Visual Recognition of Affect from Human Movement

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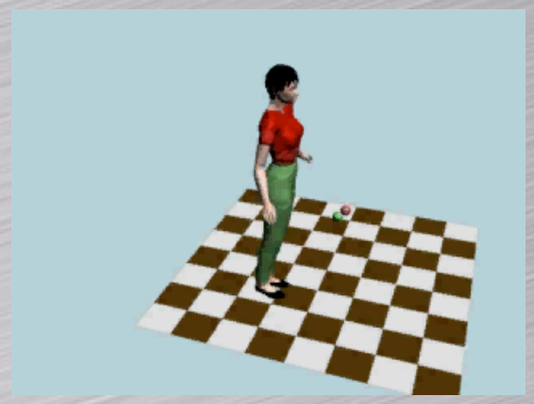


Talk Outline

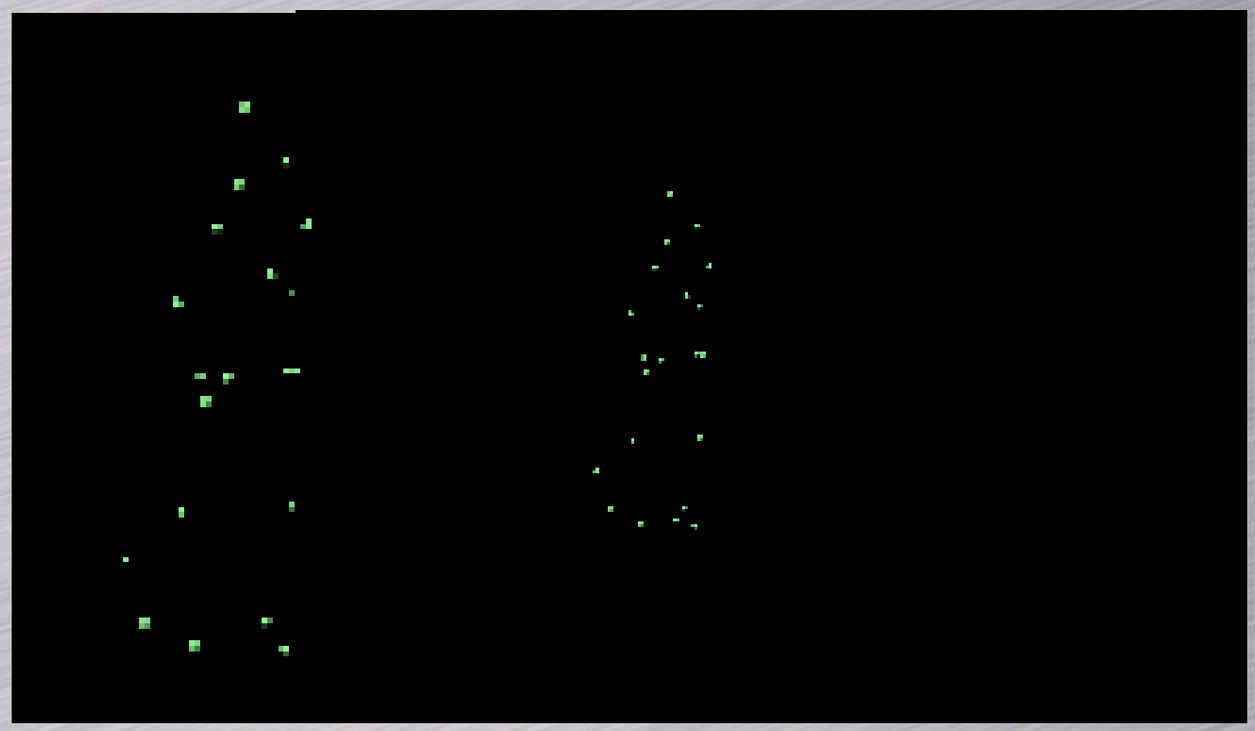
- Background
- Experimental Methods
- 3 Questions about perceiving affect
- Discussion & Future Directions

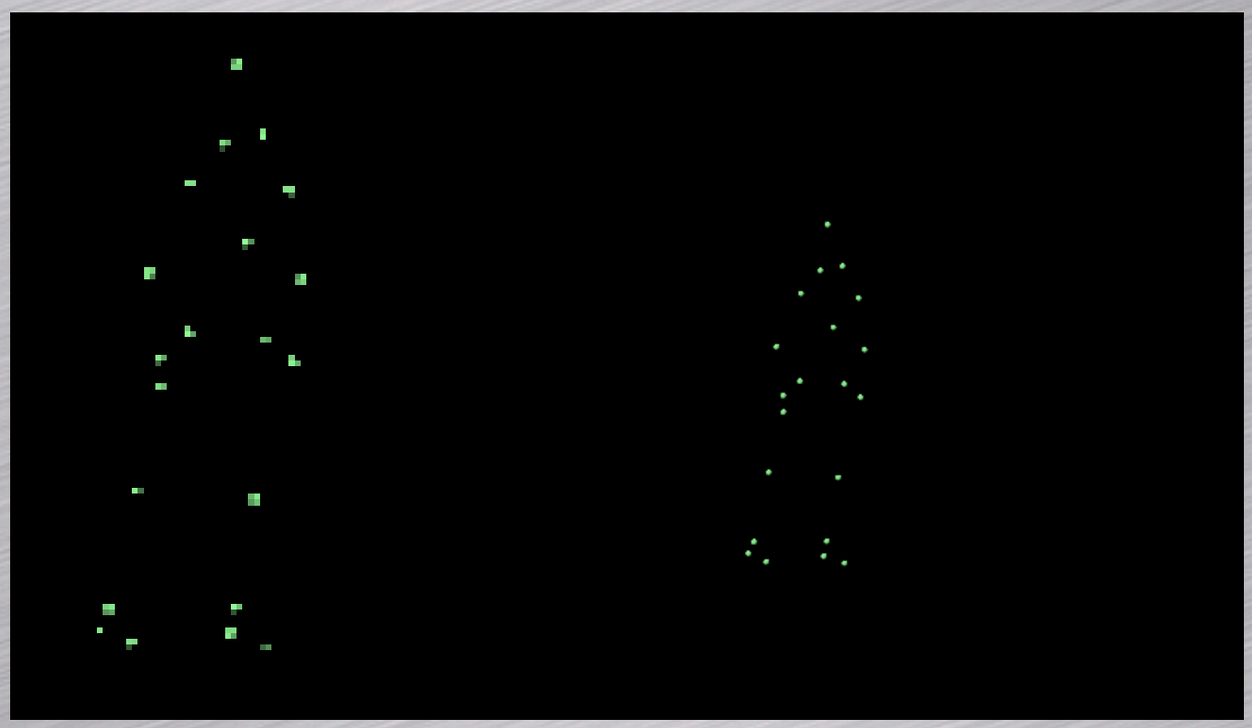
Background

- Perceiving human movement
- Neural basis of movement perception
- Application to humanoid robots

Biological Motion

- Johansson point light displays, 1973
  - spontaneously organized
  - can appreciate detailed properties of actor & action





Properties Recognized

- Gender
  - meta-analysis of 20 published experiments reveals 67% correct*
- Identity
- Emotion/Affect

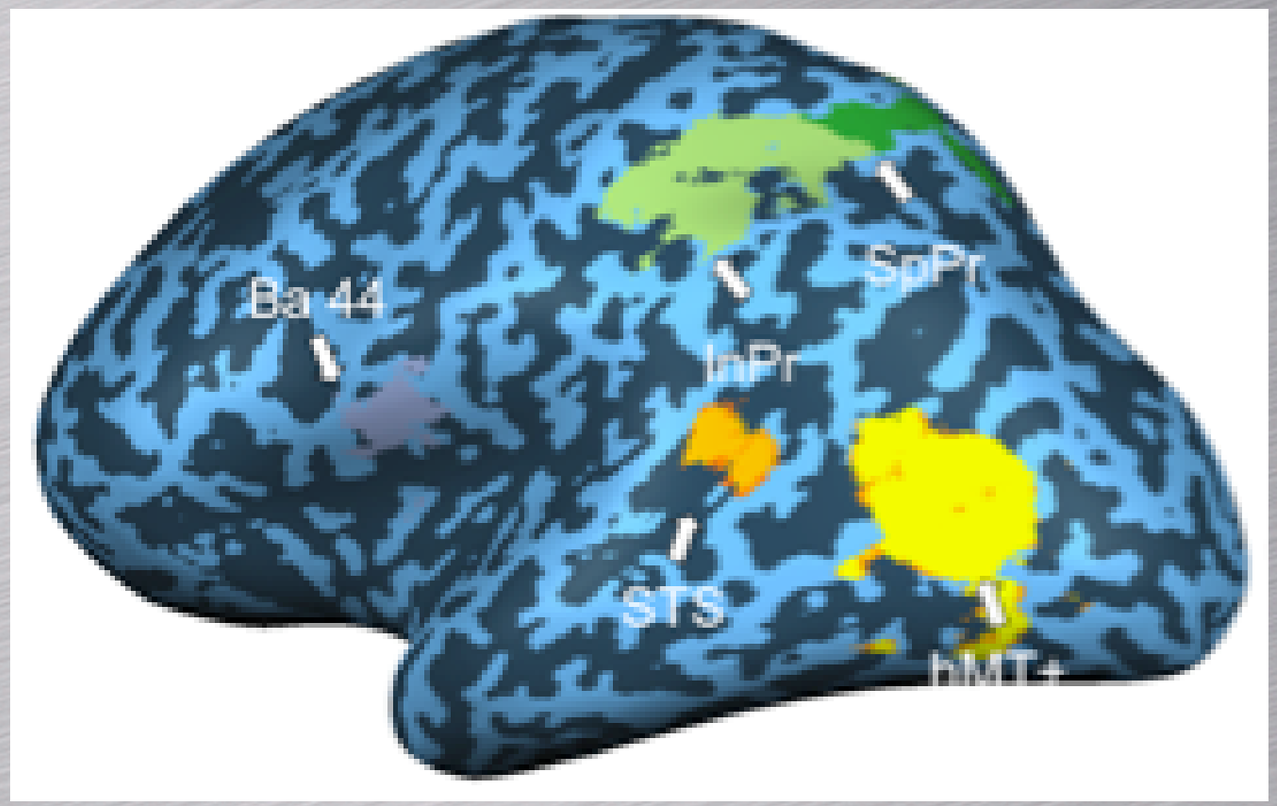
*Pollick, FE, Kay, J, Heim, K, & Stringer, R. (Submitted), A review of gender recognition from point-light walkers.

