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Relevant Angry Affect Slows Response Time To Commands

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RELEVANT ANGRY AFFECT SLOWS RESPONSE TIME TO COMMANDS

THESIS

A thesis submitted in partial
fulfillment of the requirements for
the degree of Master of Arts in
Linguistic Theory and Typology in
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By

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2020

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ABSTRACT OF THESIS

RELEVANT ANGRY AFFECT SLOWS RESPONSE TIME TO COMMANDS

Previous research has found that emotional prosody can interact with speech perception and listeners' processing of the meaning of particular word/emotion pairings (Kim and Sumner, 2017). What remains unclear is how this interactive processing can affect behavioral responses such as responses to imperatives. To answer this question, 71 participants were presented with a series of commands given in a relevant affect. Commands were read either with angry prosody, happy prosody, or neutral prosody (control) and the participants were instructed to press the requested button on a response box as quickly and accurately as possible. All emotional states were simulated and normed for perceived emotion, rather than induced. On average, participants responded 50ms slower to the commands which were performed with angry prosody than to the control (neutral prosody), and 164 ms slower when that angry prosody was given in a pragmatically relevant situation: after an incorrect response (see 4.1. There was no significant difference between responses to happy prosody commands and the control. This difference in response time may be due to the heightened neurological responses to angry stimuli. (Frühholz and Grandjean, 2013). These results are consistent with a model of speech perception in which linguistic and social information are processed simultaneously and interactively (Sumner et al., 2014), but not with a model in which emotional aspects of the speech signal are discarded or irrelevant to perception. The latency of the response to the pragmatically relevant angry commands observed in experiment two reinforces the findings from experiment one, where angry affect slows response time to commands.

KEYWORDS: response time, affect, emotion, prosody

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Dedicated to the hope that one day theses will be allowed in comic-strip form.

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To the UK Phonetics and Speech Perception Lab: Thank you for hosting three years of my button-pressing participants.

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Chapter 1 Introduction

Affect is a display of emotion through speech. The acoustic features of affect in spoken language often model after the physical features of emotion Bachorowski (1999).

Affect, also called emotional prosody, is often categorized as social information (Kim and Sumner, 2017). The boundaries between the categories of "social" vs "semantic" are contested along with the level of interactivity that occurs at the level of processing ((Sumner et al., 2014)).

Affect can affect processing time. Affect can cause changes in response time on a lexical decision task Kim and Sumner (2017). Affect of high enough intensity, and particularly of the negative variety, can also be associated with higher-intensity neurological responses from listeners, particularly in the amygdala Frühholz and Grandjean (2013).

Processing takes time, which is why response time studies shed light on things like processing order and load. Wingrove and Bond (2005) shows correlation between faster response times and congruent affect in a story reading task, concluding that interpreting an anger-inducing situation in a narrative while performing anger is a lower processing load than when the performance emotion and the narrative situation do not match.

Affect as the independent variable in a response time study illuminates the work it takes for a listener to process acoustic information that codes for emotion, as well as whether the amount of work differs between emotions. Slower response times may be due to greater neurological response loads in emotion processing centers, especially if the act of processing the emotion attached to the command competes with a listener's ability to complete the action requested by the speaker (Schirmer and Kotz, 2003).

In this thesis, response time to happy affect (a positive valence emotion) and angry affect (a negative valence emotion) will be measured against a neutral control to answer the question: what does affect do to the ability to follow directives?

Chapter 2 Important Concepts and Previous Work

2.1 Concepts

Brain Matters

Human brains process some events in our environment simultaneously. They process other events sequentially. Human brains are constantly processing their environments. This means there is a processing timeline.

There's a processing timeline for everything, from brushing your teeth to performing a gymnastics routine. Different neurologists are interested in different aspects of processing timelines. Likewise, different linguists are interested in different aspects of language and speech. When looking at the same concept, say word-final devoicing, a phonetician might see the sonority sequencing principle at work (wherein a syllable tends to have its most sonorant sounds in the middle and its most obstruent sounds on the ends) and a historical linguist would see the same phenomenon and be able to use that information to place the word in a time frame of the language's development where that sound change was common.

