

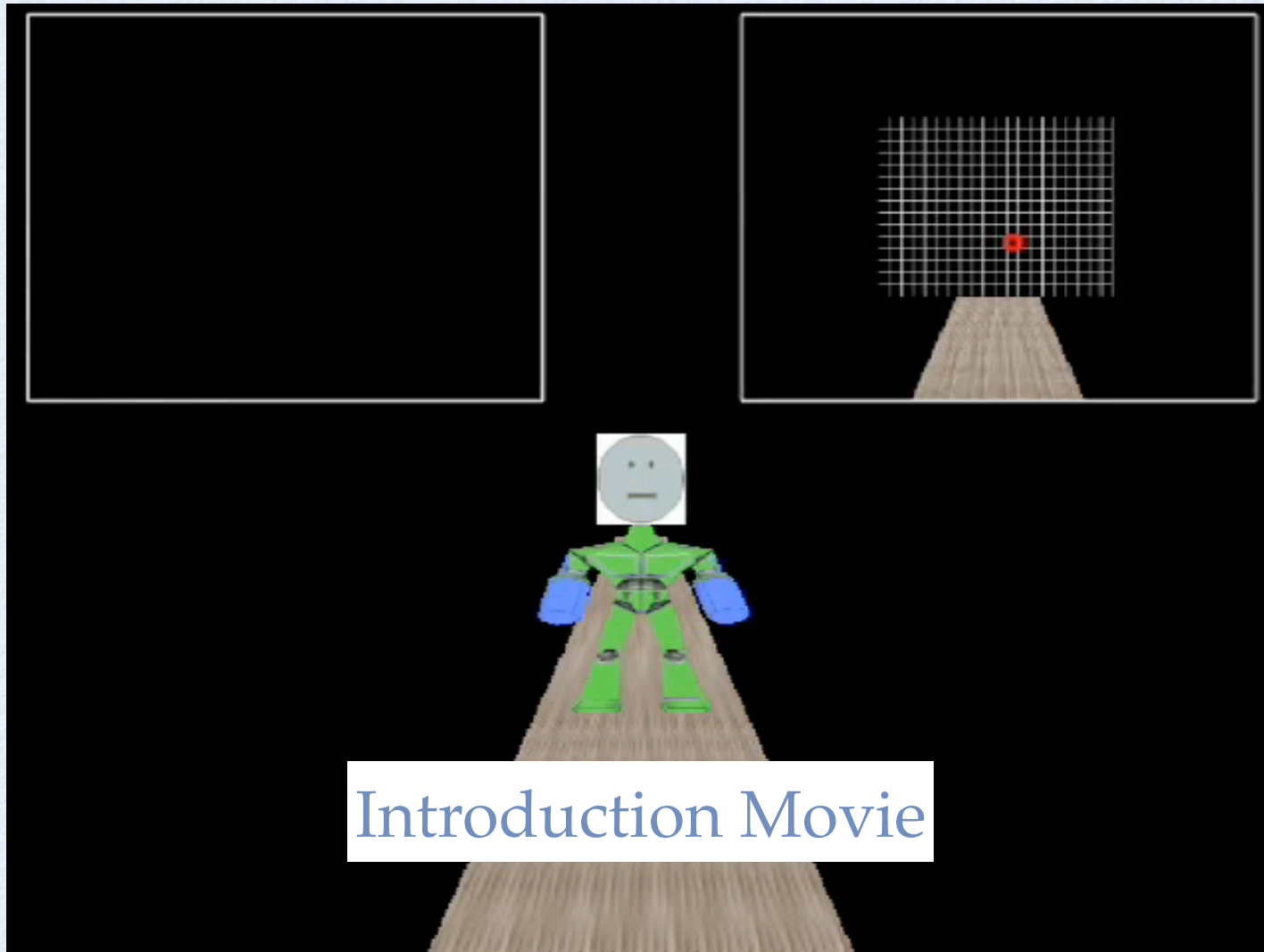
Emotional Robotics Tug of War

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Introduction






Facial Expression for Communication

- Facial Expressions presented by a robot enables faster communication with humans.

Facial Expression for Communication

- Facial Expressions presented by a robot enables faster communication with humans.
- Is this always true?

