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Social Science Analysis: Relational Messages and Deception during Group Interaction

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Agenda

1. What Are Relational Messages?
2. How Do They Relate to Deception?
 - a. A Lens Model
 - b. Do behavioral indicators predict relationships?
 - c. Do behavioral indicators predict deception?
 - d. Do relationship indicators indirectly signal deception?
3. Behavioral Indicators
 - a. Participant perceptions
 - b. Automated analysis



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Relational Messages

- How people use verbal and nonverbal messages to signal how they relate to one another
 - Who is dominant?
 - Do they trust one another?
 - Are they composed or nervous around one another?
- How does this relate to deception?



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Relational Messages - Perceptions

- Players rate each other after beginning ice breaker
 - Served as a baseline
 - Scales ranged from 1 (not at all) to 5 (very)
- Collected after every two rounds to obtain dynamics of interaction
 - After Round 2, Round 4, Last round
 - Only villagers' ratings were considered
 - Spies' ratings would be contaminated by their knowledge of one another's role

Relational Messages Measurement

- Perceptions of one another measured with self-report surveys
 - Pre-game measures
 - In-game perceptions
 - Post-game survey
- Multiple sensors
 - Audio-visual signals from tablets at each desk
 - 360 degree overhead camera
 - Profile view with webcam





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Kinesic Indicators



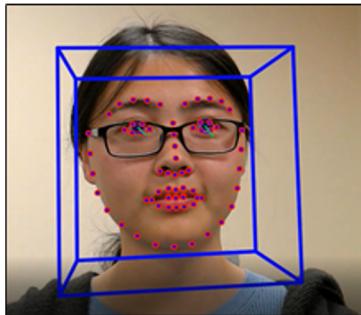
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Extraction of Facial and Head Kinesic Indicators from Video Data



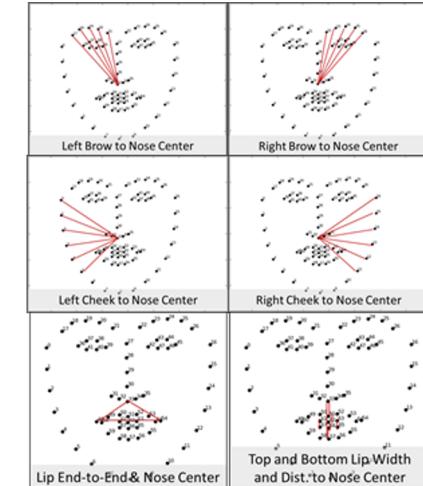
Eye Gaze Vector
Head Pose
Face Landmarks 2D & 3D

AU #	FACS name
1	Innerbrow raiser
2	Outer brow raiser
4	Brow lowerer
5	Upper lid raiser
6	Cheek raiser
7	Lid tightener
9	Nose wrinkler
10	Upper lip raiser
12	Lip corner puller
14	Dimpler
15	Lip cornerdepressor
17	Chin raiser
20	Lip stretcher
23	Lip tightener
25	Lips part
26	Jaw drop
28	Lip suck
45	Blink

18 Facial Action Units (AUs)

Emotion	Action Units
Happiness	6+12
Sadness	1+4+15
Surprise	1+2+5+26
Fear	1+2+4+5+7+20+26
Anger	4+5+7+23
Disgust	9+15+16

