The Search for the Uncanny Valley

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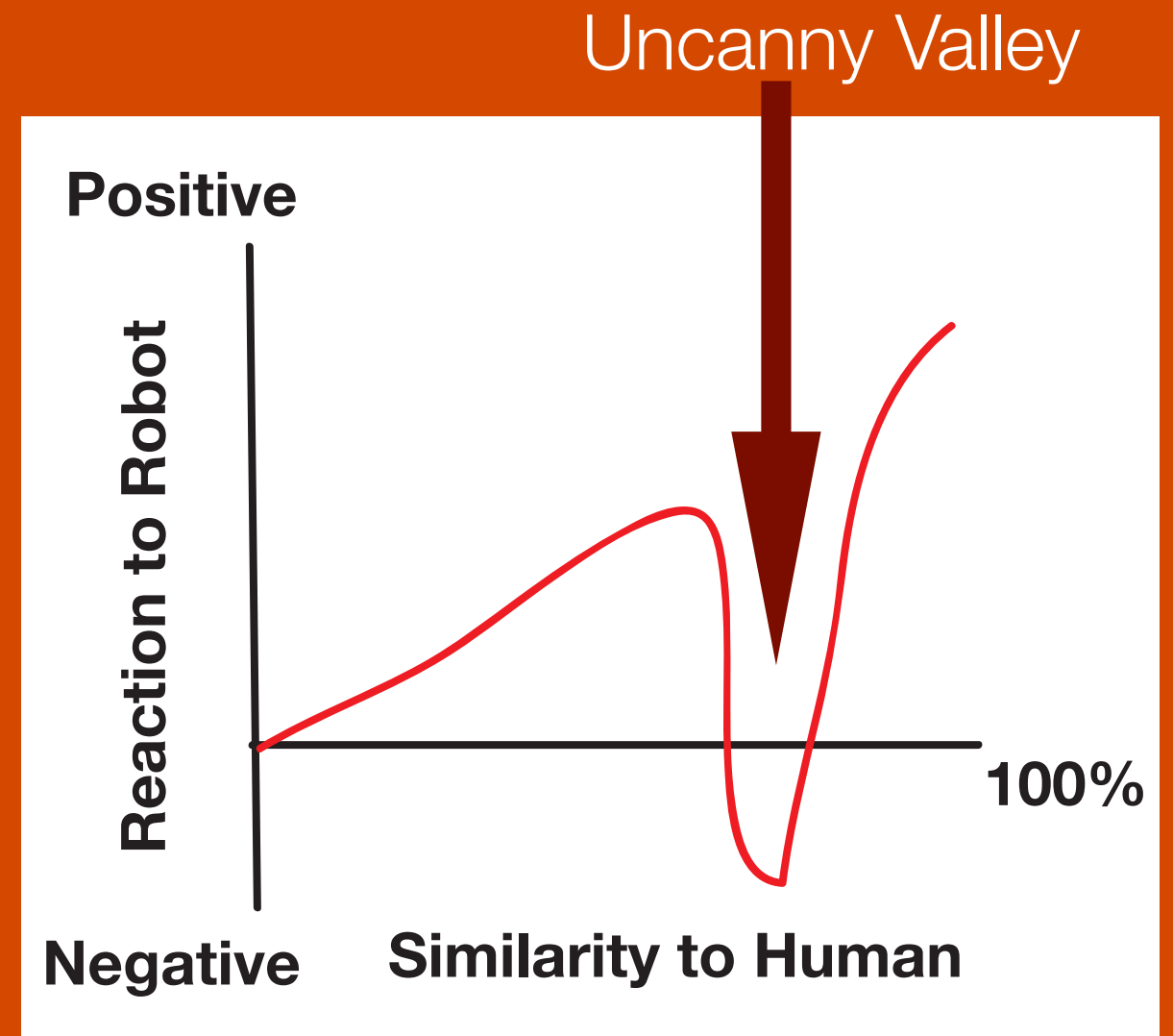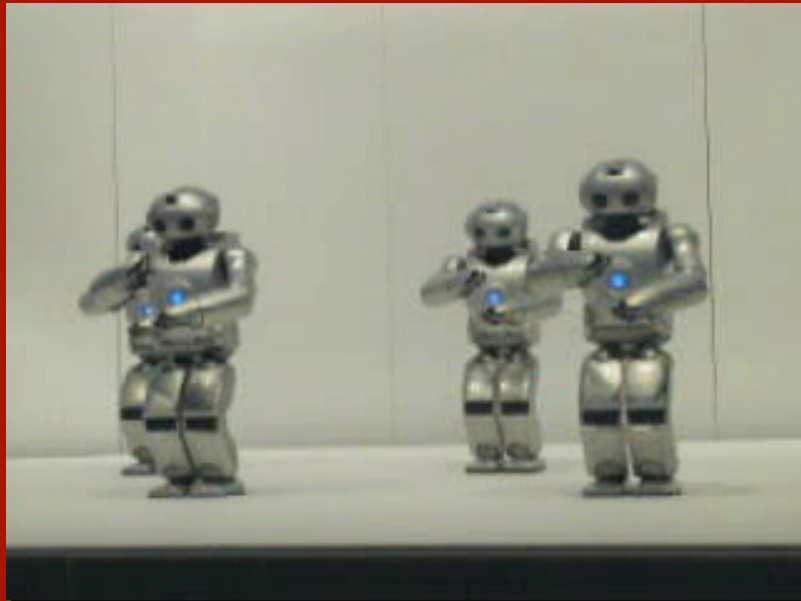# Preliminaries

definitions
robots
Hollywood
brains

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Simple Definition

▶ To the right is the basic version of the uncanny valley reaction to a robot is plotted against its similarity to a human likeness

▶ Originally described by roboticist Masahiro Mori in 1970 and called 「不気味の谷」 or "bukimi no tani" in Japanese
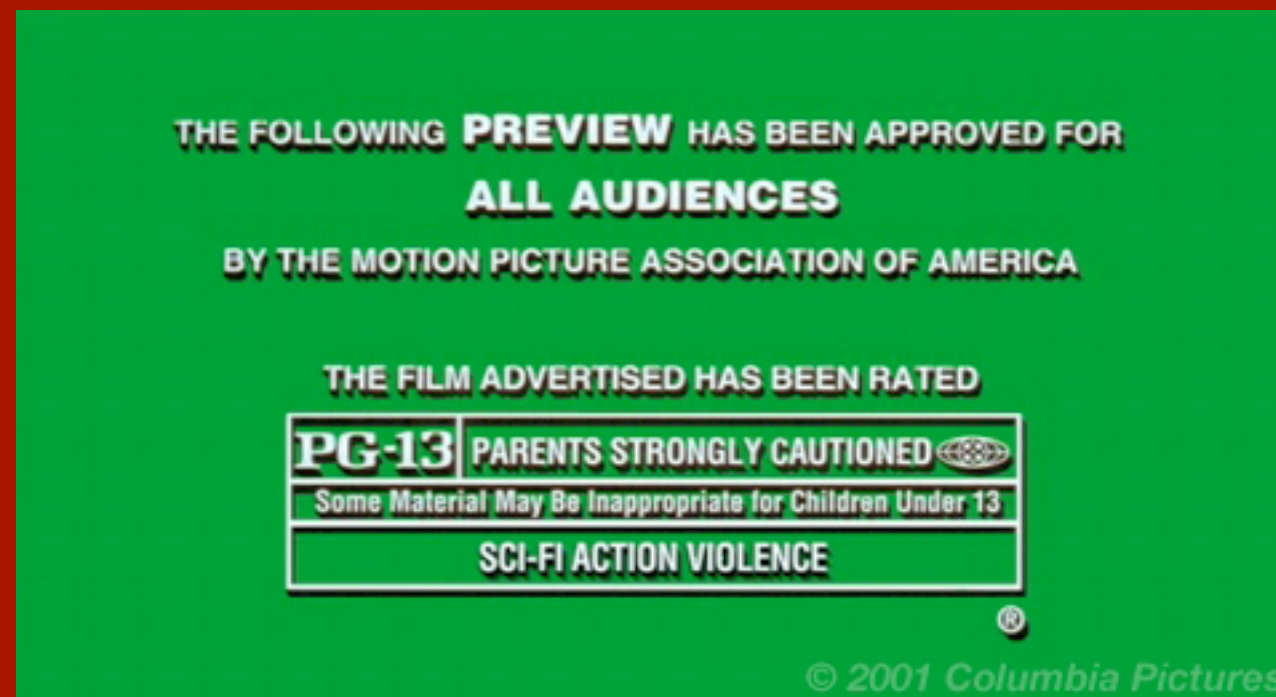
Personal Robots Make the 21st Century
More Fun

Corporate Executive Vice President, Sony Corporation
President, Intelligent Dynamics Research Institute
Chairman, Sony Computer Science Laboratories, Inc.
Founder, ROBODEX

Engineer **Toshitada Doi**

What do you think about the "character" of robots?