Neural Basis

- Imitation and action understanding circuit
- Social perception circuit

Imitation and Action

- Proposed Network
  - Frontal region codes goals
  - Parietal region codes goals & kinematics
  - Temporal region (STS) more visual but also codes goals & kinematics



Lestou,V., Pollick, FE, & Kourtzi, Z. (2003), differential involvement of prefrontal and parietal areas revealed by fMRI adaptation, Society for Neuroscience, New Orleans, Louisiana, USA, 7-11 November

Social Cognition

- The region along the superior temporal sulcus (STS) appears activated by a variety of human movement and social cues

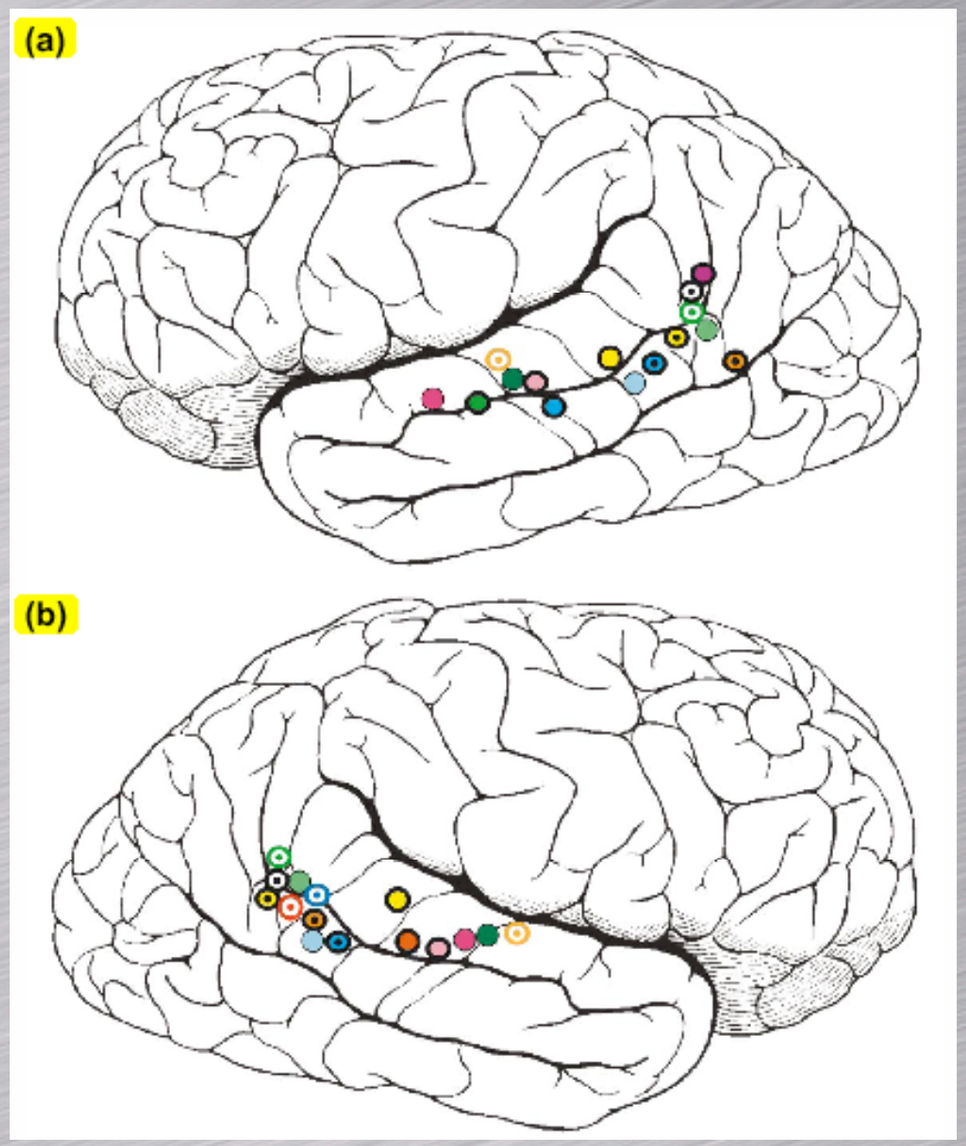


Figure from Allison et al (2000), Trends in Cognitive Science

Humanoid Robots

- Humanoid structure should facilitate compatibility for environments designed for humans
- Ultimately human-humanoid cooperation will be facilitated by both being able to appreciate visual movement cues that suggest intent

Sticky Hands

Hale & Pollick (in press) 'Sticky Hands': Learning and generalization for cooperative physical interactions with a humanoid robot. IEEE Transactions on Systems Man and Cybernetics: C

Methods

- Record human movements
- Analyze movement kinematics
- For some cases, synthesize new movements based on recordings
- Present as point-light displays or solid-body models
- Record & analyze subjects' responses

Record Movements

Optotrak - active marker system

Motion Analysis Corp - passive marker system

Perception of Affect

- Introduction
- Questions
  - What is the structure of affect?
  - Can this structure be exploited in the synthesis of new movements?
  - How powerful is movement as a cue to affect?

Introduction

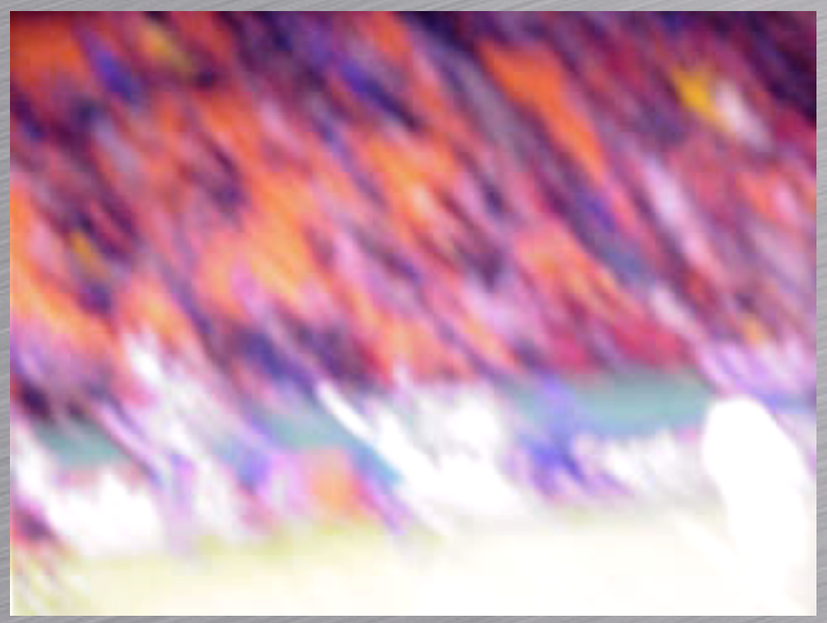
- Basic questions
  - what movements to study?
    - freely generated, dance, music performance, simple goal directed
  - what emotions/affects to study?
    - 7 basic emotions from face perception, general affects

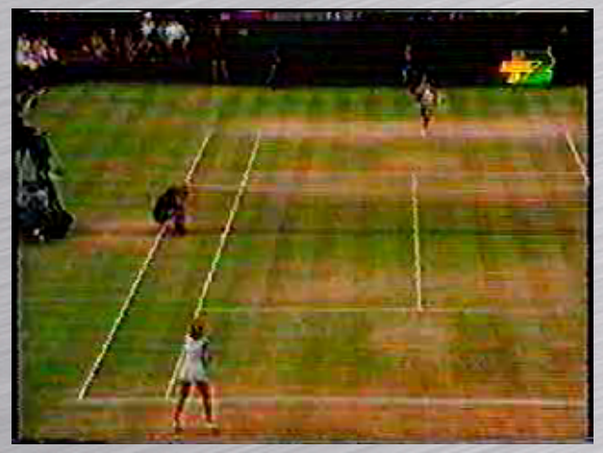
Our emphasis

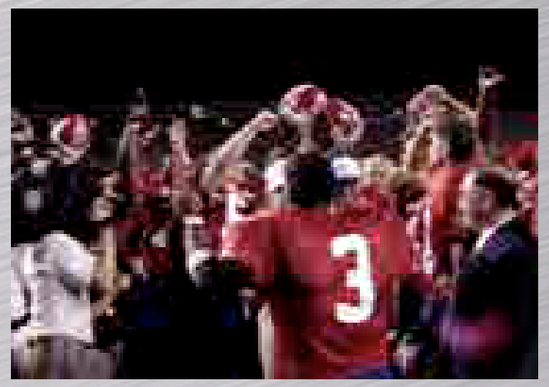
- Study simple goal directed movements with a variety of affects as well as some basic emotions
- This choice will pose some limits on our results and will miss some types of movement. For example....

For Example... we miss

[redacted]







But...

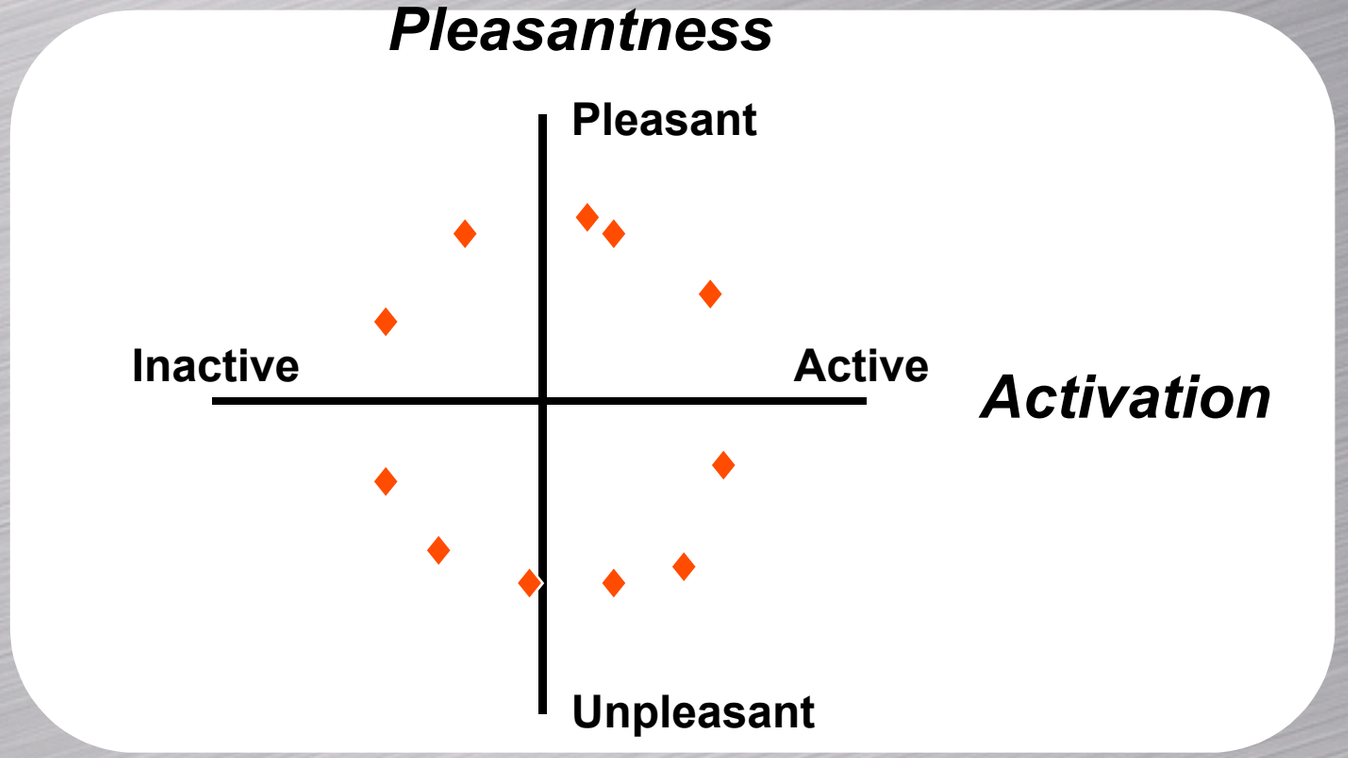
- Our goal is to study the properties of movement in isolation of other cues
- Want to consider affective movement as a special case of normal movement