Neurolinguists want to know what happens to the brain when we encounter language. In other words, they would like to know the events that occur, the location of brain activity associated with those events, and the order they occur in.

Emotions

Emotion is a biological response to a relevant aspect of an environment.

It is not the only biological response to a relevant aspect of an environment. Logical processing is also a biological response to a relevant aspect of an environment.

Emotions can guide a person to a response, just as logical processing can.

This is because most emotions trigger the amygdalaLin et al. (2020), which mandatorily triggers the response known as Fight, Flight, Freeze, or Fawn. This response is due to something called the sympathetic nervous system. [1] If humans were simpler mammals, emotion would simply be something to be experienced. But humans have social structures. Humans have language. Emotion, for humans, is not just experienced. It can also be communicated. And this is where the linguistics comes in.

Emotions are communicated to manipulate social structures and convey need. Because of the importance of social structures in human society, the ability to com-

[1] When the sympathetic nervous system is triggered, it temporarily alters the body in a few ways. It releases response-catalyzing adrenaline, constricts blood vessels, stops biological processes like digestion and libido, and increases both heart rate and blood flow to muscles. Simply put, each of these changes helps a human's chances against a physical threat. If a physical threat fails to manifest, the body returns to its default state using the parasympathetic nervous system. This heightened state of defense can keep a person out of a potentially dangerous situation.

municate emotion is valuable (Lamers and Hall, 2003). Being able to parse emotion is also essential.

Human emotion can be described as a set of distinct feelings, but here it is helpful to imagine it on a graph where the y-axis is valence (how positive is the emotion?) and the x-axis is arousal (how intense is the emotion?) (Hepach et al., 2011). This conceptualization of emotion is illustrated visually in the graphic 2.1.

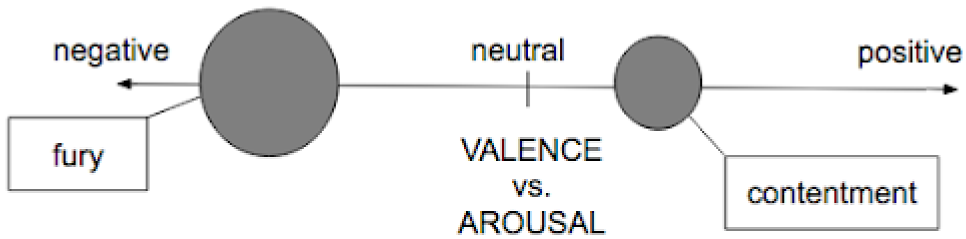

Figure 2.1: Arousal and Valence Graphic. Categorizing emotion. Left to right, negative to positive valence with neutral as a midpoint. Arousal is indicated by circle size on the spectrum of negative to positive. Fury is high arousal, negative valence. Contentment is low arousal, positive valence.

Perception of Affective Prosody

Language is arbitrary. For example, 2.2 is a sketch of a house.

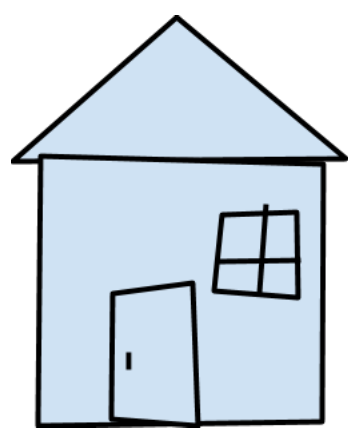

Figure 2.2: House. Two-dimensional line drawing with a roof, window, and door.