Take QRIO as an example. We suggested the idea of an "eight year-old space life form" to the designer -- we didn't want to make it too similar to a human. In the background, as well, lay an idea passed down from the man whose work forms the foundation of the Japanese robot industry, Masahiro Mori: "the valley of eeriness". *If your design is too close to human form, at a certain point it becomes just too . . . uncanny.* So, while we created QRIO in a human image, we also wanted to give it little bit of a "spaceman" feel.

THE FOLLOWING **PREVIEW** HAS BEEN APPROVED FOR
ALL AUDIENCES
BY THE MOTION PICTURE ASSOCIATION OF AMERICA

THE FILM ADVERTISED HAS BEEN RATED

PG-13 | PARENTS STRONGLY CAUTIONED
Some Material May Be Inappropriate for Children Under 13
SCI-FI ACTION VIOLENCE

© 2001 Columbia Pictures

Andy Jones, Final Fantasy animation director, makes a similar point, arguing that, while a completely convincing replication of a human being had never been his team's goal, he, too, had noticed how "***it can get eerie. As you push further and further, it begins to get grotesque***. You start to feel like you're puppeteering a corpse.
—Lawrence Weschler, "Why is this man smiling," Wired, June 2002

Gollum stuck in 'Uncanny Valley' of the 'Rings'
January 11, 2004 Chicago Sun Times

BY ROGER EBERT

Q. Andy Serkis is brilliant as Gollum, the CGI character in "Lord of the Rings: Return of the King." Given the increasing overlap between technology and acting, when do you see an actor in such a role getting nominated for best supporting actor at the Oscars

A. .... It is possible that the rejection of the sci-fi movie "Final Fantasy," which used computer animation to create "real characters," was caused because it fell into the **Uncanny Valley.** The genius of Gollum is that it seems like a convincingly real creature -- but not one we have ever seen before, so that its realism does not seem creepy except in the ordinary way. If Serkis brought Gollum to life, **other artists fine-tuned the balance with the Uncanny Valley**. So this is something other than a conventional performance, and should not compete against characters of a different nature. Perhaps a new category is called for? ***Beyond the Oscar of the Uncanniest Valley?***
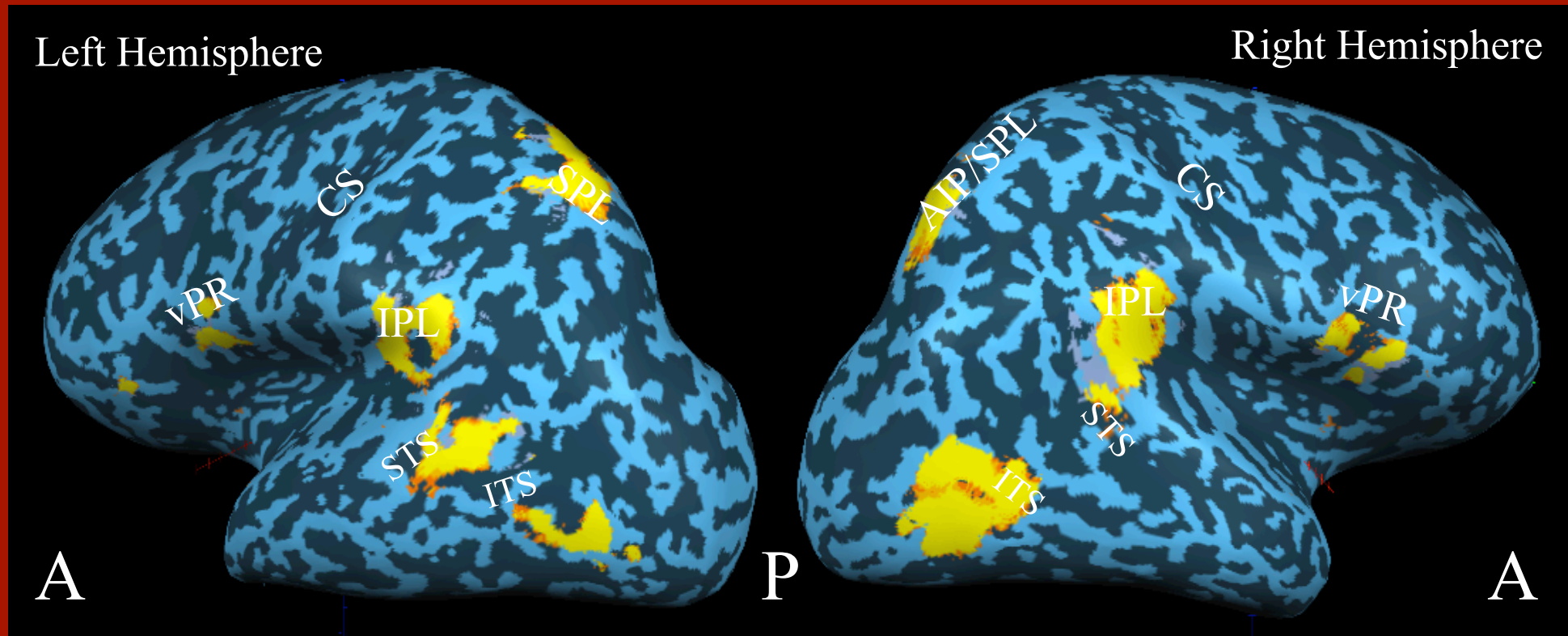
"That's where every neuron is focused on what's wrong with the robot, on how its motion is not quite right," said Bruce Blumberg, head of the synthetic character program at the MIT Media Lab. "***The uncanny valley is a very bad place to be.***"

—Michael A. Hiltzik, "Synthetic Actors Guild," Los Angeles Times , May 8, 2001

Enough Examples!!

▶ Not that you can really trust what you read in newspapers and magazines, but it seems reasonable to believe that some sort of problem exists

▶ Are there any related research studies?

Uncanny Valley Research

- As far as I can tell, no direct research exists. However, there is related applied psychology research into:

  - Presence in virtual environments

  - Social computer characters

Suspension of Disbelief

▶ Work in virtual environments and computer chararcters often reduces to some measure of suspension of disbelief

▶ "That willing suspension of disbelief for the moment, which constitutes poetic faith". [Biographia Literaria (1817), Samuel Taylor Coleridge (1772 -1834), English Poet]

Plausibility

An essential property
Explorations of Movement Space
Pretense

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An essential aspect to the uncanny valley

▶ Variations about a normal movement of an actor can have a substantial effect on recognition, including some sort of categorical change in subjective experience
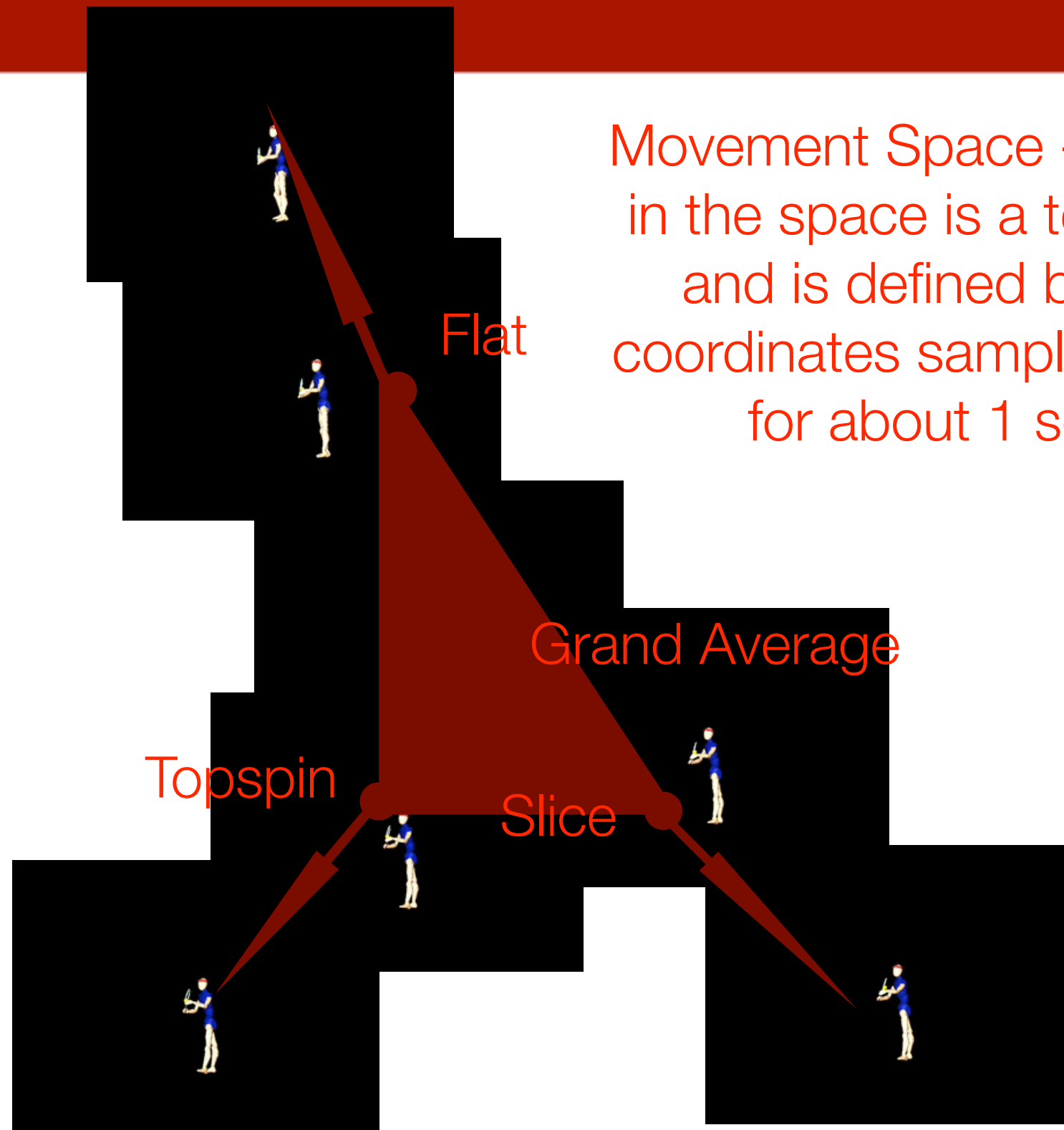
Explorations of Movement Space

