of IPRO 343 had previously conducted a scientific experiment; this project allowed all members to be involved in the research, design, and experiment processes.

ii. None of the team members had experience using the sound recording software; this project allowed some members to learn how to use PRAAT to edit sound files.

iii. Most team members had not previously taken any courses in linguistics; as a result, for the first month of the semester, the team heard lectures which explained the four dimensions of communication. These included issues of acoustics, cognition, intercultural communication, and human-technology interaction Based on these lectures and the input of industry executives, the focus was narrowed to the acoustic and culture/cognition issues of communication.

iv. The process of recruiting more than 70 participants also provided a critical experience and employed a number of methods which included emails, posters, and individual contact. Recommendations about recruitment are made to future IPROs in our continuity plan.

b. Research findings

All findings related to research conducted in IPRO 343 are documented in Appendix 3.

c. Assessment of objectives

All objectives listed in this report were successfully met, within budget and the time constraints of the semester. As this is a continuing IPRO, the team has provided a continuity plan to the academic advisor, Matt Bauer.

d. Ethical, moral, cultural or scientific issues

The team did not encounter any ethical, moral, cultural or scientific issues in the conduct of the experiment. All participants signed the consent forms and no complaints have been directed to either the team or the IPRO office regarding the conduct of the experiments. The confidentiality of all participants has been maintained.

8. Obstacles

a. Acoustic team

The acoustic team encountered a few obstacles, some of which were simply about making decisions when it came to creating the audio elements for the experiment. There are several methods that can be used to create background conversational babble, and different types of speech were recorded and compared. Initial recordings were created for both scripted babble (these were recordings based on articles read from the Chicago Tribune) and conversational babble (recordings made from free-flowing conversation between two people) When the recordings were played back and analyzed by the team, it became clear that the audio quality of the conversation style babble was not of the quality required. The team decided to use the scripted-style babble.

In order to make the babble realistically reflect the level of noise in a drive-thru environment, the team needed to get decibel readings inside a kitchen. There was initial trouble finding a restaurant that would allow a team member to come in and take readings during business hours. One of the team members works in a restaurant and provided the solution to this challenge when she did the readings with the owner's permission.

The acoustic team did encounter obstacles but these were part of the process of creating an experiment and could not be avoided. They were part of the learning and designing process and were overcome successfully.

b. Experimental Design

The obstacles encountered by the experimental design team were minimal. The main obstacle was figuring out a way to make an interface, stimulus, and order form that worked well together, enabling participants to easily understand what they were doing during the experiment and ensuring that valid results could be obtained.

The group first decided on a form and the stimulus words that would be used. After recording a few practice stimuli, it was found that other members of our IPRO had trouble navigating the form that had been made, and very few of the words were similar enough in sound to obtain useful data from them. Options were discussed in class and the experimental design team produced a new form, with team co-leader Kevin Arnold writing the final script. The obstacles encountered in this sub-team could not be avoided, as these are a natural part of designing any experiment. This was a great learning experience and what has been documented in the Experiment Methodology Report (Appendix 3) should enable future students to design other experiments of this type.

9. Recommendations

All recommendations based on the team's research findings and conclusions are presented in Appendix 3.

10. References

The team developed an annotated bibliography given in appendix 4.

11. Resources

Our team's responsibilities and goals are below; hours listed do not include class time:

Kevin Arnold

	Time Expended (in hours)	Associated Cost
Co-Team Leader		
overseeing IPRO Day team	10 hours	$80.46
creating Final Presentation	12 hours	
Acoustics Team Member		
creating babble	1 hour	
creating sound files	18 hours	
Mid-term Presentation Team Member	6.5 hours	
Experiment Team		
participating in 4 experiment days, leading experiment for 2 days	9 hours	
Team Assignments		
creating script	2 hours	
grading participant forms	8 hours	
Project Plan	4 hours	
Procedures Team	2 hours	

Matthew Campen

	Time Expended (in hours)	Associated Cost
Ethics Team Leader		
writing IRB Application first draft	2 hours	
Acoustics Team	In class	
Experiment Team		

recording stimulus	.25 hours	
participating in 2 experiment days	2 hours	
grading participant forms	6 hours	
Recruitment		
helping with recruitment	1 hour	
reminding participants to show up	.5 hours	
Data Analysis	.25 hours	
IPRO Day		
co-writing first draft/final report	3 hours	
building IPRO day exhibit	2 hours	

Shaun Doran

	Time Expended (in hours)	**Associated Cost**
Budget and Facilities leader	2 hours	
Acoustics Team Member		
creating white noise	1 hour	
creating babble	1 hour	
Mid-term Presentation Team Member	3 hours	
Experiment Team		
participating in 2 experiment days	5 hours	
grading participant forms	6 hours	
Data Analysis	1 hour	
IPRO Day		
reading team (research references)	1 hour	
building IPRO day exhibit	1 hour	

Karen Hong

	Time Expended (in hours)	**Associated Cost**
Documentation Manager		
creating daily agenda and minutes	4 hours	
Ethics Sub-team		
reading requirements for NIH/certification test	3 hours	
Acoustics Sub-team		
determining decibel level sound readings and write-up	2 hours	
creating recordings for experiment	.25 hours	
Experiment		
participating in 1 experiment day	2 hours	

grading participant forms	6 hours	
Data analysis/results		
editing graph	2 hours	
IPRO day		
creating continuity plan	4 hours	

Sarah Johnson

	Time Expended (in hours)	**Associated Cost**
Ethics Sub-team		
writing IRB Application second draft	1.5 hours	
Acoustics Sub-Team Leader		
creating recordings for experiment (conversation and article babble)	1.5 hours	
Experiment		
arranging orders	2.5 hours	
creating original grading sheet	1 hour	
participating in 2 experiment days	5 hours	
grading participant forms	6 hours	
Procedure Write-up Team		
summarizing acoustic team procedures	2 hours	
IPRO day		
creating abstract	12 hours	
building IPRO day exhibit	8 hours	

Scott Justus

	Time Expended (in hours)	**Associated Cost**
Project Plan Development	6 hours	
Experimental Design Team Leader		
developing script	4 hours	
developing order form	4 hours	
working on experiment interface	3 hours	
discussing recruitment	1 hour	
recording stimuli	.5 hours	
Experiment		
participating in 2 experiment days	5 hours	
Data Analysis		
editing graph	1 hour	
IPRO Day exhibit & table setup	8 hours	

Halcyon Lawrence

	Time Expended (in hours)	Associated Cost
Co-Team Leader		
compiling final documentation: final report; continuity plan; creating experimental design; creating and editing abstract & posters	20 hours	
preparing and giving final presentation	4 hours	
Experimental Design Team Member		
creating experiment interface	6 hours	
creating experiment instrument	4 hours	
Mid-term report collaboration	4 hours	
Recruitment of non-native participants	1 hour	
Experiment Team		
participating in 3 experiment days, leader for one	6 hours	
grading participant forms	6 hours	
creating grading instrument	1 hour	
leading procedures documentation team	3 hours	

Susan Mallgrave

	Time Expended (in hours)	Associated Cost
Comprehensive editing of all documents: Project plan, IRB document, recruitment forms, experiment documents, methodology document, IPRO day posters and abstract, and final report	24 hours	
Recruitment		
proofing, copying, cutting recruitment forms	1 hour	
manning recruitment table at MTCC center	1 hour	
IPRO Day	8 hours	
creating literature review	2 hours	
Experiment Team		
leading experiment 1 day	3.5 hours	
grading participant forms	6 hours	

Shavanna Pinder

	Time Expended (in hours)	Associated Cost
Ethics		

reading NIH requirements/certification test	4 hours	
Experimental Design Team Member		
designing experiment interface	2 hours	
designing experiment instrument	2 hours	
participating in 2 experiment days	5 hours	
grading participant forms	6 hours	
Recruitment	10 hours	
designing/distributing poster		
developing recruitment form		
recruiting		
reminding participants to show up		
IPRO Final Report		
writing recruitment section	1 hour	
IPRO Day	5 hours	
creating poster	5 hours	

Russell Ucci

	Time Expended (in hours)	Associated Cost
Experiments Team Leader		
organizing catering for experiment participants	1 hour	
collaborating with sub-teams	2 hours	
grading participant forms	6 hours	
participating in experiment days	5 hours	
Experimental Design Team		$689.96
recording experiment stimuli	.25 hour	
writing script	1 hour	
Ethics Team		
participating in NIH training	4 hour	
IPRO Day		
co-writing first draft/final report	2 hours	

12. Acknowledgements

IPRO 343 team members would like to thank:

- Our advisors, Dr. Matt Bauer and Dr. Kathryn Riley for their invaluable guidance with our project;
- Jim Maciukenas for documenting the group's activities through photography;
- Dr. Greg Pulliam for his input with our final presentation preparations; and
- Frank Parker for his timely advice and encouragement.