Observe the structure of this sketch. You can identify the walls, the window, the door, the roof, and the floor, all from simple lines. These are things that are inherent to the definition of "house". But not everything about how we communicate this concept is inherent. While we sometimes use visual representation to convey the concept of "the thing with walls and a roof and a door and a window where people live", we more often use language.

Specifically, in American English, we use some approximation of the sound structure /haus/. So I ask you to look again. Where in this image is the /h/ sound?
...

There is no /h/ in the above image. This is, of course, because while there is an /h/ in the pronunciation of "house" as well as the orthography, there is no /h/ in the concept of house.

This illustrates a point that might be obvious at this point but bears explicit statement nonetheless: language is a code, a shortcut, almost always one step removed from the concepts it is able to represent.

Affective prosody is a part of language, just like phonemes. But unlike phonemes, it sits in a gray area between arbitrary and inherent.

An analogy to onomatopoeia is, I think, fitting here. Because onomatopoeia, the words that sound like the things they refer to (think: words for animal sounds, noise words like "crash" and "bang", and texture words like "gush" and "squish"), are not arbitrary. The word for "that sound a cat makes" differs from language to language, but all share significant features with the noise itself. Like onomatopoeia, where there is a set of nonlinguistic sounds imitated in speech, there is a set of emotions that talkers try to communicate.

Response Time Studies

Response-time studies measure one thing. That one thing is the role of a variable as an inhibitor vs. the role of a variable as a catalyst. Response-time studies consist of an activity (held constant), an environment (held constant), and a variable in that environment (changes). A variable can be defined as an inhibitor if its presence causes a slower response time. A variable can be defined as a catalyst if its presence causes a faster response time.

Lexical decision tasks are one such response-time format, wherein a participant is asked to identify a visual stimulus as a word or a non-word. The response times for different visual stimuli can tell researchers how much time it took for the participant to identify the word status of the stimulus. Researchers can infer things like difficulty, processing load, and priming effects from how long it takes the participant to perform the task (Rubenstein et al., 1971).

A processing feature relevant to response time is the startle response. The body presents with certain measurable symptoms when presented with a novel stimulus. Pupillary dilation, subtle increase in heart rate and sweat production, and of course, changes in electrical current in the brain itself. The brain releases a measurable signal called the N400 when presented with a semantically novel stimulus. The N400 refers to a negative charge that occurs roughly 400ms after a stimulus is presented.

The brain also releases a P600 when presented with a syntactically novel stimulus, where the P refers to a positive charge and the 600 refers to 600ms after a stimulus is presented. Both the N400 and P600 responses can be associated with slower response times (Carlsen et al., 2012).

2.2 Previous Work

Previous literature examines the interactivity between lexical and social information in the form of a lexical decision task. In Kim and Sumner (2017), an experiment at Stanford explored whether emotion information could cross the perceived boundary between social and semantic processing. Kim and Sumner did this by exposing a participant to a stimulus (such as "refrigerator" or "pineapple") in voices that sounded angry, terrified, sad, or happy, with neutral as the control. Participants were shown a sequence of letters that could belong to one of four categories: not a word, a matching emotion word (e.g. 'fight' after the angry voice), a non-matching emotion word (e.g. 'smile' after the angry voice), or a word that had no semantic relationship to emotion (e.g. 'grass' after the angry voice).

Kim and Sumner show that the introduction of affective prosody can decrease decision time for words semantically related to that same prosody on a word/nonword task.

The ability to perceive the affective prosody of a stimulus does not stay isolated in one part of the brain while the rest works on semantic parsing. If that were so, the prosody of the word would not have been able to affect the response time to the emotion words, because the processes would not have contact with one another.

But what if the prosody itself was enough to speed or slow responses? The interaction between prosody-processing and semantic-processing wouldn't have to happen if prosody itself affected the ability to react.

If this were true, the expectation would be results with different response times regardless of visual stimulus, based only on the variance of the speaker's emotion. Instead, we see significance only in the decrease of response time (indicating priming) when a voice indicating anger precedes a word semantically related to anger.