- If we record the 3D positions of the joints during an action and treat these data as a point in a movement space defining this action then we can explore how deviations from the recorded movement result in changes in perception
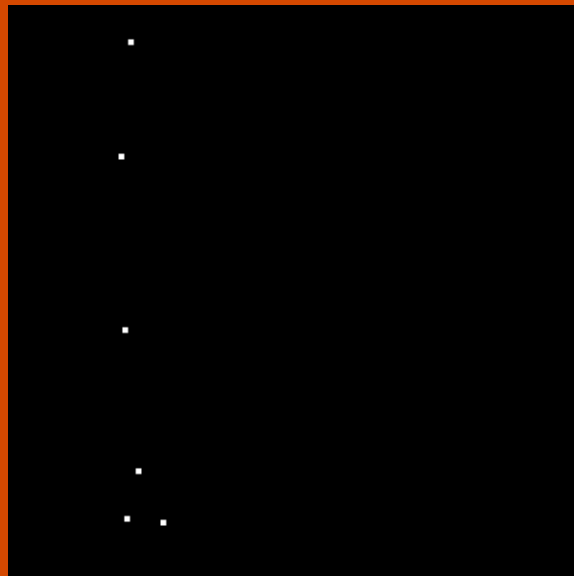
Enhancing Style Recognition

Style 1

Style 3   ...ral   Style 2
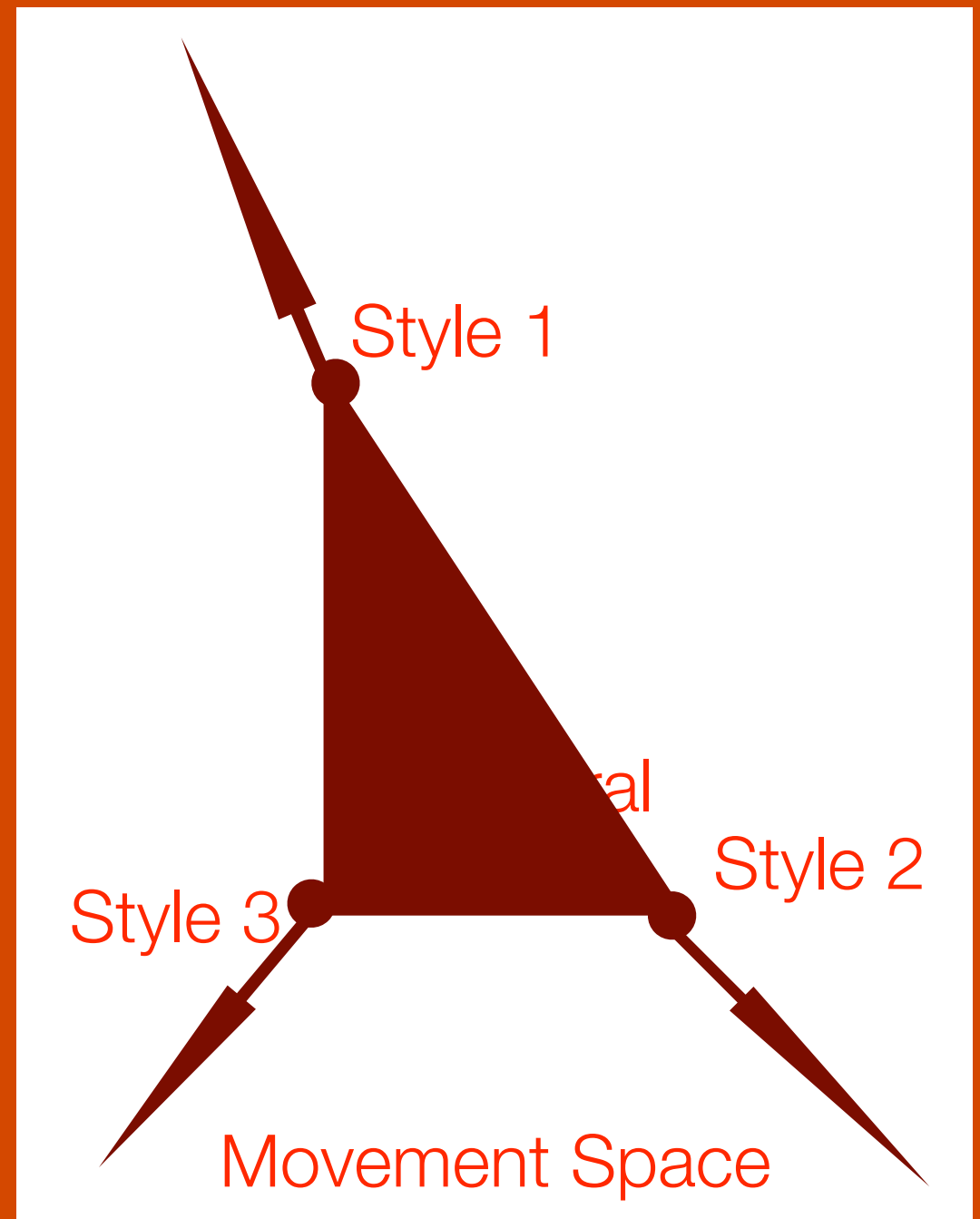
Movement Space

Tennis Serves

Movement Space - each point in the space is a tennis serve and is defined by the 3D coordinates sampled at 60 Hz for about 1 second

Flat

Grand Average

Topspin

Slice

Pollick, F.E., Fidopiastis, C.M., & Braden, V. (2001). Recognizing the style of spatially exaggerated tennis serves. Perception, **30**, 323-338
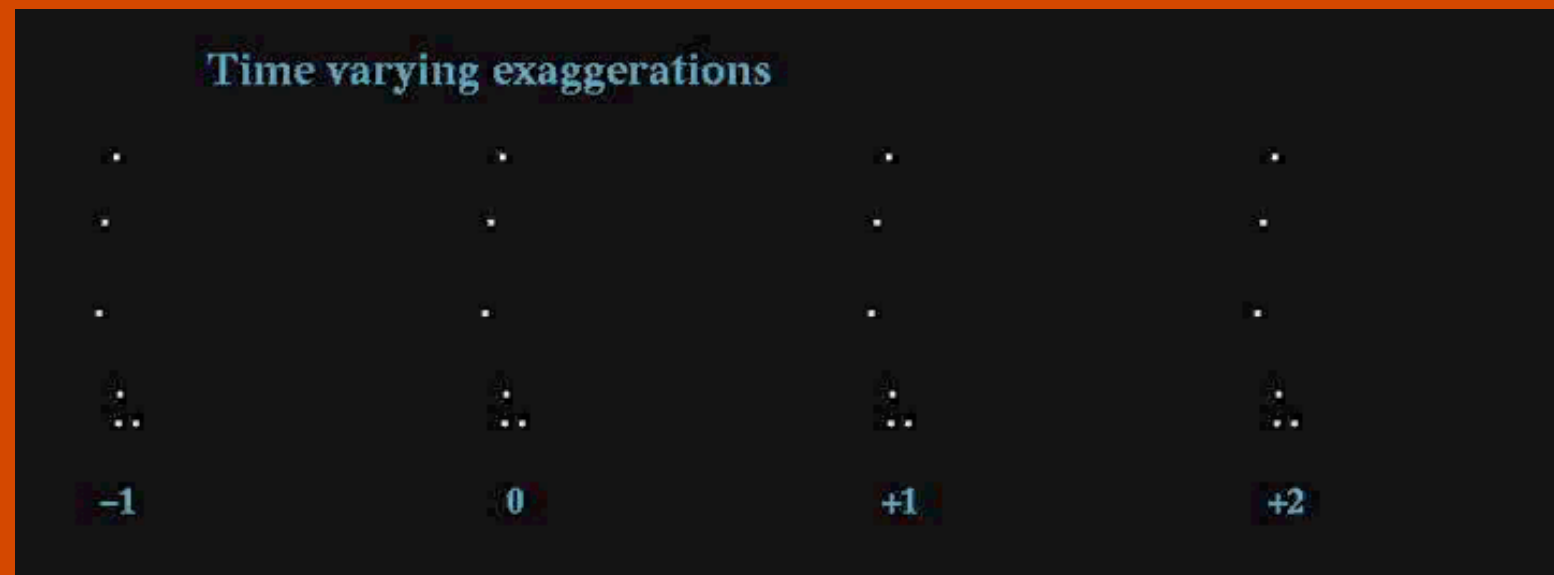
Identity

A

B

Exaggerations of B

Time varying exaggerations

−1   0   +1   +2

Hill, H, H., Pollick, F.E. (2000). Exaggerating temporal differences enhances recognition of individual from point light displays. *Psychological Science,* **11**, 223-228.