6 Basic Emotions

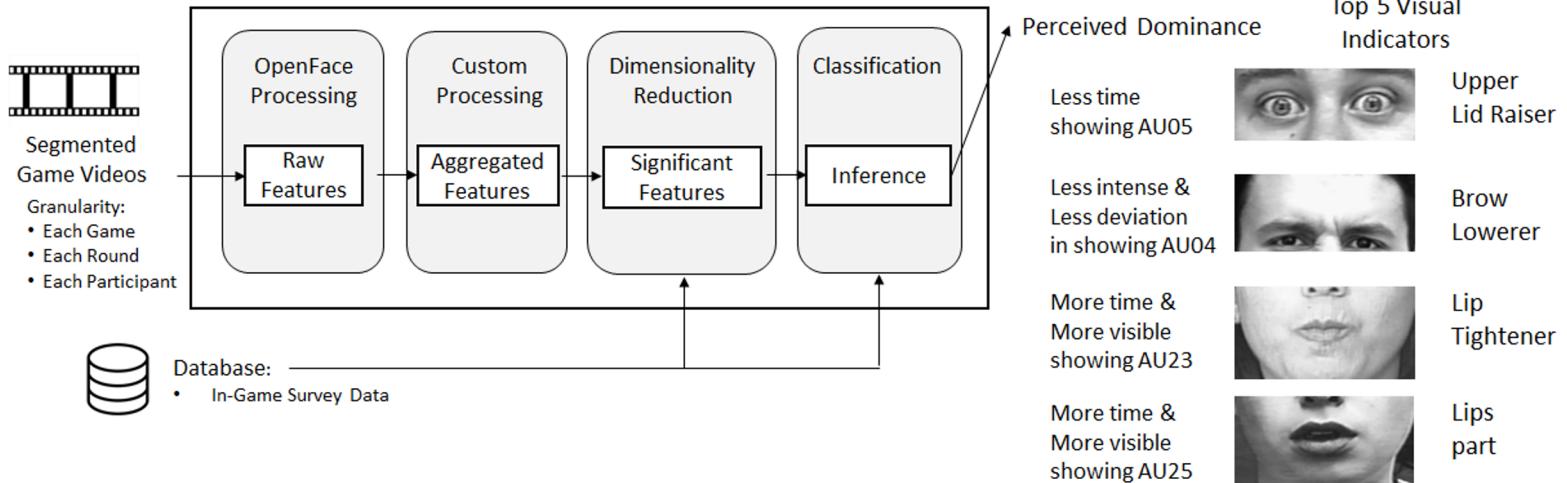


10 Facial Rigidity Values

Values Directly Output from OpenFace

Calculated Values from OpenFace Data

Analysis of Facial and Head Indicators



		Predicted Condition											
		0	1	# 0	# 1								
True Condition	0	155	26	181	174								
	1	24	150										
For Positive Condition <table border="1"> <thead> <tr> <th>Accuracy</th> <th>Recall</th> <th>Precision</th> <th>F1</th> </tr> </thead> <tbody> <tr> <td>85.915</td> <td>85.227</td> <td>86.206</td> <td>85.714</td> </tr> </tbody> </table>						Accuracy	Recall	Precision	F1	85.915	85.227	86.206	85.714
Accuracy	Recall	Precision	F1										
85.915	85.227	86.206	85.714										

Note: Current kinesic analysis is currently using only domestic data collected at UA, UCSB, & UMD.



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Vocalic Indicators



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Voice Measure Extraction Process

	Steps	Tools	Purposes
1	Identify time segments of Turns-at-Talk	Manually conducted using RA's	Provided audio segments of speech to analyze
2	Extract audio features from speech segments	OpenSmile	Provided voice measures of interest for each Turn-at-Talk
3	Aggregate features based on game rounds T1) Introduction T2) Rounds 1 and 2 T3) All remaining rounds	R	Standardizes game length for games with different number of rounds



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Automatically Extracted Voice Measures

Measure Name	Definition
F ₀ (pitch) Mean	The lowest frequency of a periodic waveform
F ₀ (pitch) Std	
Loudness-Mean	Subjective perception of sound pressure
Loudness-Std	
HNR-Mean	The harmonic-to-noise ratio (HNR) is the proportion of harmonic sound to noise in the voice measured in decibels
HNR-Std	
Jitter-Mean	Jitter is a measure of period-to-period fluctuations in fundamental frequency
Jitter-Std	
Shimmer-Mean	Shimmer measures the variability of the amplitude value
Shimmer-Std	
Turn-at-talk Duration	Duration in seconds of a turn-at-talk



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Linguistic Indicators



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Linguistic Measures Extraction Process

	Steps	Tools	Purposes
1	Convert audio recordings of each player to text transcriptions	IBM's Watson Speech-to-Text service	Produced multiple transcriptions for each game.
2	Merge multiple transcripts into a single transcript	Recognizer Output Voting Error Reduction (ROVER)	Produced a transcript and word-level timestamps for each game and reduced the word error rate of transcription
3	Coded the speakers in the transcription	Research assistants	Produced a final transcript including the speakers
4	Extract linguistic features	SPLICE and VADER	Obtained linguistic features (see the next slide for examples)