Appendices

Appendix 1 – IRB Application Form & Participant Consent Form

APPLICATION FOR THE REVIEW OF RESEARCH INVOLVING HUMAN SUBJECTS

This application incorporates requirements from the Code of Federal Regulations, Title 45, Part 46, Protection of Human Subjects (rev. 3/83). Complete copies of 45 CFR 46 are available on the IIT IRB website at http://www.grad.iit.edu/research/irbhome.html.

ESSENTIAL DATA

1. **Responsible Project Investigator (qualified faculty/staff supervisor): Matt Bauer**

   Dept: _______HUM______________ Phone: __77967_____ Email: __matt.bauer@iit.edu_____

2. **Name of Investigator (if different from Responsible Project Investigator):**

   Dept: _____________________ Phone: _____________ Email: __________________

3. **Project Title:**

   IPRO 343: Improving communication quality in the drive thru environment

4. **Project Dates: From: _Oct 2008_ To: _Oct 2009_____**

5. **Type of Investigator(s):** **__x_Faculty**

(check all that apply) **____Staff**

__x_Graduate Student

__x_Undergraduate Student

6. **Status of Project:** **__x_New Project**

____Periodic Review

____Change in Protocol

7. **Site of Work:**

Siegel Hall 236

8. **Type(s) of Subject:** **____Adult, non-student**

_x__IIT student

____Non-IIT student

____Minor (under 18)

9. **Characteristics**

of Subject: **_x__Normal Volunteer**

____In-patient

____Out-patient

____Mentally disabled individual

____Pregnant woman, fetus

____Individual with limited civil freedom

____Individual with a court-appointed guardian

Note: The IRB encourages you to make double-sided copies in order to conserve resources.

10. Number of subjects, including "controls": 100

11. Sponsor, if externally funded:

____

12. If you have previously used human subjects in this research program, provide the information below for all subjects of the last twelve months:

____Number of subjects screened

____Number admitted to project

____Number of withdrawals

____Number who completed participation

____Number still active

On a separate sheet, describe any problems encountered by participants. See Certifications for ongoing reporting requirements.

13. Is this research exempt from federal regulation? ( )YES (x)NO See Appendix I for conditions. If you believe that your research falls into categories listed, and therefore qualifies for expedited IRB review, CIRCLE the identifying numbers of those conditions below:

1 2 3 4 5

B. OBJECTIVES OF RESEARCH. Describe the objectives and significance of the proposed research involving human subjects:

1. Overview

This project will examine acoustic and cognitive factors that contribute to understanding speech in noisy environments. The goal of the project is to determine which of these aspects facilitate speech intelligibility among both native and non-native listeners. In particular, the project will focus on factors that may improve accuracy of taking customer orders in a simulated fast food drive-thru environment.

2. Objective

Representatives from a major fast food company claim many of their employees have difficulty understanding orders in the drive-thru environmen, a situation the representatives attribute to interference from other employees talking (Poonja, Karim 2008, personal communication). At issue is whether the apparent negative effect of employee chatter can be masked to improve speech intelligibility of drive-thru orders.

The problem of understanding speech in noisy environments is not unique to drive-thru environments. A number of studies have shown that noisy environments reduce a person's ability to understand speech, particularly when the noise is due to background talk of a few people, compared to when the noise is due to environmental sources (e.g. "white noise") (Koul & Allen 1993; Payton et al 1994; Hoen et al. 2007; Barker 2007). Thus, environmental noise has less of a negative effect on speech intelligibility for listeners than noise due to background talk. Moreover, non-native listeners are especially prone to misunderstanding speech in noisy environments compared to native listeners (Van Wingaarden et al. 2002; Van Engeb & Bradlow 2007).

The current project tests the hypothesis that background talk masked by white noise will improve understanding of speech delivered in a drive-thru environment.

C. <u>PROTOCOLS</u>. Give details of the procedures that relate to the subjects' participation. What will the subjects do or what will be done to them? Append copies of all questionnaires or test instruments. If a research proposal has been or will be submitted to an external sponsor, append a copy of the technical portion of the proposal.

In the study, native English-speaking participants will be asked to play the part of an employee of a fast food restaurant in a simulated drive-thru situation. Participants will listen to a series of drive-thru orders from customers and mark what food items they ordered. All participants will listen to the same order, but the recording quality of the order will depend on two factors (2x2 design), which include hearing the order (1) with background talk at a low signal-to-noise ratio (SNR) or high SNR, and (2) the presence or absence of white noise (broadband noise between 100Hz and 10,000Hz). The participant pool will be divided into groups of 20 in each experimental condition. In addition, 20 non-native English speaking participants will listen to the drive-thru orders in the high SNR condition with white noise.

Participants will listen to recordings of orders through headphones. The headphones will play the individual orders on one side while the background talk and white noise play on the other side (following industry practice of drive-thru employees generally using head sets with speakers covering only one ear, Poonja, Karim 2008, personal communication). Participants will then be asked to mark the order on a worksheet as quickly as possible. Each participant will hear approximately 10 to 20 orders.

The study will take place in Siegel Hall 236, a computer lab. Participants will be seated in front of a computer and wear over-the-ear headphones (Sennheisser HD 280 headphones, or equivalent). Before the start of the experiment, participants will hear a test signal and be told to adjust the volume to a level of their own comfort.

Sentence stimuli will consist of natural speech and exhibit a duration of approximately 10 - 15 seconds, e.g. "I would like 2 cheeseburgers, a diet Coke, 3 fries, and a chicken sandwich with pickles but no mayo."

In addition, participants will be asked a set of demographic questions, including (1) age, (2) familiarity with English (Native, Native-like, or Non-native), and (3) frequency of using drive-thru environments.

The study will take about 20 minutes.

Participants will be volunteers, but will be offered a free lunch for participating, regardless of whether they complete the experiment or not (i.e. participants who withdraw will also be offered lunch). The lunch will be offered in Siegel Hall 218.

D. <u>SELECTION OF SUBJECTS</u>. Please check the appropriate responses and describe the methods you used to select your subjects. If you are using IIT students and offering credit for their participation, you must comply with IIT-IRB policy on this practice; the policy is attached as Appendix I.

1. Subjects will receive payment or course credit compensation for participation. If yes, state amount, form, and conditions in the case of monetary compensation; or attach a list of credit alternatives in the case of credit compensation (see Appendix II).

__x_yes ____no

Participants will not be given cash payment but will be offered a lunch of some kind (e.g. pizza).

2. Access to subjects will be gained through cooperating institutions. If yes, attach letter of agreement, or, for sponsored projects, DHHS Form 596. If agreement is conditional upon IIT approval, explain here.

