

The Linguistic Cues Observed when Lying in Realistic Personal Stake Situations

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### Abstract

There are said to be two categories of lies: prepared lies and spontaneous lies. This study aims to investigate the linguistic cues differentiating the two compared to truthful responses in a realistic situation. Experiment 1 collected data from 80 participants, all between the ages of 18 and 22, and data from 47 participants was collected in experiment 2. Both experiments recruited participants through the Intro Psych Subject Pool at the University of Michigan. The psychology researcher disguised themselves as a senior in the nursing school and conducted examinations of each participant. Based on which condition they were in, participants were given different instructions on how to answer the questions. Experiment 2 was a perception study where participants were played excerpts from the examinations and were then asked to identify if the responses were truths or lies. We found that people who lied had a slower response time, shorter length of utterance, and slower speech rate. These findings show a significant difference between truths and lies which leads to two possible explanations for the different types of lies.

### The Linguistic Cues Observed when Lying in Realistic Personal Stake Situations

In today's society, people from many different backgrounds could benefit from the ability to detect lies: researchers, doctors, law enforcement officers, jurors, and teachers alike just to name a few. Psychologists have been conducting laboratory experiments to learn to detect lies for the past forty years. Previous research has found evidence for two types of lies. Linguistic cues differentiating the two types have been observed in experiments conducted in controlled laboratory settings. Natural language is different than the language produced in experiments, so these findings cannot yet be applied to natural occurrences of lies. Will the linguistic cues associated with lies be found in realistic high stakes environments? (Park, Levine, McCornack, Morrison, & Ferrara, 2002, 146).

According to prior research, models have been proposed for two types of lies: prepared and spontaneous lies. Spontaneous lies can be explained to take more time to formulate a response due to research proposing a cognitive model for lying in response to a question called the Activation Decision Construction Model (ADCM). In the model, there are three cognitive steps to lying: activation, decision, and construction. The activation component is performed automatically whenever being asked a question. The string of words is interpreted, and the relevant information in memory is made accessible. The truth is then transferred to the working memory space. If the intention is to tell the truth, the speaker will output the information in their working memory as their spoken answer and have then completed the process of answering the question. If the speaker intends to lie, they proceed to the next stages which are only accessed intentionally. In the decision component, the memories and corresponding feelings are considered. Potential liars determine whether telling the truth would be in their best interest. Memories associated with negative emotions such as guilt, anxiety or embarrassment lead to the decision to lie in an attempt to avoid

these anticipated negative feelings. If one decides to tell the truth, the response stored in working memory will be outputted, but performing the extra step in deciding which answer to share will increase the response time. The final step in the process is the construction component in which the speaker will inhibit the true response stored in working memory, and instead build a lie. Social constraints will eliminate the implausible lies, and the best option left will be sent to working memory to be given as the answer to the questions. Completing the decision and construction process should add even more to response time (Walczyk, Roper, Seeman, & Humphrey, 2003, 758-759). This model operates under the condition that the more cognitive processes needed to complete a task, the more resources and time it will take. This increase corresponds to the elongated response times that are seen when questions are answered with lies (771). Since the decision process to determine when to lie is a task in this model, and there is a visible increase in response time with that segment is isolated, this shows lies told in this fashion are spontaneous. The process of deciding is not predetermined. Therefore, the theory of using more memory thus resulting in longer response latencies is supported in the literature, but only for spontaneous lies.

Rehearsed lies are said to shorten the pause between the question and answer. Liars try to imitate people that are telling the truth so their lies will hopefully go undetected. Liars often assume long response times are clues to deception because in taking longer to decide what they say, people may easily assume they are thinking about lying. To avoid this “misconception”, people purposefully attempt to answer quicker, shortening their response times so much they become shorter than the expected average latency (Mapala, Warmelink, & Linkenauger, 2017, 1351). A series of studies with both shorter and longer than average response times as indicators are the basis of evidence of shorter response times depicting lies. In the first experiment, participants heard monologues of three statements followed by a question and were instructed to answer each

question with the word “yes” but were told to say it as honestly or dishonestly as possible. The results when participants tried to sound dishonest showed that the pauses between the question and the response were significantly shorter than for any other speech condition. In the second experiment, the participant was shown the same three monologues and questions, but this time, listened to an automated male speaker reply “yes”. The participant will hear the answer in seven different trials, each with a different response latency. Three trials’ latencies were shorter than the average, three were longer, and one was the optimal average for responding truthfully. The participants then had to identify which answers were true and which were lies. They identified shorter than optimal and longer than optimal latencies as indicators of dishonest answers. In the first experiment, only shorter than average response times were present in the dishonest condition. In experiment one, participants were instructed to prepare a response most representative of being dishonest. This means the participants were only producing rehearsed lies, making the expectation to find lies only indicated by shorter response times. Long response latencies occur with spontaneous lies, and since experiment two was conducted under the premise that spontaneous or rehearsed lies could have occurred, both differences were specified by the participants (Boltz, 2005, 132-135). This study not only presents solid evidence that response times are a consistent factor in determining lies, but that these latencies are present enough to be recognized by speakers and differentiated as shorter or longer than average.

Recently, research has expanded to investigate high stake environments with a strong potential for lying meaning there is something personal at stake for the participant. The first example of this was in a study published in 2015. Recordings of a meeting between high level executives discussing earnings were submitted to an automated analysis device to identify distinct linguistic cues. Some of the statements were true, while others were lies. Of the ones that were lies,

some were rehearsed, and others were unscripted. The analysis shows that shorter response lengths are correlated with being spontaneous lies and that longer utterance lengths were corresponded with rehearsed lies. In terms of response time latency, there was a significant difference between latencies in truthful statements and those of faulty statements. Between rehearsed and unscripted lies, however, there was not the longer response time that Burgoon et al predicted (Burgoon et al).

Another study completed in 2017 only tested the production of prepared lies but was completed in a real-life situation. Mapala et al. incorporated recent advances in technology to create a virtual reality. They set the experiment in an airport at a security checkpoint, and participants were asked questions by a virtual security guard. The technology allowed the participant to be immersed in the setting through a first-person perspective and interact with characters and voices on screen. Each participant was given an assigned condition and were told what to pack to be taken on the plane: some were assigned to pack illegal objects, and of that group, half were instructed to lie about having restricted items. In the simulation, the guards asked control questions such as are you traveling on your own or does your bag contain any food items? The guards also asked experimental questions such as are you in possession of any dangerous items and are you sure there are no restricted item in your bag? Participants were given a condition to either lie or tell the truth when answering the questions. The results of this experiment were intriguing to the researchers because they were opposite what they expected. The response times were shorter for the lies in the deception condition than they were for the control and the truths. (Mapala, Warmelink, & Linkenauger, 2017, 1354). The researchers predicted the lies would have longer response latencies, but these results support the claim that rehearsed lies have shorter response latencies than truths. The participants knew which condition they belonged to and what

was in their backpacks, so they knew when they would have to lie leaving ample time for planning and preemptive responses.