Question 1

- Can we identify a representation of affect that can be related to movement properties?
  - In the following I review 2 experiments that suggest a plausible structure
    - Affect from knocking & drinking movements
    - Affect from butoh dance

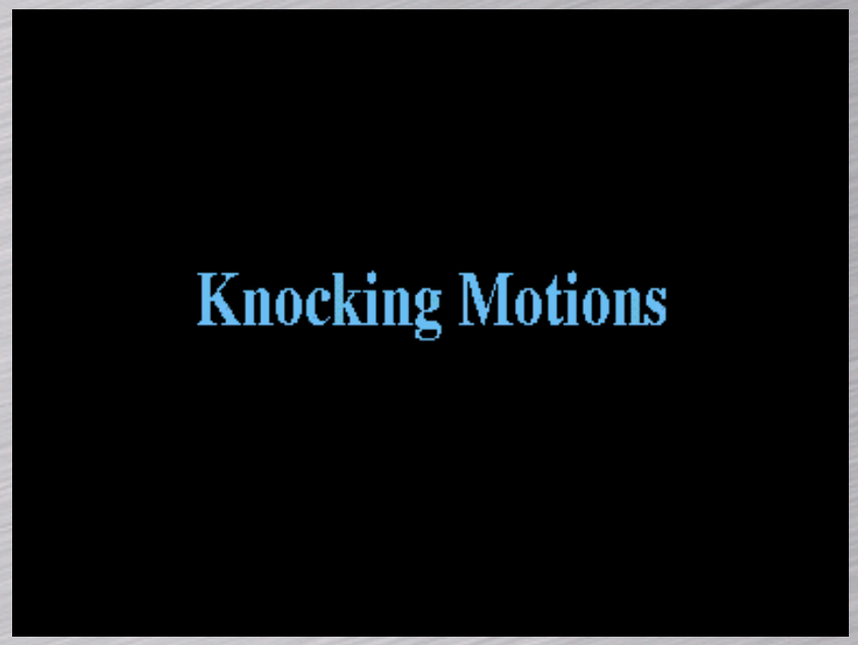
Starting Point

- Circumplex model
  - Proposed by Russell, 1980
  - cognitive model originated from card sorting of affective words



Stimuli & Task

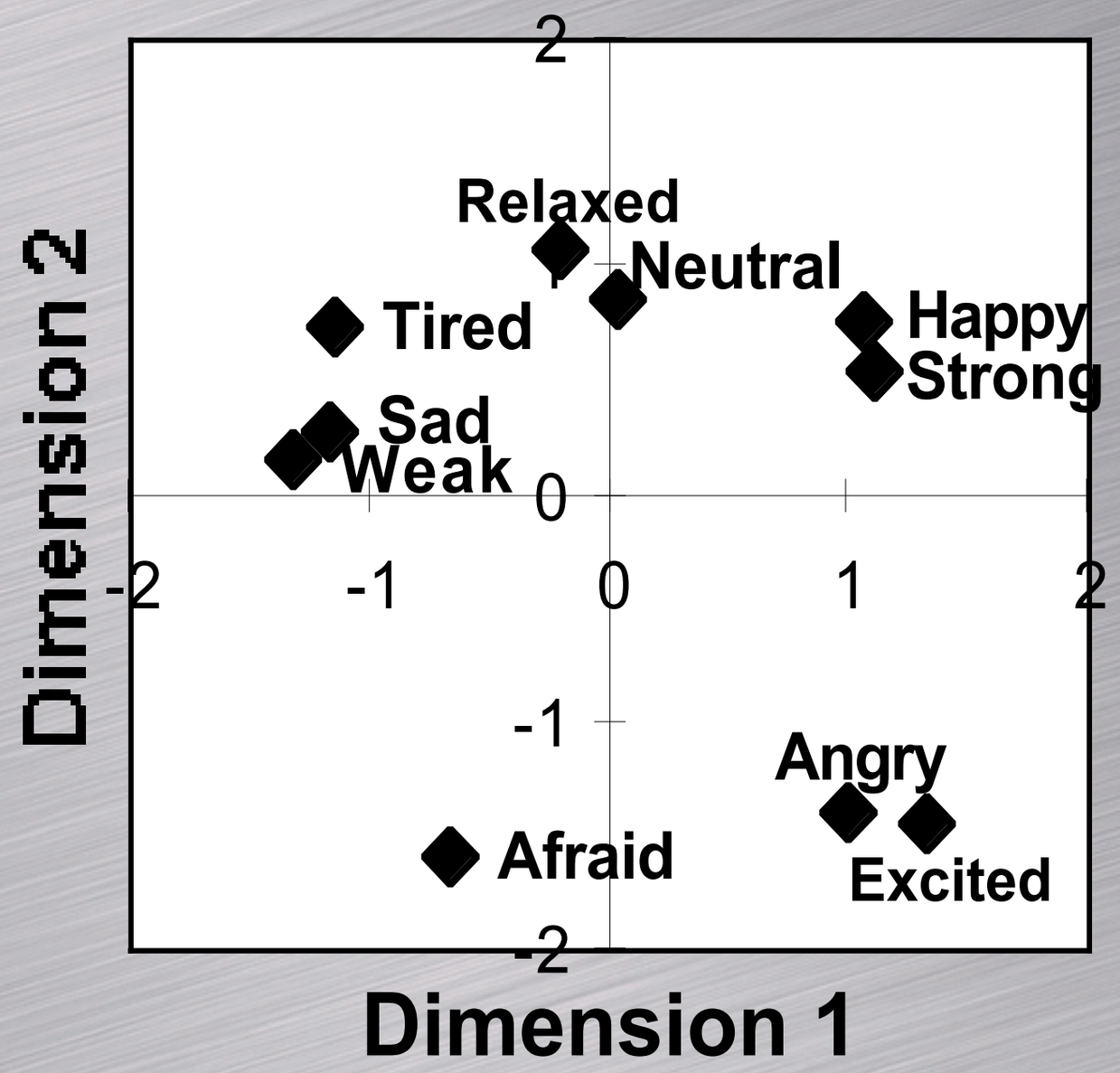
- Participants view a display and categorize it as one of 10 affects
- Confusion matrix is analyzed using multidimensional scaling (MDS)



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

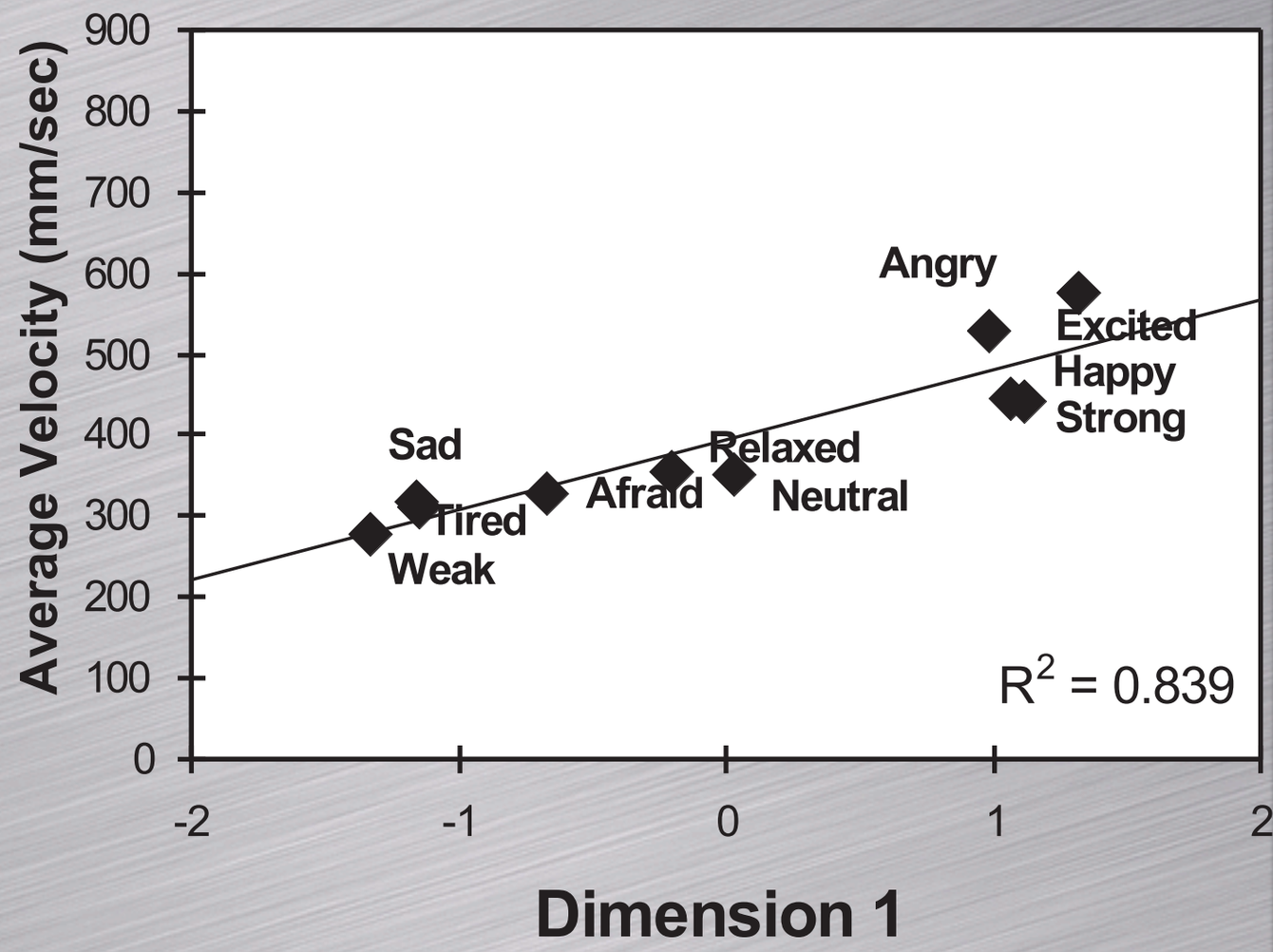
Results

- MDS solution or "psychological space"