____yes __x_no

3. This project involves investigators at another institution. If yes, identify investigators and institution(s).

____yes __x_no

4. Describe method of selecting subjects:

Members of the IPRO 343 will send email flyers to their friends and acquaintances throughout campus (flyer attached).

E. <u>DECEPTION</u>. If subjects are deceived or misled, or if information is withheld, identify the information involved, justify the deception, and describe the debriefing plan if there is one.

The study does not involve deception.

F. <u>CONFIDENTIALITY OF DATA</u>: Confidentiality of data is required unless subjects give express permission that data may be identified. Indicate which of the following categories describes this research, and provide supporting information as needed.

X__ Responses will be anonymous. No one, including the researchers, will be able to identify participants, whether through names or identifiers linked to names.

_ Responses will be confidential. Identifying information will be accessible only by the project researchers.

<u>Describe the methods to be used to ensure confidentiality, such as where identifying information will be stored, and when identifying records will be destroyed.</u>

__ Responses will not be confidential. Explain.

__ Other. Explain.

G. <u>INFORMED CONSENT</u>. Informed consent is a legal requirement for research involving human subjects: "No investigator may involve a human being as a subject in research covered by these regulations unless the investigator has obtained the legally effective informed consent of the subject or the subject's legally authorized representative. An investigator shall seek such consent only under circumstances that provide the prospective subject or the representative sufficient opportunity to consider whether or not to participate and that minimize the possibility of coercion or undue influence. The information that is given to the subject or the representative shall be in language understandable to the subject or the representative" (45 CFR 46.116). If the subject is a minor, at least verbal assent should be obtained from the child in addition to the required written consent by the parent/guardian. EACH SUBJECT MUST BE GIVEN A COPY OF THE CONSENT FORM.

Yes_x_No__Informed consent will be obtained from all research participants.

Yes_x_No__Informed consent will be documented through a written form which will be signed by the research participant or a legal guardian.

If you answered no to either of the above questions, please explain.

H. <u>RISKS</u>. Will subjects in the proposed research be placed at more than minimal risk? (*Minimal risk* means that the risks of harm anticipated are not greater, considering probability and magnitude, than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.)

_x__Minimal risk
____More than minimal risk

1. **<u>Describe the risks</u> and the precautions that will be taken to minimize them, even if risk is minimal. The concept of risk goes beyond physical risk and includes risk to the subject's dignity and self-respect, as well as psychological, emotional, or behavioral risk. "*No risk" is not an acceptable answer.***

There may be a slight discomfort from wearing headphones for an extended period of time, as well as possible discomfort from sitting in a chair for an extended period of time. There is also a possibility that participants experience increased stress from being asked to make decisions quickly.

2. **Will any part of this research allow the investigator to identify participants who are likely to cause harm to themselves or others? (e.g. suicidal thoughts, child abuse)**

   No __x___

   Yes _____ If yes, what procedures will be implemented?

I. BENEFITS. Describe the benefits to the subject and society. The IRB must have sufficient information to make a determination that the benefits outweigh whatever risks are involved.

The study will not benefit participants in any way, beyond the possible psychological benefit of participating in ongoing research. In general, the goal of the project is to isolate factors that may facilitate understanding speech in noisy conditions. While the focus of the study is designed to improve communication quality in the drive-thru experience, results may be applicable to other practical domains (e.g., improving intelligibility of speech synthesis in devices intended to comply with requirements of effective communication under the Americans with Disability Act).

J. CERTIFICATIONS:

I am familiar with the ethical guidelines and application requirements provided by the IRB and will adhere to the policies and procedures explained.

Should any change in procedures involving human subjects become advisable, I will submit it for review prior to initiating the change.

I certify using the consent form approved and stamped by IIT IRB.

If any problems involving a human subject occur, I will immediately notify the Director of Research Compliance and Proposal Development, who is also the Executive Officer of the IRB.

Signature of Responsible Project Investigator: Date:

Signature of Investigator (if different from Responsible Project Investigator): Date:

ILLINOIS INSTITUTE OF TECHNOLOGY

Consent to Participate in Research

Project Title: Improving Communication Quality of the Drive-Thru Experience

Researcher: Matt Bauer

Introduction

You are invited to participate in a study about receiving orders from a drive-thru speaker. You are requested to read this form and ask any questions that you might have before deciding to be in the study. The purpose of this study is to test the benefits of white noise in noisy situations and how it affects the clarity of drive-thru orders

Total Number of Participants

About 100 people will participate in this study.

General Plan of the Study

If you decide to be in the study, you will be asked to listen to a series of sound recordings. After each recording, you will be prompted with three possible answers, and asked which of them contains the order given in the recording. As you answer each question, a timer will be recording your time on each particular question as well as a total time on the test. To take this test, you will be seated and listening to the recordings on headphones alongside several other participants.

Length of the Study

About 20 minutes

Possible Risks or Benefits of Participating in This Study

This study involves the use of noise-canceling headphones. While not inherently dangerous, there may be discomfort from wearing the headphones for the duration of this study. If the volume setting on the headphones is set too high, it may result in hearing loss worse than listening to loud stereo speakers. By participating in this research, you understand that IIT is not responsible for any injuries or medical conditions you may suffer during the time you are a participant unless those injuries or medical conditions are due to IIT's negligence.

Data Security and Confidentiality

The records of this study will be kept in private. In any sort of report that might be published, no information will be included that would make it possible to identify you, aside from whether or not you are a native speaker of the English language. Research records will be kept in a locked file; only the researchers will have access to the records. If you later decide that all or portions of your recordings should not be included in the study, your request will be granted without question.

Your Rights as a Participant

Your decision whether or not to participate in this study will not affect your current or future relations with IIT or the research staff. If you decide to participate, you are free to withdraw at any time without affecting those relationships. If you have any questions about your rights as a research participant, call the IIT IRB office, (312) 567-7141, IRB #2006-067).

Researcher's Statement

I have fully explained this study to the participant. I have discussed the procedures and have answered all of the questions that the participant has asked.

Signature of Investigator ______________________________ Date __________

Participant's Consent

I have read the information provided in this Informed Consent Form. All my questions were answered to my satisfaction. I have received a copy of the consent form. I voluntarily agree to participate in this study.