The new study proposed will combine aspects of the two previous studies to fill the gap in the research. It will include prepared lies, spontaneous lies, a realistic situation, and human appraisal. The aim is to replicate the findings from Mapala et al(2017), using similar methods, but having the participants interact face to face when responding to questions. The previous study only looked at planned lies and response time latencies. This new study will use similar methods to also investigate the presence of such linguistic cues in spontaneous lies. We predict that the response latencies for planned lies will be shorter than response times during truth telling. When testing spontaneous lies, we predict the response times to be longer than those of truthful responses.

### **Experiment One**

The design of this experiment was adapted from the previous study mentioned above. Data collection for this research took place from September 2018 through February 2019 and was broken down into two separate experiments: the first aimed at producing deceptive language and the second focused on the ability of different subjects to classify speech as either a truth or a lie.

### **Methods**

**Participants.** Eighty-three undergraduate students from the University of Michigan were recruited to participate in this study through the Intro Psych Subject Pool, all between the ages of eighteen and twenty-three. All students enrolled in introductory psychology classes must take part in seven hours of research studies to fulfill requirements of the course. After completing a prescreening survey, students may sign up for any study they qualify for, and upon registering, they are only told the time and place of the study, and the official study number, no information about what the study entails. Students who participated were granted an hour towards their total.

Forty-three of the participants were female, and forty were male, all were native English speakers, and all provided informed consent.

**Design.** Two researchers were needed to run the experiment: one to play the role of the nursing student and perform the examination and another to act as the administrator and handle paperwork and the introduction. Deception was used to make the staged laboratory environment as realistic as possible to allow for the most natural behavior. The participant was led to believe that this study was a collaboration between psychology and the school of nursing. The presented research goal was to analyze the ways medical health professionals deliver questions and what impact this has on the comfort level of the patient. Participants were randomly assigned to one of three Response Type groups prior to arrival.

This study was a 3(Response Type) x 2(Question Type) x 8(Question) mixed design. The response type variable was between subjects: one third of participants were in the truth condition, one third in the prepared lie condition, and the last third in the spontaneous lie condition. Participants in the truth condition were told to respond truthfully to all questions asked by the nurse. The people in the prepared lie condition were given a list of questions and were told to lie to questions 7, 8, and 9 which were targeting patterns of nicotine use, alcohol use, and other uses of recreational drugs respectively. In the spontaneous condition, the participants were told they will be asked to disclose personal information and are not required to tell the truth. They may answer with whatever would make them feel the most comfortable.

Question type and Question were manipulated within subjects. There were two types of questions used in the examinations: control questions and target deception questions. Each participant, regardless of assigned condition, was asked all the questions, equal numbers of each type, and in the same order.



The dependent variables are the linguistic measures: response time latency, speech rate, use of disfluencies, and length of utterance. The inclusion of the response time latency variable is motivated by Mapala et al(2017), who also looked at this variable. However, response latency is just one of many measures including the other dependent variables mentioned above that are used to describe fluency. All audio from the interaction between the “nurse” and participant was recorded, transcribed, and analyzed on Praat Software. We assessed the truth value of each participants’ responses through a questionnaire asking participants to anonymously disclose which questions they were not 100% truthful in their answers. Omitting truthful information or refusing to disclose was also considered non-truthful responses.

**Materials.** A room was constructed to mimic the concept of a doctor’s office waiting room with an adjoining procedure room. The first room held a check-in desk, waiting area chairs, and a research assistant while the inner experimental room held a table and chair for the researcher, an examination table and chair for the participant, and shelves of medical supplies such as hand sanitizer, rubber gloves, face masks, clean sheets, and cotton swabs. The researcher was dressed in scrubs and a lab coat, and held instruments such as a stethoscope, bathroom scale, throat light, and mallet that are used in the experimental procedure. In addition to the office set up, the procedure contains 16 questions, but there are only 8 questions in the design. This is because each participant is asked 8 questions from each question type: control and experimental. The control questions were categorized as those least likely to be lied to. For example, the questions, “what is your age”, or “what meal do you eat most frequently” fall under this category. Experimental questions were ones based on more taboo topics with a greater chance of being lied to. Examples of these are, “how would you describe your pattern of sexual activity” or “how often do you exercise”. The complete list of questions will be included in Appendix A. The written list of

questions to be asked by the experimenter was provided to some participants prior to the procedure as determined by the randomly assigned condition. A written questionnaire was administered post examination asking the participants to disclose which questions they did not respond to truthfully during the interview. This is included in Appendix B.

**Procedure.** Upon arrival, the participant met with the first researcher who obtained informed consent and briefed the participant on what was to come depending on their condition, assigned randomly. In the prepared lie condition, the participant viewed the questions and was given time to prepare their answers. They were not allowed to write anything down. All participants then waited ten minutes in the waiting room after which the nursing student arrived to take them back into the examination room. This ten-minute period was inserted into the procedure to simulate the anxious waiting often felt in waiting rooms of medical professionals to make this experience feel as authentic as possible. The participant was instructed to sit either on the exam table bed or in the chair alongside it. Once settled in the room and the recorder was switched on, the “nurse” asked questions 1 and 2 about general background information and what medications the participant was currently taking. After question 2, the participant was instructed to move to the exam table if they were not there already. The “nurse” then performed a series of tests familiar to a physical checkup: examined the throat, listened to the heart and lungs, and checked joint reflexes. The “nurse” then proceeded to ask questions 3 – 16 after which they left the room. During the exam, the “nurse” had no knowledge of what condition the participant was assigned. After the “nurse’s” departure, the first researcher reentered the exam room to bring the participant the disclosure questionnaire. Once finished, the researcher starts to walk the participant back to the main lab room but stops them as they exit the waiting room. The participant is then weighed. This was completed for two reasons; first, logistically, the exam and waiting rooms were carpeted and

the scale only registered properly in the linoleum hallways. Secondly, we compared the observed weight with the self-reported weight the participants gave earlier in the exam, and we wanted these measurements to seem as unconnected as possible, so the participants would not alter their natural behavior. Lastly, the participant was debriefed. They are explained the deception that was used and asks for a signature saying they allow their recorded exam to be used as stimuli in future studies.

## **Results**

The truth condition contained 27 participants, but only 18 were used in the analysis of the truth condition. 21 participants were run in the prepared lie condition, and 1 was excluded from the analysis because of not following directions. 33 participants were run in the spontaneous lie condition. 20 were excluded from analysis due to not lying during the interview. The remaining 9 participants from the truth condition will be included in the analysis of the spontaneous lie condition because each of the nine disclosed on their questionnaire that they lied to at least one question spontaneously, regardless of instructions. In the results reported below, the spontaneous lie condition will now be labeled as the Spontaneous combined condition and contains 22 participants' data.

