Metakinesis
Neuroscience
Dance

Do motor expertise effects generalize to average dance audiences?

W. P. Seeley
Bates College
Philosophy Department
Arch enemies or natural bedfellows...

CogSci  the interdisciplinary study of how organisms **acquire**, **represent**, **manipulate**, and **use** information in the production of behavior.

Artworks  communicative devices, stimuli designed to trigger perceptual, affective, & cognitive responses that enable consumers to recover their formal aesthetic, depictive, expressive, and representational content.

Artists  formal & compositional strategies are:
- developed from systematic explorations of behavioral effects.
- fine tuned to the operations of cognitive systems.

... & Art  **acquire**, **represent**, **manipulate**, & **use information** embedded in the formal and compositional structure of artworks in order to **recognize and evaluate** their content.
Arch enemies or natural bedfellows...

CogSci  ARMUI

Artworks  Communicative Devices

Artists  Productive Practices

Research Questions:
- what are the key formal features / strategies of an artform?
- how do they carry/communicate diagnostic information?
- what about artistic salience?
A two-way street...

• artworks & the operations of cognitive systems:
  – psychology & cognitive neuroscience can clearly provide data to help answer these questions.
  – the operations of cognitive systems are revealed in our engagement with artworks

• enter neuroscience of dance
A two-way street...


- embodied cognition & motor simulation
- sensorimotor contributions to perception
  - f(MRI): premotor, IPL, STS
  - TMS & surface EMG
- generic / individual motor repertoire?
- visual / motor representations?

ballet & capoeira (motor expertise)
- formally distinct
- kinematically homologous
- arbitrary, intransitive motions

Figure 1. Stimuli: Colour videos of standard classical ballet and capoeira movements were performed by professional dancers. Twelve different moves of each style (a, ballet; b, capoeira) were matched by a professional choreographer for kinematic features (for examples see videos in the supplementary information online).
participants (male, 18-28):
10 - Royal Ballet, London
9 - professional capoeira dancers
10 - non dancer controls

3-second movement videos (color)
12 pairs standard B/C movements
matched for body shape & appearance
matched for spatial locations & kinematics
4 null events / black screen
“How tiring is the movement?”

Expertise effect = interaction between 3 subject groups & 2 kinds of dance stimuli
Results:

- bilateral activation in **premotor cortex**
- bilateral activation in **intraparietal lobe (IPL)**
- left **superior temporal sulcus (STS)**

**crossover pattern** (significant interaction):
- higher activation in experts for dance movements they can perform
- no significant activations/difference across movement types in controls

Discussion:

- complete action patterns
- learned motor skills
- individual motor repertoire
A two-way street...

perceptual effects: what you see?
  configural vs. featural cues
  point-light displays / upright v. inverted stimuli

gender specificity: visual familiarity & motor expertise
participants (18-31):
- 24 Royal Ballet, London (12 M / 12 F)
- 24 age-matched controls (12 M / 12 F)

3-second point light display videos (6 blocks; 48 trials each)
- 3 F dancers
- 8 classical ballet movements (female only / gender common)
- balanced for: body displacement, kinematics, gender specificity/commonality
- multiple recordings of each dancer performing each movement
  “identical/different exemplar of dancer/movement?”
- pairs differentiated by movement dynamics alone:
  ¬ morphological body cues
  ¬ formal stylistic idiosyncrasies
- expert / non-expert
- visual- / motor-expertise
Results:

**crossover pattern:**

- **inverted stimuli:** similar sensitivity across groups
- **upright stimuli:** expert dancers > non-dancers
  - female dancers > male dancers
  - male dancers > non-dancers (M/ F)

- no inversion effect for non-dancers
- no significant main effect for type of dance movement
**Discussion:**

- Inverted stimuli = shared featural processing mechanisms
- Upright stimuli = categorial configural advantage for dancers
- Female dancers performance = motor expertise effect
- Male dancers/female specific movements = visual familiarity effect
Metakinesis
Metakinesis

Since we respond muscularly to the strains in architectural masses and the attitudes of rocks, it is plain to be seen that we will respond even more vigorously to the action of a body exactly like our own. We will cease to be mere spectators and become participants in the movement that is presented to us...

Naturally these motor responses are registered by our movement sense receptors, and awaken appropriate emotional associations akin to those which have animated the dancer in the first place...

It is the dancer’s whole function to lead us into imitating his actions with our faculty for inner mimicry in order that we may experience his feelings....

John Martin, *The Modern Dance* (1933)
Metakinesis

action observation & kinesthetic empathy

**diagnostic features = biological movement cues**

- fMRI: stylistic categories of dance (Calvo-Merino et al, 2006)
- point-light displays: interpersonal dialogue (Clarke et al, 2005)
- point-light displays: expressive dance movements (Dittrich et al, 1998)

http://www.perceptionweb.com/misc.cgi?id=p5203/
Metakinesis

action observation & kinesthetic empathy

diagnostic features = biological movement cues

stereotyped movements, actions, & emotions
  • kinetic transfer: motor mimicry, motor simulation
  • embodied sensorimotor understanding of character & story
Metakinesis

action observation & kinesthetic empathy

diagnostic features = biological movement cues
stereotyped movements, actions, & emotions

cues to sensorimotor categories of dance

stylistic categories
direct how to attend to & interpret the work
So here’s the rub...

...these are motor expertise studies.

...they are designed to demonstrate the influence of one’s own individual, learned motor repertoire in perception.

...dance is used as a limit case of intransitive action to selectively control for the influence of motor programs in perception (see also Cross, Hamilton, & Grafton, 2006).

...non-dancer controls don’t exhibit the right responses.
A two-way street...