Your Name ________________________________

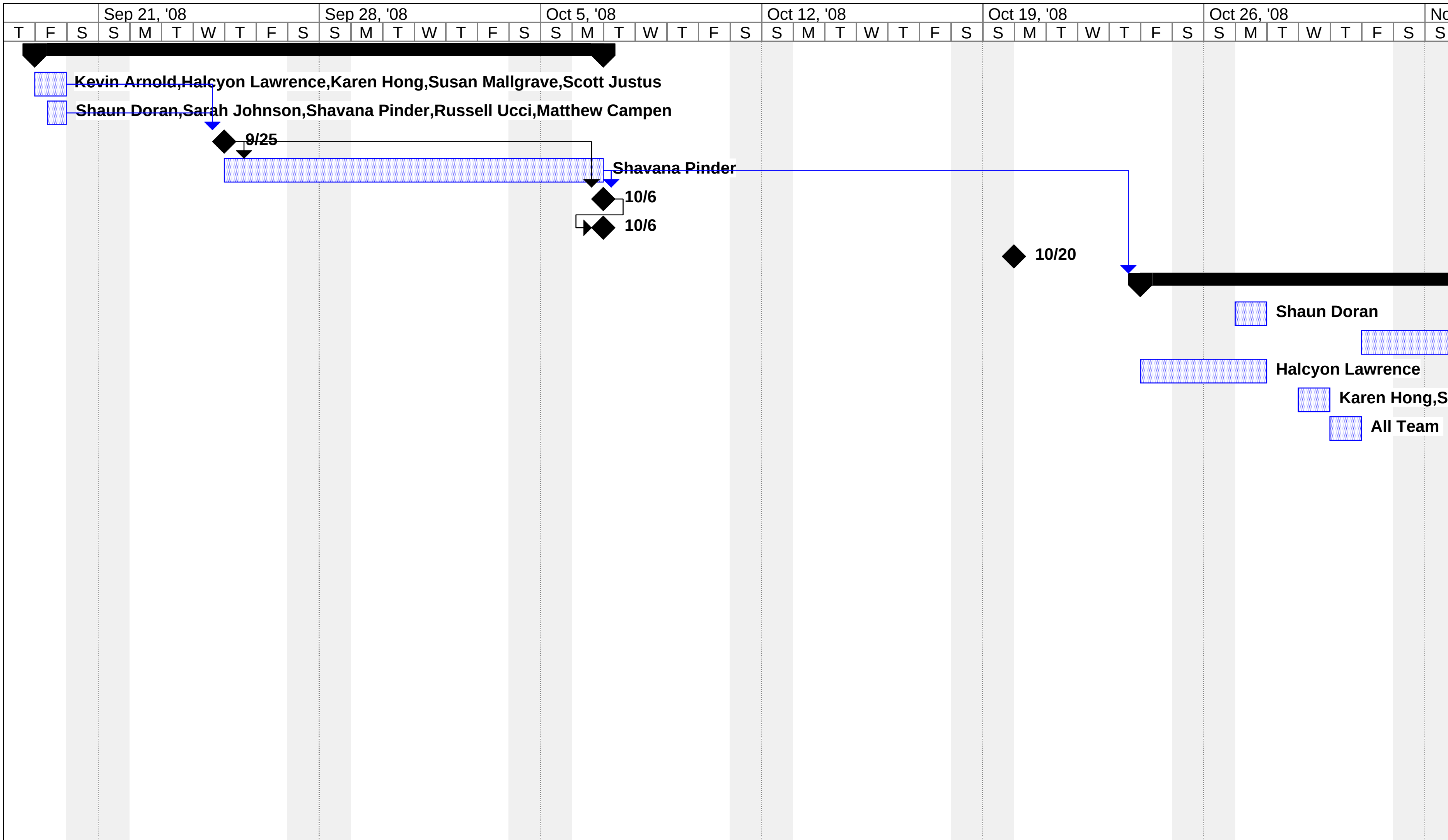
Your Signature _________________________________ Date ________

Appendix 2 – Revised Gantt Chart

ID	Task Name	Duration	Start	Finish	Predecess	Resource Names
1	**Research Design Phase**	**12 days**	**Fri 9/19/08**	**Mon 10/6/08**		
2	Project Plan Due	1 day	Fri 9/19/08	Fri 9/19/08		Kevin Arnold,Halcyon Lawrence,Karen Hong,Susan Mallgrave,Scott Justus
3	Ethics Module Completed	0.8 days	Fri 9/19/08	Fri 9/19/08		Shaun Doran,Sarah Johnson,Shavana Pinder,Russell Ucci,Matthew Campen
4	Research Design Completed	0 days	Thu 9/25/08	Thu 9/25/08	2,3	Experimental Design Subteam,Acoustics Subteam
5	Participant Recruitment	8 days	Thu 9/25/08	Mon 10/6/08	4	Shavana Pinder
6	MidTerm Presentation to Group	0 days	Mon 10/6/08	Mon 10/6/08	4,5	Kevin Arnold,Karen Hong,Halcyon Lawrence,Susan Mallgrave,Scott Justus
7	MidTerm Presentation	0 days	Mon 10/6/08	Mon 10/6/08	6	Kevin Arnold,Shaun Doran,Sarah Johnson
8	IRB Approval	0 days	Mon 10/20/08	Mon 10/20/08		
9	**Experimental Phase**	**11 days**	**Fri 10/24/08**	**Fri 11/7/08**	**5**	**Russell Ucci**
10	Booking of Facilities	1 day	Mon 10/27/08	Mon 10/27/08		Shaun Doran
11	Creation of Sound Files	2 days	Fri 10/31/08	Mon 11/3/08		Sarah Johnson,Kevin Arnold
12	Creation of Experiment Instrument	2 days	Fri 10/24/08	Mon 10/27/08		Halcyon Lawrence
13	Creation of Experimental Interface	1 day	Wed 10/29/08	Wed 10/29/08		Karen Hong,Shavana Pinder
14	Experimental Test	1 day	Thu 10/30/08	Thu 10/30/08		All Team Members
15	Experiments Completed	4 days	Tue 11/4/08	Fri 11/7/08		
16	**Analysis Phase**	**9 days**	**Fri 11/7/08**	**Thu 11/20/08**	**9**	
17	Coding of Data	6 days	Tue 11/11/08	Tue 11/18/08		All Team Members
18	Analysis of Data	3 days	Tue 11/18/08	Thu 11/20/08		Analysis Subteam
19	Analysis completed	0 days	Fri 11/7/08	Fri 11/7/08		
20	**IPRO Day Preparation Phase**	**10 days**	**Thu 11/20/08**	**Fri 12/5/08**	**16**	
21	IPRO Day Preparation Seminar	0 days	Thu 11/20/08	Thu 11/20/08		Kevin Arnold,Halcyon Lawrence
22	Final Report Submissions	0 days	Tue 11/25/08	Tue 11/25/08		All Team Members
23	Presentation Dry Run	0 days	Mon 12/1/08	Mon 12/1/08		Kevin Arnold,Halcyon Lawrence
24	Continutity Plan Due	0 days	Thu 11/20/08	Thu 11/20/08		Karen Hong
25	Poster/Abstract Due	0 days	Wed 11/26/08	Wed 11/26/08		Sarah Johnson,Shavana Pinder
26	Final Presentation Due	0 days	Wed 12/3/08	Wed 12/3/08		Kevin Arnold,Halcyon Lawrence
27	Final Report Due	0 days	Thu 12/4/08	Thu 12/4/08		Matthew Campen,Susan Mallgrave,Russell Ucci
28	IPRO Day; CD Due	0 days	Fri 12/5/08	Fri 12/5/08		All Team Members