**Coding.** All the recorded data was transcribed using Praat. The first interval tier held the “nurse’s” questions, and the bottom tier held the participants answers. When transcribing, the question number as seen on the interview question list was written prior to the content of the speech. If follow-up questions were asked, they received a lowercase letter added to the number for differentiation. For example, a transcribed question would look like, “[7. How would you describe your use of Nicotine?]”, and the answer on the tier below might read, “[7. I smoke cigarettes daily]”. If a participant began a response with a disfluency, that utterance would be separated from the content of the response but was still labeled with the same question number. Words considered

disfluencies in this experiment were: um, uh, so, like, mmm, well. If the example response above was started with a disfluency, the transcription might look like so, “[7. Uh] |7. I smoke cigarettes daily]”. The vertical lines included in the transcriptions signify the precise start and stopping points of each utterance. A Praat script was used to isolate the content, start, and end times of each utterance and outputted them to a spreadsheet, one per participant containing all the data from their interview.

For each spreadsheet, the dependent measures of response latency, speech rate, and utterance length we calculated for the participant’s response to each question. The means of each linguistic measure were calculated for two distinct subsets of questions: Target and Truth. For the truth condition, the target group was made up of questions 7, 8, and 9, and the truth group were all other questions. For the prepared lie condition and the spontaneous lie combined conditions, the target group were the lies, and the truth group were all remaining responses. In the prepared condition, the target group was only questions 7, 8, and 9. In the spontaneous combined condition, the question numbers included in the target group varied because the questions lied to varied by participant. Data presented in the figures below showcase the two groups of data for each condition. The first three figures are bar graphs, one for each dependent variable analyzed. Table 1 below holds the mean values for each group and in each condition for ease of reference when making comparisons.

**Descriptive Results.** The dependent variable measured in connection with the previous lie detection studies was response time latency. We found that all responses in the truth condition had a shorter response time latency than either of the other conditions. The mean latencies in the truth condition for both the truth and target groups were very similar, 1.056 and 0.983 seconds respectively. The same trend was observed in the prepared and spontaneous conditions; the mean

response latencies of the truth groups were shorter than the responses in the target group. For the prepared lie condition, the mean truth response time latency was found to be 1.138, while the mean latency in the target condition was 1.408 seconds. We observed that the response times in the spontaneous condition were even longer still. The mean latency for the spontaneous responses in the truth group was 1.257, and the mean response time latency for the target questions was 1.45 seconds. These results were supported with an Anova run between three variables: condition, response type, and people (entered as a random variable). Condition was found to be a reliable, significant predictor ( $p = 0.0368$ ), while response type was only marginally significant ( $p = 0.0746$ ). The subsequent relevant t-tests showed the truth condition's mean latencies to be reliably, significantly shorter than the spontaneous conditions ( $p = 0.047$ ) and marginally significant when compared to the prepared lie condition ( $p = 0.095$ ). The prepared and spontaneous conditions were super similar with a p-value of 0.949.

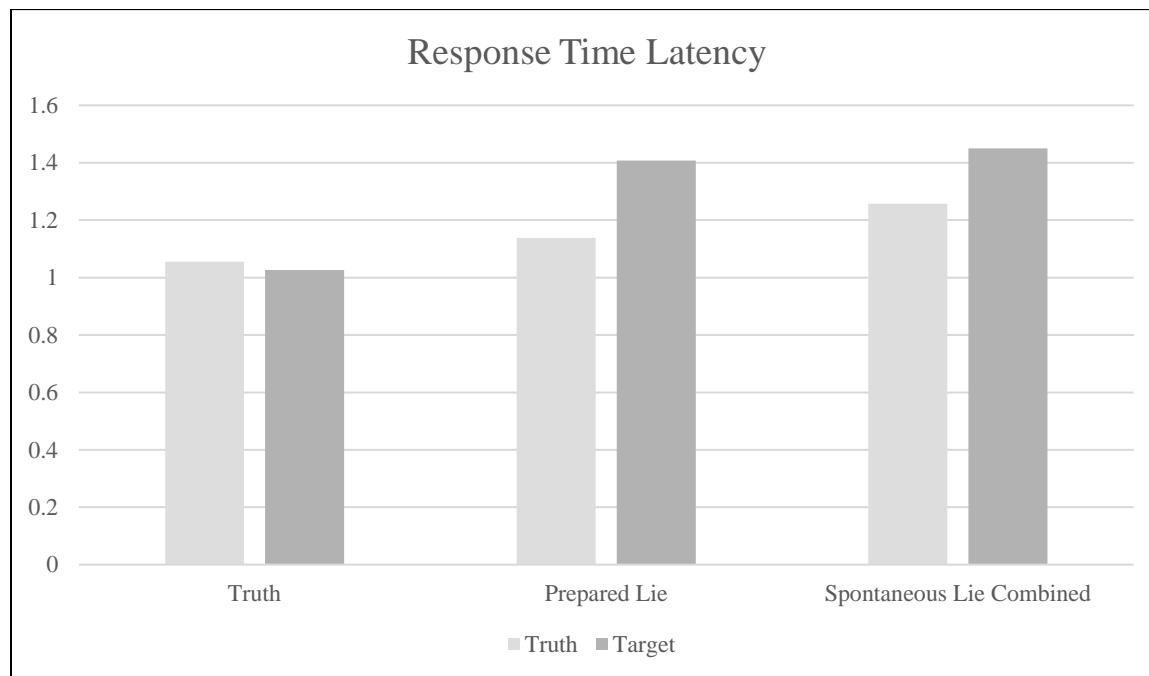


Figure 1. Mean response time latency in seconds for the truth and target groups across all three conditions.

Next, we expanded the scope of deceptive language research by analyzing two other speech measures: speech rate and length of utterance. In terms of speech rate, responses in the spontaneous condition had a slower speech rate than those in the truth conditions and the prepared lie conditions. For the spontaneous condition, the mean speech rate of the truthful responses was 2.682, and the mean rate of the target responses was 2.551 words per second. The mean speech rate of the responses in the prepared lie condition were slower than those in the truth condition. The mean speech rate for the prepared lie truth group was 3.177 and 2.947 words per second for the target group. The mean speech rate for the responses in the truth condition was 3.157 for the truth group and 3.292 words per second for the target group. These trends were supported by an Anova run between the same three variables as with the one for response time latency. Condition turned out to be a significant factor in predicting speech rate ( $p = 0.000018$ ), and the relevant t-tests show the spontaneous condition was reliably the slowest between the three ( $p = 0.000015$  and  $p = 0.0031$ ), with no distinction between the truth and prepared conditions ( $p = 0.3014$ ).