Facial Expression

Pollick, F.E., Hill, H., Calder, A. & Paterson, H. (2003). Recognizing facial expression from spatially and temporally modified movements. Perception, 32, 813-826.
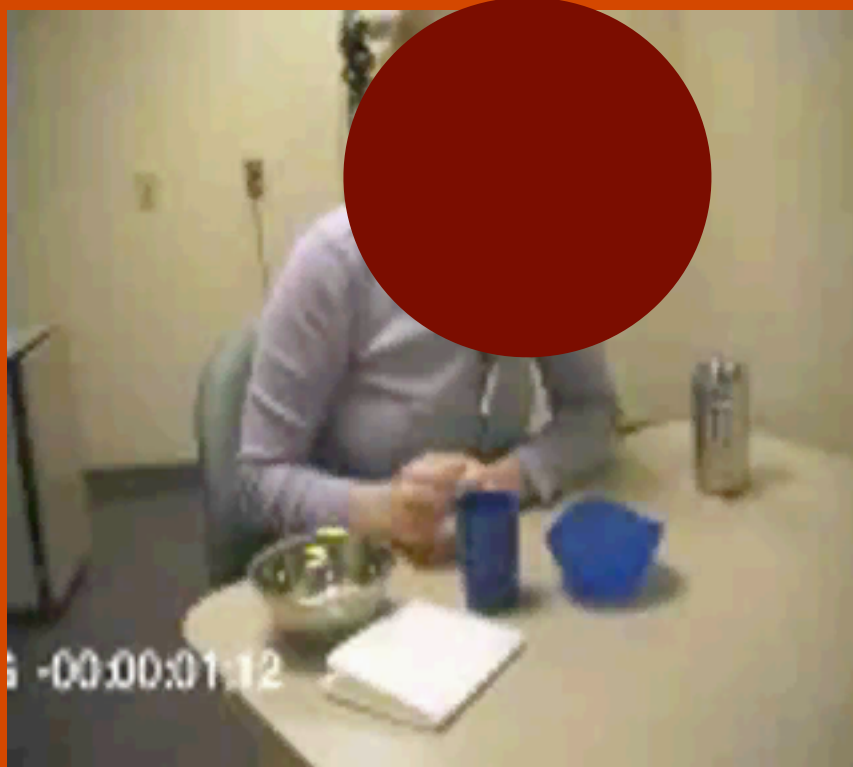
Psychological Plausibility?

▶ Distortion of natural movements can lead to enhanced & diminished recognition of movements

Pretense in toddlers

▶ Children systematically distinguish fantasy from reality, but are tempted to believe in the existence of what they have merely imagined

▶ Research by Angeline Lillard has investigated what cues are available to toddlers to distinguish real from pretense actions

Mothers' Snack Behavior

Real

Pretend

Note: Faces were visible on actual stimuli, however consent not obtained for distribution on web

Lillard, A.S., & Witherington, D. (2004). Mothers' behavior modifications during pretense snacks and their possible signal value for toddlers. Developmental Psychology, 40, 95-113.
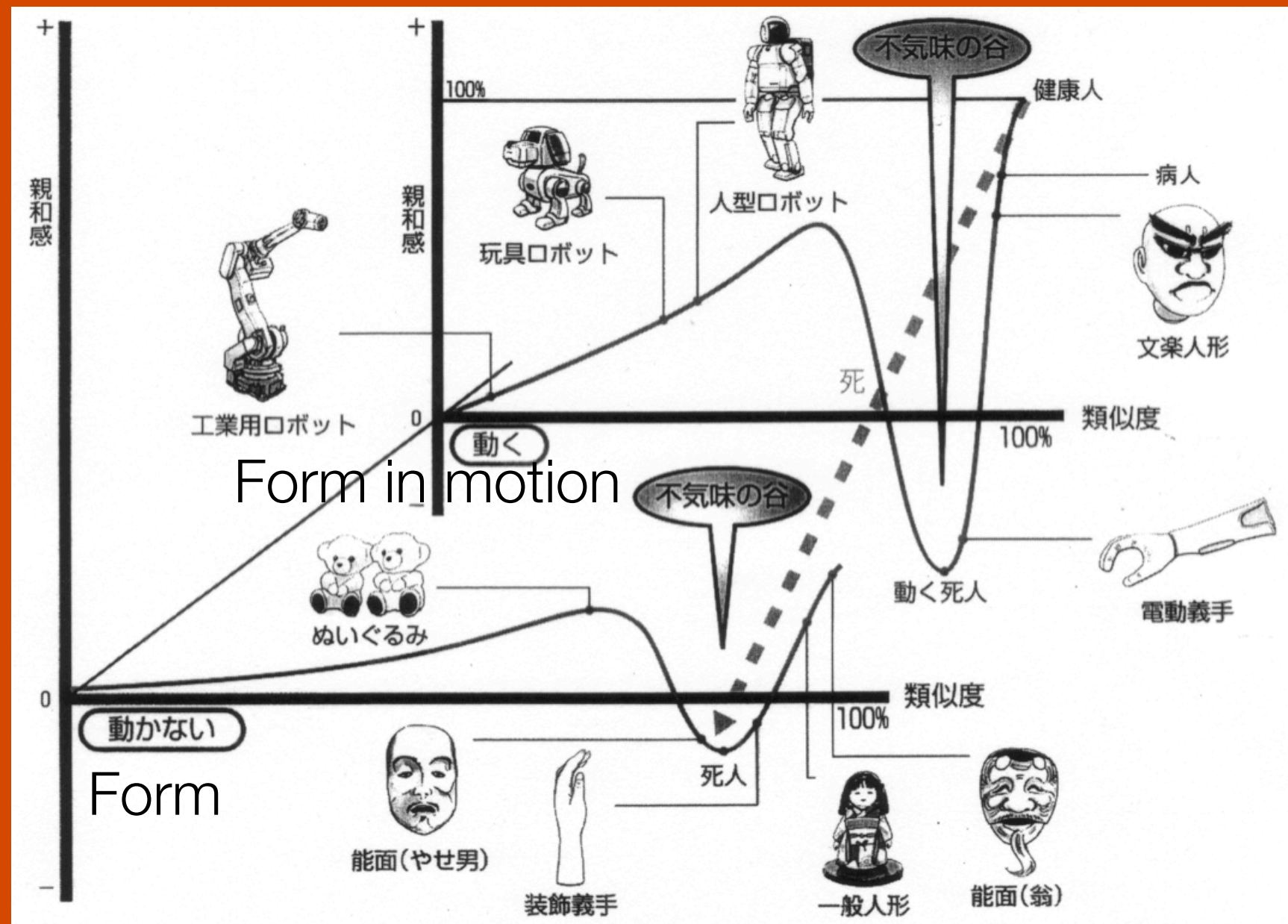
Psychological Plausibility?