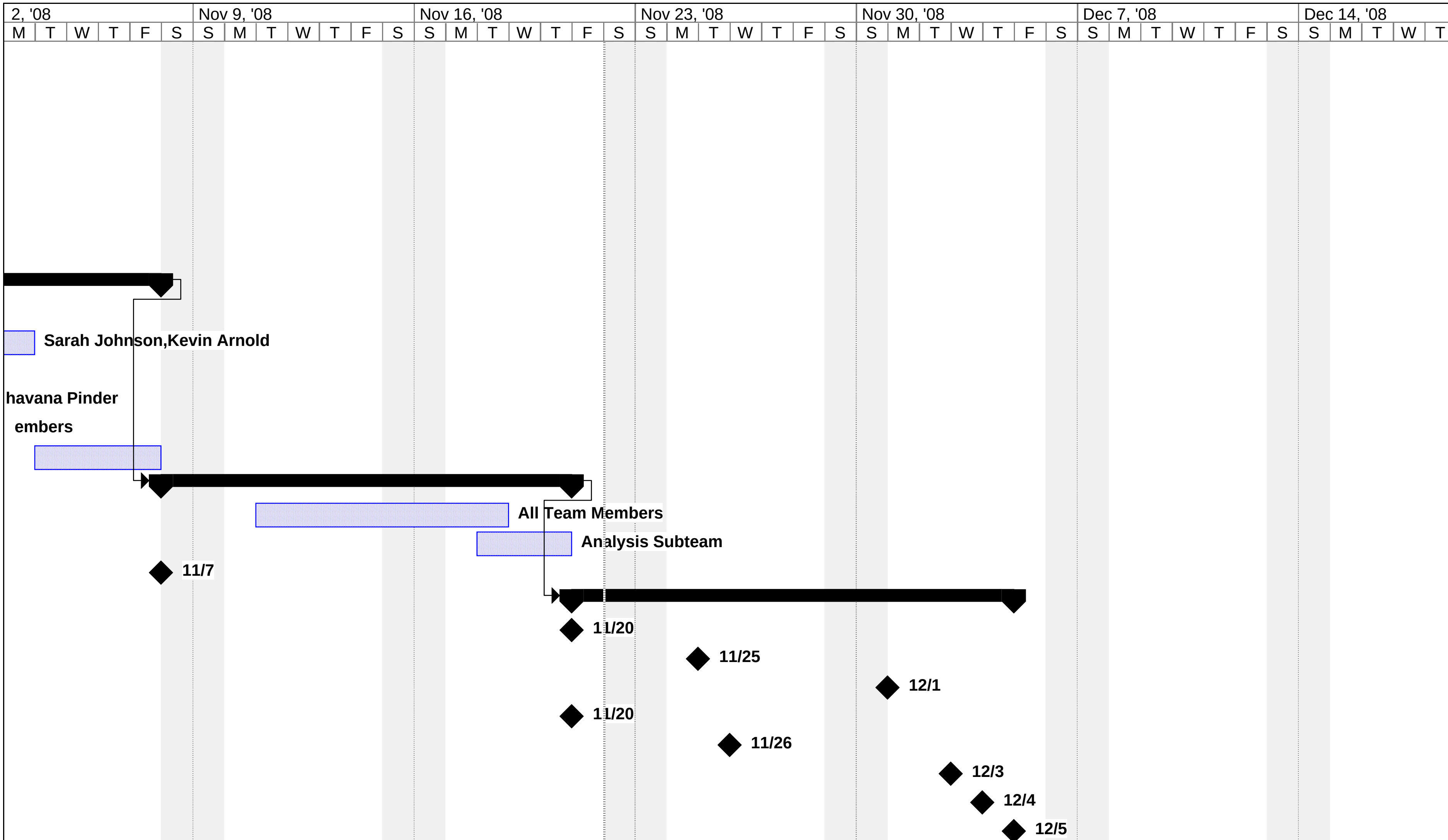
Project: IPRO 343
Date: Sat 11/22/08

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline



Project: IPRO 343
Date: Sat 11/22/08

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	



Project: IPRO 343
Date: Sat 11/22/08

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Appendix 3 – Experiment Methodology Report

"Using White Noise to Improve Order Accuracy in Noisy and Distracting Environments."

Kevin Arnold

Matthew Campen

Shaun Doran

Karen Hong

Sarah Johnson

Scott Justus

Halcyon Lawrence

Susan Mallgrave

Shavanna Pinder

Russel Ucci

25 November 2008

I. ABSTRACT

In this study, we investigated whether the addition of white noise (broadband noise between 100Hz and 10,000Hz) delivered to a listener through one side of a headphone set while listening to speech-in-noise through the other side, influenced speech intelligibility for native and non-native English speaking listeners. In an experiment conducted over four days, we explored the influence of white noise for our native and non-native participants, as they listened to pre-recorded simulated fast-food orders and then noted down these orders on data sheets. The results showed that white noise had a positive effect on order accuracy, perhaps even as much as more expensive alternatives such as higher-quality microphones, headsets, and other hardware.

II. INTRODUCTION

Research in the area of acoustics is not new. Its application specific to quick-service restaurants (QSR) is a new area and provides IPRO 343 with an opportunity to apply existing methodology to a relatively new problem. IPRO team 343 conducted an experiment designed to test factors that influence an employee's ability to accurately capture an order. In particular, the goal of the experiment was to determine whether the addition of white noise improves order accuracy in a kitchen environment with significant ambient noise.

A three-factor mixed experimental design was used to test the hypotheses. The design consisted of (1) a two-factor within-subjects Analysis of Variance, where factors under consideration were the presence or absence of broadband noise, and fidelity of the signal (high or low fidelity), and (2) a between-subjects Analysis of Variance, where the factor under consideration was participant familiarity with English (native speaker or not). Broadband noise is a signal with all frequencies between 100 and 10,000 Hz present, i.e. TV static. A low fidelity signal is one where frequencies below 300 and above 3400 Hz are filtered (i.e. telephone quality), and a high fidelity signal is one that is not filtered. The dependant variables are (1) speech intelligibility index (2) and duration of time to complete the listening task. Methods for collecting and measuring the dependant variable are described below.

II. METHOD

This experiment compared the intelligibility of phrases for 60 native English-speaking listeners in the presence of pre-recorded background chatter, presented either at a high babble level of75 decibels (dBA) or at a low babble level of 70 decibels under one of four conditions: high fidelity with white noise (broadband noise between 100Hz and 10,000Hz), low fidelity with white noise, high fidelity with no white noise, and low fidelity with no white noise. Included in the study were non-native English-speaking listeners who heard only the high babble (75 decibels) condition.

The team hypothesized that masking background chatter with white noise may contribute to order accuracy, perhaps even as much as more expensive alternatives such as higher-quality microphones, headsets, and other hardware.

Participants were asked to play the part of employees in a simulated drive-thru station in a quick-service restaurant (QSR) and were asked to listen to pre-recorded "orders" from "customers". Listeners were asked to note down these orders while simultaneously hearing pre-recorded background chatter (four speakers reading different articles from Chicago Tribune newspaper at the same time). The orders were presented in both high- and low-quality formats (the latter, to simulate the current low-quality audio of most drive-thru environments) and for half of the orders, white noise was included. The participants wore Koss UR/20 headphones that played individual orders on one side and background talk and white noise on the other side, consistent with the industry practice of drive-thru employees typically using head sets with speakers covering just one ear.

A. Participants

1. Speakers

Six native speakers of general American English provided recordings to be used as the orders for the experiment.

Four native speakers of general American English provided recordings to be used as the babble for the experiment.

All eight speakers were undergraduate and graduate students of Illinois Institute of Technology.

2. Listeners

Seventy-seven undergraduate and graduate participants were recruited (Appendix A: “Recruitment methods”) from IIT's campus and received a meal of pizza, soda, and cookies for their participation in the experiment. Five participants were omitted from the final analysis: one participant lost track of which answer he was on during experiment and the overall sequence of answers became confused on his data sheet, one participant was observed to occasionally remove one side of her headphones so that she could hear the prerecorded order without babble interference, and three participants only recorded 4 out of 5 item answers to each of 84 questions on their data sheets. The remaining 72 participants were native and non-native speakers of

English, all of whom reported having normal hearing.

B. Stimuli

The sound files for the experiment were designed with the purpose of creating four conditions within two sound levels. In order to accurately represent a drive-thru environment, babble was recorded to simulate the effect of hearing kitchen chatter, as most employees do at quick service restaurants. In addition, white noise was used in some conditions to mask the babble; this was the independent variable. Stimulus files were created and filtered at high- and low-fidelities: the low-fidelity stimulus files are representative of the common fidelity levels in drive-thru communication systems today. The high-fidelity files are representative of communication that could take place with an improved speaker and microphone system.

The sound files were created in 3 parts:

1) stimulus was recorded and filtered
2) white noise was created
3) babble was recorded

1. Generating stimuli

A uniform script pattern was developed that could be used for each order. In an effort to achieve a test that would not have a ceiling effect (perfect scores by subjects), the script was intentionally designed using words that would be difficult to understand in low-fidelity situations, as filtering the sound would also filter some of the sounds' distinguishing frequencies. The script had three sections: first, a number between one and ten was selected, as "I would like a number" (number of order selected between one and ten). Next, the script included a selection of "topping." This section included the words "cheese, beans, peas, pickles, potatoes, and tomatoes." The spoken script followed two sequences; first "with (topping one)", and "without (topping two)," second, "without (topping one)" and "(topping two)." Therefore, in each order, a participant would need to select two toppings, one to include with the order and one to exclude. The final section included sides and drinks, with the following words: "pies, fries, rice, Sprite, Coke, Diet Coke, lemonade, and Gatorade." The complete order was as follows:

"I would like a number (order number), with (topping one), without (topping two), with (side/drink one) and (side/drink two)."