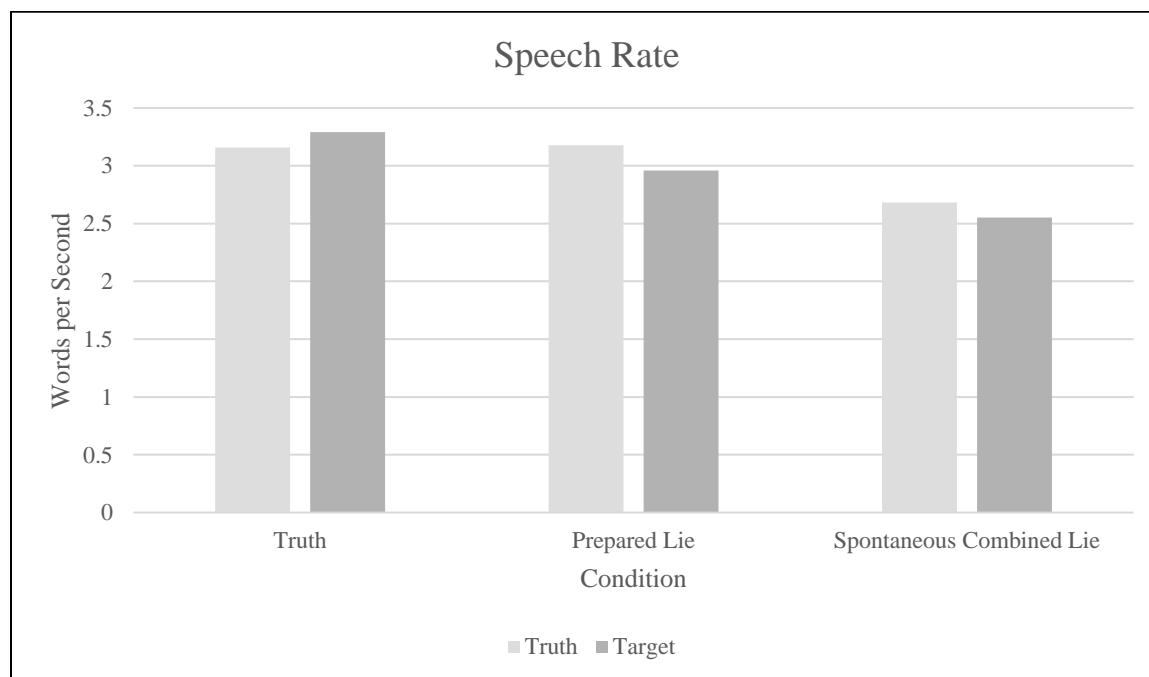


Figure 2. Mean speech rate in words per second for the truth and target groups across all three conditions.

The last measure looked at was length of utterance. As you can see in Figure 3, we discovered a pattern where the responses in the truth group were consistently longer than the target responses in each of the three conditions. The mean number of words per utterance for the truth condition's truth and target groups was 6.668 and 4.340 words respectively; the means for the prepared lie condition were 5.765 and 3.854 words, and the spontaneous condition's group had means of 5.581 for the truth and 4.494 words for the target. Across all three conditions, the difference in the two groups' means were very similar. We did not run an Anova on this data because it told us something interesting about the nature of the questions asked, not behavior observed within the responses.

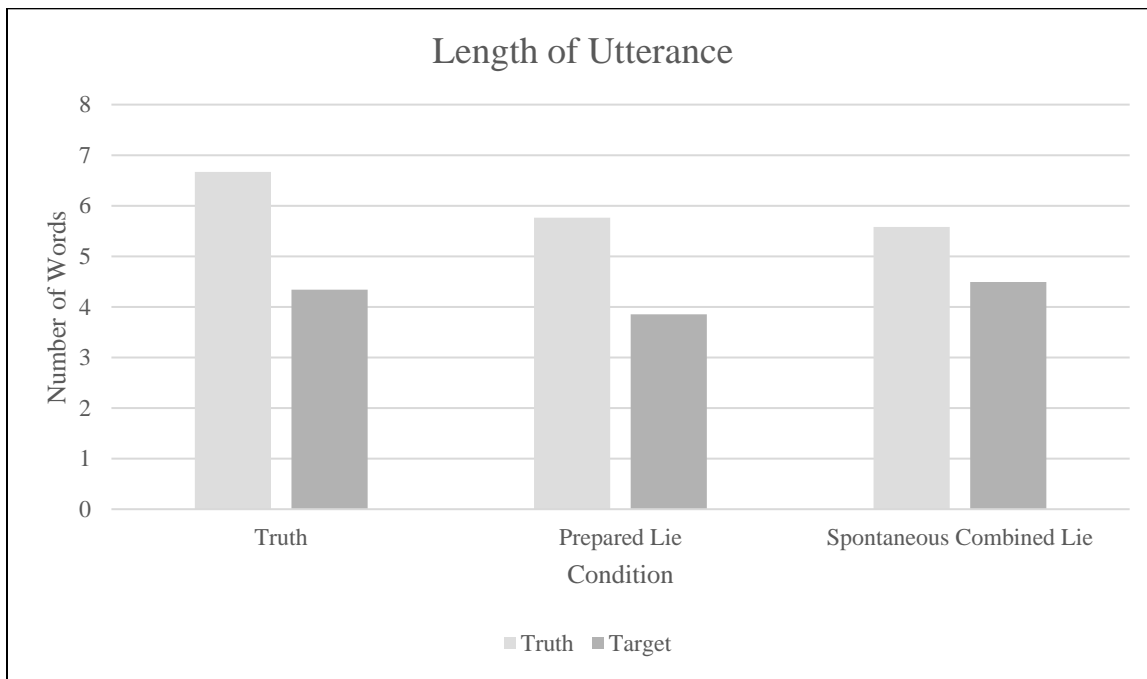


Figure 3. Mean length of utterance in words for the truth and target groups across all three conditions.

Table 1

Descriptive Data Means

Rounded to the nearest thousandth	Truth Condition Truth	Truth Condition Target	Prepared Condition Truth	Prepared Condition Target	Spontaneous Combined Condition Truth	Spontaneous Combined Condition Target
Response Time Latency (seconds)	1.056	0.983	1.138	1.408	1.257	1.45
Speech Rate (words per second)	3.157	3.292	3.177	2.947	2.682	2.551
Length of Utterance (words)	6.668	4.340	5.765	3.854	5.581	4.494

**Inferential Statistics.** The tables below hold results from both Anovas and related tests performed for statistical analysis. The model used to represent the data was a three-factor analysis with replication: 3(condition) x 2(response type, shortened to “response” below) x 18(person). Person was a random variable added to account for variances. There were three complete replications with the number of participants in the truth condition as the limiting factor. To perform the analysis, two participants needed to be removed from the prepared condition and four from the spontaneous. These were determined at random.