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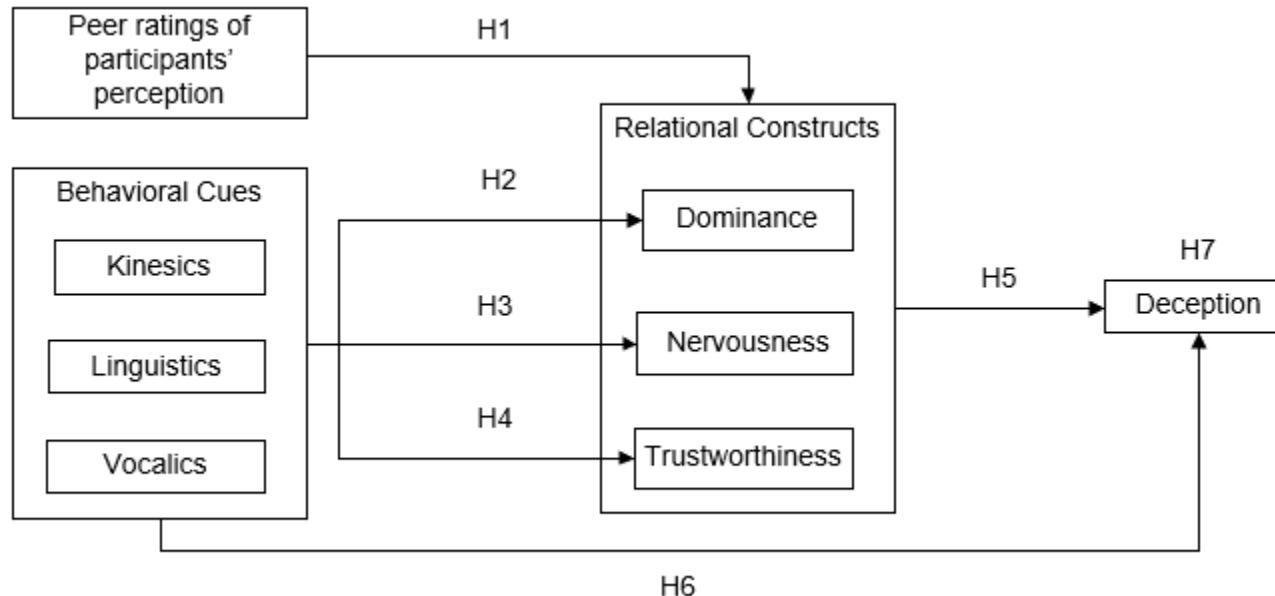
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Extracted Linguistic Measures

Measure Name	Definition
# of Words	Total words spoken by a participant for a given time window
# of Turns-at-Talk	Number of times a participant spoke for a given time window
Dominance Ratio	Dominant turns-at-talk are those which contain phrases like “you must” or “I can”, and the ratio is computed with the number of dominant turns-at-talk divided by the total number of turns-at-talk for a player in a time interval
Disfluency Ratio	Ratio of repeat phrases (e.g. “I think that... that is a good idea.”) and filled pauses (e.g. “um”, “uh”, etc.) to the total number of words. Filled pauses are transcribed as “%HESITATION” by IBM Watson Speech-to-Text
Polarity score	Absolute value of the compound sentiment score computed by the VADER sentiment algorithm in NLTK (Hutto & Gilbert, 2014)
Hedging Ratio	Ratio of number of hedging and uncertainty terms to total number of words

The Lens Model: Overview of Behavioral Analysis on Relational Messages and Deception





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H1: Relational Messages Hypotheses

1. *“Hiding in the weeds”*

- a. Deceivers are initially more passive (less dominant) than truth tellers to conceal their identity
- b. Might increasingly engage in “persuasive dominance”

2. *Trust*

- a. Deceivers are trusted less than truth tellers
- b. Judgments change over time

3. *Nervous leakage*

- a. Deceivers trying to conceal their deception give themselves away through patterns of rigidity
- b. Deceivers betray more nervousness than truth tellers



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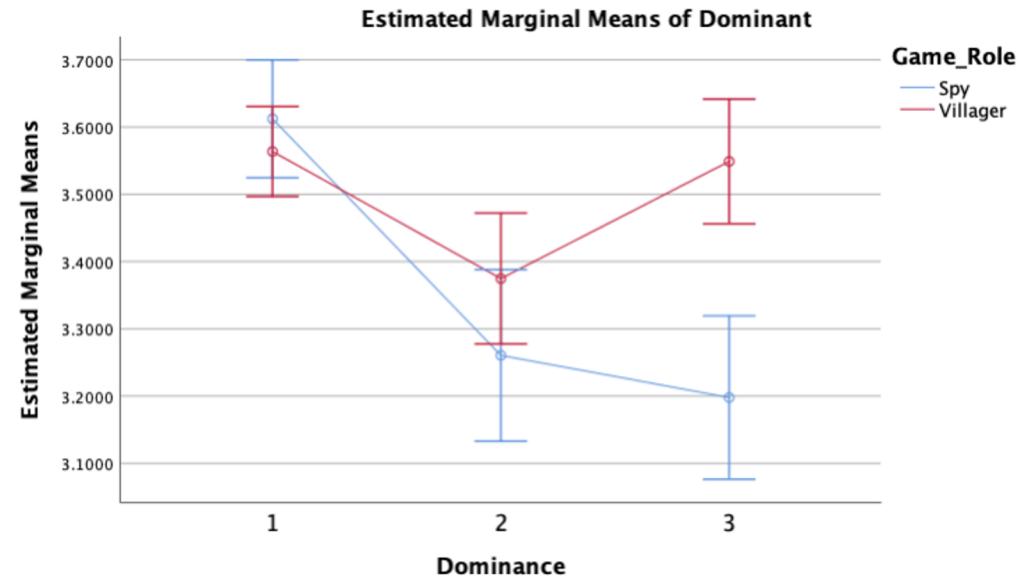


