SURFACE vs. STRUCTURAL PROPERTIES OF MULTISENSORY OBJECT REPRESENTATIONS

Krish Sathian

Departments of Neurology, Rehabilitation Medicine & Psychology, Emory University
Rehabilitation R&D Center of Excellence, Atlanta VAMC

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Spatial versus object visualizers: A new characterization of visual cognitive style

MARIA KOZHEVNIKOV
Rutgers University, Newark, New Jersey

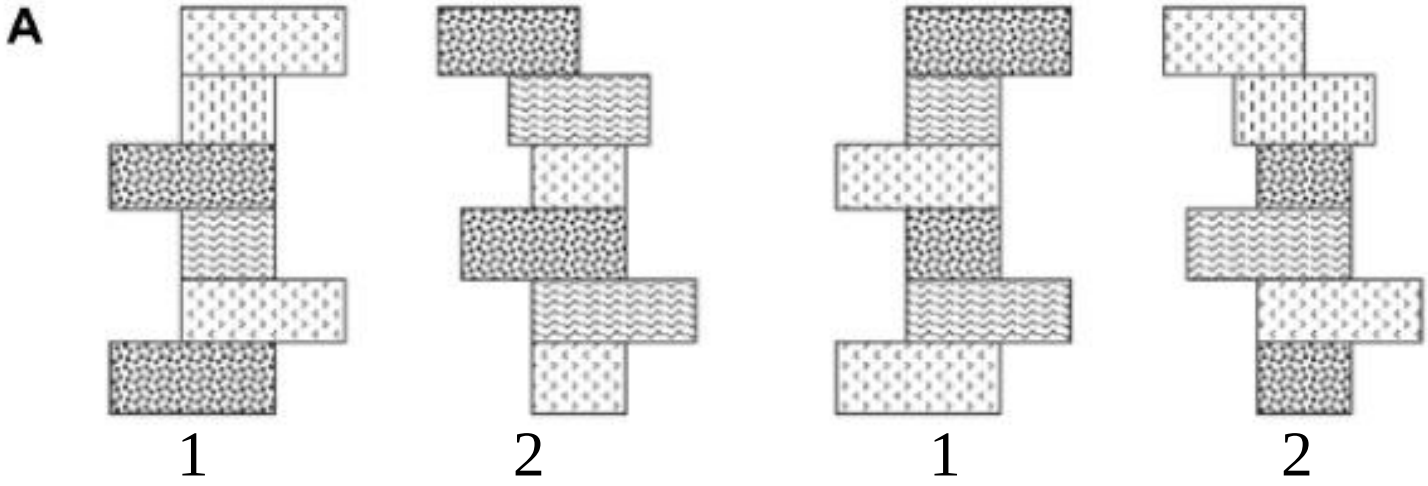
and

STEPHEN KOSSLYN and JENNIFER SHEPHARD
Harvard University, Cambridge, Massachusetts