The rightmost column indicates which variables were significant given the model, each symbol corresponding to a different level of significance. The variables marked with a \* are statistically significant in accordance with alpha being .05; the more stars next to the name, the lower the p-value. The ● means a variable was marginally significant but was just higher than the confidence level. The table on the left-hand side describes the additional t-tests performed by a Tukey’s Range Test. This was needed to determine which conditions’ means differed and in which direction. The same significance codes were used to describe these results as well.



Table 2

*Inferential Statistical Analysis Using Anova – Response Time Latency*

<b><u>Response</u></b>	<b>DF</b>	<b>Sum</b>	<b>Mean</b>	<b>P value</b>	<b><u>Relevant</u></b>	<b>P adj</b>
<b><u>Latency</u></b>		<b>Sq</b>	<b>Sq</b>		<b><u>t-tests</u></b>	
Condition**	2	2.65	1.3230	0.0368	Spon + Prep	0.9499781
Response •	1	1.26	1.2553	0.0746	Truth + Prep •	0.0955585
Person	17	10.38	0.6105	0.0861	Truth + Spon *	0.0474622
Residual	87	33.54	0.3855			

Table 3

*Inferential Statistical Analysis Using Anova – Speech Rate*

<b><u>Speech Rate</u></b>	<b>DF</b>	<b>Sum</b>	<b>Mean</b>	<b>P value</b>	<b><u>Relevant</u></b>	<b>P adj</b>
		<b>Sq</b>	<b>Sq</b>		<b><u>t-tests</u></b>	
Condition****	2	8.757	4.378	0.000018	Spon + Prep	0.0031
Response	1	0.796	0.796	0.1365	**	
Person *	17	12.456	0.733	0.0147	Truth + Prep	0.3014
Residual	87	30.675	0.353		Truth + Spon	0.000015
					****	

## Discussion

Our results observed in response time latencies were opposite those found in Mapala et al (2017). We found participants in the prepared lie condition to have longer response time latencies than those in the truth condition. All response latencies in the truth condition were equal regardless of question type, but for the prepared lie condition, the questions in the target group had a longer response time than those in the truth group. In this study, we were also attempting to isolate the spontaneous lie. We found the response time latencies in the spontaneous condition mirrored those seen in the prepared condition. The mean latencies were significantly longer than those in the truth condition, with the target group having the longer response times when compared to the truth group. These results support our hypothesis for the spontaneous condition, but not for the prepared lie condition. We suspected there would be significant differences between the two types of lies, but the response time latencies for the spontaneous condition differed from the truth in the direction we predicted.

Our prediction that the prepared lie condition would have shorter response times than those in the truth condition was an optimistic prediction. In Mapala et al (2017), each response was only one word, yes or no. In our study, all questions required more elaborate answers making the mean response length multiple words or phrases. These longer responses help explain our results because of the constraints put on preparing lies. When participants crafted responses to open ended questions, we were still expecting them to repeat their responses in full at a later time. Due to differing capabilities of working memory, it might not be feasible to parrot back a lengthy prepared response. The participants in the prepared lie condition practiced lies for questions 7, 8, and 9. By the time they were asked these questions in the check-up, they had answered the 6 previous questions and had been given a physical examination. Having to remember their exact response

across multiple tasks and novel situations also goes beyond the scope of working memory making it even more unlikely one would remember their practiced response when the time came to produce it. Due to difficulties in producing truly prepared lies, and the difference in response lengths between this study and the one completed by Mapala et al, these differences needed to be accounted for in our prediction of response time latency for the prepared lie condition. Since our initial prediction did not adjust for this added noise in data collection, the prediction that the response time latencies would be even shorter than the truthful responses, as found in Mapala et al, was unrealistic and did not account for our experimental design differences.

After analyzing the response time latency data, there were no significant differences between the responses in the prepared lie condition and those in the spontaneous lie condition. We ran paired-sample t-tests between the target groups in both conditions, and the adjusted p-value was not statistically significant. Because of this, and the previously mentioned difficulties in producing prepared lies, what if all the lies produced in this experiment were spontaneous lies? Due to the constraints on working memory, and the order of proceedings upon starting the interview, it would be a lot more difficult to retain a pre-thought-out response to an open-ended question than to a simple yes/no. Therefore, by the time the participants were asked the target questions in their interview, they had already forgotten their prepared answers and instead answered the questions as spontaneous lies. According to the explanation that both conditions produced the same types of lies, it makes sense that the two conditions also produced identical response time latencies. From the current view of spontaneous lies, the Activation Decision Construction Model (ADCM), the lies have longer response times because it involves an appraisal process. One needs time to appraise the situation, decide whether to lie, and then formulate a response. In the case of the prepared lies, there would be no need for the participant to appraise

the situation considering they knew to lie, the extra time would be accounted for with the participant trying to recall what their planned response was.

When we ran the Anova on our data, we expected there to be a significant interaction between the condition and the response type. In reality, we only found a minimally significant interaction with a p-value of 0.07. We can explain this lack of a reliable interaction with the increased response time latencies observed in the truth groups of both the prepared and spontaneous lie conditions. For there to be a reliable interaction, there needed to be a significant difference between the response time latencies in the truth group and the target group across the three conditions. We predicted there would be no difference in means in the truth condition because both groups of responses had the same truth value. We did not, however, take the theory of spontaneous lies into account. If going off the ADCM, the response time latencies of truthful responses in spontaneous lie situations will also be affected and is again connected to the appraisal process mentioned above. In the spontaneous condition, the participant could respond with either a truth or a lie; neither the researcher nor the participant knew the expected truth value of responses before being delivered. This meant that for every question, the participant must go through the ADCM. Even if they appraised the situation and decided to tell the truth, this process took time. When responding truthfully in the truth or prepared lie conditions, this appraisal process did not occur making the response time latencies of responses in the spontaneous lie truth group condition longer than any other truth group. Having elongated response time latencies in a truth group shrunk the overall difference in mean response times between the two groups which in turn negated the significance of the interaction between the condition and response type in the analysis.

We analyzed two other linguistic measures, both predicted to differentiate truth and lies: speech rate and length of utterance, but we only found speech rate to be a significant factor in

differentiating truths from lies. Through paired-sample t-tests, we found the mean length of utterance for the truth group's responses to be significantly longer than the responses in the target group across all three conditions. The differences in lengths were not significant across conditions meaning utterance length was not a significant measure in determining truth or lie. We predicted the spontaneous lie condition to be the least fluent of the three conditions and our results supported that. For speech rate, condition was found to be a significant factor through our Anova, and the relevant t-tests showed the spontaneous condition to have the slowest speech rate; it was statistically significant against the prepared lie condition and the truth condition. Our findings for speech rate were interesting because they seem to disprove our claim made above that all lies produced in this experiment were spontaneous lies. The mean speech rates for the responses in the prepared lie condition did not match the speech rates of those in the spontaneous lie condition. If both conditions produced the same kind of lie, the two conditions' speech rates would have been similar. Because their paired-sample means were statistically significant in a t-test, the lies in the two condition have distinct linguistic measures for speech rate. This provides evidence for the two types of lies, and suggests we succeeded in our goal to design an experiment capable of comparing the linguistic cues of both prepared lies and spontaneous lies.