▶ Pretense displays suggests that at least for toddlers, subtle movement cues can possibly contribute to changing the subjective experience

A Closer Look

Form and Motion

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- Motion can interact with form to intensify the impact
- Described in original 1970 paper by Mori (in Japanese)
  - Dave Bryant review on web
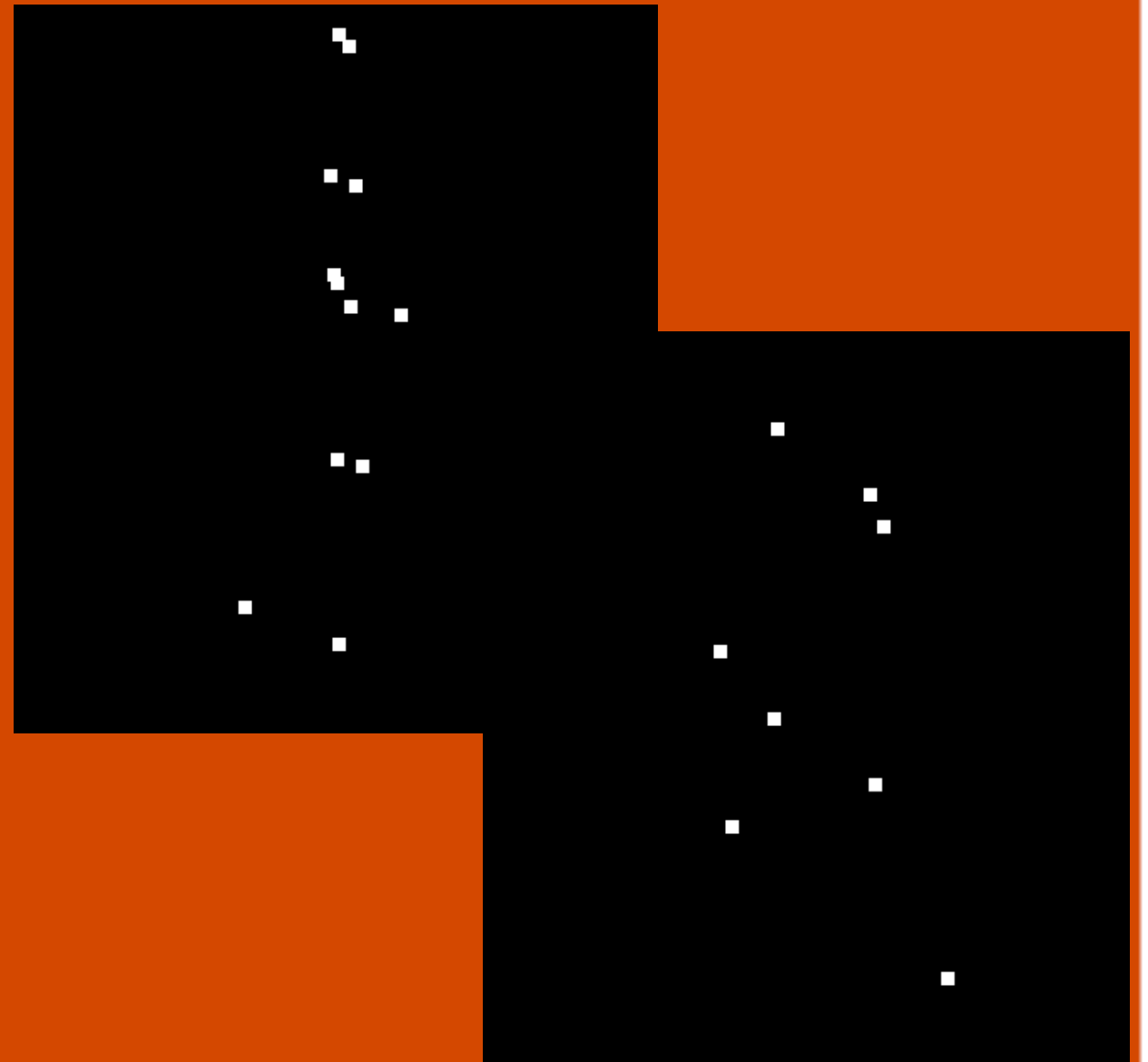 - Robocon 2003, #28 (in Japanese)

Form and Motion

Point-light Displays (PLD)

- Typically, human movement is studied via the use of point-light displays

- With point-light displays form is obtained via motion (structure-from-motion).
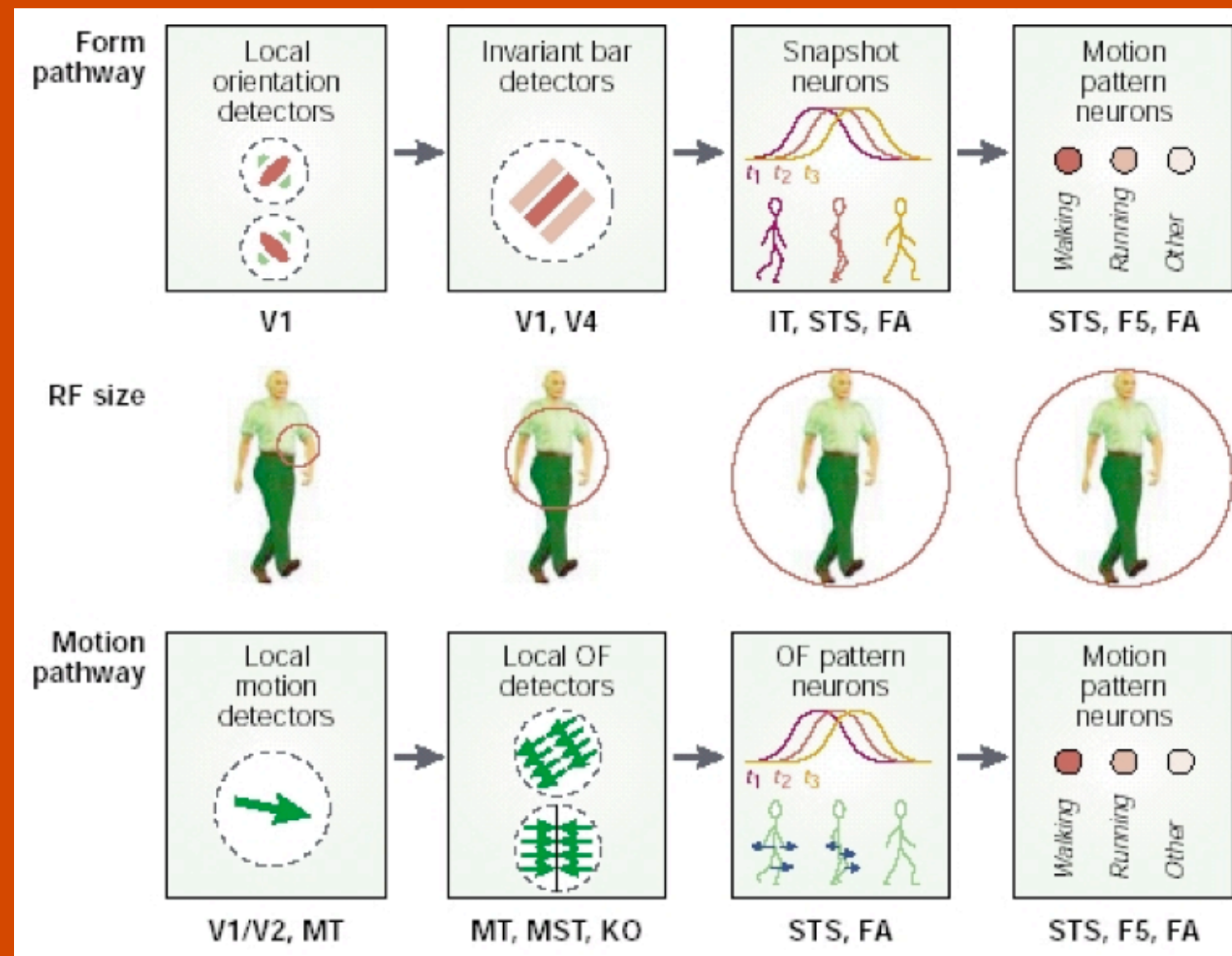
- Thus, not many results comparing form & motion
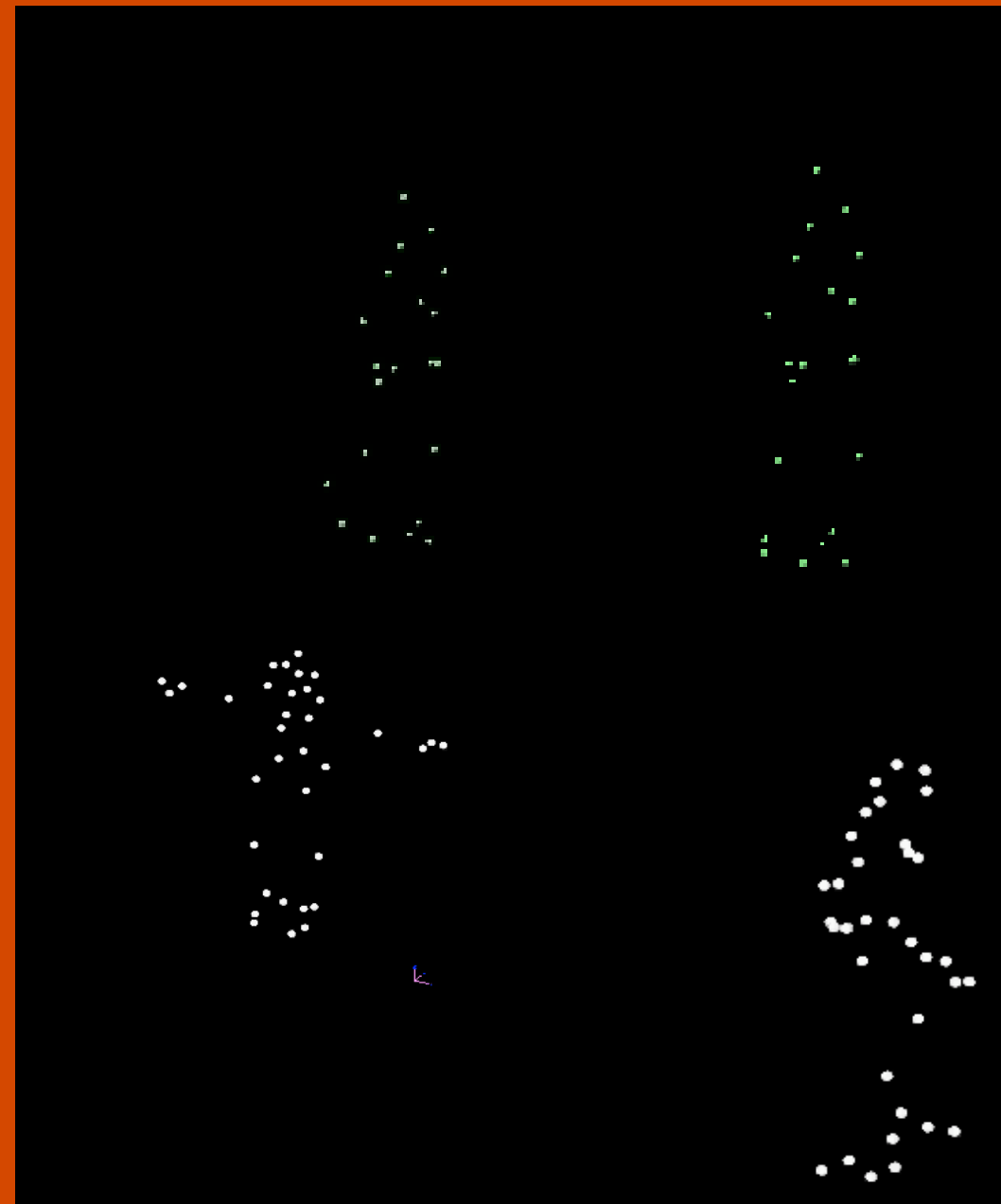
Limited Lifetime PLD