Or

"I would like a number (order number), without (topping one) with (topping two), with (side/drink one) and (side/drink two)."

The orders were created using the random function in Microsoft Excel. To assign words, each word was given a number, for example, cheese was one and beans were two. Once Excel had generated a column of random numbers for each space in the script, the numbers were replaced with the correlating word. This was completed for a total of 24 orders.

Once the script was completed, members of the IPRO 343 team recorded each order. Each of 6 members spoke 4 of the order scripts to record the 24 stimulus files. These recordings were saved in 2 formats. The first were saved at the fidelity of the recording equipment to make 24 high-fidelity files. A second set of 24 were filtered, using Praat, between 200 and 340Hz; these were used as low-fidelity files in the experiment.

2. Generating white noise

White noise (broadband noise between 100Hz and 10,000Hz, essentially, TV static) was created using Praat. The program allows users to create sounds, and white noise with a range of 20,000Hz was created for the experiment.

3. Generating multi-talker babble

Several methods were tested in the attempt to produce a recording that would mimic background chatter similar to the babble present for employees in a fast-food drive-thru environment. Recorded live conversations were thought to be most realistic, as speakers talk naturally, with varied pitch and intonation. However, overlapping two conversations resulted in only two voices at any one time rather than four voices, and the recorded conversations were found to be of low quality.

Subsequently, four speakers were recorded simultaneously reading different articles from Chicago Tribune newspaper. It was feared that speakers reading from a script or article might result in flat speech that sounded unnatural, but when combined with other scripted recordings, the outcome was realistic and functional for this experiment.

Sound levels were needed to decide the volume of the babble. The acoustics team determined to take decibel level readings inside a restaurant kitchen. No fast food restaurant was available, so Chicago Chop House was chosen for this experimental procedure. A member of the team used a decibel reader for a minute at a time five different times (during the same visit) in order to capture the decibel level. The results were as follows:

1) 87.3 dBA
2) 83.8 dBA
3) 81.6 dBA
4) 87.5 dBA
5) 89.7 dBA

4. Combining the files

Combining the stimuli, babble, and white noise created the complete sound file for the experiment. Each stimulus was placed in 8 conditions with the following features: first, the sound was of high or low fidelity (+/-), second, the sound was combined with high (75Hz) babble or low (70Hz) babble (H/L), and third, the babble was masked with noise or left unmasked (N/X). For the experiment, participants either heard high babble levels or low babble levels, meaning they would only listen to 4 conditions:(HX+, HX-, HN+, HX-) or (LX+, LX-, LN+, LN-). The files in each of the conditions was created using Praat. First, stimulus recordings were reformatted to mono sound files. The files were filtered and saved in low-fidelity. Next, each individual sound file for the babble was made into a mono file. Two of the files were combined together and then made mono, and the other two were combined and made mono. These two files were then combined and made mono. White noise was added to these files for the conditions with white noise. Finally, combining the babble files with the stimulus files created a stereo file that could be imbedded in the experimental interface.

C. Designing the experimental procedure

1. Generating experiment instrument—rating form

The instrument could not be designed until the stimulus was finalized. The final stimulus had a specific pattern for each order. For example: "I'd like a number 2 with peas, without beans and coke and fries."

The first iteration of the form, (see figure 1) created a challenge, because the columns for 'with' and 'without' were separated. It was determined that this layout would point the participants too easily to the pattern of the stimulus.

Figure 2: Participant rating form – 1st iteration

Q	I'd would like a number:	with…	without…	and…
1	1 2 3 4 5 6 7 8 9 10	□ Cheese □ Beans □ Peas □ Pickles □ Potatoes □ Tomatoes	□ Cheese □ Beans □ Peas □ Pickles □ Potatoes □ Tomatoes	□ Pies □ Fries □ Rice □ Sprite □ Coke □ Diet coke □ Lemonade □ Gatorade

The second and final iteration combined these two columns and participants were given very specific instructions how to indicate 'with' and 'without' options (see figure 2).

Figure 3: Participant rating form & instructions – final iteration

For each order you hear please check (✓) or cross out the appropriate word as in the example given below:

I would like a number 2, with cheese, without pickles and a diet coke and fries.

				For Official Use Only	
Q	I'd would like a number:	Topping	Side/Drink	Total Correct	Time Taken
1	1 2 3 4 5 6 7 8 9 10	□ Cheese	□ Cheese		

		□ Beans □ Peas □ Pickles □ Potatoes □ Tomatoes	□ Beans □ Peas □ Pickles □ Potatoes □ Tomatoes		

The cover page of the rating form required team members to fill out the following participant data: Participant number (this will be discussed later in this section) and if the participant would be exposed to high or low babble (75/70 condition) and demographics such as age, left- or right-handedness, and whether the participant was a native- or non-native speaker of English. A sample of the final rating form is provided in Appendix B: "Rating Form."

2. Creating the experiment interface—PowerPoint document

The interface for the experiment was Microsoft PowerPoint. This package was chosen because:

- It provided a simple way of timing the experiment.
- Each order could be mapped to one slide.
- It was assumed that participants would have relatively little or no problems in using the software.
- The software was very familiar to team members.
- The interface allowed for both the audio and visual interface.

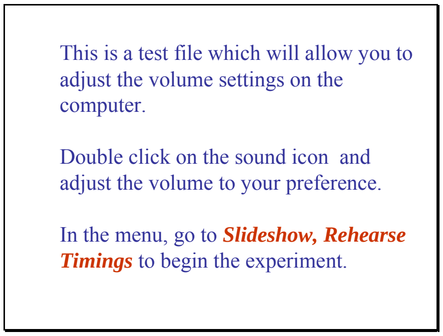
3. Designing the PowerPoint file

The PowerPoint file had 95 slides, including one with pre-experiment instructions and one with post-experiment instructions to the participant and 1 slide for each order—84 slides in all.

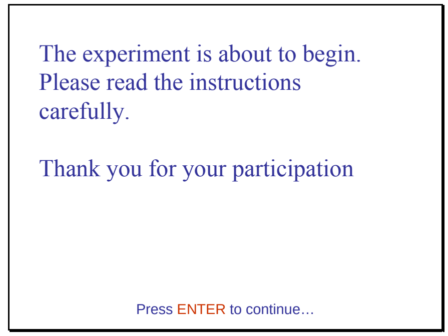
Figure 3 below provides a sample of the slides used in the PowerPoint presentation. Because slides 4 and 5 provided instructions to participants on how to fill out the instrument, these instructions were not duplicated on the instrument itself.