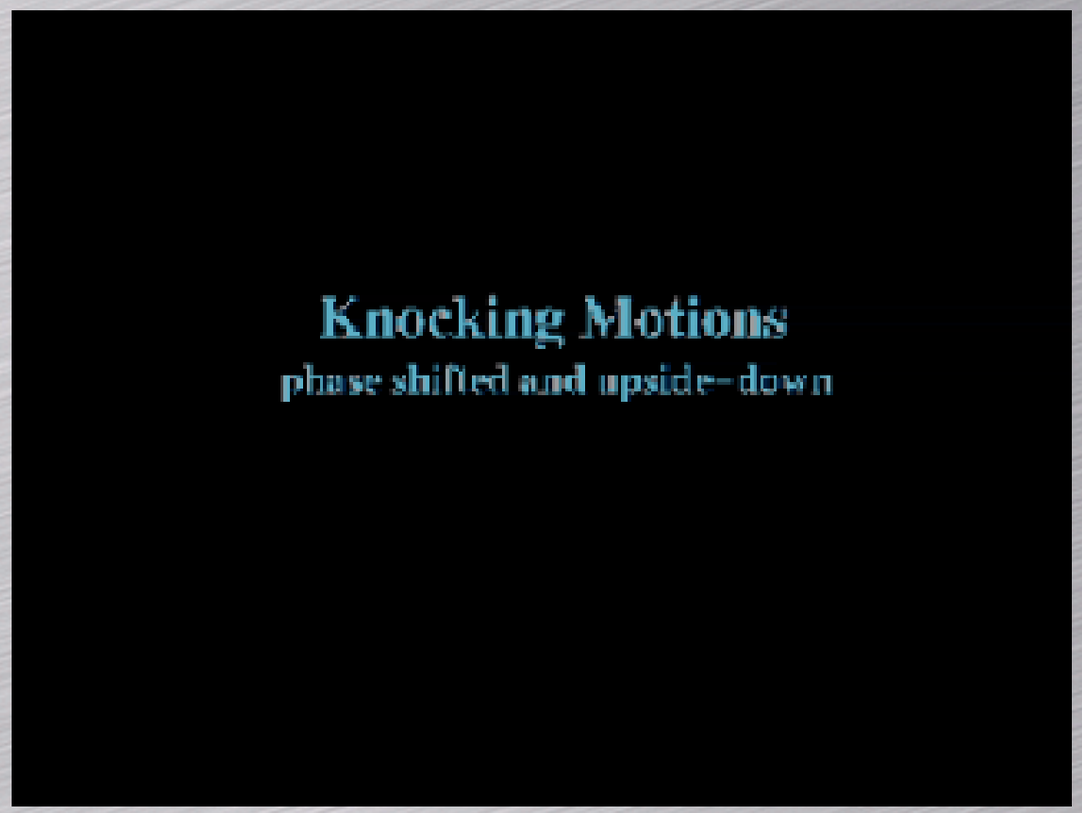
Relation to Kinematics

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



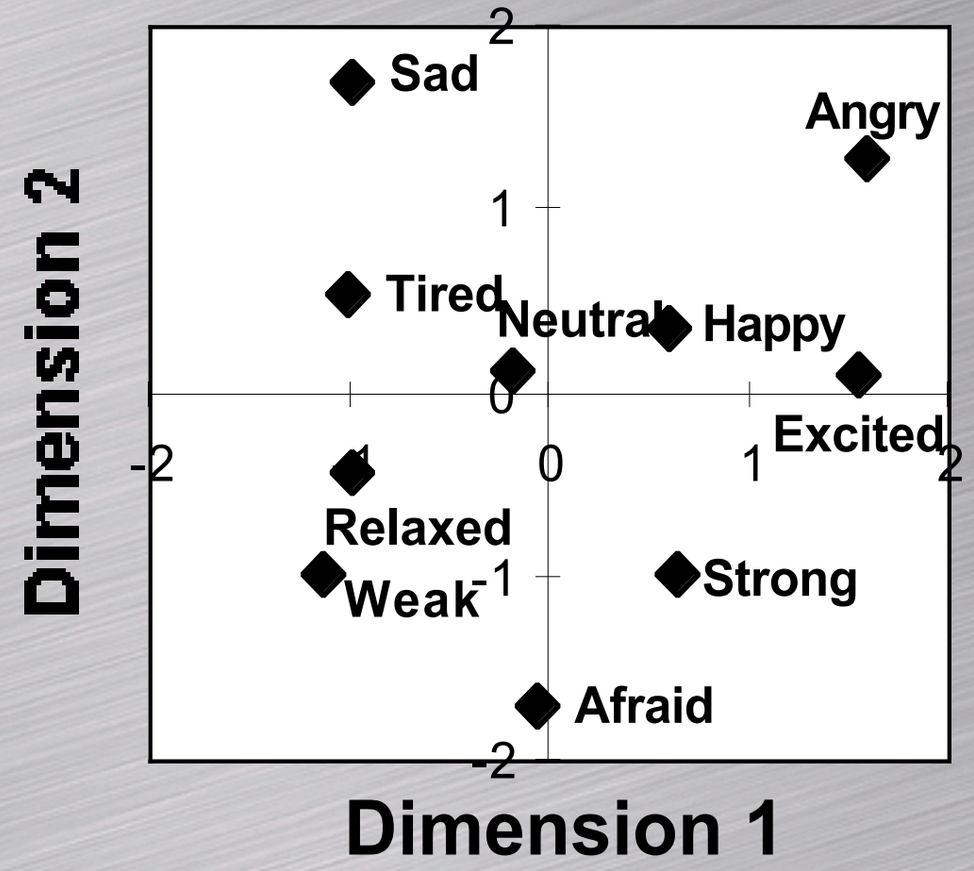
Scrambled Stimuli

- What happens when we repeat Experiment 1 with the same stimuli upside-down and scrambled?



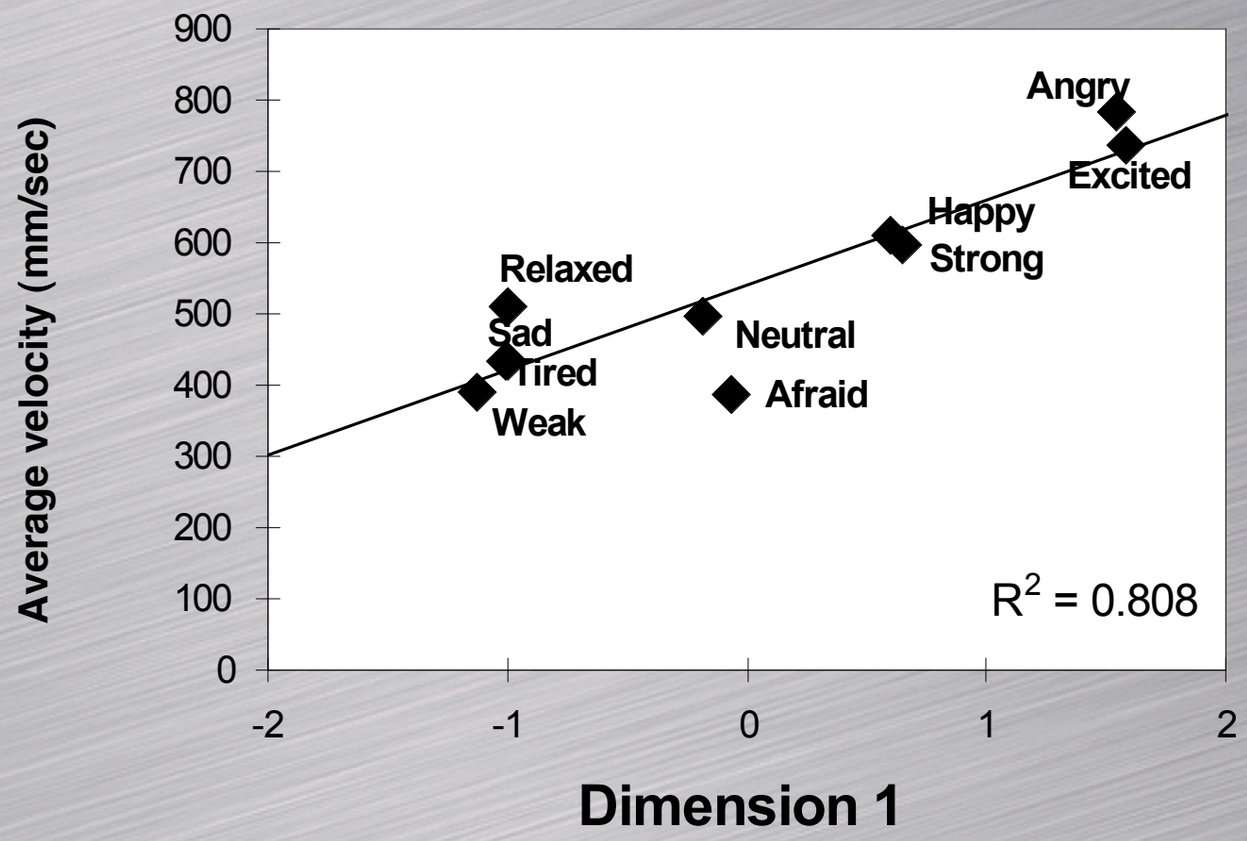
Results

- Psychological space obtained for upside-down, scrambled displays



Relation to Kinematics

- Dimension 1 is still correlated to the velocity of the wrist



Conclusion

- The perception of affect from movement can be explained by a 2D model
  - Dimension 1 appears to correspond to a formless cue of the quantity of motion of the points
  - Dimension 2 appears to correspond to spatial information and the recognition of positive versus negative valence