▶ Use of limited-lifetime points still enables perception of human movement even though the motion signal is substantially degraded

J. A. Beintema & M. Lappe, Perception of biological motion without local image motion. Proceedings of the National Academy of Sciences, 99: 5661-5663
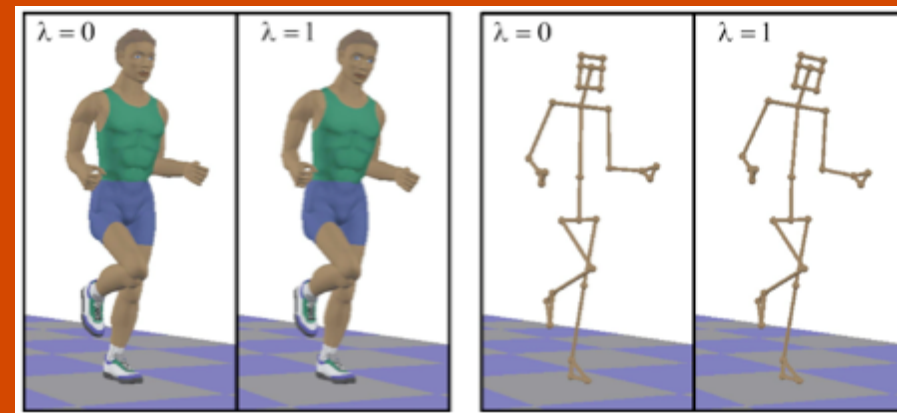
Neuro-computational Model

▶ STS as biological motion area where form and motion information converge (Oram & Perrett, 1994)

Giese, MA, Poggio, T, (2003). Neural mechanisms for the recognitions of biological movements. Nature Neuroscience Reviews, 4, 179-192

Effect of Form

▶ solid body better than stick figure (Hodgins et al, 1998)
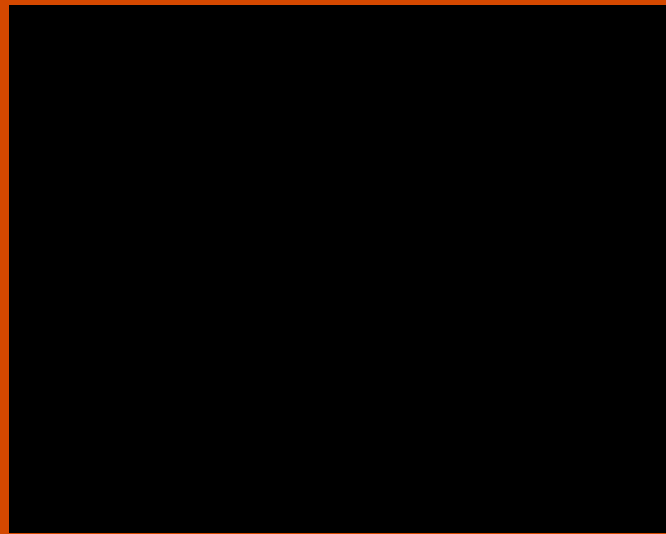
▶ solid body same as point lights (Hill et al, 2003)

Motion

- Motion by itself is thought to be sufficient to make complex social attributions

- Viewers of the classic Heider & Simmel (1944) sequence consistenly describe it using causal attribution of social events

Heider & Simmel (1944) display provided by James Davis of Ohio State

Animacy from Video

McAleer, P., Mazzarino, B., Volpe, G., Camurri, A., Smith, K., Paterson, H., Pollick, F.E. (2004) Perceiving Animacy and Arousal in Transformed Displays of Human Interaction. Proceedings for The 2nd International Symposium on Measurement, Analysis and Modelling of Human Functions and The 1st Medditeranean Conference of Measurement, 67-71
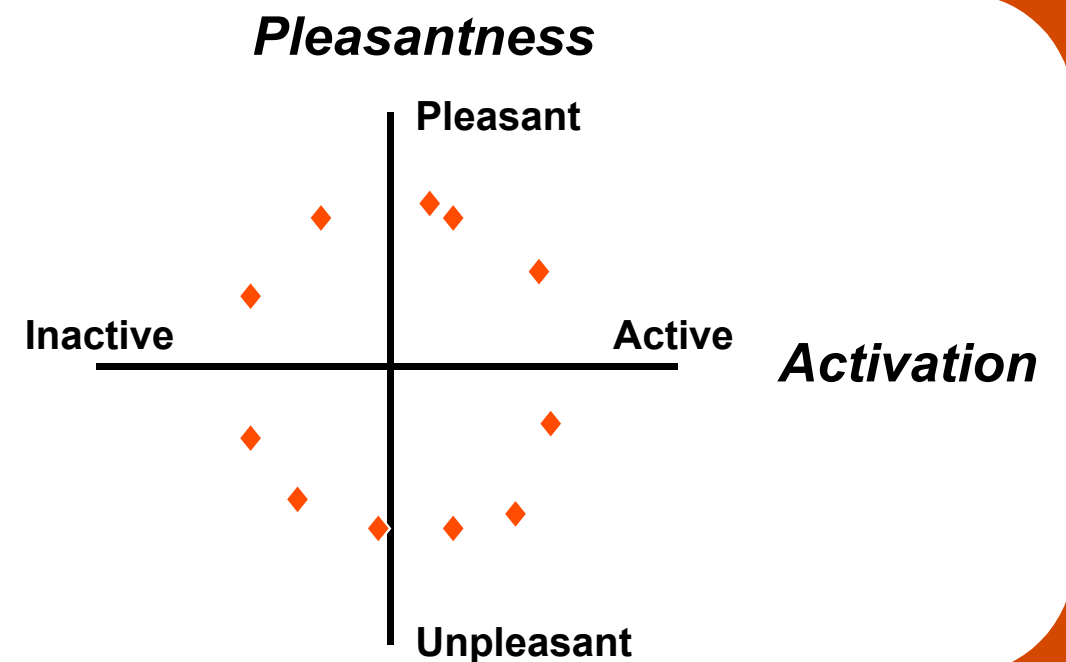
Form & Motion in Gender Recognition

▶ Studies by James Cutting and colleagues (1970s) suggest that form cue of center of moment is used for recognizing gender from PLDs

▶ Mather & Murdoch (1994) suggest that lateral body sway is a more powerful cue. See also Troje (2002)

Review of Gender Recognition

- Meta-analysis of 21 published experiments on gender recognition yield average 67% correct