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H1a: Dominance Patterns between Spies and Villagers

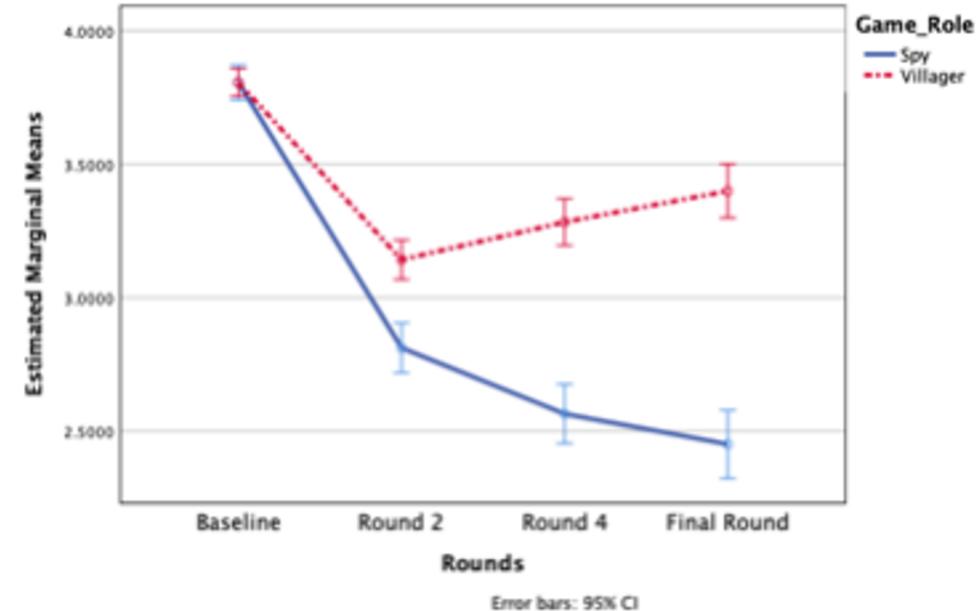
- Spies (deceivers) less dominant than villagers (truth tellers)



Mean Dominance Ratings by Role and Round

H1b: Predictors of Trustworthiness

- Main effects for game role, trust ratings across time, and interaction between game role and trust
- Spies were trusted less than villagers
 - Ratings declined over the course of the game
 - Ratings of villagers remained higher and showed an upswing over time
 - Trust and nervousness could be an indirect (proxy) measure for deception



Mean Trust Ratings by Game Role and Rounds



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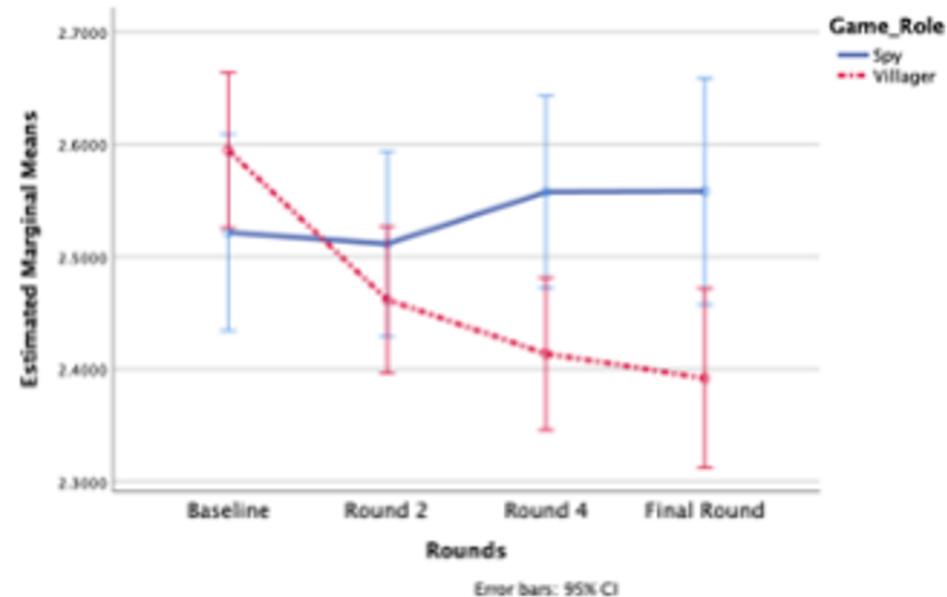