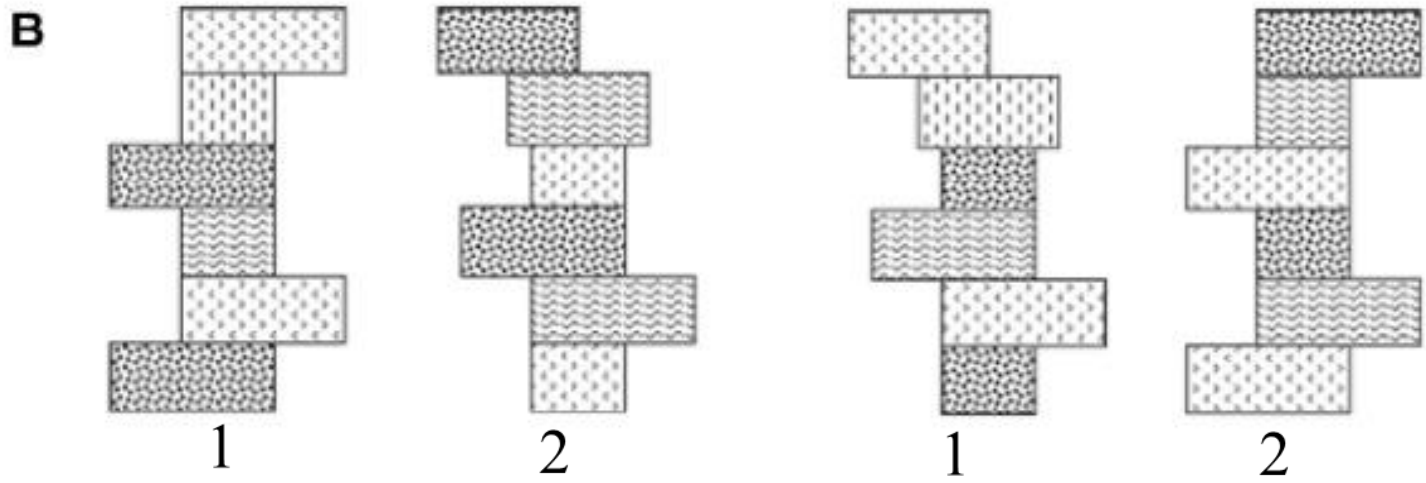
The visual system processes object properties (such as shape and color) and spatial properties (such as location and spatial relations) in distinct systems, and neuropsychological evidence reveals that mental imagery respects this distinction. The findings reported in this article demonstrate that verbalizers typically perform at an *intermediate* level on imagery tasks, whereas visualizers can be divided into two groups. Specifically, scores on spatial and object imagery tasks, along with a visualizer–verbalizer cognitive style questionnaire, identified a group of visualizers who scored poorly on spatial imagery tasks but excelled on object imagery tasks. In contrast, a second group of visualizers scored high on spatial imagery tasks but poorly on object imagery tasks. The results also indicate that object visualizers encode and process images holistically, as a single perceptual unit, whereas spatial visualizers generate and process images analytically, part by part. In addition, we found that scientists and engineers excel in spatial imagery and prefer spatial strategies, whereas visual artists excel in object imagery and prefer object-based strategies.