Thus Kim and Sumner conclude that the listener is able to access semantic and social information at the same time, and in such a way that one type of information can inform the other.

The interactivity shown here is true for angry prosody, but not significant for prosodies emulating feelings like happiness, fear, or neutrality. Thus we go into our experiment with the knowledge that anger behaves differently in the brain of the listener, and the hypothesis that it will behave either as a catalyst or an inhibitor in our response time study.

Anger behaves differently. By now, this is a theme in the literature surrounding perception of affective prosody. At the Utrecht University in The Netherlands, Quené et al. (2012) explore the phonetic phenomenon of audible facial expression: the fact that smiling and frowning alters the acoustic information of an utterance. The motor theorists hypothesize that a sort of acoustic Stroop effect (Stroop, 1935; Schirmer and Kotz, 2003) would occur when a voice with an audible smile is paired with an affectively negative word: slower response time consistent with that of an inhibitor. The researchers interpret this particular incongruence as a semantic novelty, thus it is reasonable to predict that an N400 signal occurs. This appears to be the case. In stimuli normed for affect perception, response times to incongruent voice-semantic pairs are significantly slower than their phonetically neutral counterparts.

In essence, the intent of this investigation is to test whether an angry or happy voice can affect the accuracy and latency of an individual performing a direction-following task, and in doing so, gain insight into the effect perceived emotion has on information processing.

Chapter 3 Methods

I used a response time study to test the hypothesis that accuracy and latency of a response can be affected by emotionally neutral words (BIRD, DOG, FISH, GOAT) uttered in a non-neutral emotional prosody.

3.1 Participants

The participants in Experiments one and two were undergraduate students at the University of Kentucky. A total of 71 students participated in the two studies in exchange for extra credit in introductory linguistics classes (42 for experiment one and 29 for experiment two).

3.2 Experiment 1

In this section I report previous collaborative work performed prior to the thesis. Combs et al. (2019) reports a simple reaction time experiment designed to test listeners' ability to follow commands given with different emotional prosodies.

Auditory Stimuli

Stimuli were recorded for the phrase "Press the [target] button."

Targets were:
- Bird
- Dog
- Fish
- Goat

Each phrase was recorded in three different prosody modes.

Prosody modes were:
- ANGRY
- HAPPY
- NEUTRAL

Of each of these twelve prosody TYPES, our voice actor recorded three TOKENS. The decision to play more than one iteration of each type to the participant was made so that I could measure response to TYPE rather than to individual TOKENS (i.e. "this was the average response time to our actor's ANGRY voice", not "this was the average response time to our actor's ANGRY voice file."). This gave me 36 total stimuli, plus four practice stimuli whose purpose was simply to aid the participant in task learning and whose results were therefore not included in the analysis.

Stimuli were controlled for intensity on the grounds that intensity can index emotional prosodies on its own (Chen et al., 2012).

Implementation

The experiment was implemented in OpenSesame, which is a modular interface that runs on a Python base (Mathôt et al. (2012). Participants were instructed to interact with the experiment through a four-button Black Box USB response pad. Stickers on each button denoted which animal the button corresponded to, and the layout was also displayed on the screen. From left to right, the buttons were DOG, FISH, GOAT, BIRD. Participants heard the stimuli via over-the-ear wired headphones set to a comfortable listening level.

Participants were allotted 3000 ms to respond to each stimulus, after which the response window would time out, and the next stimulus would begin. Average response time and overall accuracy was shown to them once after the practice round, and again after the experiment.

There were 42 participants in Experiment 1, but four participants indicated lack of understanding or engagement with the task (received an accuracy score of under 85%).

Thus there were 38 participants whose results were included in the analysis.

Using neutral as a control, Experiment 1 found significant slowdown in the angry prosody responses, from 876.3 ms to 923.4 ms. There was not significant slowdown from neutral to happy, or from happy to angry, as avg. response time to happy was 902.6 ms.