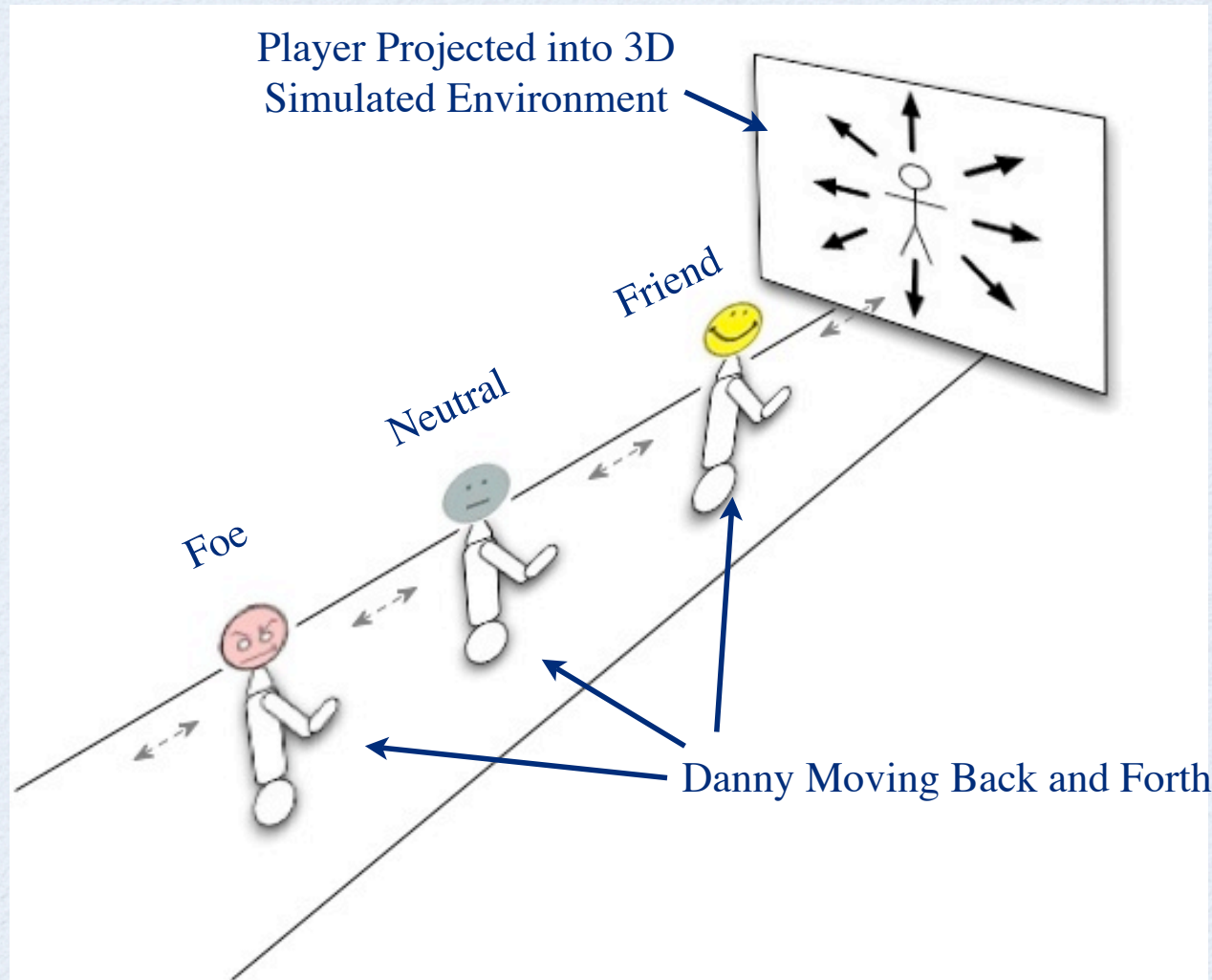
Research Question

- Can    Expressions supplement motion as feedback from a robot for improved learning?
- Previous work:
 - human facial expression learned as a trigger to change human behavior (Kringelbach, 2004)
 - affective robot, Kismet, can cause changes in human behavior using facial expression, motion and electronic voice (Breazeal, 1998-2000)