SURFACE & STRUCTURAL PROPERTIES IN OBJECT REPRESENTATIONS

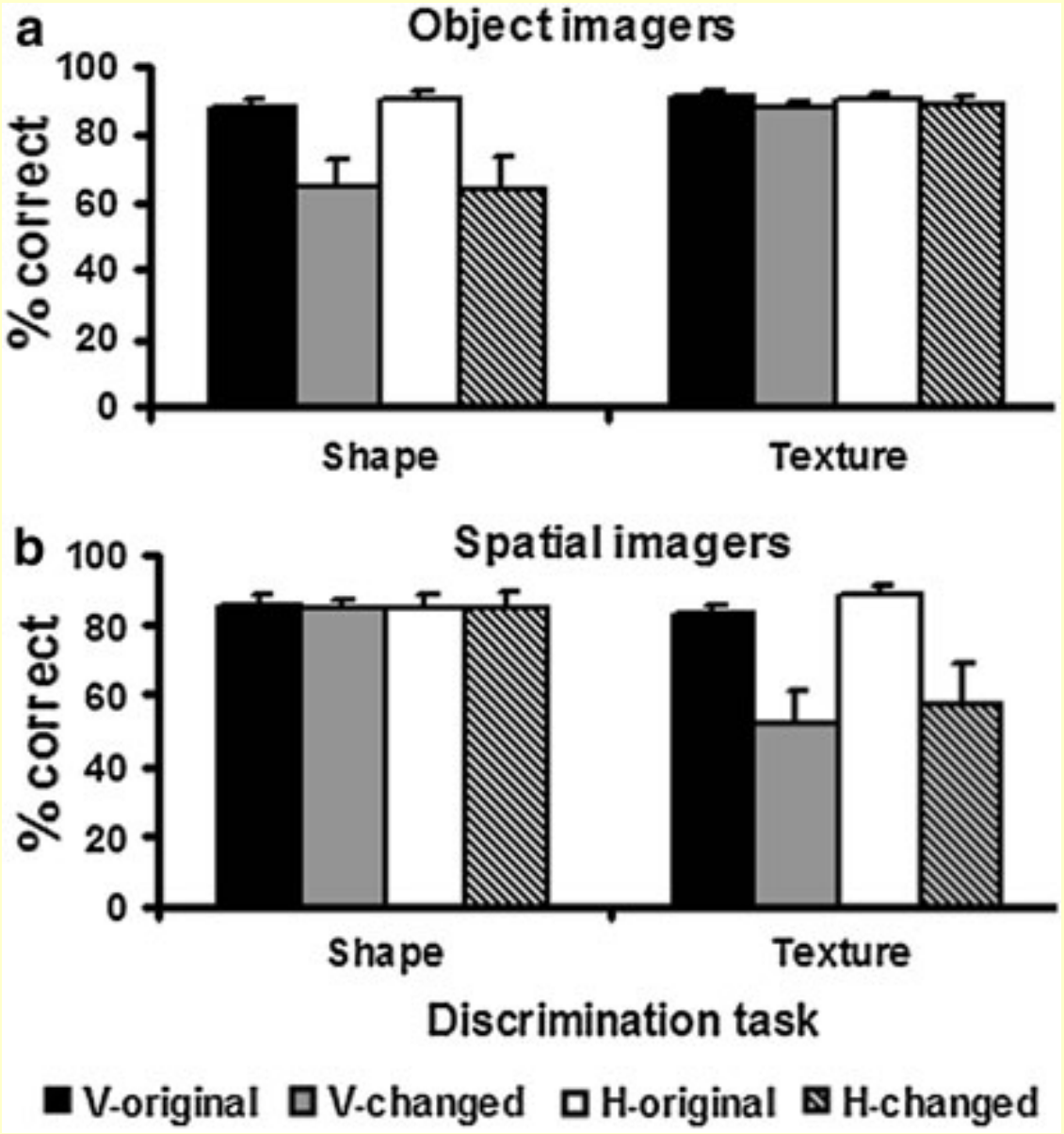
SHAPE



TEXTURE



INDIVIDUAL VARIATIONS IN OBJECT & SPATIAL IMAGERY ABILITIES



IN VISION & TOUCH:

- Object imagers can discriminate texture across shape changes, but not shape across texture changes.
- Spatial imagers can discriminate shape across texture changes but not texture across shape changes.

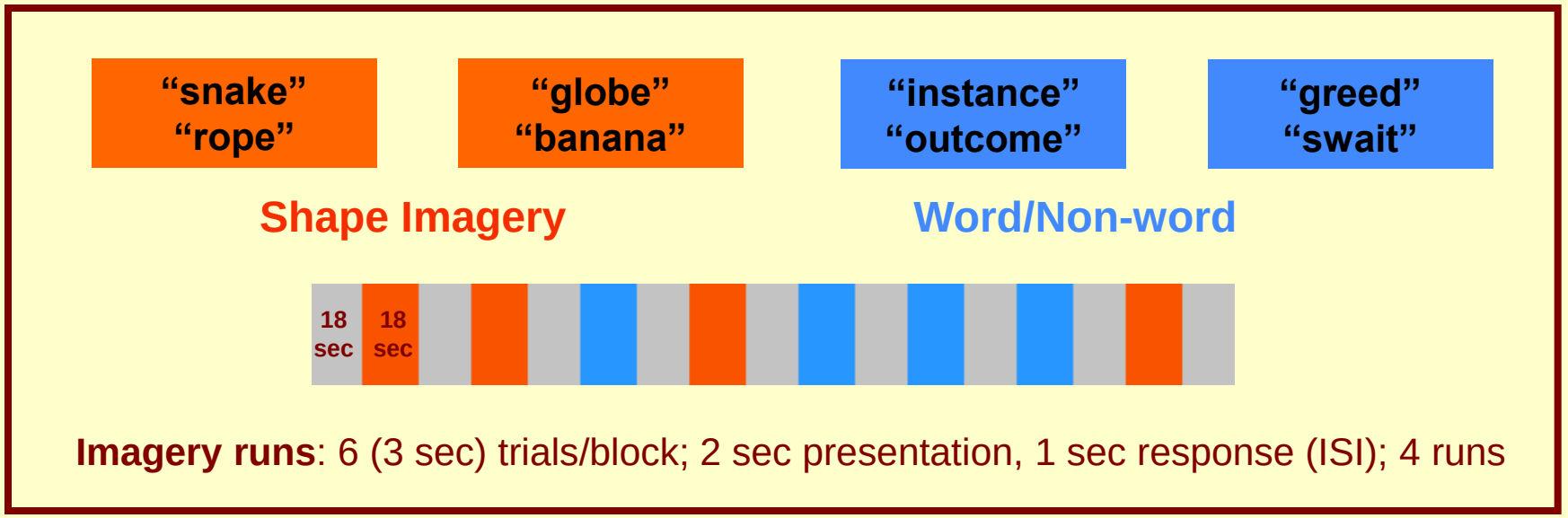
Lacey, Lin & Sathian, Exp Brain Res 2011

How do visual object imagery and spatial imagery relate to haptic shape perception? Are the relationships modulated by object familiarity?