Discussion

Not only were these stimuli not normed (there's no quantitative way to tell whether the participants perceived the stimuli as the emotion intended), but I chose two prosodies that occur fairly often without context in Mainstream American English (happiness and neutrality), and one that doesn't (anger). Thus the slower response rate cannot be attributed to prosody alone, and implications cannot be extended to other situations in much of a useful way at all. There is a case here for lack of context masquerading as a response to the angry stimulus itself: in their exploration on the effect of idioms in a lexical decision task, Swinney and Cutler (1979) postulate the existence of "a decision device which considers context in a pragmatic manner and which allows the most likely of several computed meanings to be made available to conscious access". Their findings directly imply that context decision takes time and processing power.

3.3 Experiment 2

Auditory Stimuli: Reimagined

For Experiment 2, the stimuli were re-recorded using a visual metronome, a survey for perceived emotion, and two voice actors instead of one.

Since the Black Box features four buttons, my stimuli had the same four targets as Experiment 1. The prosody modes also remained unchanged from Experiment 1.

So that my results were not constrained to "variation in prosody in masculine-performed voices produces X results", there are two SPEAKER types, masculine and feminine.

The stimuli were normed for perceived emotion on 16 undergraduate students, and I removed all recordings that were not consistently rated as having the intended emotion.

Again, three tokens of each type (ex. MALE—ANGRY—FISH) were selected so that I could be sure the participants were not reacting to the tokens themselves, but the types they represented. In Experiment 2, there were a total of 72 tokens.

Implementation

Crucially, in Experiment 2, angry stimuli were contextualized. The experiment was modified so that angry stimuli were always and exclusively presented after the participant gave an incorrect response.

The issue with that was that my experiment was not designed to induce wrong answers, and in fact the accuracy cutoff for participants was 85% in Experiment 1 because the task was so easy that if someone got less than 85%, I assumed that they were just pressing random buttons. Therefore, the new task had to increase in difficulty so that the coveted angry stimuli would actually be encountered.

I removed the stickers.

Instead of each button being a constant, where the goat is always the second from the right button, for example, there were three layouts.

LAYOUT 1: DOG FISH GOAT BIRD

LAYOUT 2: BIRD GOAT DOG FISH

LAYOUT 3: FISH BIRD DOG GOAT

In Experiment 2, the three layouts were presented in random order. The participant was shown the key on the screen, and was allowed to look at it as long as they needed to memorize it. Then, the buttons were shown without the animals on them, but the layout number remained. When a response was correct, the participant was shown a green dot. The next stimulus was randomly selected from the happy and neutral file pool. When a response was incorrect, the participant was shown a red dot. When a participant did not answer in 2300 ms, the participant was shown a gray clock and the words "speed up".

In either of these cases, the next stimulus was randomly selected from the angry file pool. The experiment did not switch between the layouts during a trial set, and the practice was always presented in the same order as the experimental loop.

Chapter 4 Results

On average, participants responded 164ms slower to the commands issued in an angry voice than to the neutral (control) voice.

The median difference between anger and the control was 134ms.

On average, participants responded 2ms slower to the commands issued in a happy voice than to the neutral (control) voice. This gap increased to 22ms in the analysis of median response time.

The masculine voice was associated with slower response times as well as greater variance. Neither voice leads the response time effect in the main variable (emotion).

Angry commands elicited lower accuracy when compared to control (82.5% vs 91.1%).

4.1 Response Time

Response Time Tables

The average and median response times for each emotion are shown in the table below.

Table 4.1: Response time (ms) by emotion. This table sorts average and median reaction time to all non-practice commands for all participants by the emotion the command was given in.