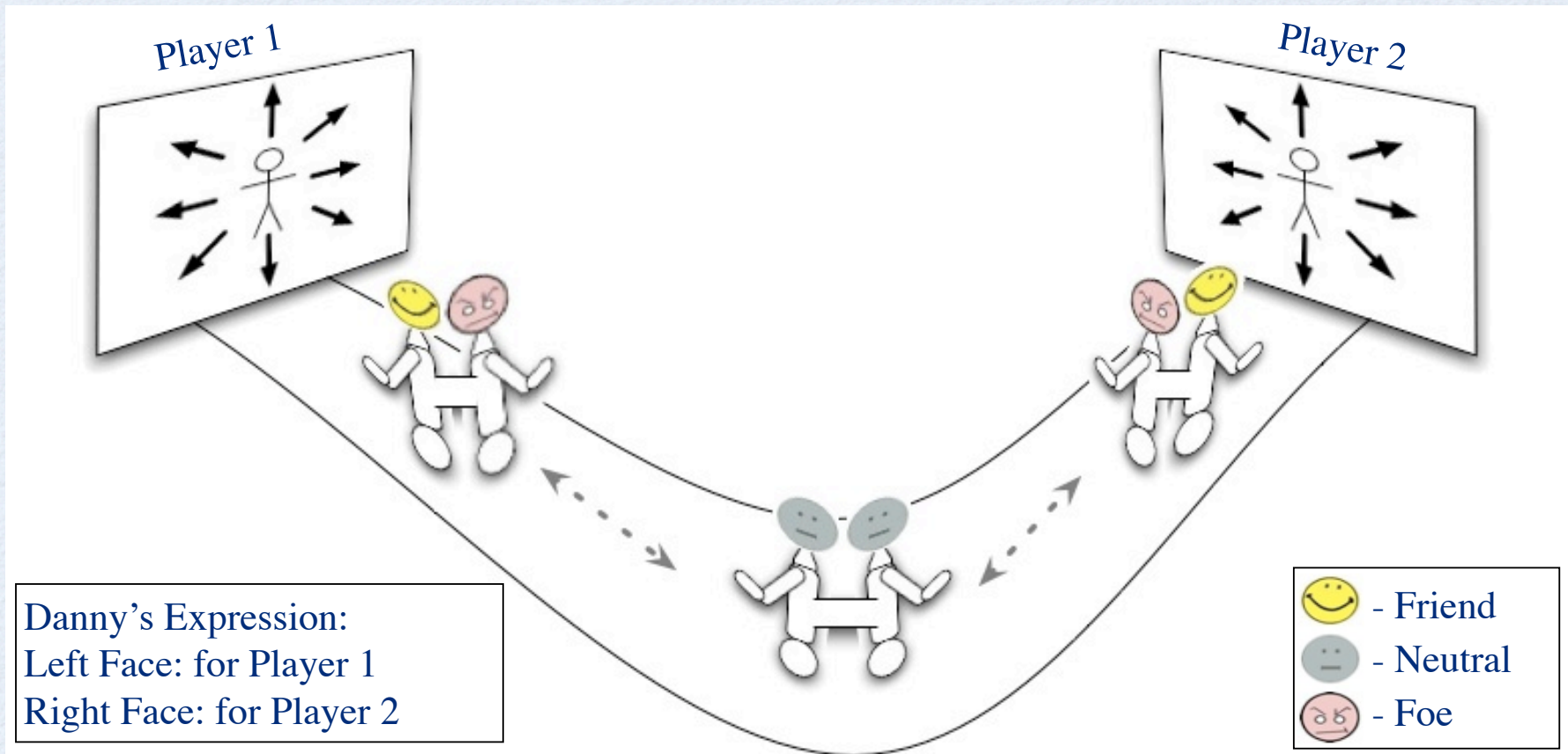
Environment

- Danny, the simulated robot, interacts with humans.
- Player's **Goal**:
 - Get Danny to come close to player
 - Danny approaches what it likes
- Danny can detect:
 - player's **Face**
 - player's **Motion**
 - player's **Pitch**

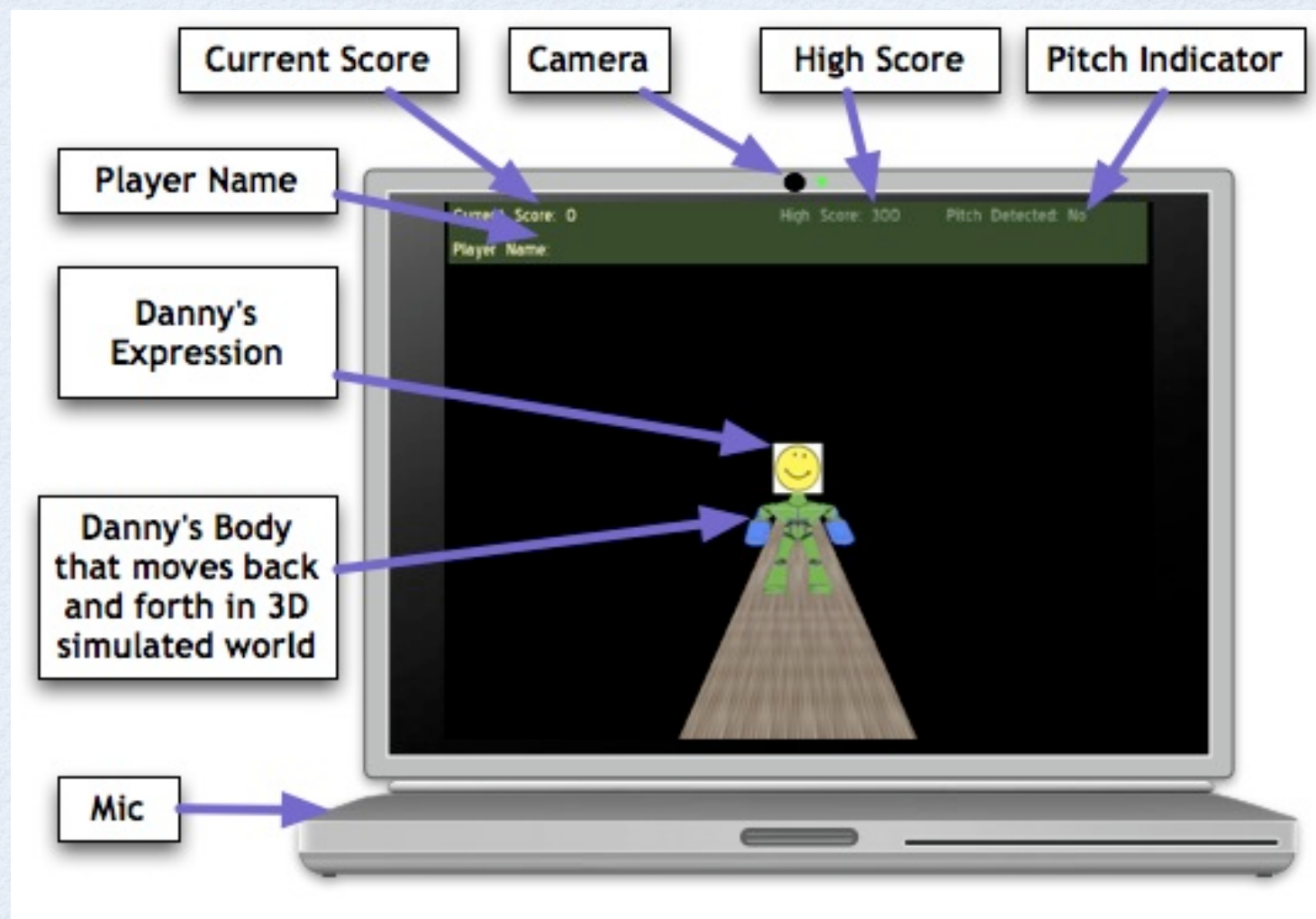
One Player Game










Two Player: Tug of War



The Platform (One Player)



Output Features

State Value	Face	How Friendly	Steps Towards Person	Change in Score
friend > 0.80		+3	+3	+3
friend > 0.65		+2	+2	+2
friend > 0.55		+1	+1	+1
friend & foe <= 0.55		Neutral	0	0
foe > 0.55		-1	-1	0
foe > 0.65		-2	-2	0
foe > 0.80		-3	-3	0