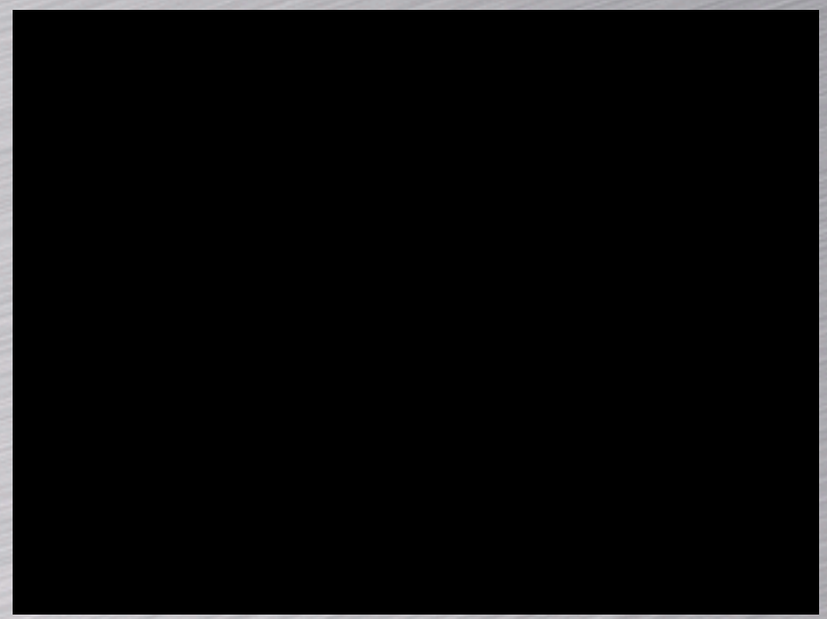
Affect from Butoh

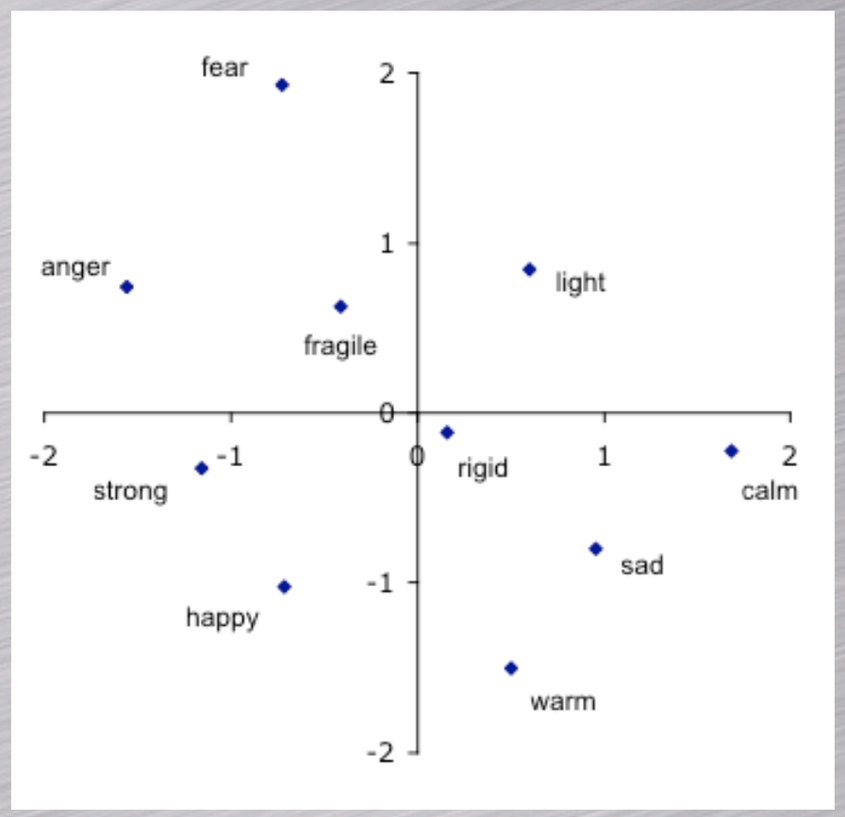
- The Japanese style of butoh dance provides a unique approach to studying affect
- In this study we examine whether the perception of affect from butoh dance is consistent with the circumplex model

MacFarlane, L, Kulka, I, Pollick, FE, (in press). The Representation of Affect Revealed by Butoh Dance, Psychologia

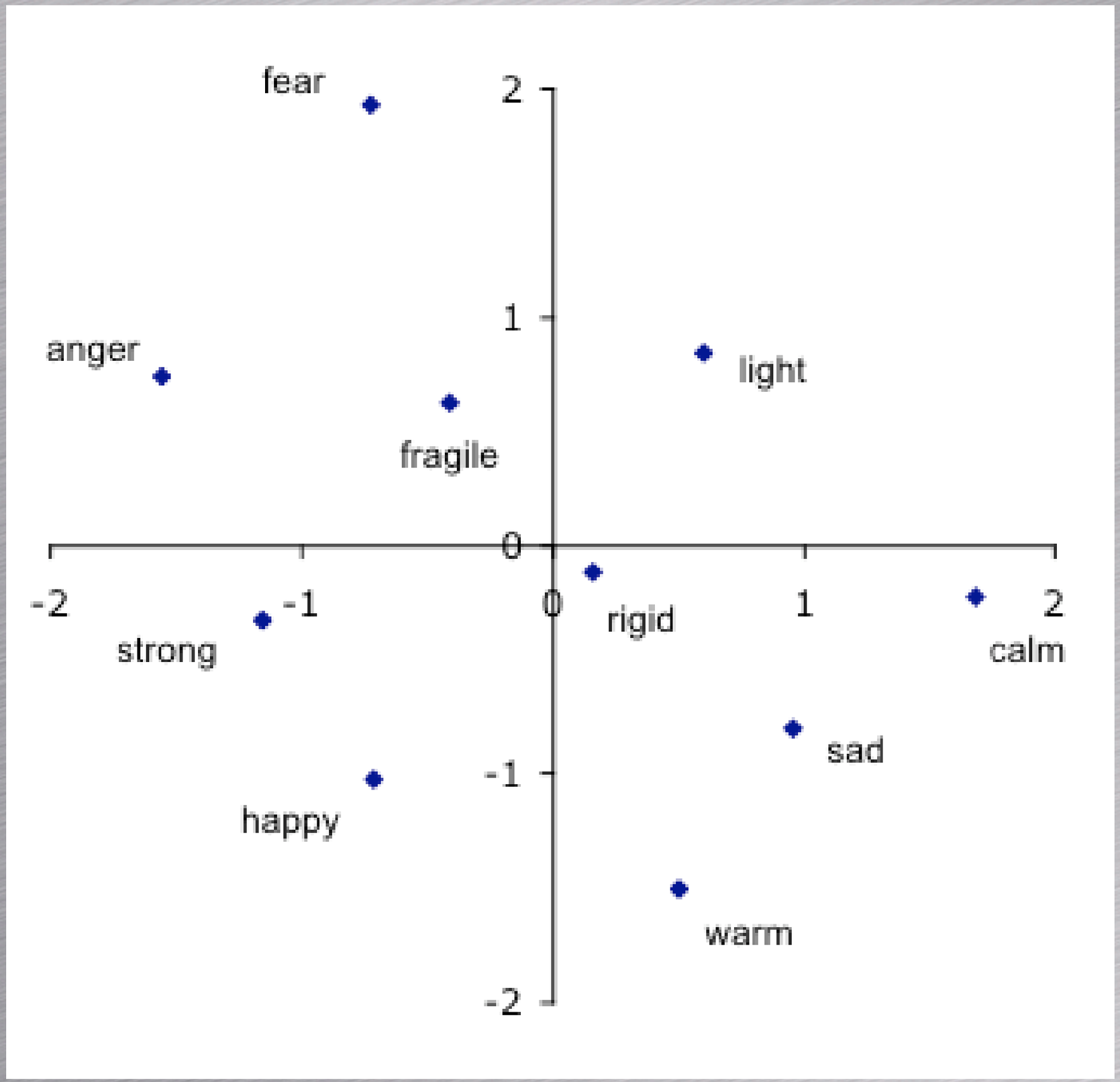
Stimuli, Task, Results

- Participants viewed a pair of butoh dance movements depicting different affects and judged their dissimilarity





Results


fear
anger
fragile
light
strong
rigid
calm
sad
happy
warm
2
1
0
-1
-2
-2
-1
0
1
2

Answer to Question 1

- Can we identify a representation of affect that can be related to movement properties?
  - A two-dimensional structure of affect with the dimensions of activation and valence appears to provide a parsimonious description of perceived affect from human movement

Question 2

- Can the structure of affect be exploited in the synthesis of new movements?
- Hypothesis: If our interpretation of the circumplex is correct then temporal and spatial morphing of movement should yield predictable results

Prediction

- morphing temporal properties (ie duration of a movement) should alter the perception of activation
- morphing spatial properties (ie position of a limb) should influence the perception of valence
- of course space and time are not independent, e.g. velocity