Affect	Mean (ms)	Median (ms)
Angry	1682.847	1590.719
Happy	1521.221	1479.297
Neutral	1519.090	1457.142

Table 4.2: Response time (ms) by emotion and speaker gender. This table sorts average and median reaction time to all non-practice commands by emotion in which the command was given. The table further sorts these commands into the masculine-presenting voice and the feminine-presenting voice, comparing them to the total values as shown in 4.1

Affect	Mean (ms)			Median (ms)		
	Total	Fem Voice	Masc Voice	Total	Fem Voice	Masc Voice
Angry	1682.847	1698.647	1664.106	1590.719	1566.412	1612.654
Happy	1521.221	1599.219	1432.843	1479.297	1564.125	1357.238
Neutral	1519.090	1590.135	1432.315	1457.142	1532.593	1432.315

Response Time Plots

Anger shows increased response time in violin plots.

Response Time by Speaker Affect.

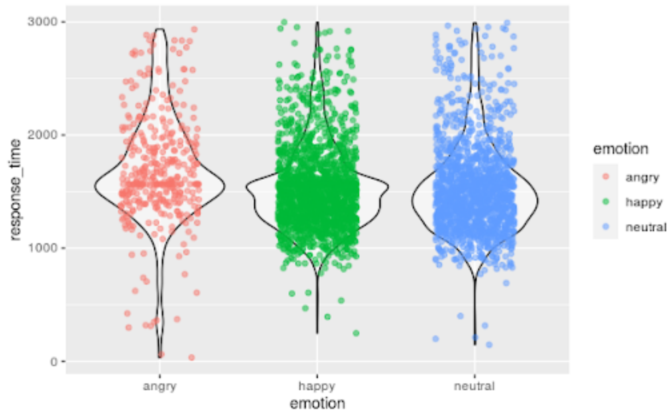

Figure 4.1: Violin plots compare individual trials for each prosody mode for response time. A visual representation of the data shown in 4.1, except instead of averages and medians, each trial's response time is shown as a point on the plot, allowing the graphic representation of variance.

Response Time by Speaker Gender.

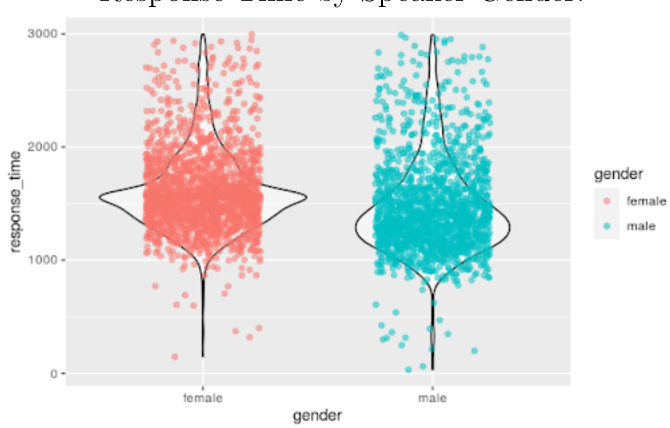

Figure 4.2: Violin plots compare individual trials for response time by speaker. Without looking at emotion, this graph shows each trial's response time as a point on the plot, allowing for the graphic representation of variance for masculine- and feminine-voiced commands.

Response Time by Speaker Affect and Gender.

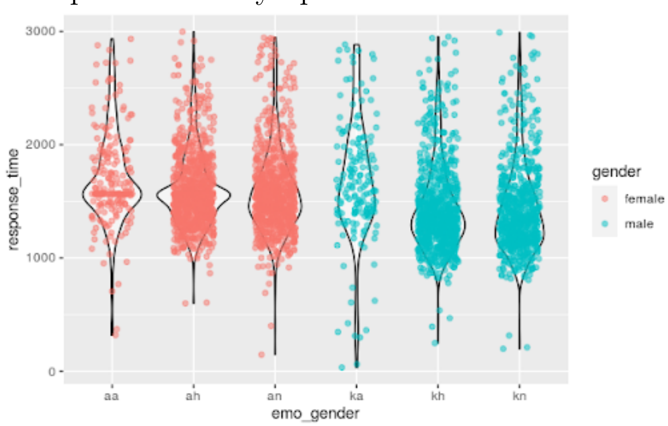

Figure 4.3: Violin plots compare individual trials for each prosody mode for response time by speaker gender. A visual representation of the data shown in 4.2, except instead of averages and medians, each response time is shown as a point on the plot, allowing the graphic representation of variance.