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H1c: Predictors of Nervousness

- Main effect and interaction between nervousness and game role
 - Deceivers (Spies) maintained the same degree of nervousness they displayed at the outset of the game
 - Truth tellers (Villagers) became increasingly relaxed



Mean Nervousness Ratings by Role and Round



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Behavioral Predictors of Relational Messages



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Dominance Analysis



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H2a: Kinesic Indicators (Facial Expression) of Dominance

Characteristics of Dominance	Kinesic Cues of Dominance	Related Facial Action Units
Monopolizing / leadership	Lower brows Non-smiling mouths	FAU 4/14
Influential and self-confident	More talking	FAU 25 and other mouth related FAUs
Authoritative and avoiding uncertainty	Lower brows Non-smiling mouths	FAU 4/14
Animated and open, transparent with emotions	More happy/angry/disgusted expression Less fearful and sad expression Strong facial expressions	FAU 1/2/4/5/6/7/12/15/16/20/23/26



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H2b: Kinesic Predictors of Dominance

Linear Mixed-Effect Model on Dominance		
Control Variables	Gender, Game experience, English proficiency	
Dependent Variable	Dominance category (Low/Medium/High Dominance)	
Significant FAUs	Coefficient	p-value
AU05 mean	0.058	0.055
AU14 mean	0.170	0.018
AU15 mean	0.394	0.002
AU17 mean	0.250	0.013
AU25 mean	0.316	0.007
AU26 mean	0.410	0.003



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H2b: Kinesic Predictors of Dominance (Cont.)

Linear Mixed-Effect Model on Dominance		
Significant FAUs	Coefficient	p-value
AU06 standard deviation	0.262	0.089
AU10 standard deviation	0.322	0.050
AU12 standard deviation	0.376	0.011
AU14 standard deviation	0.460	0.002
AU15 standard deviation	0.255	0.003
AU17 standard deviation	0.271	0.028
AU25 standard deviation	0.231	0.050
AU26 standard deviation	0.248	0.081



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H2b: Voice Indicators of Dominance

Characteristics of Dominance	Cues of Dominance	Description of Cues
Monopolizing / leadership	Fundamental frequency Vocal energy	Lower/deeper pitch More pitch variability Larger amplitude
Influential and self-confident	Speech fluency	Few hesitations Short response latencies
Authoritative and avoiding uncertainty	Uncertainty	Few hesitations Short response latencies Rapid speaking rate
Animated and open, transparent with emotions	Vocal diversity	More pitch variability More change in jitter/shimmer/hoarseness



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H2b: Vocalic Predictors of Dominance

		Dominance Score		
		Baseline Model	Reduced Model	Full Model
Control Variables	Gender	0.220(-0.084) ***	0.058(-0.142)	0.031(-0.143)
	Game Experience	0.157(-0.101)	0.155(-0.097)	0.158(-0.098)
	Native English Speaker	0.196(-0.109) *	0.16(-0.106)	0.158(-0.107)
	Game Status	-0.018(-0.038)	-0.024(-0.037)	-0.025(-0.037)
Vocalic Features	TaT duration		0.020(-0.007) ***	0.019(-0.008) **
	F ₀ -mean		-0.004(-0.002) *	-0.004(-0.002)
	F ₀ -Sd		0.007(-0.004) *	0.006(-0.004)
	Loudness-mean		0.221(-1.01)	0.026(-1.022)
	Loudness-Sd		2.663(-1.323) **	2.412(-1.378) *
	HNR-mean		0.004(-0.002) **	0.004(-0.002) **
	HNR-Sd		-0.011(-0.005) **	-0.010(-0.005) **
	Jitter-mean			0.727(-4.357)
	Jitter-Sd			1.99(-2.852)
	Shimmer-mean			8.547(-5.027) *
Main Effects	Shimmer-Sd			-2.981(-4.171)
	T3	0.266(-0.12) **	0.207(-0.124) *	0.192(-0.124)
	T2	0.081(-0.124)	0.033(-0.123)	0.02(-0.122)
Interactions	Game Role	0.165(-0.132)	0.107(-0.126)	0.097(-0.126)
	Game Role * T3	-0.733(-0.188) ***	-0.658(-0.18) ***	-0.675(-0.178) ***
	Game Role * T2	-0.244(-0.193)	-0.194(-0.184)	-0.193(-0.183)