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

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

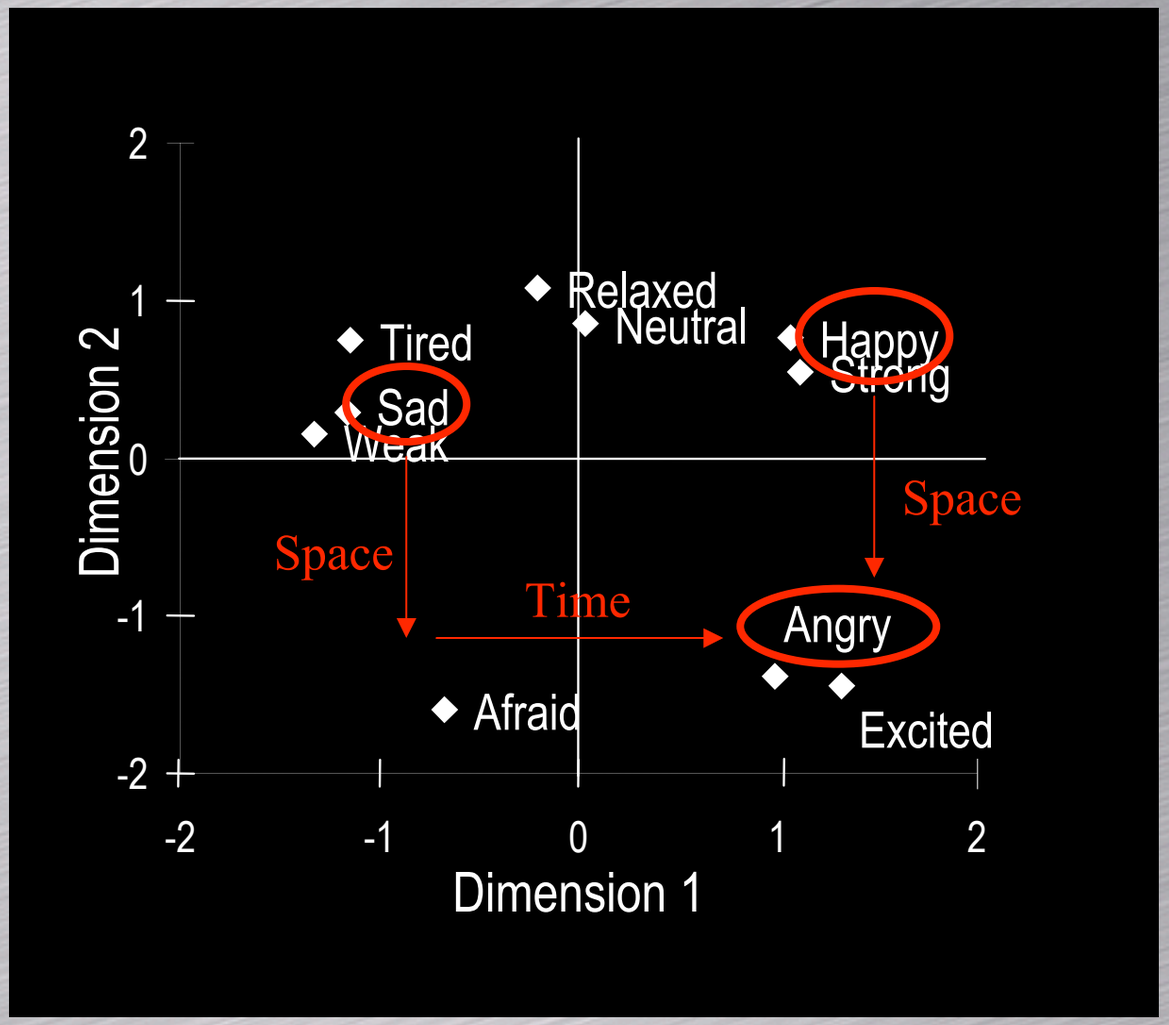
Morphing Experiment

- We took simple arm movements that displayed affect and performed temporal and spatial morphs between movements

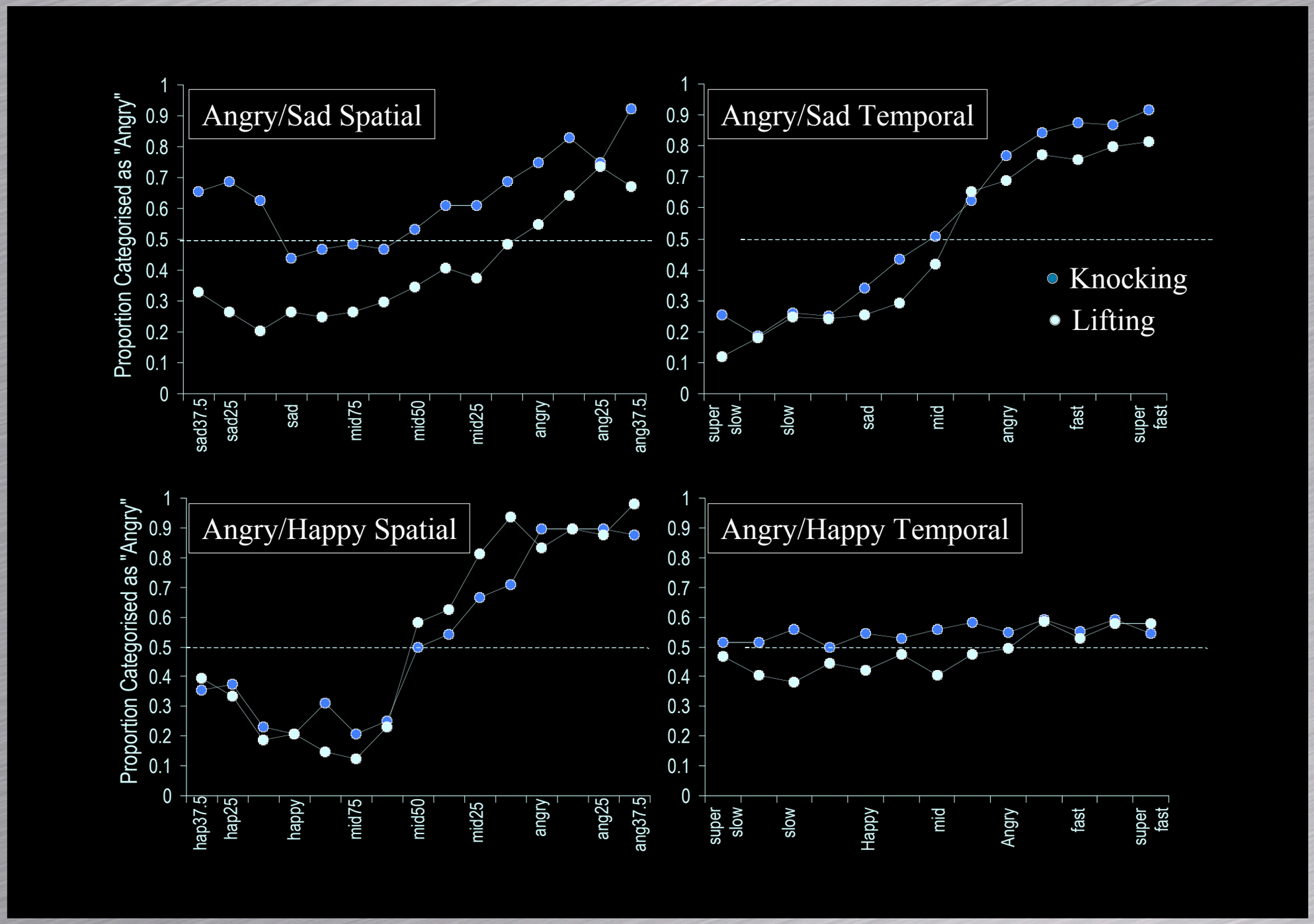
Paterson, H, & Pollick, FE (in preparation), Spatial and Temporal Morphing of Affective Movements

Stimuli Choice

- Predictions
  - temporal morphs should have a strong effect on sad-angry distinctions
  - spatial morphs should have a strong effect on angry-happy distinctions



Results


Angry/Sad Spatial
Angry/Sad Temporal
Angry/Happy Spatial
Angry/Happy Temporal
Proportion Categorised as "Angry"
Knocking
Lifting
sad37.5
sad25
sad
mid75
mid50
mid25
angry
ang25
ang37.5
super slow
slow
sad
mid
angry
fast
super fast
hap37.5
hap25
happy
mid75
mid50
mid25
angry
ang25
ang37.5
super slow
slow
Happy
mid
Angry
fast
super fast

Retargeting

- The retargeting problem in computer animation addresses how to use information recorded from one person to modify the recorded movements of another
- We are trying to use the circumplex structure to guide retargeting of emotional movements

Ma, Y, & Pollick, FE (submitted), Emotion Interpolation and Transform through 3D Trajectory Curves

Example

Throwing

Movements

Answer to Question 2

- The morphing techniques/approach suggested by the circumplex model appears to be appropriate for modifying the affect of recorded movements

Question 3

- How powerful is movement as a cue to affect?
  - Human efficiency at recognizing affect
  - Cue combination: faces & movement

Efficiency

- One way to quantify human performance at a perceptual task is to calculate efficiency
- Efficiency is defined as the squared ratio of human sensitivity (d′) to sensitivity (d′) of an ideal observer

Pollick, F.E., Lestou, V., Ryu, J. & Cho, SB. (2002) Estimating the efficiency of recognizing gender and affect from biological motion. Vision Research, 42, 2345-2355.

Efficiency

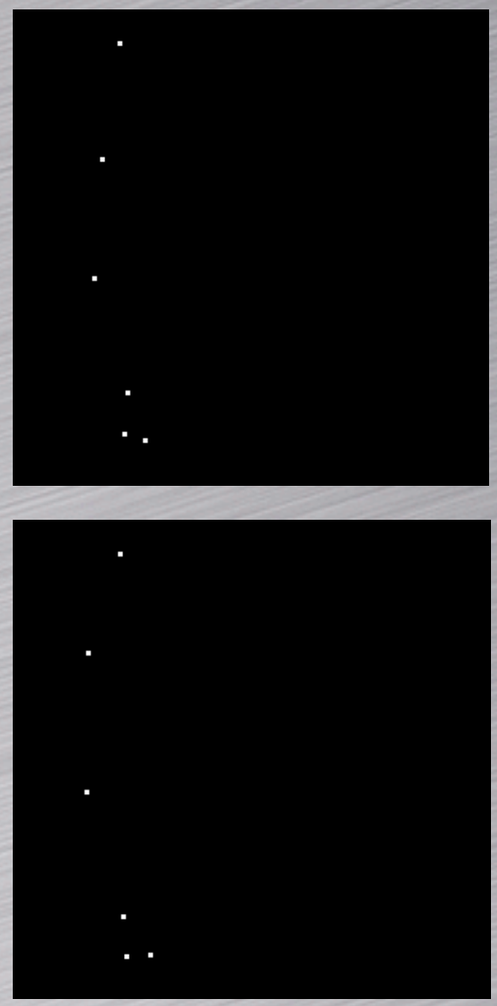
- If all technical assumptions are satisfied (e.g. ideal observer can be proven to be optimal) then efficiency gives the percentage of information that people use to make their judgement, as compared to all the information available in the display.