4.2 Accuracy

The average and median accuracies for each emotion are shown in the table below.

Table 4.3: Accuracy (%) by emotion.This table sorts average and median accuracy to commands by the emotion in which that command was given.

Affect	Mean (%)	Median (%)
Angry	82.50	85.17
Happy	91.17	93.75
Neutral	91.10	94.19

Table 4.4: Accuracy (%) by speaker voice and affect. This table sorts average and median accuracy to commands by the emotion in which the commands were given. These values are further sorted into the gender voice that the commands were given in. These are compared to the totals in 4.3.

Affect	Mean (%) Total	Fem Voice	Masc Voice	Median (%) Total	Fem Voice	Masc Voice
Angry	82.50	82.81	82.13	85.17	86.31	84.32
Happy	91.17	91.06	91.30	93.75	93.33	94.19
Neutral	91.10	91.08	91.13	94.19	94.19	94.19

Accuracy Plots

Accuracy by Speaker Affect.

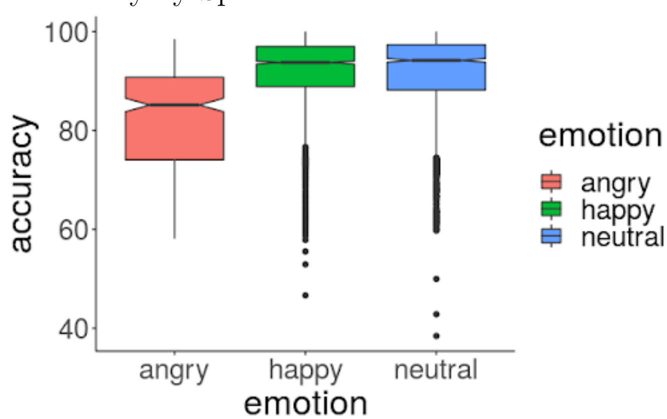

Figure 4.4: Box-and-whisker plots compare accuracy for each prosody mode. A visual representation of the data shown in 4.3, using total accuracy at the level of individual trial rather than averages/medians.

Accuracy by Speaker Gender.

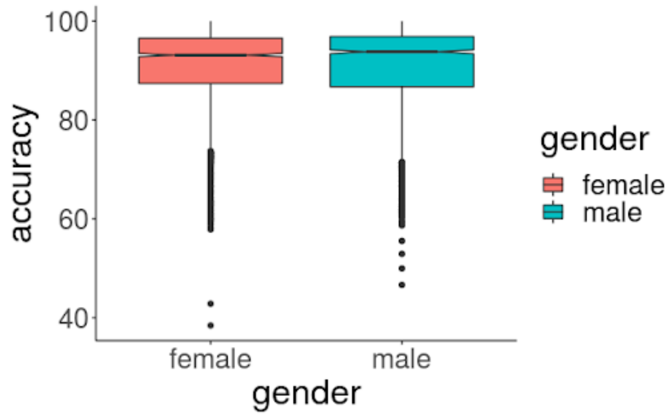

Figure 4.5: Box-and-whisker plots compare accuracy for both speakers. Showing little variance, this plot illustrates the conclusion that neither gender voice led the result.

Accuracy by Speaker Affect and Gender.