Jola et al (2012)

visual familiarity, motor learning, & motor simulation

observation & motor learning (Frey & Gerry, 2006; Jasteroff, Kourtzi, & Giese, 2009)
somatotopic mapping, anatomical constraints, and generic motor programs
(Carroll & Seeley, 2013; Jasteroff et al, 2009)

ballet (B) & bharata natyam (BN)

arms & hands are used extensively in B & BN to communicate meaning
however arms & hands are used differently in these two styles

B = 5 strictly defined arm postures;
fingers held in the same position for each throughout

BN = hands and fingers are moved/used expressively
Jola et al (2012) visual familiarity, motor learning, & motor simulation

ballet (B) & bharata natyam (BN)

single pulse TMS/surface EMG:
  extensor carpi radialis (ECR)
  first dorsal interosseous (FDI)
  EMG = 500ms after pulse (target)
  100ms before pulse (baseline control)

30 single pulses, triggered randomly 7-9 seconds apart, and timed to arm/hand movement sequences.
32 participants (age, 20-72; 10 male):
- no formal dance training
- 12 experienced in watching ballet
- 8 experienced in watching bharata natyam
- 9 no experience watching dance
- visual familiarity = self report of the number of dance performance attended in the previous year

live 5 minute performances (6 blocks; 48 trials each)

ballet (a concatenation of three traditional solos from Sleeping Beauty)
Indian dance (a popular ‘padam’ from the traditional repertoire)
acting piece (matched for appearance, spatial displacement, & kinematics)
female performers; recoded music
baseline rest period (relaxed with eyes closed)

Results:

**B:** visual experience = heightened (ECR) MEPs  
visual experience = ECR (B) > ECR (BN)  
visual experience ≠ heightened (FDI) MEPs

**BN:** no significant effects of visual experience
Discussion:
suggests visuo-motor matching for understanding ballet hands miming everyday activities in BN did not influence (FDI) MEPs variance from predicted muscle use differences in visual experience:

**B** = older, more formalized performances (mean = 13.75)

**BN** = fewer formalized performances (mean = 4.75); more social dances, more video performances
A two-way street...

Opacic, Stevens, & Tillmann (2009)

**implicit learning & dance grammars**

**ballet vs. contemporary dance**

sequences of movements chained together form a grammar

recognition = related stylistic expectancies

variance in contemporary contexts - dance grammars must often be learned on the fly

**dance & artificial grammar research:**

– implicit learning / temporally extended stimuli

**artificial grammar research & dance:**

– a model for how naive dance audiences bootstrap visual familiarity with novel styles

– a means to control for visual familiarity in experimental contexts
Opacic, Stevens, & Tillmann (2009)

- implicit learning & dance grammars
- ballet vs. contemporary dance
- artificial grammar research & dance
dance & artificial grammar research

dance grammars:
- anatomical constraints
- generic motor programs
- physics
- natural kinematics\dynamics of human biological motion
participants:
31 Psychology 1 students
26 female / 5 male
15 - exposure group
16 - control group

66 movement sequence videos (9-19s)
22 grammatical (exposure)
22 grammatical (test)
22 non-grammatical
5 characteristic dance movements:
  M1 triple turn
  M2 side fall
  M3 body wave
  M4 side kick and lunge
  M5 leg swing across floor front and back
disrupted natural flow/momentum
3, 4, & 5 movement sequences
ungrammatical sequences:
replace a movement in a grammatical sequence
produce a grammatical bigram
that is an ungrammatical trigram

Table 1

<table>
<thead>
<tr>
<th>Grammatical bigram</th>
<th>Exposure</th>
<th>Test</th>
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<tbody>
<tr>
<td></td>
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<td>Grammatical</td>
</tr>
<tr>
<td>M1–M1</td>
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<td>4</td>
</tr>
<tr>
<td>M1–M2</td>
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<td>1</td>
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<tr>
<td>M1–M5</td>
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<tr>
<td>M2–M3</td>
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Table 2

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<th>Grammatical trigram</th>
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<tr>
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</table>

Note. For ungrammatical sequences, 12 ungrammatical trigrams were introduced: M1–M1–M1, M1–M1–M5, M1–M2–M4, M1–M5–M3, M2–M4–M3, M3–M4–M5, M4–M1–M1, M4–M1–M2, M4–M3–M4, M4–M5–M5, M5–M1–M1, M5–M1–M5, M5–M2–M4, M5–M4–M5. M1–M5 = Movement 1–Movement 5.
Procedure:

22 exposure sequences - twice each in random order. “have you seen this previously?” (memory task)

22 pairs of test/ungrammatical sequences
“closest match” for movements and transition probabilities
“which of the pair was grammatical?”
“confidence?” rating on a 5-point Likert scale

control group 1: 22 test/ungrammatical sequences
control group 2: “which of the two sequences is more flowing?”
Results:

exposure group “memory task” performance above chance
(61.6% $t(14) = 8.04, p < 0.0001$)

exposure group test performance above chance
(M = 57.17%, SD = 12.12%)

exposure group > control group 1
$t(29) = 3.70, p < 0.001$)

control group 1/2 < chance

Discussion:

implicit learning through visual familiarity (exposure) of an artificial grammar structuring sequences of dance movements.

“disruption of flow” shows that learning is for the movement sequences themselves.
Do motor expertise results generalize to average dance audiences?

- evidence suggests that **visual familiarity** is sufficient for **motor learning** for generic and goal directed movements, cases where there are sufficient cues to map novel movement sequences to an individual’s motor repertoire.

- evidence demonstrates **implicit learning** for **configural cues** governing **novel dance sequences** - complex, abstract, intransitive movement sequences.

- our suggestion is that this is the missing link to bridge the gap between Calvo-Merino & Jola and shore up the model for metakinesisis as a mechanism for dance communication.