Note:

*p<0.1; **p<0.05; ***p<0.01



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H2c: Linguistic Indicators of Dominance

Characteristics of Dominance	Cues of Dominance	Description of Cues
Monopolizing	Speech quantity	Talking often and talking for a longer duration
Influential and self-confident	Subjunctive phrases	A more definitive speech style and less use of subjunctive language
Authoritative and avoiding uncertainty	Uncertainty	Less hedging and fewer hesitations
Animated and open, transparent with emotions	Emotion	Greater exhibition of positive or negative emotions



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H2c: Linguistic Predictors of Dominance

- Players with a **higher dominance ratio** are rated as being more dominant
- Players with a **larger number of words** are rated as being more dominant
- Only two of the expected linguistic cues (number of words and dominance ratio) were significantly related to perceived dominance
- Dominance declined in T3
- This perhaps demonstrates that **it is not what you say, but how you say it.** Perceived dominance appears to be a function of overt characteristics of the voice opposed to semantic content

Dependent variable: Dominance Score			
	Variable Names	Baseline Model	Full Model
Control Variables	Gender (Male = 1)	0.322*** (0.085)	0.132* (0.077)
	Game Experience	0.130 (0.101)	0.082 (0.090)
	Native English Speaker	0.132 (0.113)	0.014 (0.105)
	Game Status	-0.008 (0.037)	-0.008 (0.033)
Linguistic Variables	Dominance Ratio		0.733* (0.395)
	Number of Words		0.291*** (0.105)
	Number of Sentences		0.160 (0.111)
	Polarity		-0.243 (0.412)
	Hedge Ratio		-0.269 (1.093)
	Disfluency Ratio		-0.815 (0.916)
Main Effects	T3 (After Round 2)	0.240*(0.125)	-0.204* (0.123)
	T2 (Round 1 and 2)	-0.019 (0.131)	-0.167 (0.118)
	Game Role (Spy = 1)	0.221 (0.138)	0.173 (0.120)
Interactions	T3 * Game Role	-0.789*** (0.197)	-0.687*** (0.171)
	T2 * Game Role	-0.307 (0.198)	-0.235 (0.173)
	Observations	409	409
Note:			*p<0.1; **p<0.05; ***p<0.01



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Dominance Analysis Summary

In adversarial group settings, cues of perceived dominance include:

- Longer turn-at-talk duration
- Lower pitch and greater pitch variance
- Greater loudness variance
- Less hoarseness and less variance in voice hoarseness
- Higher dominance ratio
- Higher number of words



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Trust Analysis



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H3a: Kinesic Predictors of Trustworthiness

Kinesic Cues of Trustworthiness	Description of Cues	Related Facial Action Units
Happy face/ Authentic Smile	Raised cheek/lip corner pulled up etc.	FAU 6/7/12/13/14/15/17/25/26
High variability of facial expression	More expressive	More variability of FAU existence
Perceived facial attractiveness	--	--



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H3a: Kinesic Predictors of Trustworthiness

Linear Mixed-Effect Model on Trustworthiness		
Control Variables	Gender, Game experience, English proficiency	
Dependent Variable	Dominance category (Low/Medium/High Dominance)	
Significant FAUs	Coefficient	p-value
AU05 mean	0.531	0.060
AU02 standard deviation	-0.343	0.056



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H3b: Hypothesized Voice Indicators

Cues of Trustworthiness	Description of Cues	Explanations
Mean fundamental frequency (pitch)	Deceivers show initial increase	Higher nervousness initially
F ₀ (pitch)	Lower average pitch over time / lower maximum pitch	Increased perceived composure, competence and trustworthiness
Vocal Variations	Higher vocal variations (e.g., higher standard deviations of loudness, pitch, HNR, jitter, shimmer, etc.)	Increased nonverbal immediacy and perceptions of closeness and intimacy



