Double dissociation(s) between the extrastriate body area (EBA) and the posterior superior temporal sulcus (pSTS) during biological motion perception

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why study biological motion?

✦ visual stimulus: cortex & (retina) → interpret // meaningfulness // experience

✦ very frequent stimulus: other people's faces and bodies (ecological validity ↔ gratings)

✦ other people most often move (dynamic)

✦ high maneuverability at stimulus level → sparked research (psychophysics, functional imaging, electrophysiology, modeling...)

adapted from G. Mather
how can we recognize biological movements?

(static body poses vs dynamic sequence)

We're in pSTS!

I'm at EBA!

me too

so am i...

fwd/bwd direction task

(static body poses)

Zidane

facing orientation task

[based on Lange & Lappe, 2006]

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(common) brain network

[minus]

[Grossman et al, 2010]
[Saygin et al, 2004]
electrophysiology in macaques

we know that the two exist in the macaque brain, but how about the human brain?

**dynamic (sequence) neurons**

**static body pose neurons**

[Vangeneugden et al, 2009]
we know that the two exist in the macaque brain, but how about the human brain?

dynamic sequence neurons
significant correlations between multivoxel patterns comparing pointlight actions and static bodies in EBA

unspecified parieto-frontal regions respond more to coherent than incoherent sequences

[Peelen et al, 2006]
[Thompson & Baccus, 2012]

[Downing et al, 2006]
outstanding questions?

given:

✦ both static body pose and dynamic processing are important
✦ there's electrophysiological evidence for both mechanisms in the macaque brain
✦ the suggestions of static pose processing in EBA and dynamic processing in pSTS
✦ but no conclusive fMRI nor causal (TMS) evidence in the human brain

we wanted to know:

psychophysics

✦ using precise manipulations of pose versus dynamic processing with a new kind of stimulus

fMRI (MVPA)

✦ whether there's information about pose and/or dynamic processing present in EBA and/or pSTS

TMS

✦ and if so whether this relationship is of a causal nature
psychophysics: stimuli

aligned

misaligned
psychophysics: results

aligned

misaligned

fwd/bwd direction

facing orientation

I frame

body pose

no dynamic

no body pose

dynamic

N=14

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<table>
<thead>
<tr>
<th>static body pose processing</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>探查</td>
<td>面对任务</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dynamic sequence processing</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>探查</td>
<td>向前/向后任务</td>
<td></td>
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</table>
fMRI: localizers

EBA & FBA [bodies - chairs]

MT [scrambled action - scrambled static]

pSTS [intact - scrambled actions]
fMRI: conditions to decode

- static body pose
  - facing right
  - facing left

- fwd or bwd (#1,2)
  - dynamic

- fwd or bwd (#3,4)
  - dynamic

- left or right (#5,6)
  - static body pose

[presentation: left or right visual field (1.5° ecc.)]

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fMRI: representational information (MVPA)

EBA [bodies - chairs]

[Kamitani & Tong, 2005]
fMRI: representational information (indices)

<table>
<thead>
<tr>
<th>Fwd Bwd</th>
<th>Facing</th>
<th></th>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Different</td>
<td></td>
<td>Same</td>
</tr>
<tr>
<td>Different</td>
<td>(Rf,Lb)+(Rb,Lf)</td>
<td></td>
<td>(Rf,Rb)+(Lb,Lf)</td>
</tr>
<tr>
<td>Same</td>
<td>(Rf,Lf)+(Rb,Lb)</td>
<td></td>
<td>(Rf,Rf)+(Rb,Rb)</td>
</tr>
</tbody>
</table>

Information derived from dynamic actions:

- static body pose
- dynamic sequence

Information derived from static poses:

(Generalization index)

Congruent - incongruent
fMRI: results

- Static body pose index
- Dynamic sequence index
- Generalisation index

Graphs showing data for EBA, pSTS, FBA, and MT+.
fMRI: conclusions

<table>
<thead>
<tr>
<th>Psychophysics</th>
<th>fMRI (MVPA) information</th>
<th>TMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>probed facing task</strong></td>
<td><strong>largely EBA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>probed fwd/bwd task</strong></td>
<td><strong>mainly pSTS</strong></td>
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</tbody>
</table>

- static body pose processing
- dynamic sequence processing

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TMS: protocol

- Pre-test (12 min)
- TMS (20 min)
  - (1 Hz, 70%)
  - (EBA/pSTS)
  - MRI-guided
  - Online positional feedback
- TMS-test (12 min)
- Break (min. 1 hour)
- Post-test (12 min)

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TMS: results

right EBA

right pSTS

static body pose
[ facing task ]

dynamic sequence
[ fwd/bwd task ]

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TMS: conclusions

**Psychophysics**
- Probed facing task only EBA
- Probed fwd/bwd task only pSTS

**fMRI (MVPA)**
- Only EBA
- Only pSTS

**TMS causal role**
- Only EBA
- Only pSTS

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**Static body pose processing**
- Dynamic sequence processing
**how do we conclude?**

<table>
<thead>
<tr>
<th>literature</th>
<th>✦ no conclusive evidence on the (potential) neural substrate of <strong>static body pose</strong> vs <strong>dynamic</strong> processing during biological motion perception</th>
</tr>
</thead>
</table>
| psychophysics | ✦ **good operationalization** of the two tasks  
   ➢ facing orientation task: **static body pose** processing  
   ➢ fwd/bwd direction task: **dynamic** processing |
| fMRI (MVPA) | ✦ **double dissociation** wrt **information value**:  
   ➢ information on the static body pose processing in **EBA**, not in **pSTS**  
   ➢ information about dynamic processing in **pSTS**, not in **EBA** |
| TMS | ✦ **double dissociation** wrt **causal evidence**:  
   ➢ static body pose processing in **EBA**, not **pSTS**  
   ➢ dynamic processing in **pSTS**, not **EBA** |
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