Facial Expression Conditions

Control
Just Approach and Withdraw

Conditions Movie

The Self-Absorbed State

- Represents robots non-social needs
 - charge battery
 - perform other tasks
 - etc.
- Independent of the emotional input
- Cycle based on a timer
- Tends to a neutral expression
- Overrides robot's emotional expression

States and Transitions

- Internal Emotional State Vector

- $s = [s_{friend}, s_{foe}, s_{absorbed}]$

- Update Rules:

- $s_{friend} \leftarrow s_{friend} + w \cdot F_{friend}(Input)$

- $s_{foe} \leftarrow s_{foe} + w \cdot F_{foe}(Input)$

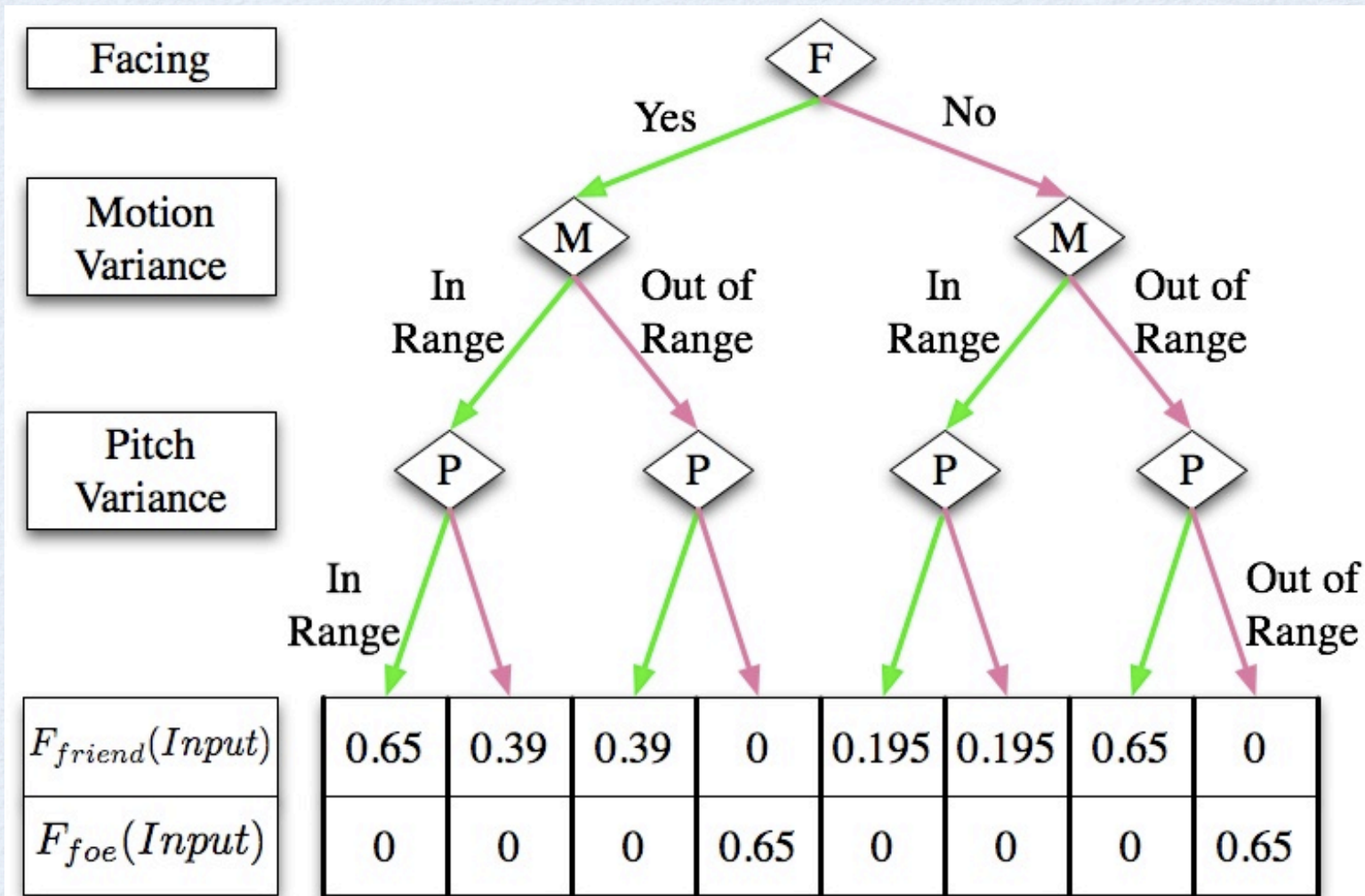
- $s_{absorbed} \leftarrow s_{absorbed} + w \cdot F_{absorbed}(Cycle)$