Figure 4: PowerPoint interface for experiment

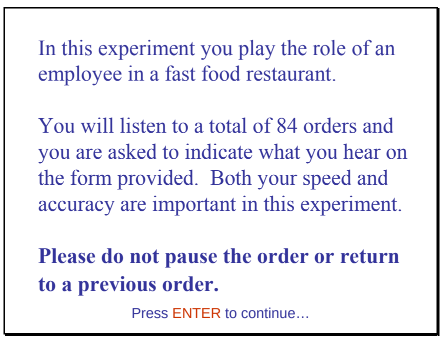
Slide 1



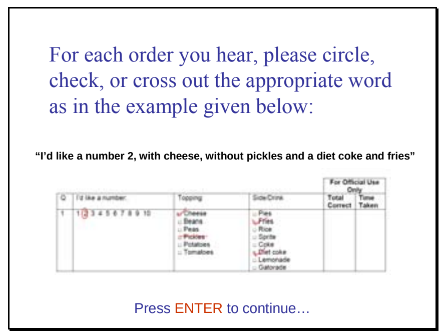
Slide 2



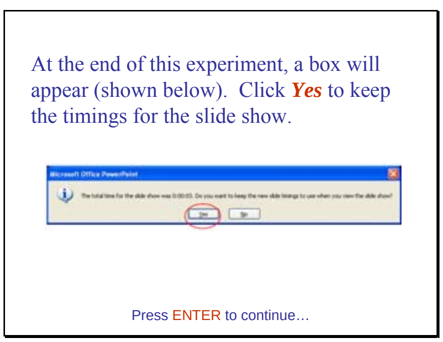
Slide 3



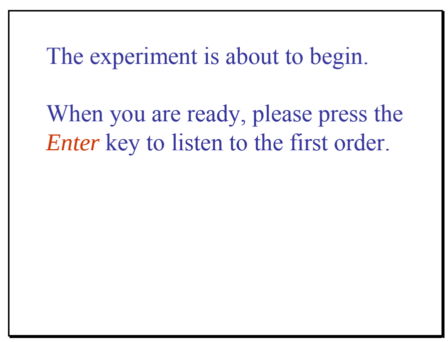
Slide 4



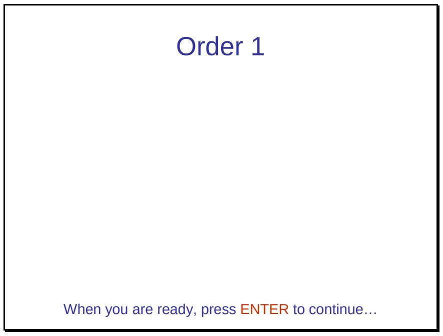
Slide 5



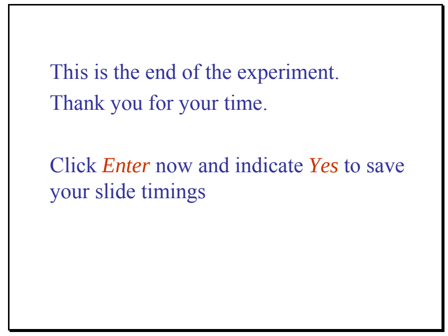
Slide 6



Slide 7



Slide 8



4. Integrating sound and visual using PowerPoint

Three team members worked on integrating the sound and the visuals. Once the template was completed (see Figure 3) and all the sound files were recorded, team members were provided with the order in which participants would hear the sound files (see section B "Stimuli"). A step by step presentation has been created using Camtasia which illustrates how the sounds and visuals were integrated.

5. Setting up the experiment

For every experiment, a team leader was selected. The following is a chronological listing of activities undertaken by both the team leaders and the members to conduct the experiment:

- The experiment PowerPoint file was copied onto the hard drive (c:\) of the machines.
- To save participant results, a folder was created on the desktop of machine named **IPRO343_ddmmyy**. **This task is only done once for the day, not for each experiment time period.**
- The master registration sheet was filled out by the experiment team leader for each new participant. This was done to ensure that unique participant numbers were assigned.

D. Procedure

As each participant entered the computer lab on the days of the experiment, he/she was asked to read and sign a consent form. When this task was completed, the participant was assigned a unique number, which was written on the cover sheet of his/her rating form (to be used by the participant during the experiment). Also written on this cover sheet were the answers to 4 questions posed to the participant:

1. "How old are you?"
2. "Are you right- or left-handed?"
3. "Is English your native language?"
4. "Are you aware of any hearing problems you have?"

At this point, the participant was seated facing a computer monitor and given headphones to be worn one way if participant was right-handed (indicated by instructions on the headphones), and reversed if the participant was left-handed. Participant was then shown how to test the sound level of the headphones to make sure of comfort level. The participant was given instructions on what to do to begin a PowerPoint file, and told they could raise a hand to ask a question at any point during the experiment. Slides 1-6 of the PowerPoint file contained instructions on how to proceed with the experiment (for all instructions contained in slides 1-6, see page __ part *3. Designing the PowerPoint file* under section *C. Designing the experimental procedure*).

Stimuli were presented diotically over headphones (describe make and model of headphones). Participants were presented with a total of 84 trials—prerecorded simulated fast-food orders—and asked to indicate what he/she heard by making notations (circle, check, or cross-out) on the rating form. They were told in the instruction slides that both speed and accuracy were important. Each participant heard "orders" in the presence of pre-recorded background chatter, presented either at a high-babble level (75 decibels) or at a low-babble-level (70 decibels) under one of four conditions: high-fidelity (definition) with white noise (broadband noise between 100Hz and 10,000Hz), low-fidelity (definition) with white noise, high-fidelity with no white noise, and low-fidelity with no white noise. The task was self-paced; a participant pressed the enter button to advance from trial to trial. Participants could listen to each order no more than once and were informed of the end of the experiment by the last slide of the PowerPoint, which also instructed them to "click *enter* now and indicate *yes* to save your slide timings."

III. RESULTS

Results of the Analysis of Variance for speech intelligibility revealed significant main effects for all three factors, and an interaction between the noise and fidelity conditions. There were no other interactions (Table 1). There were no main effects or interactions for duration of time to complete the listening task.

TABLE 1. Results of Analysis of Variance, by factor and interactions, performed on speech intelligibility (a)

FACTOR	F
Noise	64.4**
Fidelity	93.4**
Nativeness	21.3**
Noise*Fidelity	36.1**
Noise*Native	1.8
Fidelity*Native	0.4
Fidelity*Native*Noise	0.7

IV. Discussion

The noise condition led to improved intelligibility, as did the high fidelity condition, and the low fidelity condition without noise led to the worst intelligibility. Both native and non-native English speakers performed similarly; however, native speakers performed, on average, better than non-native speakers, but this does not mean that native speakers had categorically higher scores than non-native speakers. Some non-native English speakers performed just as well as native speakers. Indeed, almost a fourth of the non-native participants scored in the top half of the overall pool of participants. At the same times, several non-native speakers had very low intelligibility scores, which skewed the performance of the overall group downward.

V. Recommendations

The team found that white noise had essentially the same benefit on order accuracy of low quality orders as on orders of higher signal quality. In short, adding a white-noise generator or some similar noise-cancelling device near the drive-thru window might be a viable tool to improve order accuracy in the QSR industry, providing the same benefits as a major overhaul of audio hardware and at a fraction of the cost.

Appendix 4 – Annotated Bibliography

Bent, Tessa, & Bradlow, Ann R. (2003). The interlanguage speech intelligibility benefit. *Journal of the Acoustical Society of America*, 114 (3), 1600-1610.

Second-language learners often report that the speech of a fellow non-native talker is easier to understand that the speech of a native talker. This paper investigates this phenomenon and that of native and target language interaction during the acquisition of second language sound structure at the level of overall sentence intelligibility. Native talkers of Chinese, Korean, and English were recorded reading simple English sentences. Native listeners of English, Chinese, and Korean, along with a group from various language backgrounds then performed a sentence recognition talk with the recordings from the five talkers. Findings show that native English talker was most intelligible for native English listeners, but for non-native listeners, speech from a relatively high proficiency non-native talker from the same native language background was as intelligible as speech from a native talker ("matched interlanguage speech intelligibility benefit"). Also, this benefit extended to non-native talkers and listeners from different language backgrounds as well ("mismatched interlanguage speech intelligibility benefit"). Findings are relevant to IPRO 343 and international client.

Bradlow, Ann R. & Pisoni, David. (1999). Recognition of spoken words by native and non-native listeners: Talker-, listener-, and item-related factors. Journal of the Acoustical Society of America, 106 (4), 2074-2085.