Ideal Observer

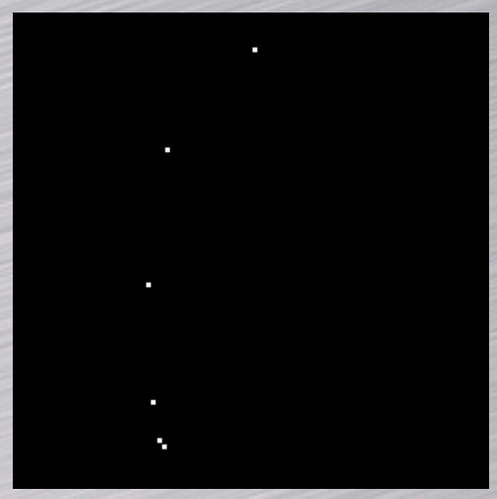
- The “ideal observer” was defined as a neural network trained on a set of 13 male and 13 female knocking, lifting and waving movements
- The neural network does not satisfy all the technical requirements so can best be thought of as an approximation to the ideal observer

Stimuli & Task

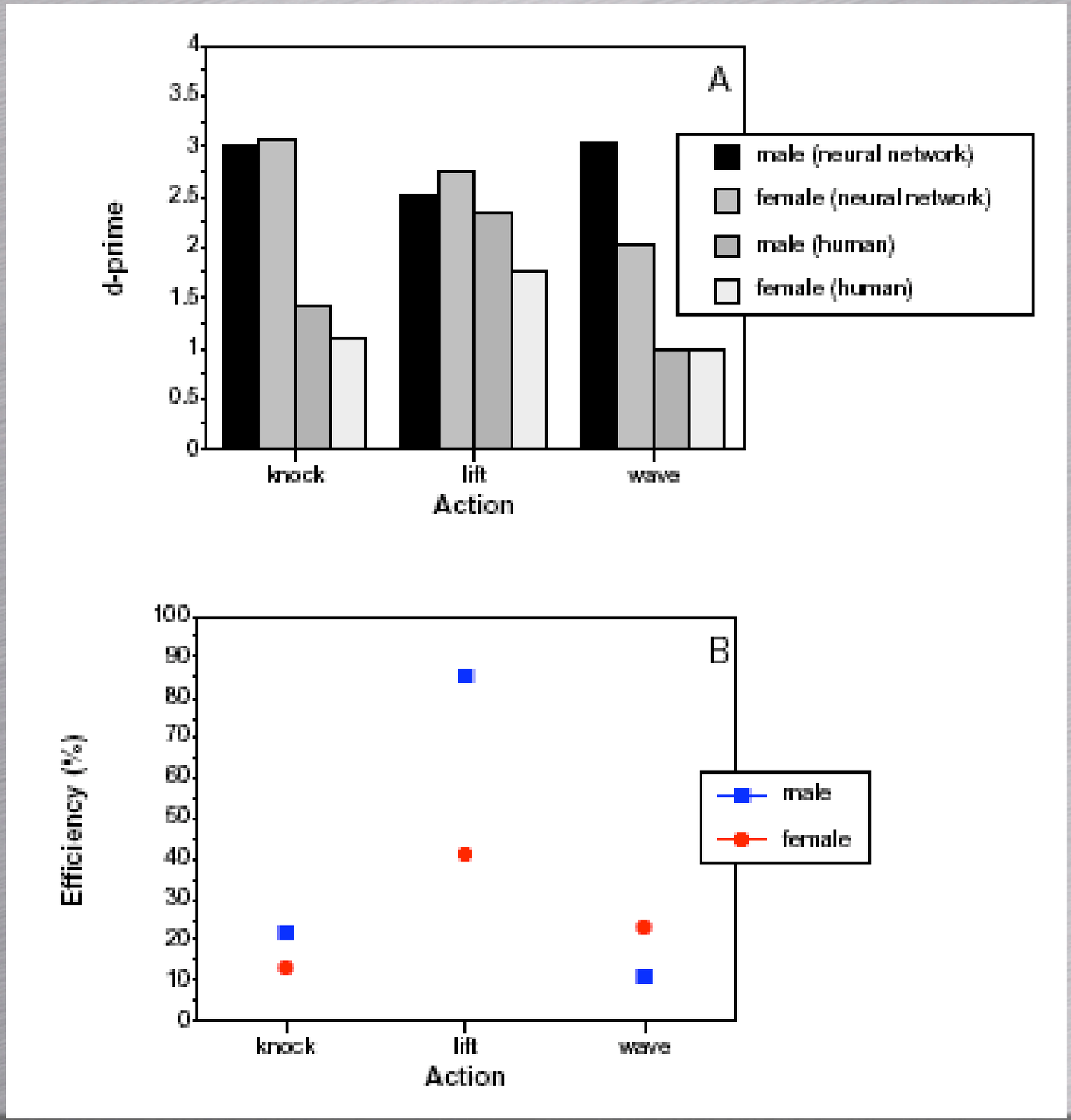
- Participants viewed angry and neutral knocking, lifting & waving movements and judged whether they were angry or neutral



Neutral Movements



Results


A
d-prime
4
3.5
3
2.5
2
1.5
1
0.5
0
knock
lift
wave
Action
male (neural network)
female (neural network)
male (human)
female (human)
B
Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
knock
lift
wave
Action
male
female

Movements & Faces

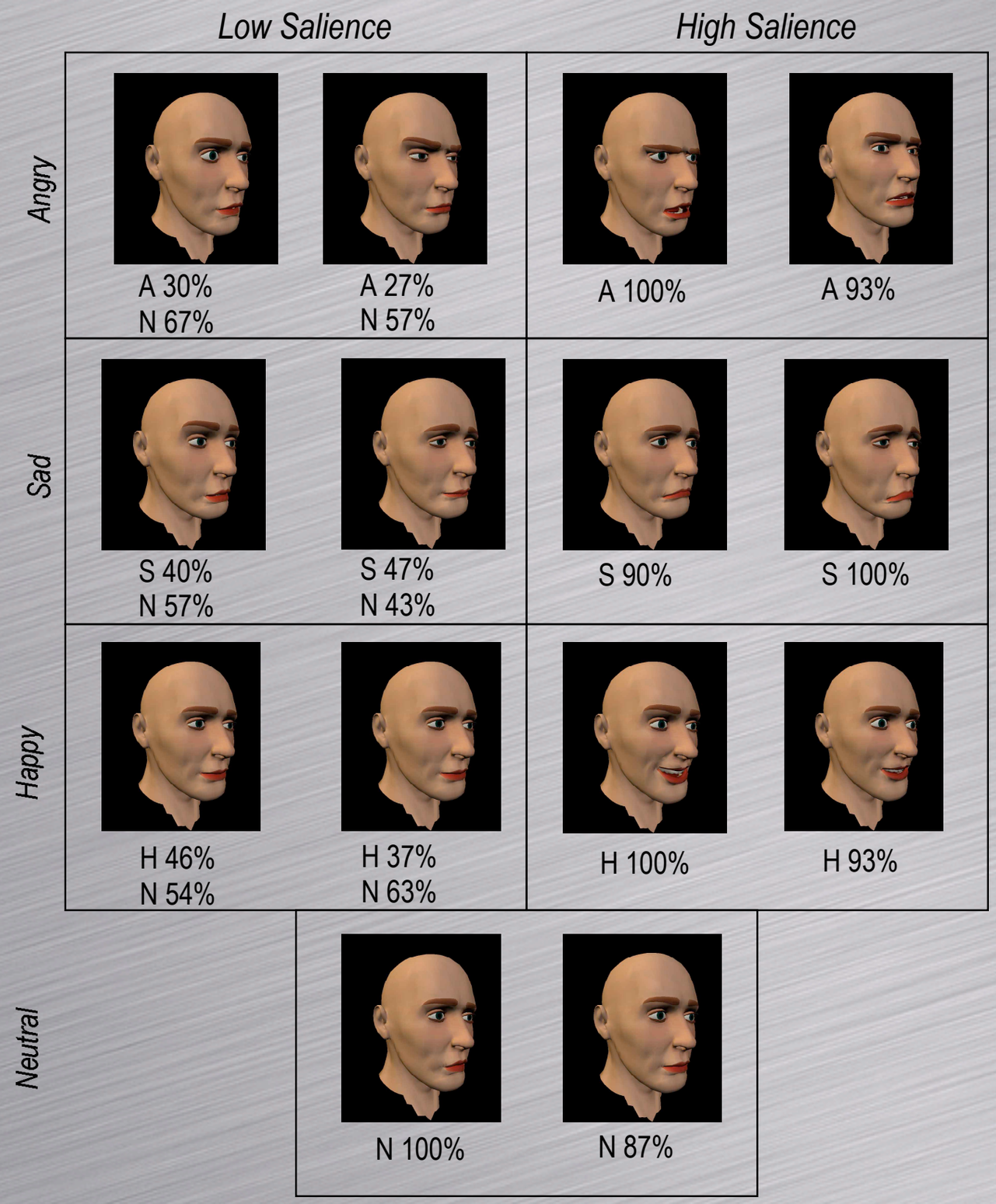
- Movement can provide an indication of affect, but so can facial information. How does movement information compare to that provided by faces?
- We examined the combination of facial and movement information within the framework of a linear cue combination model.

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 explore how the cues combined we needed to obtain movements and faces of different saliency levels
  - Faces - 3 levels of saliency
  - Movements - 2 levels of saliency

Facial Saliency



Linear Model

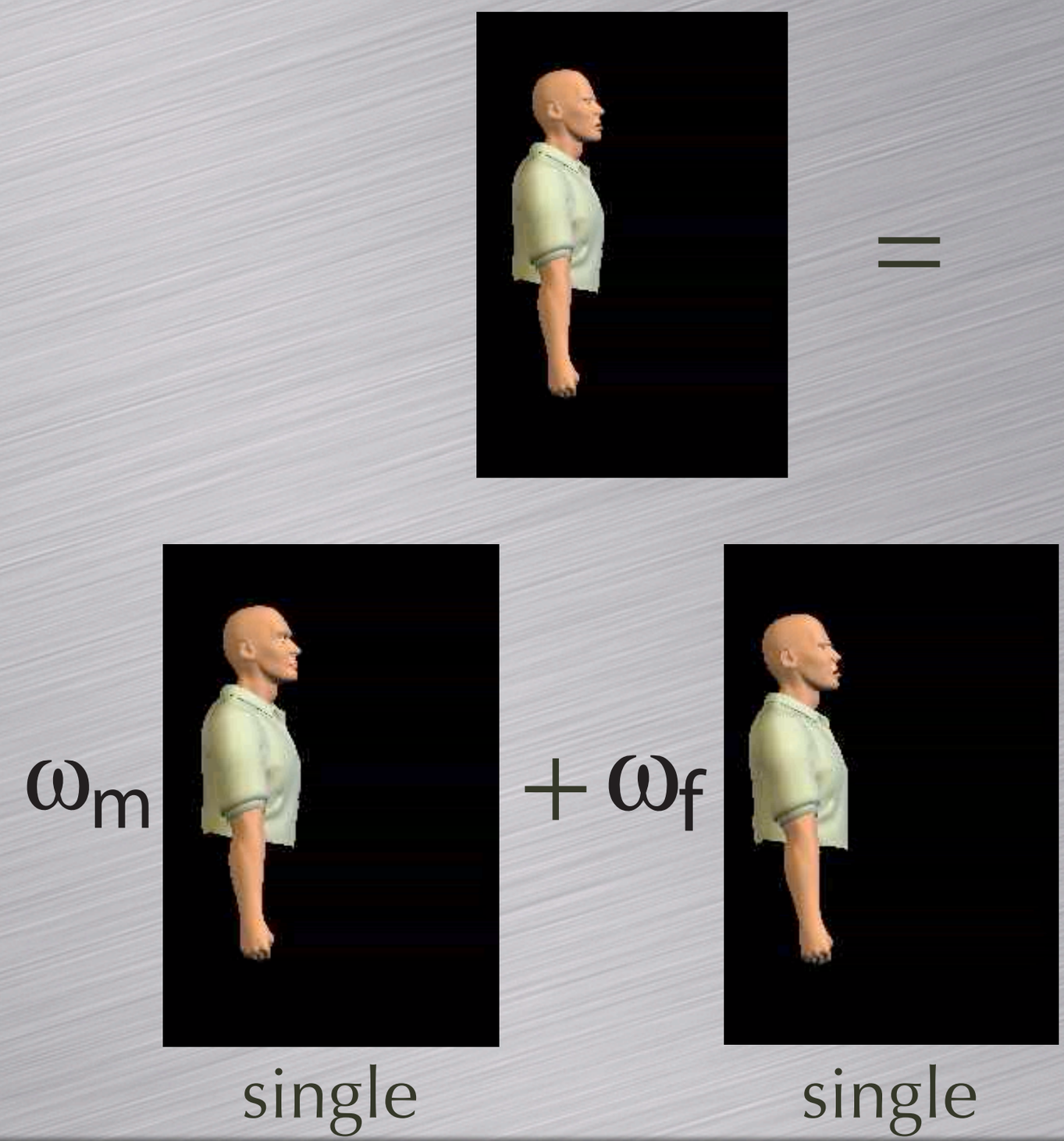
- For 2 levels of Movement saliency and 3 levels of Facial saliency we obtain for each affect:

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

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

Stimuli & 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



Weights

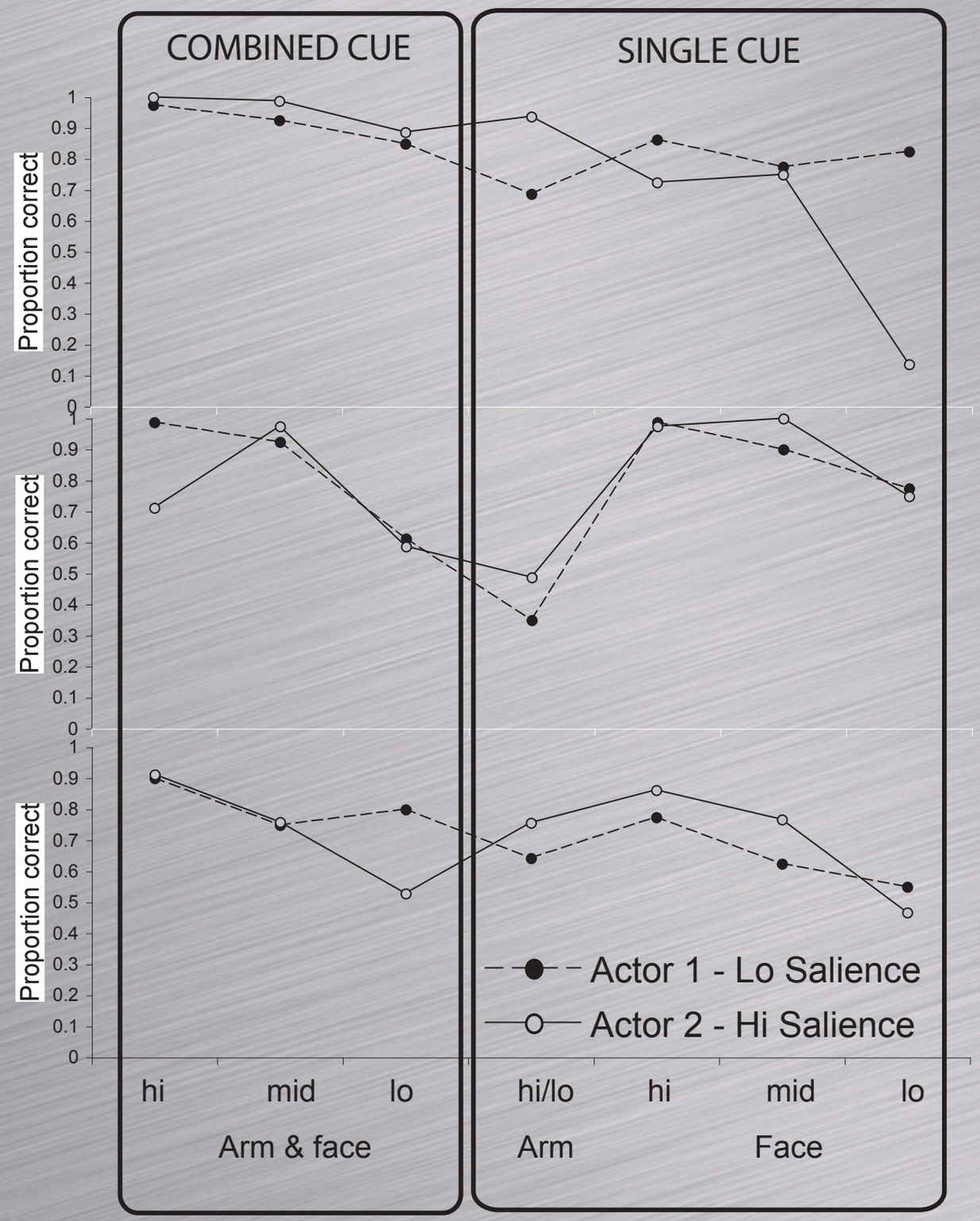

Weight
1
0.8
0.6
0.4
0.2
0
angry
happy
sad
Affect
ω_{face}
$\omega_{movement}$

Details

Angry

Happy

Sad



Answer Question 3

- At least for judging angry from neutral movements we appear to be efficient at extracting information from the movements.
- Movement information is incorporated into the perception of affect both to boost and diminish the effectiveness of information available from the face

Wrapping Up

- Hopefully, examining these 3 questions has informed you about the recognition of affect.
- Before discussing future directions I want to mention some loose ends I avoided when presenting the results

Loose Ends

- I avoided the following
  - morphing happy-angry revealed that recognition of happiness was not so stable
  - The circumplex - a third dimension accounts for a small amount more variance but defies a simple explanation
  - Individual differences are generally revealed both by the actors and the viewers

Future Directions

- Animacy
- Expertise

Animacy

- Is it possible to find more abstract motion properties?

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

Animacy from Video

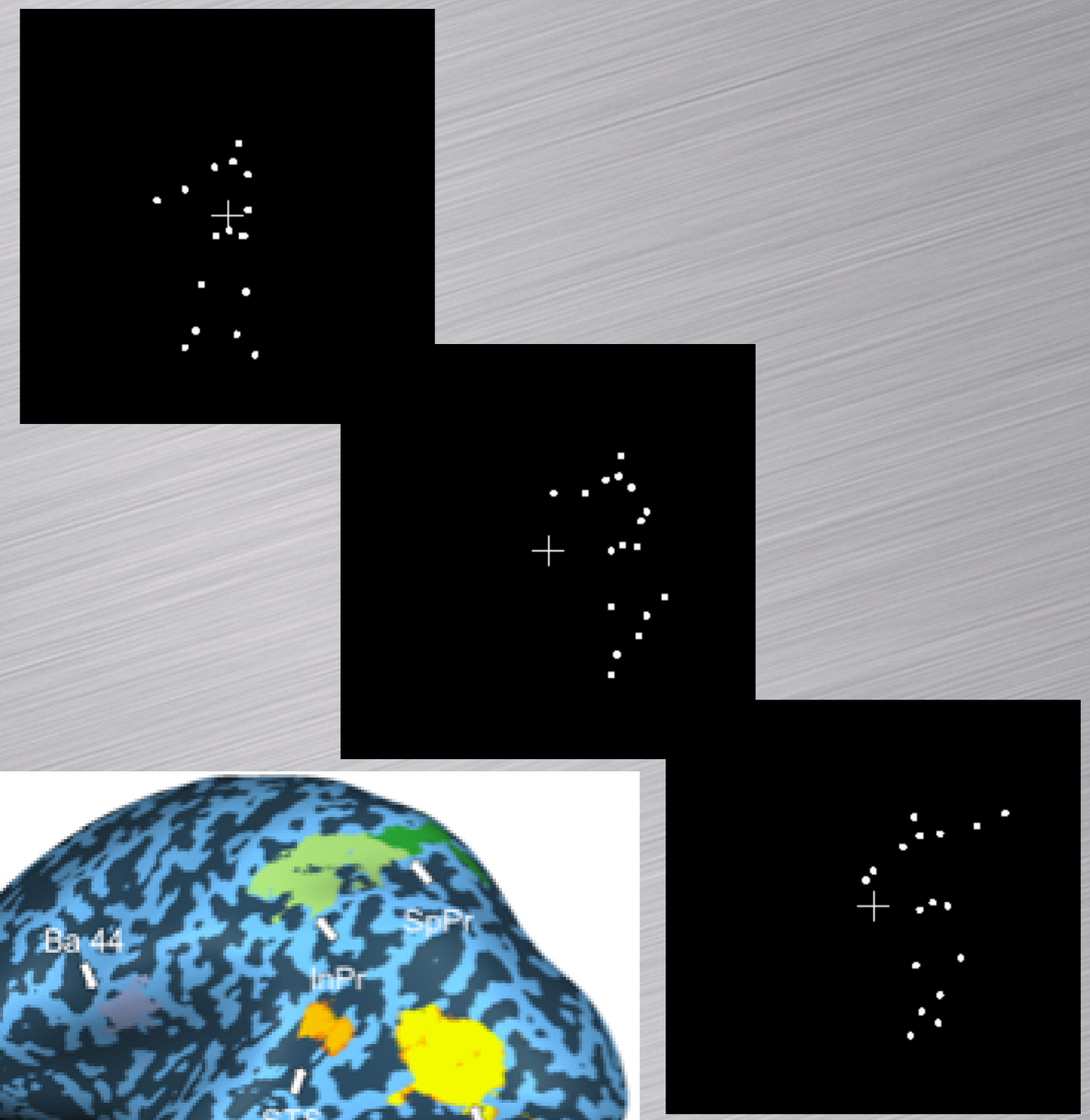
With Phil McAleer in Glasgow and Camurri & Volpe in Genoa

Expertise

- An effort to confront individual differences directly
- extend existing fMRI, brain imaging work

Perception of Ballet

- Novice-expert differences in the perception of ballet movements



With Vaia Lestou in Glasgow
Seon-Hee Jang at Sejong U
Chan-Sup Chung at Yonsei U

Thanks