H3b: Vocalic Analysis of Trust

		Trustworthiness Score		
		Baseline Model	Simplified Model	Full Model
Control Variables	Gender	-0.024(0.081)	-0.323(0.128) **	-0.215(0.140)
	Game Experience	0.151(0.091) *	0.171(0.093) *	0.172(0.092) *
	Native English Speaker	-0.011(0.096)	0.047(0.099)	0.052(0.098)
	Game Status	0.041(0.027)	0.036(0.028)	0.049(0.028) *
Vocalic Features	TaT duration		0.013(0.008)	0.016(0.008) **
	F ₀ -mean		-0.003(0.002)	-0.002(0.002)
	F ₀ -Sd		-0.007(0.004)	-0.007(0.004)
	Loudness-mean		0.759(0.882)	0.952(0.878)
	Loudness-Sd		-0.252(1.247)	-0.157(1.274)
	HNR-mean		-0.002(0.002)	-0.002(0.002)
	HNR-Sd		0.003(0.004)	0.002(0.004)
	Jitter-mean			6.475(5.149)
	Jitter-Sd			-4.109(3.511)
	Shimmer-mean			-6.210(4.454)
Main Effects	Shimmer-Sd			0.749(4.277)
	T3	-0.106(0.118)	-0.013(0.127)	-0.038(0.129)
	T2	-0.540(0.123) ***	-0.474(0.126) ***	-0.500(0.126) ***
	Game Role	-0.039(0.130)	-0.055(0.129)	-0.073(0.130)
Interactions	Game Role * T3	-1.426(0.184) ***	-1.388(-0.181) ***	-1.360(0.181) ***
	Game Role * T2	-0.510(0.191) ***	-0.502(0.188) ***	-0.478(0.188) *

Note:

*p<0.1; **p<0.05; ***p<0.01



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H3c: Linguistic Indicators of Trustworthiness

Cues of Trustworthiness	Description of Cues	Explanations
Speech quantity	More words / fewer words	Reduce uncertainty / lose clarity
Comprehensibility	High readability	Signals benevolence and competence
Pronouns	More first-person pronouns and second-person pronouns	Suggest responsibility for one's utterances, inclusiveness with others
Emotion	More positive affect	Signals benevolence and intimacy
Fluency	Less disfluency	Reduce uncertainty, create clarity and indicate competence and lesser cognitive load
Hedging	Less hedging	Reduce certainty



H3c: Linguistic Analysis of Trust

- Players with a **larger number of words** are rated as being more trustworthy
- Players with a **higher ARI readability score** (an approximation of the US grade level needed to understand the text) are rated as being more trustworthy
- Deceivers are perceived as less trustworthy in T2 and T3 than truth-tellers

Dependent Variable: Trustworthiness Score			
	Variable Names	Baseline Model	Full Model
Control Variables	Gender (Male = 1)	0.044(0.076)	0.012(0.077)
	Game Experience	0.153*(0.087)	0.144(0.088)
	Native English Speaker	-0.007(0.095)	-0.043(0.097)
	Game Status	0.080***(0.028)	0.077***(0.028)
Linguistic Features	Number of Words		0.084** (0.042)
	Positivity		-0.637(1.182)
	Negativity		1.938(1.656)
	Hedge Ratio		-0.468(1.075)
	Disfluency Ratio		0.768(0.942)
	First Person Ratio		1.114(0.781)
	Second Person Ratio		-0.365(1.311)
Main Effects	ARI Readability		0.026*(0.015)
	T3 (After Round 2)	-0.175(0.113)	-0.151(0.134)
	T2 (Round 1 and 2)	-0.632*** (0.117)	-0.608*** (0.126)
	Game Role (Spy = 1)	-0.028(0.125)	-0.044(0.124)
Interactions	T3 * Game Role	-1.466*** (0.175)	-1.449*** (0.173)
	T2 * Game Role	-0.468*** (0.181)	-0.430** (0.179)
Intercept	Constant	3.642*** (0.117)	3.544*** (0.181)
	Observations	420	420
	Note:	*p<0.1; **p<0.05; ***p<0.01	



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Trustworthiness Analysis Summary

In adversarial group settings, cues of perceived trustworthiness include:

- Longer turn-at-talk duration
- More words
- Higher comprehensibility (ARI Readability score)
- *Deceivers became less trusted as the game progressed*



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Nervousness Analysis



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H4a: Kinesic Predictors of Nervousness

Kinesic Cues of Nervousness	Related Facial Action Units
Fear related expressions	FAU 1/2/4/5/7/20/26
More eye blinks	FAU 45
Increase in total facial movement	More FAU variability
Non-enjoyment smile	FAU 13/14/24



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H4b: Vocalic Indicators of Nervousness

Category of Vocalic Features	Associated Vocalic Parameters	Predicted Relationship
Speech Rate and Fluency	Number of syllables/second Syllable duration Duration of accented vowels Number and duration of pauses	Larger Smaller Longer Larger
Fundamental Frequency and Prosody	F_0 mean (pitch) F_0 std. deviation F_0 range Gradient of F_0 rising and falling	Higher Larger Wider Larger
Vocal Effort and Phonation	Intensity mean Intensity deviation Gradient of intensity rising and falling	Higher Larger Larger