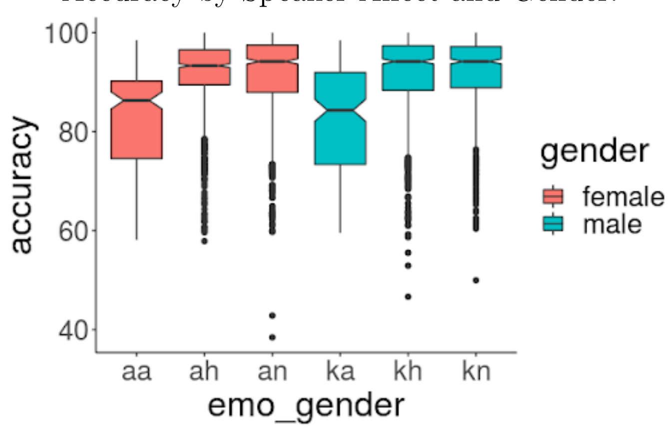

Figure 4.6: Box-and-whisker plots compare accuracy for each prosody mode and speaker gender.A visual representation of 4.4, this plot shows the different behavior of angry prosody regardless of gender.

Chapter 5 Statistical Analysis

A linear mixed effects model was used to ascertain the significance of these findings. The following table indicates significance.

Random intercepts were used in this model rather than random slopes, which is not ideal (Barr 2013), but random slopes obtained nonconvergence and singularity errors.

Table 5.1: Significance as indicated by a linear mixed effects model.

Effect	Significant?	p-value
Avg. Angry vs Neutral	yes	.015
Avg. Happy vs Neutral	no	.950

The accuracy decrease from the control to angry prosody has significance, but there is no way to tell whether the effect is from getting the previous question wrong or from hearing an angry voice since these always co-occur.

Chapter 6 Discussion

In experiments 1 and 2, there is significant slowdown for responses to the angry prosody commands (see 5.1). It can be inferred from this finding that the angry prosody itself, not the lack of salience, is what accompanies the phenomenon of higher response times.

The integrity of the accuracy measurements was sacrificed in Experiment 2 so that the relevance of the affect could be called into question, but it is notable that whether the 7% decrease in accuracy (figure 4.3) was due to participants having an immediate previous incorrect response or hearing an angry stimulus, the distinction would not be difficult at all to test.

My interpretation of the result of Experiment 2 separates the phenomenon observed from the predictions made by Swinney and Cutler (1979), wherein the activation of a context decision device increases processing power, which increases response latency. Because the effect noted in Experiment 2 occurs with and without the contextual cushion of wrong answers and angry voices co-occurring, I can predict the slowdown in response time observed alongside angry voices in an environment regardless of the variable of salience.

Chapter 7 Conclusions

The observed difference in response time may be due to heightened neurological responses to angry stimuli wherein immediate amygdalar response delays any physical response to the command, as neural effort diverts subject attention from processing the content of the command in favor of the emotional information presented in the utterance (Lin et al., 2020). The cost, in other words, is greater when the subject is presented with an utterance that has a negative valence, high arousal weight.

These findings have abundant practical applications, suggesting that expressing requests and demands in a neutral or happy tone of voice will consistently elicit a quicker response from a listener. If the phenomenon we observed in a controlled lab environment is also seen in stressful situations or environments where cognitive demand is already quite high (such as military or medical environments), the ability of authority figures to consciously control the prosody of their speech will result in less cognitive strain on the listener, a more immediate response, and ultimately more effective communication between the two parties.

Further research could be done to observe the effects of prosody on neurological responses to angry directions and commands. In the case of this study, using an EEG to track neural activity during the button-pressing task outlined in Experiment 1 could shed light on what causes the latency increase for angry-voiced stimuli, building on the work of Mitchell et al. and Lin et al.. This further research could be useful in power discrepancy settings, where one party has more power than the other. Classroom settings, employer/employee interactions, and parenting situations could benefit from the knowledge of what exactly happens in the mind when angry prosody is used, like Lamers and Hall looked at with prosody preferences in autistic children (Lamers and Hall, 2003).

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