- Simulated optimal performance using Cutting Cm algorithm provides 79% correct

Form and Motion in Representing Affect

Knocking Motions

Pleasantness

Pleasant

Inactive ——— Active   *Activation*

Unpleasant

Pollick, F.E., Paterson, H., Bruderlin, A. & Sanford, A.J. (2001) Perceiving affect from arm movement. Cognition, 82. B51-B61.
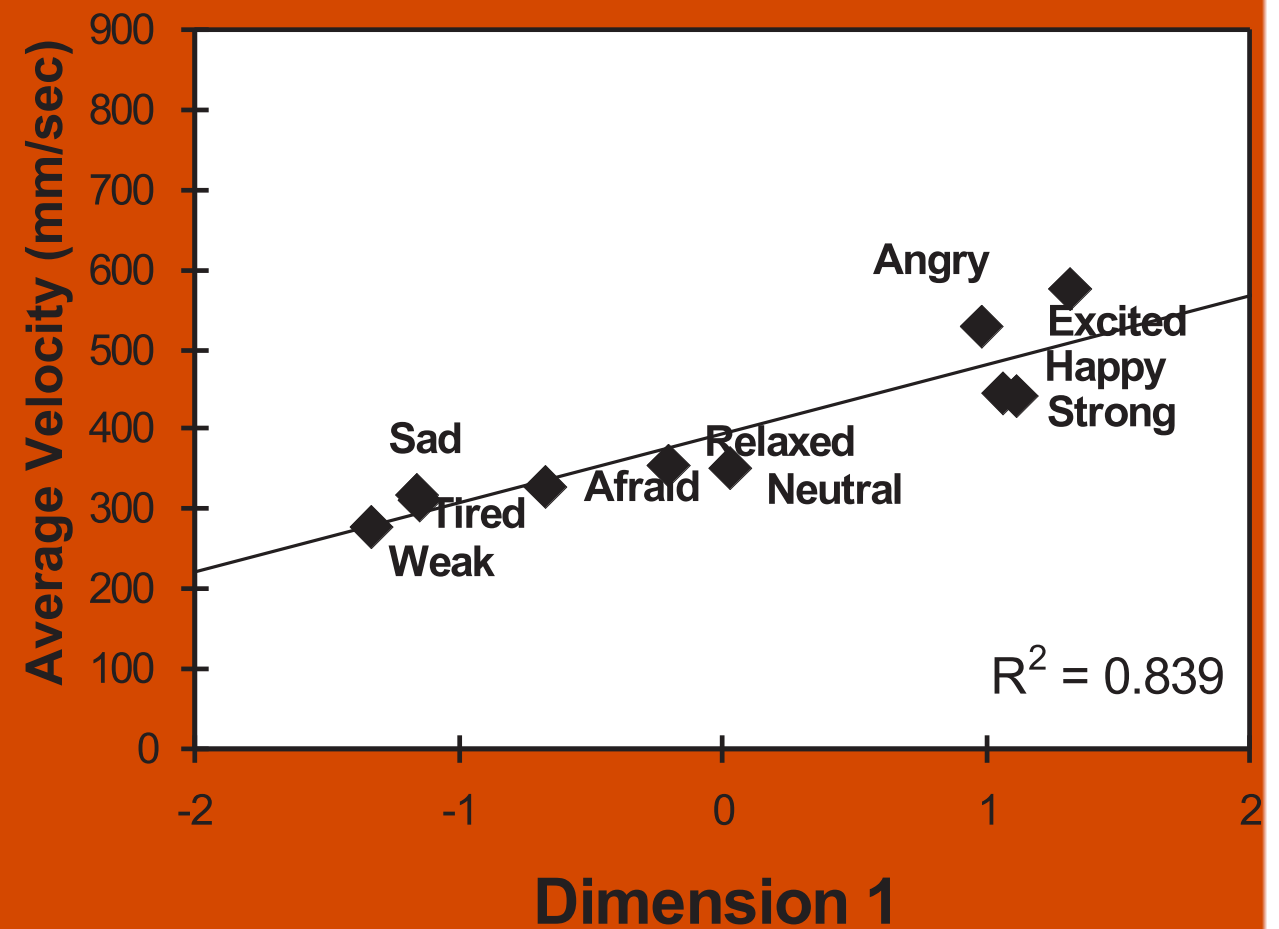
Stimuli & Task

- Participants view a display and categorize it as one of 10 affects

- Confusion matrix is analyzed using multidimensional scaling (MDS)
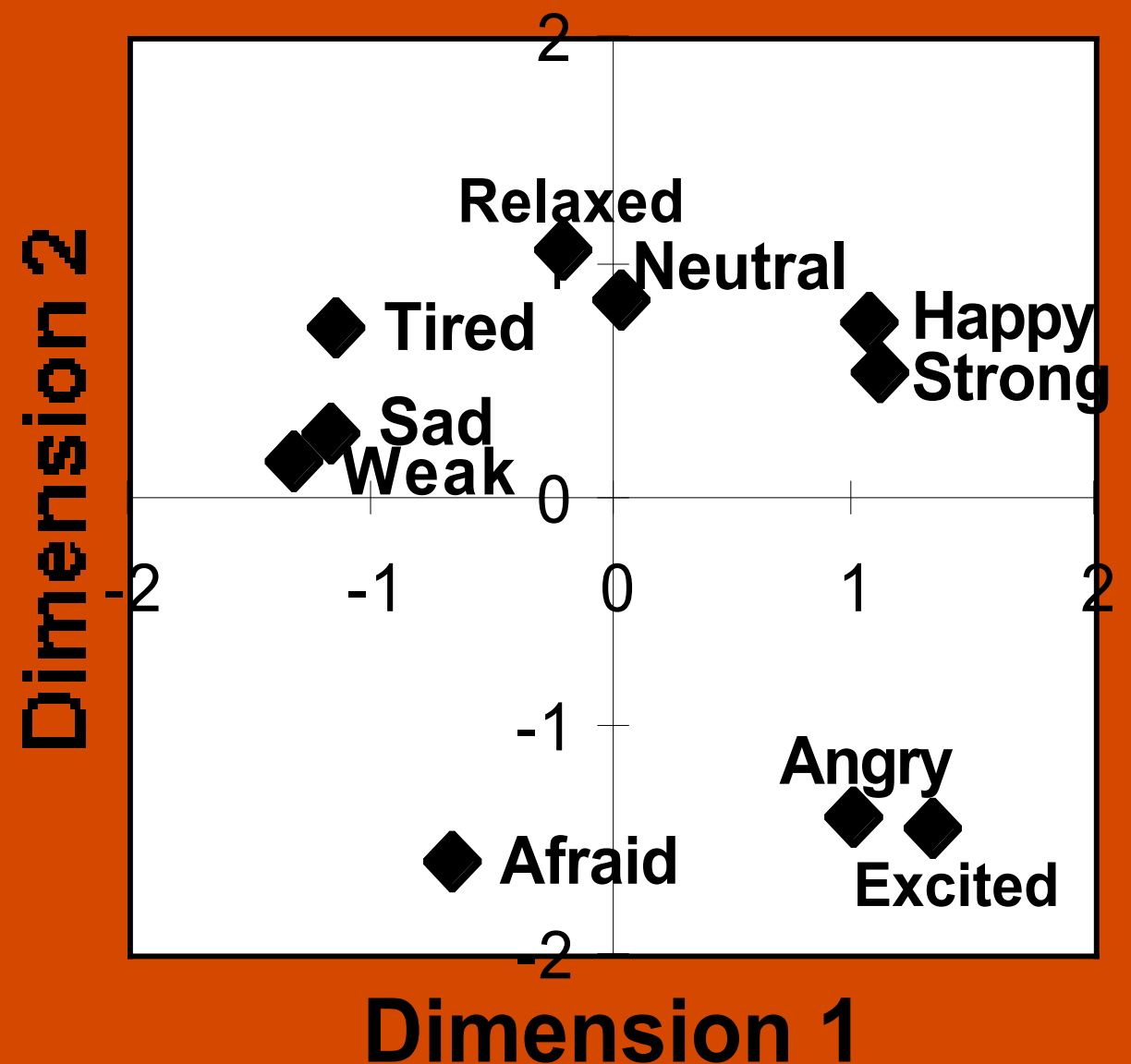
Relation to Kinematics

▶ Dimension 1 of the psychological space was correlated to the average velocity of the wrist

Summary of Affect from Movement

▶ For recognition of affect from movements

- ■ activation accorresponds to a formless velocity cue

- ■ still uncertain what precise physical property corresponds to valence, however, it appears related to form

Summary of Form and Motion

▶ Research confirms Mori's hypothesis that form and motion have unique contirbutions, but results of individual experiments and computational modeling are mixed

▶ Better possibly to speak of the diagnostic information for the task

# Getting to Know the Uncanny Neighborhood

Affect and Cue Combination

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Movements & Faces

▶ Movement can provide an indication of affect, but so can facial information. How does movement information compare to that provided by faces?

▶ We examined the combination of facial and movement information within the framework of a linear cue combination model.