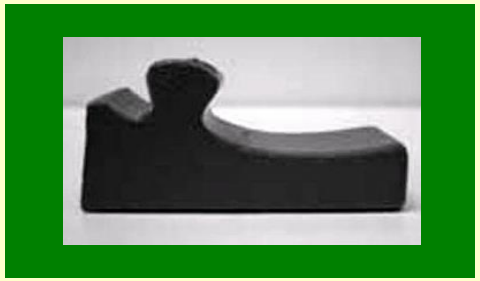
- fMRI studies

- Object imagery task: same/different shape discrimination on visual images triggered by high-imagery words presented through headphones

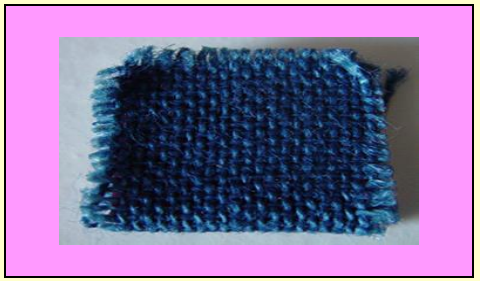
- Control task (after several iterations…): same/different word/non-word discrimination using low-imagery words and pseudowords
  (both words or both pseudowords = same
  one word and one pseudoword = different)



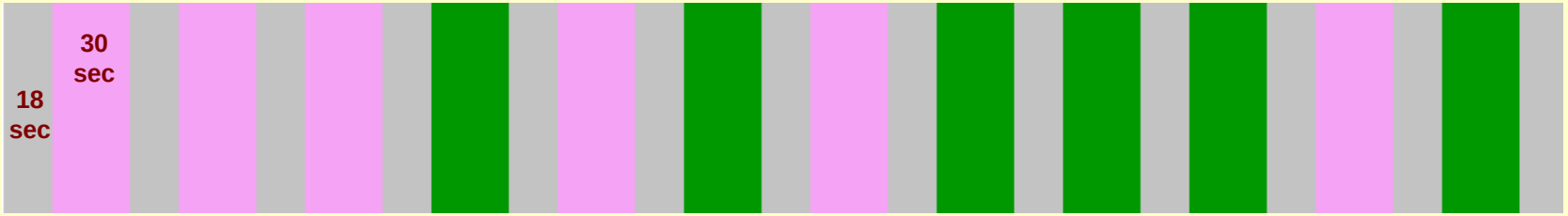
Imagery runs: 6 (3 sec) trials/block; 2 sec presentation, 1 sec response (ISI); 4 runs



Haptic Shape
(Unfamilar, meaningless objects)