Source: *Handbook of affective sciences*, Davidson et al., 2009



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H4a: Kinesic Predictors of Nervousness

Linear Mixed-Effect Model on Nervousness

Control Variables	Gender, Game experience, English proficiency	
Dependent Variable	Dominance category (Low/Medium/High Dominance)	
Significant FAUs	Coefficient	p-value
AU04 mean	0.135	0.075
AU23 mean	-0.340	0.057



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H4b: Vocalic Analysis on Nervousness

		Nervousness Score		
		Baseline Model	Simplified Model	Full Model
Control Variables	Gender	-0.071(0.066)	-0.068(0.116)	-0.080(0.118)
	Game Experience	0.039(0.078)	0.059(0.078)	0.058(0.078)
	Native English Speaker	0.003(0.083)	-0.022(0.085)	-0.025(0.085)
	Game Status	0.009(0.023)	0.000(0.024)	-0.002(0.024)
Vocalic Features	TaT duration		0.012**(0.006)	0.010(0.006)
	F ₀ -mean		0.000(0.002)	0.000(0.002)
	F ₀ -Sd		0.000(0.004)	-0.001(0.004)
	Loudness-mean		-1.385*(8.006)	-1.637*(0.008)
	Loudness-Sd		0.428(1.061)	0.760(1.102)
	HNR-mean		0.000(0.001)	0.000(0.001)
	HNR-Sd		0.000(0.004)	0.001(0.003)
	Jitter-mean			-5.093(3.556)
	Jitter-Sd			4.329*(2.332)
	Shimmer-mean			4.626(4.081)
Main Effects	Shimmer-Sd			-4.282(3.389)
	T3	0.016(0.117)	0.164(0.129)	0.142(0.130)
	T2	0.011(0.118)	0.131(0.125)	0.115(0.126)
	Game Role	0.161(0.103)	0.172*(0.103)	0.169(0.103)
Interactions	Game Role * T3	-0.352***(0.152)	-0.390***(0.146)	-0.380***(0.146)
	Game Role * T2	-0.379***(0.152)	-0.421***(0.151)	-0.415***(0.151)

Note:

*p<0.1; **p<0.05; ***p<0.01



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H4c: Linguistic Indicators of Nervousness/Arousal

Linguistic Cues	Hypothesized Direction	Explanations
Speech quantity	Fewer words / Fewer sentences / Incomplete sentences	High cognitive load/High level of anxiety
Comprehensibility	Lower readability	Due to more disruption / omission / sentence-incompletion
Emotion	Less emotional diversity	High cognitive load
Disfluency	More disfluencies and disturbance	Reduced certainty and clarity High cognitive load
Hedging	More Hedging	Reduced certainty



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H4c: Linguistic Analysis Results on Nervousness

- On average, deceivers are perceived as **more nervous** than truth tellers.
- The **more dominant the language used, the less nervous a player is rated.**
- Interaction terms show deceivers are rated as more nervous in **T2** and **T3**.

		Dependent Variable: Nervousness Score		
		Variable Names	Baseline Model	Full Model
Control Variables	Gender (Male = 1)	-0.006(0.066)	0.004(0.067)	
	Game Experience	-0.044(0.077)	-0.044(0.076)	
	Native English Speaker	-0.058(0.085)	-0.054(0.086)	
	Game Status	0.036(0.025)	0.034(0.025)	
Linguistic Features	Number of Words			0.081(0.098)
	Sentiment Score			-0.178(0.340)
	Hedge Ratio			-0.604(0.915)
	Disfluency Ratio			0.842(0.794)
	Number of Sentences			-0.003(0.003)
	Dominance Ratio			-0.641*(0.350)
Main Effects	T3 (After Round 2)	-0.041(0.121)	0.004(0.128)	
	T2 (Round 1 and 2)	0.012(0.120)	0.048(0.125)	
	Game Role (Spy = 1)	0.197*(0.107)	0.199*(0.107)	
Interactions	T3 * Game Role	-0.414***(0.151)	-0.417***(0.151)	
	T2 * Game Role	-0.464***(0.155)	-0.494***(0.155)	
Observations		419	419	
Note:		*p<0.1; **p<0.05; ***p<0.01		



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Nervousness Analysis Summary

In adversarial group settings, perceived nervousness includes

- Longer turn length
- Softer amplitude
- More jitter variance
- Less use of dominant language
- *Deceivers are perceived as more nervous than truth-tellers*



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Discussion

- *The importance of more granular, temporal measurement.*
 - Impressions at different stages of the group process add information to the ability to predict veracity
- *Relational communication becomes the leading edge in assessing the truthfulness or deceptiveness of others.*



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Questions?

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