Pollick, FE, Paterson, H, & Mamassian, P (2004). Combining Faces and Movements to Recognize Affect. Poster presented at the 4th Annual Meeting of Vision Sciences Society

Saliency

- To use the linear cue combination model we needed to obtain movements and faces of different saliency levels

  - Faces - 3 levels of saliency

  - Movements - 2 levels of saliency
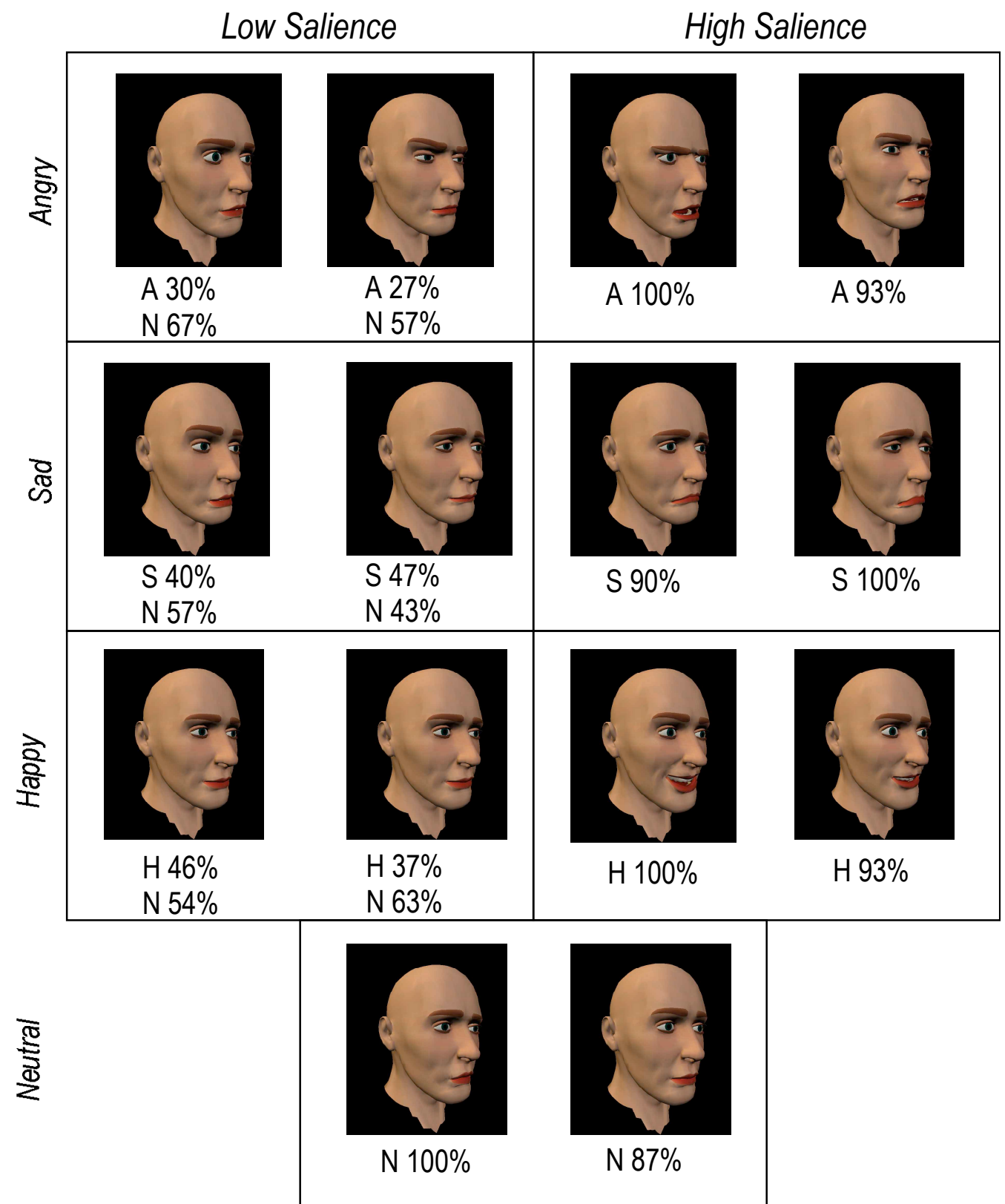
Movement Saliency

▶ For each affect we obtained a high salience and low salience exemplar

Task

▶ Participants saw a single or multiple cue condition at various levels of saliency (face and movement) and categorized the display as happy, sad or angry

▶ This gave us a proportion correct for each single and combined cue stimulus condition

Logic of Linear Model

combined
affective movement
affective face

affective movement
neutral face

neutral movement
affective face

$$= \quad \omega_m \qquad + \quad \omega_f$$

Equations

Accuracy for Combined Cues M&F = ω_m(Accuracy for Cue M) + ω_f(Accuracy for cue F)

$$CC_{lo,hi} = \omega_m * M_{lo} + \omega_f * F_{hi}$$
$$CC_{lo,mid} = \omega_m * M_{lo} + \omega_f * F_{mid}$$
$$CC_{lo,lo} = \omega_m * M_{lo} + \omega_f * F_{lo}$$

$$CC_{hi,hi} = \omega_m * M_{hi} + \omega_f * F_{hi}$$
$$CC_{hi,mid} = \omega_m * M_{hi} + \omega_f * F_{mid}$$
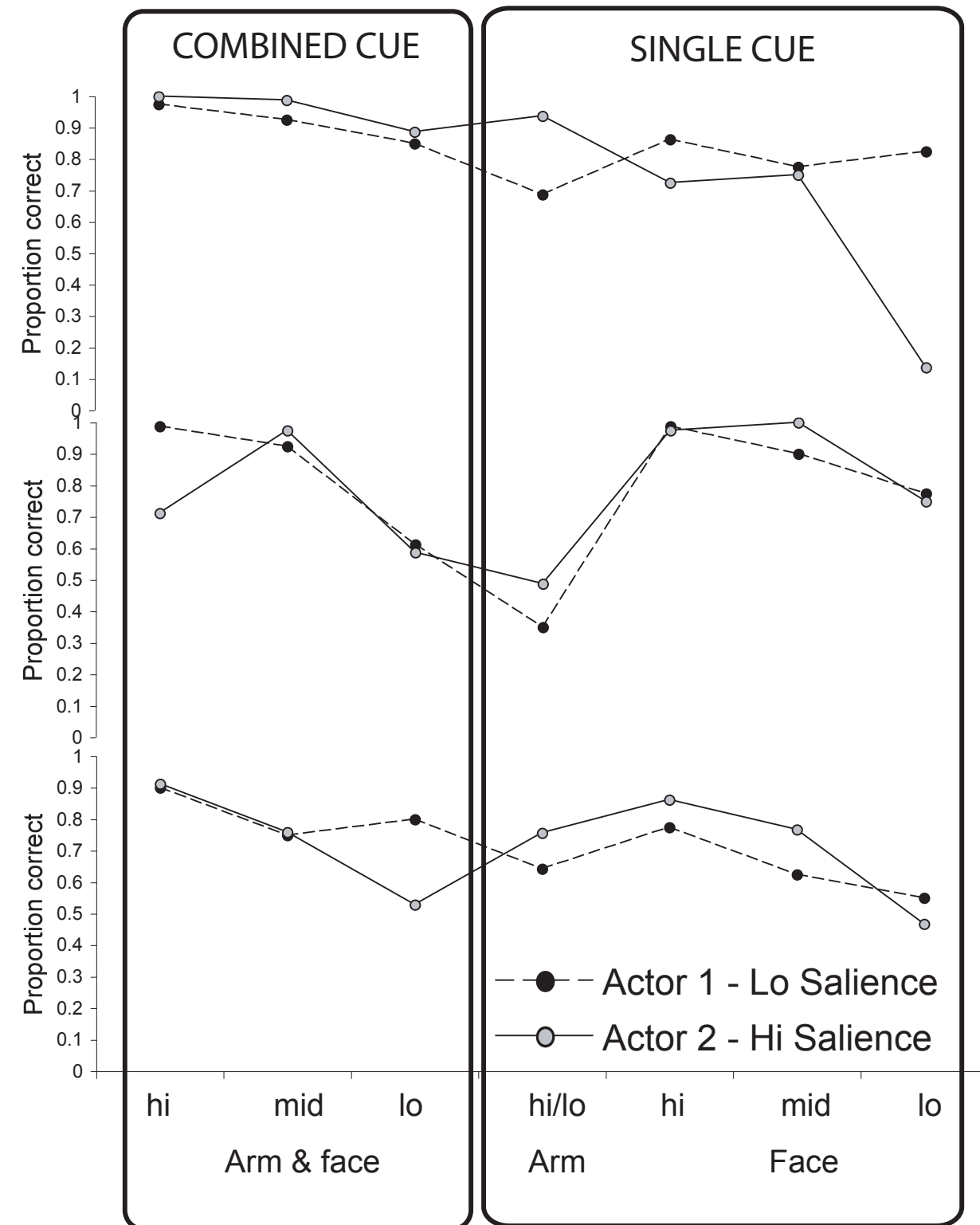$$CC_{hi,lo} = \omega_m * M_{hi} + \omega_f * F_{lo}$$

Weights

Details

Angry

Happy

Sad

The Glen of Unhappiness?

▶ At least for the case of happiness, it can be seen that the low salience of the movements can bring down the effectiveness of the happy face.

Conclusions

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Summary

▶ The Uncanny Valley appears to be a valid and important design principle

▶ As a psychological principle it is plausible, and is consistent with current research into movement perception. However, currently it is descriptive rather than prescriptive

Thanks!

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