This study design had a few limitations. First and most significant was the nature of collecting the data for the spontaneous lie condition. The number of participants' data we could use so dependent on how many people lied in their interview. We ran more than double the final number of participants included in that condition. Our goal was to have 20 participants in each condition, but due to time and resources we needed to stop collecting spontaneous data once we got to 13. When running a subject in that condition we wouldn't know if their data was usable until after they participated. Another issue with collecting the data was that we were relying on the

participants to self-disclose which questions, if any, were their answers untruthful. We are unable to determine if participants responded untruthfully to the ending questionnaire. They could have said they answered truthfully to a given question when in reality they did not and chose not to admit it. The second limitation to this research would be the age of the participants on which it was performed. Some participants were under the legal age needed to partake in certain activities. Since the questions targeted behaviors related to the aforementioned activities, this population of participants might have practice lying about these subjects making their answers more fluent than your average liar. Lastly, the nurse conducting the interviews was a college aged female, and this is a limitation because participants might have been more comfortable answering truthfully to someone similar to them in age. This increased level of comfort could have lowered the number of spontaneous lies told and therefore contributed to the low numbers of participants' data included in those analyzes.

### **Experiment Two**

An important aspect of the study completed by Burgoon et al (2015). was the perception data collected by running utterances through an automated analysis program (Burgoon et al). Experiment two aims to expand on these findings and collect information on the perceptive ability of the human ear to deception in natural language. We predict that participants will be able to differentiate between truths and lies.

### **Methods**

**Participants.** The participants in this study were students between the ages of 18 and 22 and were enrolled in Intro Psych at the University of Michigan. The 47 participants were recruited through the Psych Subject Pool and received an hour of research participation credit upon their completion. All participants were native English speakers who had not previously participated in

experiment one, and all provided informed consent. The experiment was run with anywhere between 1 and 8 participants at a time. The number of people participating at a time were determined by which time slots posted through Subject Pool did an individual sign up to come to.

**Materials.** The auditory stimuli used in this experiment was composed of segments taken from the recordings of experiment one. One's examination was only used in experiment two if they gave written informed consent after participating in experiment one. The final audio recording used for experiment two consisted of twenty-four segments and was assembled in garage band. Each was taken from a different participants' examination and included two question and answer exchanges. Of the 24 segments, 12 were from male participants and 12 from female. For each gender, there were 3 segments from each category of responses: two questions with two truthful answers, two questions answered with two lies, the first question answered with a truth and the second a lie, and the first question answered with a lie and the second a truth. The order they appeared in the final recording was random. The total duration of the audio played was around 25 minutes.

We needed access to a room with a large conference table, so all participants have a place to sit. The same room was used for each participant. A google form was used to collect the data. Each participant brought a laptop or tablet capable of connecting to the internet and accessed the google form through a secure link only provided during the experiment. The form consisted of the same three questions for each question answer pair heard. The first question asked participants to indicate whether the response they heard was a truth or a lie, the second asked how they knew, and the third was a confidence rating between 1(least confident) and 7(most confident). Bluetooth speakers were used to play the audio and were set on the middle of the conference table.

**Procedure.** Upon arrival, all participants were instructed to find a seat around the conference table and were each given time to read and sign the informed consent form. After all the people assigned to the time slot arrived, the researcher took the participants through a practice example. The questions asked were the same as the ones presented on the google form, but these were to be responded to by hand on the back of the consent form. The researcher then sent the private link of the google form to the school emails of the people present in the study. They walked around to each person's device and made sure After explaining the instructions and answering any questions the participants had, the researcher started the recording. After each question and answer pair, they would pause the recording to give people time to record their answers. After question 22, the participants were given a 5-minute break. If at any time during the experiment, someone recognized the voice of one of the subjects in the recording, they were instructed to tell the researcher and excuse themselves from the rest of the study. They would still receive credit for their participation. Upon completing responding to all 48 questions, the researcher would answer any questions regarding the purpose of the study.

## Results

The data was organized by percent truth. For each of the 48 questions included in the audio sample, we recorded the percentage of participants who guessed that answer to be a truth. The data was organized into two columns, one where the correct responses were truth and one in which they were lie. A paired-samples t test was conducted between the two response types. The mean percent truth guessed for questions whose correct response was truth came out to be 62.17%, while the percent truth for responses that were lies had a

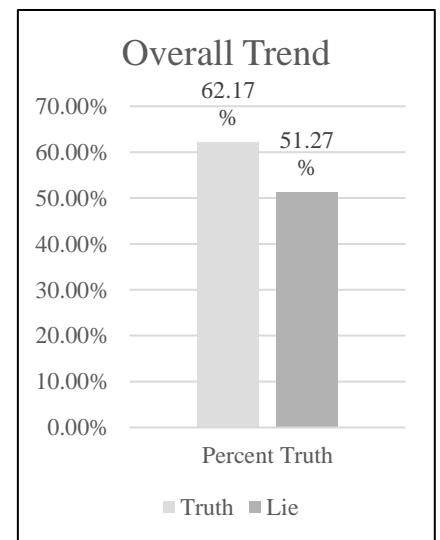


Figure 4. Mean of percent truthful responses in cases where sample was a lie verse when it was a truth.



mean of 51.27%. These two means are statistically significant with a p value of 0.04. The figure below aims to show the overall difference in the means of the two sets of data. We also represented the data through a scatter plot. Here, each question (1-48) is represented by the percent truth of the respondents. The points plotted in blue are the questions with truthful responses, and the points plotted in red represent the question numbers whose responses were a lie. This can also be interpreted as more participants guessed the questions in the red data set were lies. However, this visual also depicts the presence of questions whose projected value did not match the actual truth value.