- All variables and functions are non-negative

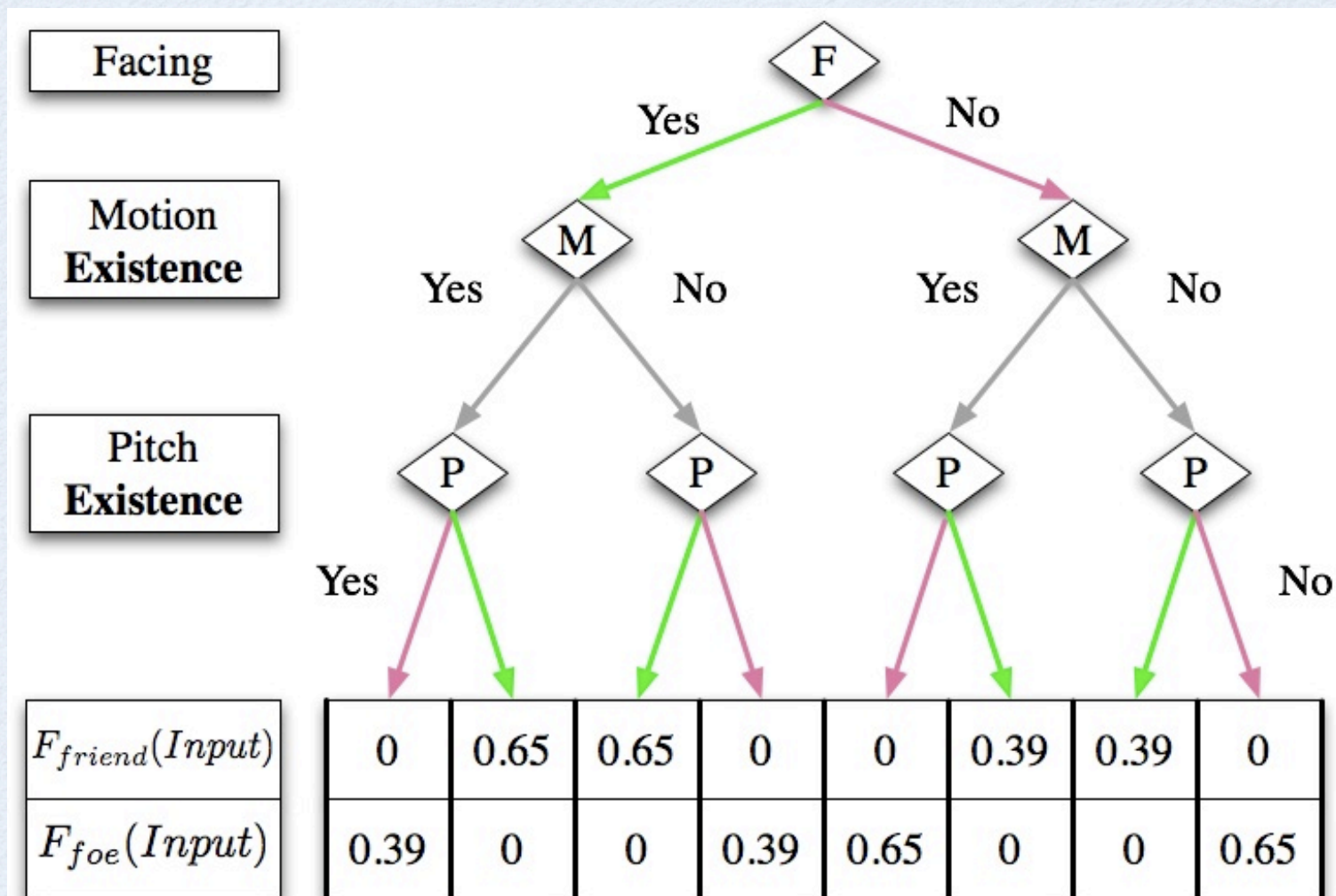
- s is normalized by \mathcal{L}_1 Norm after each update

- w is constant for a desired behavior.

Input Functions (Variance)



Either Motion Or Pitch



Experimental Design

- 4 x 4 mixed factorial design
 - Factor A: Emotional Feedback
 - **control** (just movement), **score**, **face**, **both**
 - Factor B: Desired Behavior (Mood)
 - **low**, **medium**, or **high** variance
 - **only motion or only sound**

Experimental Design

- 4 subjects per Emotional Feedback condition
- 4 Desired Behaviors randomized for each subject
 - 3 subsequent trials for each Desired Behavior
- Example presentation order:
 - Feedback: Control
 - Desired Behavior: three low, three either / or, three high, three medium

Post-Test Survey

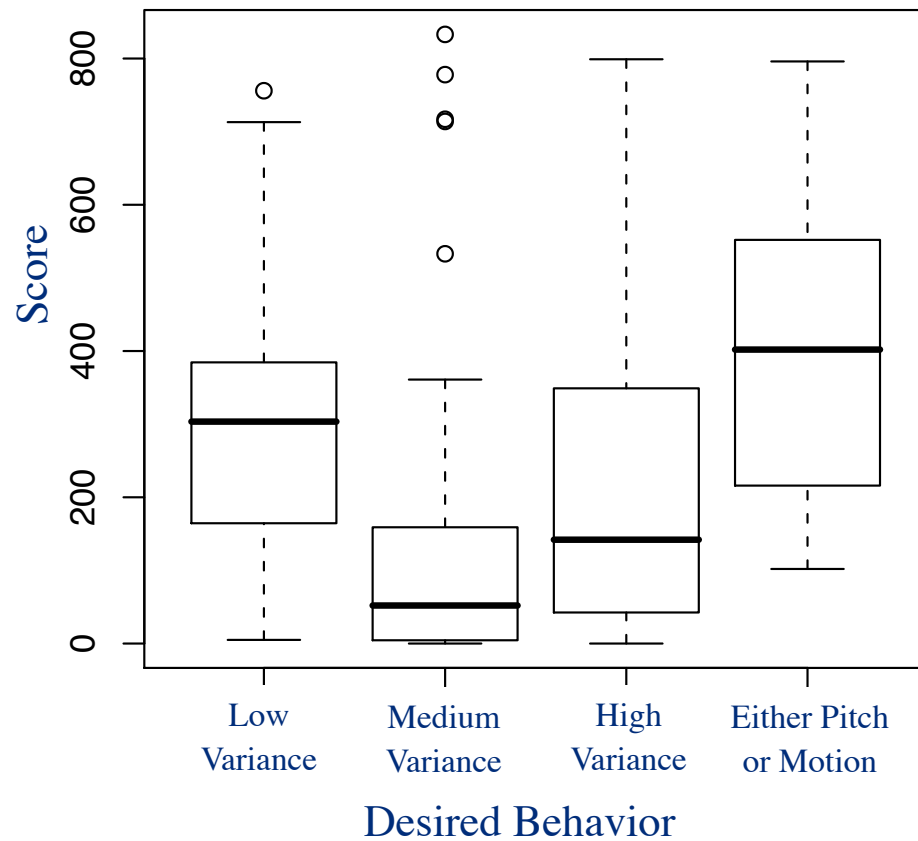
- Which Mood was easiest for you to figure out:
1st 2nd 3rd 4th
- Which Mood was hardest for you to figure out:
1st 2nd 3rd 4th
- Did the feedback help? (Yes No) How / Why / What would have helped more?
- Do you know what makes the robot happy in each Mood? If so, please describe.