Which of the clear speech acoustic-phonetic factors are most effective in aiding speech communication? How do listeners tune their performance according to communicative and situational demands? This paper looks at how the speech signal varies across a range of conditions, as well as how the variables affect listener performance. Findings provide insight into the signal-dependent and signal-independent factors (degree of variability in the stimulus materials, familiarity on the part of the listener with the talker's voice and articulatory characteristics, the lexical characteristics of the particular words in a stimulus set) that influence spoken language processing in native and non-native listeners, and that this type of fundamental knowledge about the way in which listeners compensate for multiple sources of variability in speech also provides insight into the perceptual mechanisms that underlie spoken language processing. Highly relevant to IPRO 343 examinations.

Bradlow, Ann R., Kraus, Nina, & Hayes, Erin (2003). Speaking Clearly for Children With Learning Disabilities: Sentence Perception in Noise. *Journal of Speech, Language, and Hearing Research*, 46, 80-97.

Groups of children with and without learning disabilities were studied to compare their speech-in-noise perception abilities, and whether naturally produced clear speech yields perception benefits for learning-disabled children. It was found that both groups benefited substantially from naturally produced clear speech. The authors favor talker-based approach to speech intelligibility over attempts to improve listeners' speech perceptions, or acoustic properties of speech signal, although a further goal of the study was to identify the most beneficial specific acoustic-phonetic enhancements for study subjects. (A finding that makes this study relevant to IPRO 343.) These enhancements include articulatory precision and effort, raised average pitch, and increased consonant-to-vowel intensity ratio. Research for this and earlier articles "provide evidence that various signal distortions, including background noise and reverberation, present particular difficulties for listeners with speech perception problems, including listeners with impaired hearing and from different language backgrounds" (A finding which is also relevant to IPRO 343).

Hazan, Valerie, Markham, Duncan. (2004). Acoustic-phonetic correlates of talker intelligibility for adults and children. *Journal of Acoustical Society of America*, 116 (5) 3108-3118.

Study examines whether the relative intelligibility of speakers is dependent on listener or speaker characteristics. In the first experiment (measurement of word intelligibility, with material consisting of 124 words presented to 135 adults and children in low-level background noise), the relative intelligibility of individual talkers was highly consistent across groups. In the second experiment (listener ratings on a number of voice dimensions), intelligibility was found to correlate with subjective dimensions of articulation, voice dynamics and general quality. In third experiment (measures of fundamental frequency, long-term average spectrum, word duration, consonant-vowel intensity ratio, and vowel space size), intelligibility was correlated with the total energy in the 1-to3kHz region and word duration. Findings of intelligibility being consistent across listener age groups suggests that the acoustic-phonetic features of a speaker's statements are the primary factors in determining talker intelligibility. Relevant to IPRO 343.

Krause, Jean C., Braida, Louis D. (2004). Acoustic properties of naturally produced clear speech at normal speaking rates. *Journal of the Acoustic Society of America*, 115 (1), 362-378.

In producing clear speech (shown in numerous studies to be significantly more intelligible in a variety of backgrounds than conversational speech) speakers often reduce their speaking rate. Studies (including an earlier one by these authors) have shown that talkers can produce clear speech at normal rates with training, so speaking slowly is not solely responsible for the intelligibility benefit. The present study analyzes three levels of detail (global, phonological, and phonetic) of conversational and clear speech at normal speaking rates. Findings suggest that two global-level properties, increased energy in the 1000-3000-Hz range of long-term spectra and increased modulation depth of low frequency modulations of the intensity envelope, may be involved with improvements in intelligibility provided by clear speech. Relevant to IPRO 343.

Payton, K. L., Uchanski, R. M., & Braida, L. D. (1994). Intelligibility of conversational and clear speech in noise and reverberation for listeners with normal and impaired hearing. *Journal of the Acoustical Society of America*, 95 (3), 1581-1592.

Study re-establishes that clearly articulated speech has been shown to be more intelligible to hearing-impaired listeners in quiet, and to normal-hearing listeners in noisy conditions. Attempt of present study was to determine whether normal-hearing and impaired hearing listeners would demonstrate intelligibility benefits from clear speech in a wider variety of acoustic environments. Clear speech was shown by their experiments to be more intelligible for all listeners in all degraded listening conditions, offering an important benchmark for those interested in improving intelligibility of conversational speech in such environments, as in drive-thru restaurant conditions as investigated by IPRO 343.

(Side Note: Both the **Speech Transmission Index (STI) and the Articulation Index (AI)** reliably predicted performance levels within a speaking style for normal-hearing listeners, but the AI was unable to represent the reduction in intelligibility scores due to reverberation for the hearing-impaired listeners. Neither predictor accounted for the difference in intelligibility due to speaking style.)

Smilijanić, Rajka, & Bradlow, Ann. (2007). Clear speech intelligibility: Listener and talker effects. *Saarbrücken, XVI,* 6-10.

Findings from previous studies regarding benefits of clear speech are extended in this study to explore whether clear speech strategies (decrease in speaking rate, expansion of pitch range, and other such modes adopted by speakers under adverse listening conditions) by native talkers in their first language and non-native talkers in their second language are beneficial to native and non-native listener groups. Results showed that "native" speech is preferred over "foreign" accented speech by both native and non-native listeners. Outcomes also showed listening to "foreign" accented speech affects both native and non-native listeners regardless of whether they share the same background first language or not. And finally, results revealed that clear speech is a beneficial modification regardless of the listener's and talker's first language backgrounds. All findings that have relevancy to IPRO 343 proposals.

Van Engen, Kristin J. & Bradlow, Ann R. (2007). Sentence recognition in native- and foreign-language multi-talker background noise. *Journal of the Acoustical Society of America,* 121 (1), 19-526.

Study was conducted to determine whether the adverse effect of background speech is due to the linguistic content or to the acoustic characteristics of the speech masker. Results showed poorer English sentence recognition by native English listeners in six-talker babble than in two-talker babble, regardless of the language of the babble. Results showed that in two-talker babble, native English listeners were more adversely affected by English babble than by Mandarin Chinese babble. The findings demonstrate that informational masking on sentence-in-noise recognition in the form of "linguistic interference" plays a role in perception of speech in noise.

Research would seem to have direct meaning for IPRO 343 study, to establish underlying parameters of difficulty in noisy environment, as study shows that higher noise levels and greater numbers of talkers in multi-talker babble decrease target speech intelligibility, no matter what language is being spoken in the noise.

van Wijngaarden, Sander J., Steeneken, Herman J.M., & Houtgast, Tammo. (2002). Quantifying the intelligibility of speech in noise for non-native listeners. *Journal of the Acoustical Society of America*, 111, (4), 519-526.

Particularly under adverse conditions such as noise, reverberation, background babble, and the like, non-native speech communication tends to be less effective than purely "native" speech. The approach of these researchers was to study the intelligibility effect of non-nativeness in its own right, so that this information could be directly applied in engineering-oriented disciplines associated with speech communication (speech intelligibility in room acoustics, design of communication systems, etc.) Authors stated purpose is "to quantify speech intelligibility in noise for specific populations of non-native listeners, only broadly addressing the underlying perceptual and linguistic processing." Applicable to IPRO 343 in the sense of helping to establish definitively that there is lessened intelligibility of speech in noise for non-native listeners.

Other references include:

Dodd, Barbara. (1977). The Role of Vision in the Perception of Speech. Perception, 6, 31-40

Helfer, Karen S. (1997). Auditory and Auditory-Visual Perception of Clear and Conversational Speech. Journal of Speech, Language & Hearing Research, 40 (2), 432-450

Massaro, Dominic W., & Cohen, Michael M. (1983). Evaluation and Integration of Visual and Auditory Information in Speech Perception. Journal of Experimental Psychology, 9 (5) 753-771