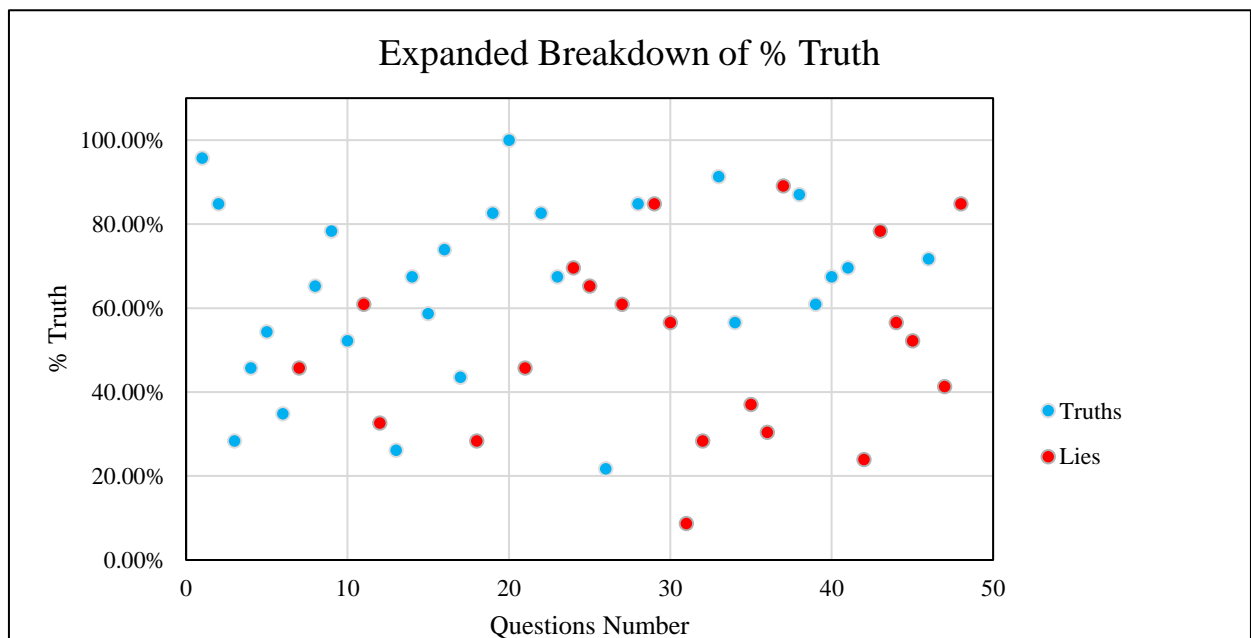


Figure 5. Expanded percent truth results for each question.

Along with the judgement of truth or lie, the participants recorded their rationale for why they responded the way they did. All justifications can be described using 7 categories: content, response time, length of utterance, tone, disfluencies, speech rate, and unsure. This classification system and the number of responses per category are included in the figures below. This data includes the coded responses for the first twenty-two participants. The most common justification was content based, and the second most common was characteristics related to tone.

Table 4

Justification Categories and Number of Responses Included

Category	Number of Responses
Content	449
Tone	336
Response Time	234
Speech Rate	91
Unsure	75
Utterance Length	66
Disfluencies	58

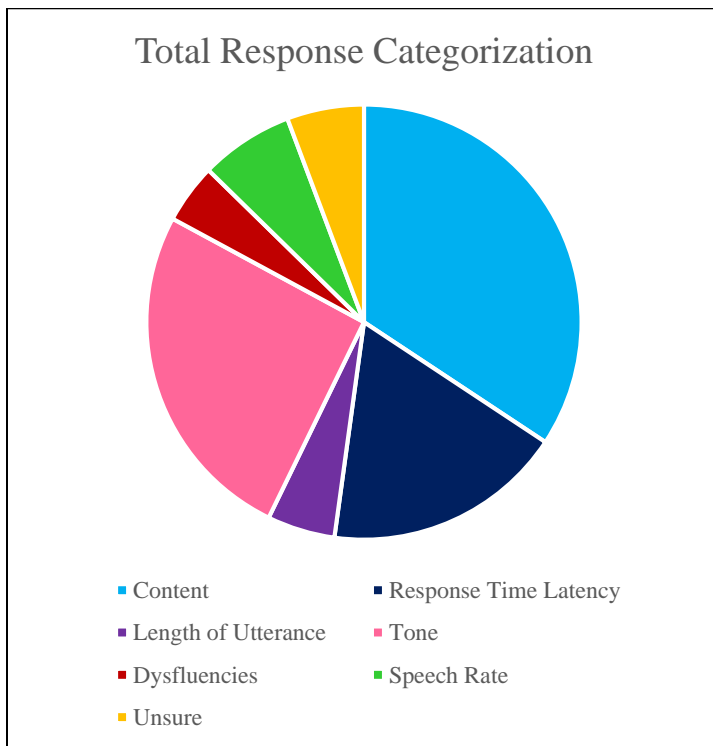


Figure 6. Percentage of each category of justification given.

Figure 7 graphs the percent accuracy for all participants showing that there were no outliers. All participants had between a 40 and 80% accuracy.

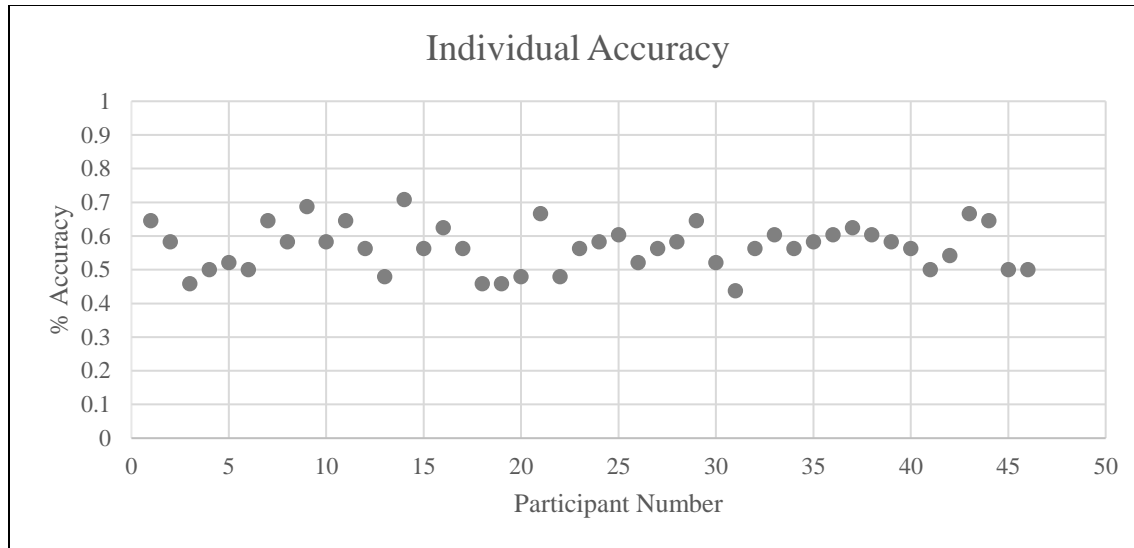


Figure 7. Percent Accuracy at determining correct truth value for each individual participant.

## Discussion

From this data, it appears participants can differentiate between truths and lies when hearing examples of each. The audio sample used in this study represented a general sampling of all the data collected. It included questions covering a wide range of topics, speakers from different genders, and varying truth values. The differences in the percent truth values between the two sets of questions tell us that people are more likely to perceive a response as truthful. An interesting observation is that while it seems people are uniform in their accuracy, their judgements on which questions were truths and which were lies were all over the place. (ADD MORE?)