Analysis of Variance

- Emotional Feedback
 - Null Hypothesis: **mean scores** of Emotional Feedback conditions are equal
 - F-score = 1.92, p-value = 0.127: **failure to reject** the Null Hypothesis
- Desired Behavior
 - Null Hypothesis: mean scores of Desired Behavior conditions are equal
 - F-score = 8.86, p-value = 0.003: **reject** the Null Hypothesis
 - Alternative Hypothesis: Desired Behavior affects score
 - H_1 : low variance is different from medium variance
 - H_2 : low variance is different from high variance
 - etc...

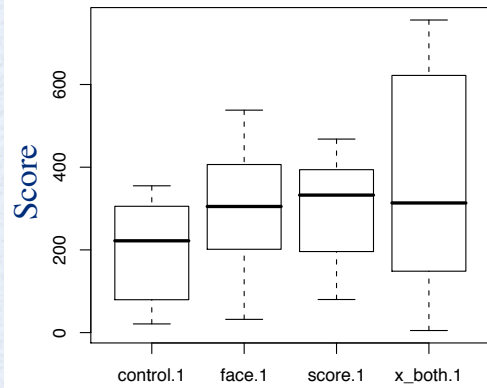
Comparing Desired Behavior

Score vs. Desired Behavior



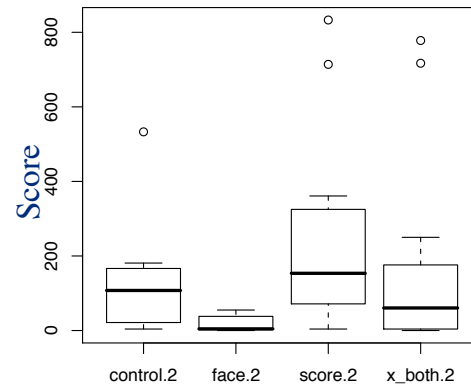
Desired Behavior vs. Feedback

Low Variance: Score vs. Feedback



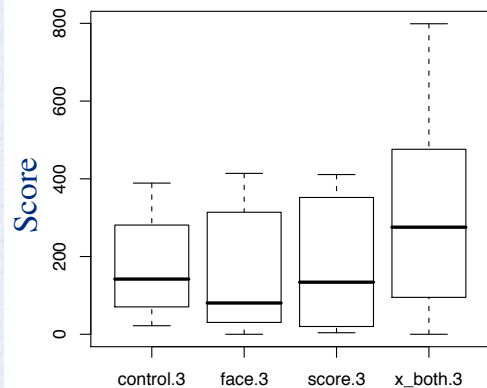
Feedback

Med Variance: Score vs. Feedback



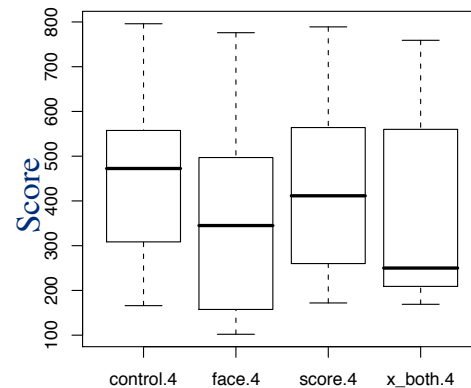
Feedback

High Variance: Score vs. Feedback



Feedback

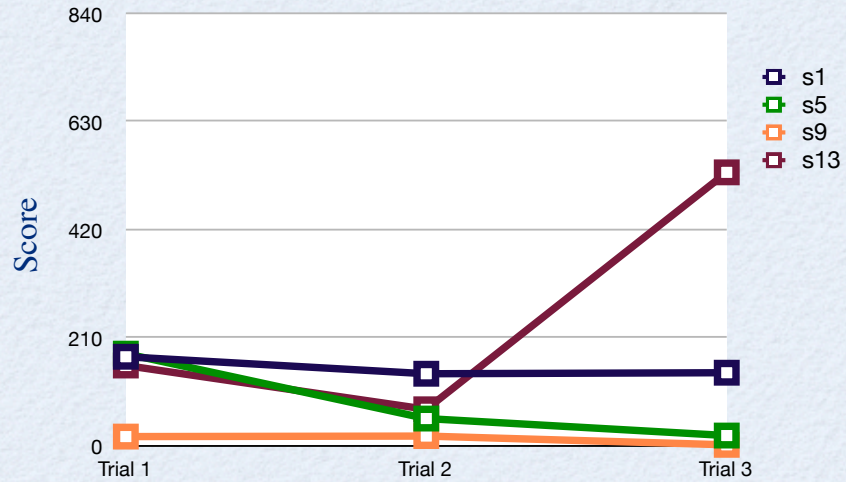
Motion or Pitch: Score vs. Feedback



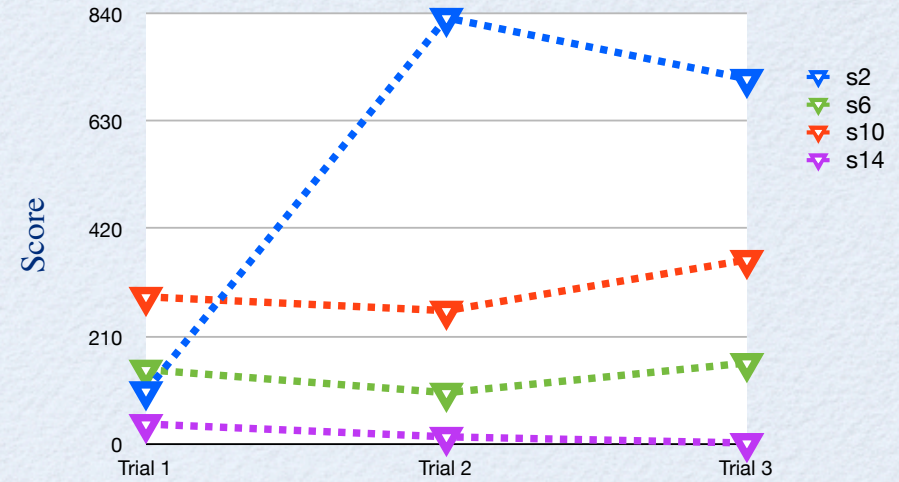
Feedback

Medium Variance

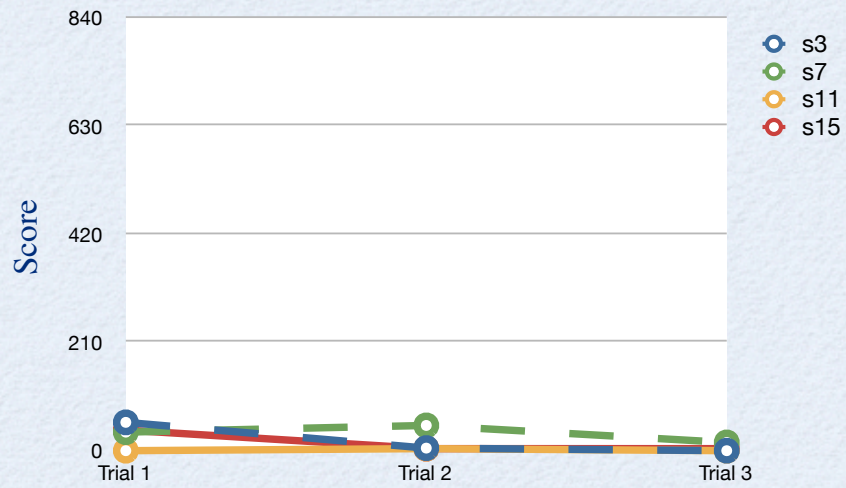
Mood 2: Control



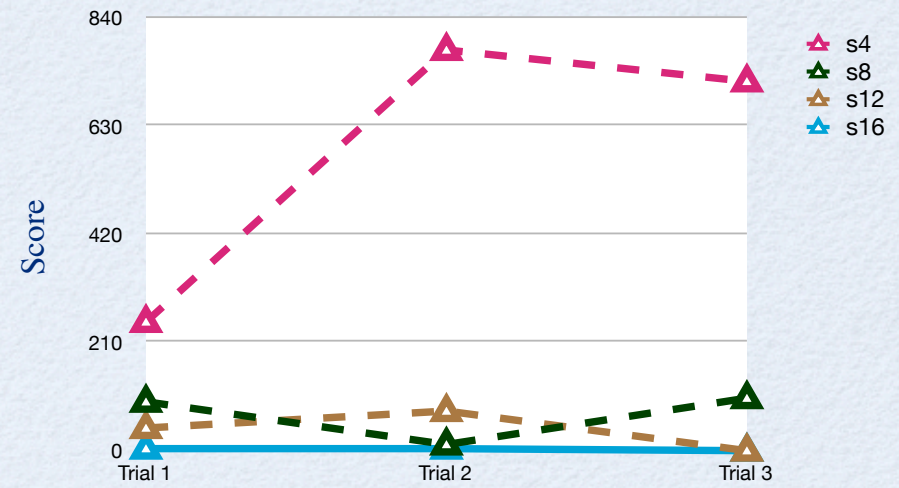
Mood 2: Score



Mood 2: Face

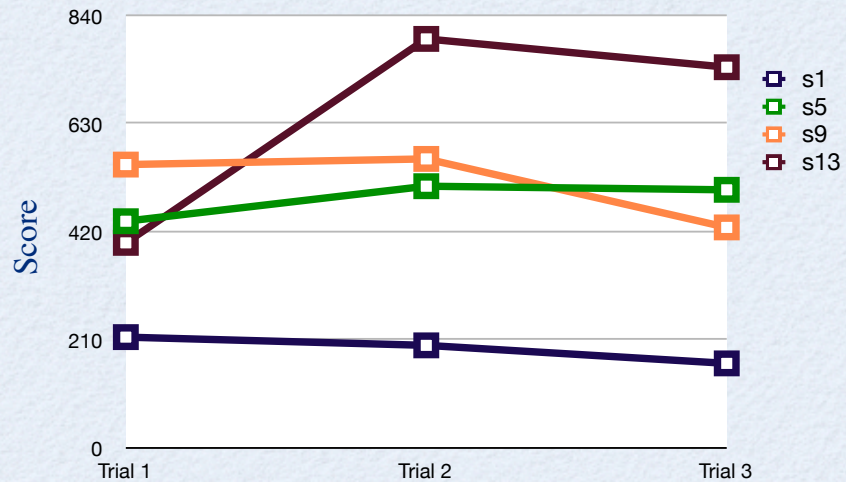


Mood 2: Both

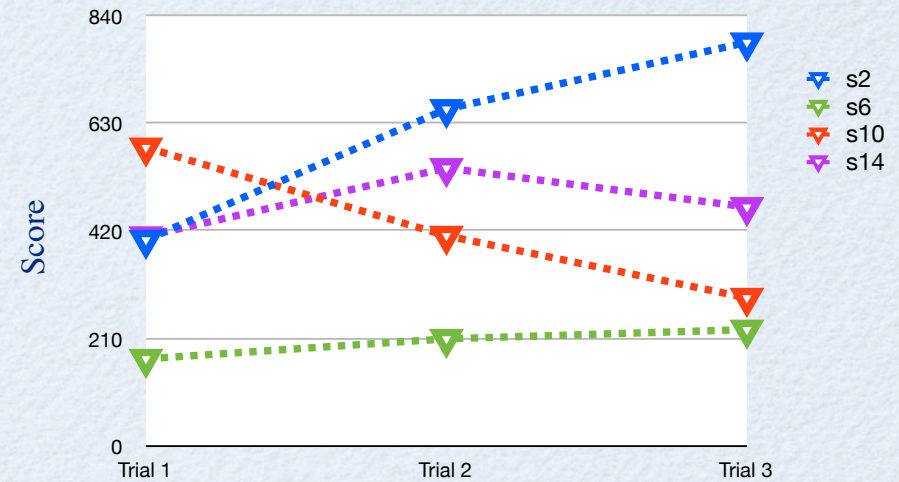


Either Motion or Pitch

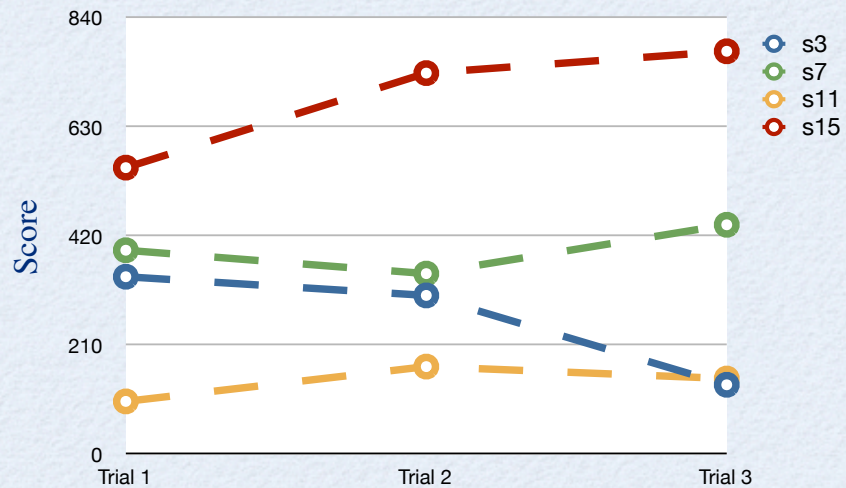
Mood 4: Control



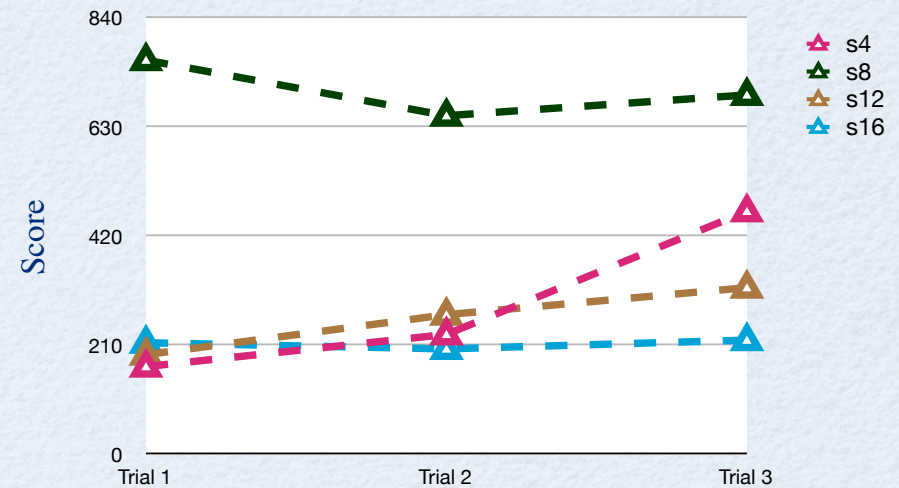
Mood 4: Score



Face



Mood 4: Both



Conclusions

- Secondary feedback to motion only has a small effect, if any
- Facial Expressions cannot simply be used as additional feedback to Motion
- Person's enjoyment improves with facial expressions
- One Player Game is a promising platform for experimentation

Future Work

- Facial Expressions
 - Two Player Tug of War
 - Instantaneous feedback (Facial and Score)
 - More advanced robot expressions
- Robot Simulation
 - Integrate emotional recognition software
 - Facial/Head Gestures (el Kaliouby and Robinson, 2004)
 - Use by other research groups
- Learn emotional behavior

Finally...

- Facial Expressions presented by a robot might not provide faster communication with humans.

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- But

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- Facial Expressions presented by a robot might not provide faster communication with humans.
- But
 - They make people more willing to team with robot

Thank you!