Since there were no restrictions as to which question numbers were included in the audio sample, varying numbers of topics with varying numbers of questions addressing that topic were present. For example, this meant there were 17 questions using numbers 7, 8, and 9 from the interview, while only two were asked about previous broken bones and hospital visits (questions 4 and 5 in the interview). This was done because there was more lie data to choose from in response to those questions. Untruthful responses from a few other questions were included from the spontaneous lie condition, and truthful responses from any question were added to break up the

clusters of 7, 8, and 9 topics. This is worrisome in terms of methodology because if participants became aware of the pattern of topics from 7, 8, and 9 being associated with potential lies, they could rely heavily on content as their way of differentiating the truth values proving futile in identifying linguistic markers of deception.

This potential drawback is supported through the qualitative analysis of the justifications provided in this study. Upon categorizing the reasons participants suggested a truth particular value, there were an overwhelming number of participants that used the content of the audio to determine if a response was a truth or a lie. The next step in this research would be to run another perception study, this time only using data from interview questions 7, 8, and 9. This will compare truths and lies from the same topics, thereby eliminating content as a predictor of truth value. If the percent truth values across the two new data sets are significant, participants were able to differentiate between truths and lies using the targeted linguistic measures involved in speech.

### **Conclusion**

The overall importance of this research boils down to improving human lie detection, and this research suggests that us humans have been focusing on the wrong characteristics of speech to differentiate between truths and lies. We found two linguistic cues that were found to differentiate the truth from the lies in a realistic personally high-stake situation: response time latency and speech rate. These two factors are interesting, however, because response time latency is shown to differentiate between truth and lie, and speech rate differentiated between the two types of lies: prepared or spontaneous. In order for these factors to be helpful in detecting lies, one must know the type of lie they are looking for, and that luxury is rarely known in high-stress situations. Even after performing this experiment, we still may be using the wrong measures to detect lies. The participants in the second experiment did not reliably use response latency or speech rate in

their justifications. Assuming we can control for content with another perception experiment, the second most frequent measure used were justifications about tone. What if tone is the linguistic factor we should be paying attention to? Mapala et al (2017) suggested is a reliable linguistic cue used to detect lies, but it's situation dependent. Going off this thought, there seems to be a couple future directions this research could take. The first would be to analyze the data we collected to determine if measurements of tone were significant factors in differentiating lies. These would be measures like volume, pitch, positive and negative emotions, and mid response changes to any of the above. A second direction this research could go would be to test investigate the context specific angle. Research could be conducted to see if the two significant factors found in the check-up situation held true with participants of varying ages or types of doctor's office interactions. A third direction this research could go in would be to investigate other situations and try to identify the specific linguistic cue that is significant in lie detection in that environment. This could be a specific location, a certain type of questions or utterances, a certain topic of conversation, a certain age group, etc. Once enough situations have been analyzed, a data base of which linguistic cue to look at for a list of common situations can be compiled and utilized in human lie detection efforts.

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## Appendix A

### Interview Questions in the Exact Order Asked

#### **Background:**

1. What is your present age? \_\_\_\_\_ What is your gender? \_\_\_\_\_  
What is your current height? \_\_\_\_\_ and weight? \_\_\_\_\_
  
2. Please list all medications you are taking (including prescription, herbal and over-the-counter medications).

Throat, lungs, temperature, reflexes

#### **Medical History:**

3. Have you been hospitalized for anything in the past?      Yes      No  
If so, for what, and when?  
  
\_\_\_\_\_  
  
\_\_\_\_\_
  
4. As an adult, have you had a history of any significant medical illnesses such as: polio, heart disease, diabetes, asthma, cancer, high cholesterol, high blood pressure, etc.? circle Y or N and please explain.
  
5. Have you broken any bones? If yes, explain
  
6. Do you have a history of drug or food allergies? Y or N  
If Y, please list them and describe the reaction you experience  
  
\_\_\_\_\_

#### **Social History:**



7. How would you describe your tobacco use?
  - a. How many daily?
  - b. How long has this been going on?
  - c. Have you ever wanted to quit, tried, thought you could, been successful?
  
8. How would you describe your alcohol use?
  - a. How many drinks in 1 sitting? Weekly? Drinking problem?
  - b. Have you ever felt the need to drink alcohol first thing in the morning?
  - c. Felt guilty about drinking?
  - d. Felt annoyed about other criticizing your habits?
  
9. Are there any substances you think about using for recreational purposes? Explain

**Fitness:**

10. Do you have a regular exercise program? If yes, describe? If not, do you follow other routines? (meds, cooking, studying, cleaning) What has stopped you?
  
11. Are you employed?
  
12. How conscious are you of what you eat? What meal do you eat most frequently?

**Reproductive Health:**

13. Describe your experience with learning about reproductive health.
  
14. How would you describe your relationship status? Married Single Engaged Dating
  
15. Are you satisfied with your current social climate?
  
16. How would you describe your pattern of sexual activity?



4. As an adult, have you had a history of any significant medical illnesses?

How comfortable were you with answering the question?

1 2 3 4 5 6 7

Not Comfortable

Most Comfortable

5. Have you broken any bones?

How comfortable were you with answering the question?

1 2 3 4 5 6 7

Not Comfortable

Most Comfortable

6. Do you have a history of drug or food allergies?

How comfortable were you with answering the question?

1 2 3 4 5 6 7

Not Comfortable

Most Comfortable

7. How would you describe your tobacco use?

How comfortable were you with answering the question?

1 2 3 4 5 6 7

Not Comfortable

Most Comfortable

8. How would you describe your alcohol use?

How comfortable were you with answering the question?

1 2 3 4 5 6 7

Not Comfortable

Most Comfortable

9. Are there any substances you think about using for recreational purposes?

How comfortable were you with answering the question?

1 2 3 4 5 6 7

Not Comfortable

Most Comfortable

10. Do you have a regular exercise program? If yes, describe? If not, do you follow other routines? (meds, cooking, studying, cleaning) What has stopped you?

How comfortable were you with answering the question?

1 2 3 4 5 6 7  
Not Comfortable Most Comfortable

11. Are you employed?

How comfortable were you with answering the question?

1 2 3 4 5 6 7  
Not Comfortable Most Comfortable

12. How conscious are you of what you eat?

How comfortable were you with answering the question?

1 2 3 4 5 6 7  
Not Comfortable Most Comfortable

13. Describe your experience with learning about reproductive health.

How comfortable were you with answering the question?

1 2 3 4 5 6 7  
Not Comfortable Most Comfortable

14. How would you describe your relationship status?

How comfortable were you with answering the question?

1 2 3 4 5 6 7  
Not Comfortable Most Comfortable

15. Are you satisfied with your current social climate?

How comfortable were you with answering the question?

1

2

3

4

5

6

7

Not Comfortable

Most Comfortable

16. How would you describe your pattern of sexual activity?

How comfortable were you with answering the question?

1

2

3

4

5

6

7

Not Comfortable

Most Comfortable