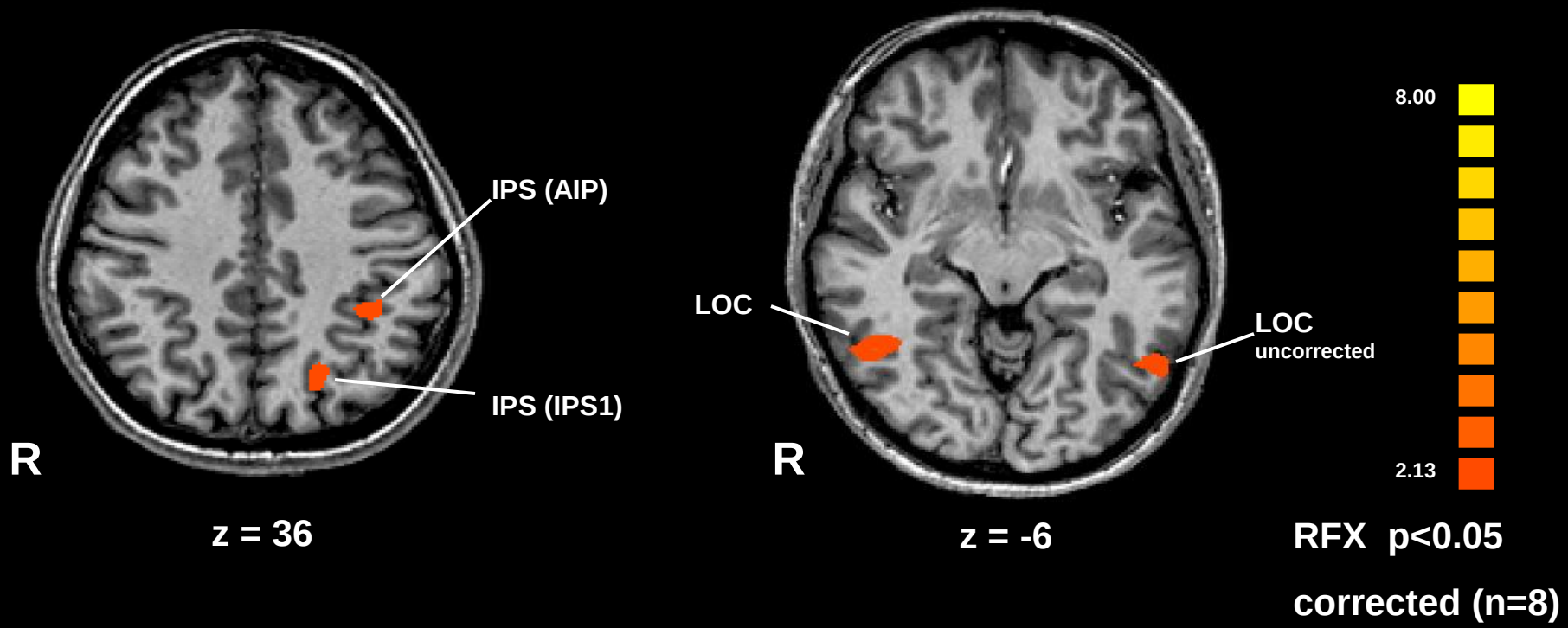


Haptic Texture



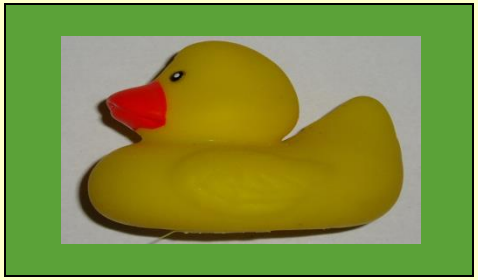
Haptic runs: 6 (5 sec) trials/block; 4 sec exploration, 1 sec response (ISI);
one-back comparison: same or different
2 runs each hand

Conjunction of activations for VI and HS (unfamiliar objects)



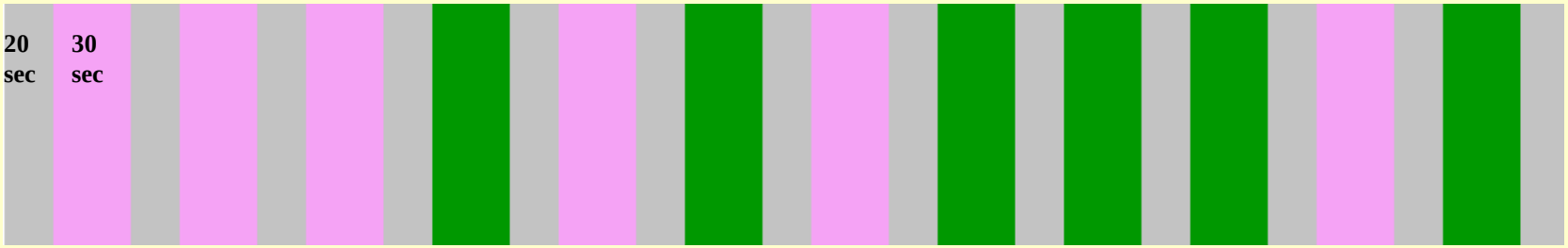
VI-HS correlns	*r*	*p*
Right LOC	0.31	0.46
Left LOC	0.64	0.09
Left AIP	0.57	0.14
Left IPS1*	**0.82**	**0.01**

Lacey, Flueckiger, Stilla, Lava & Sathian
NeuroImage 2010



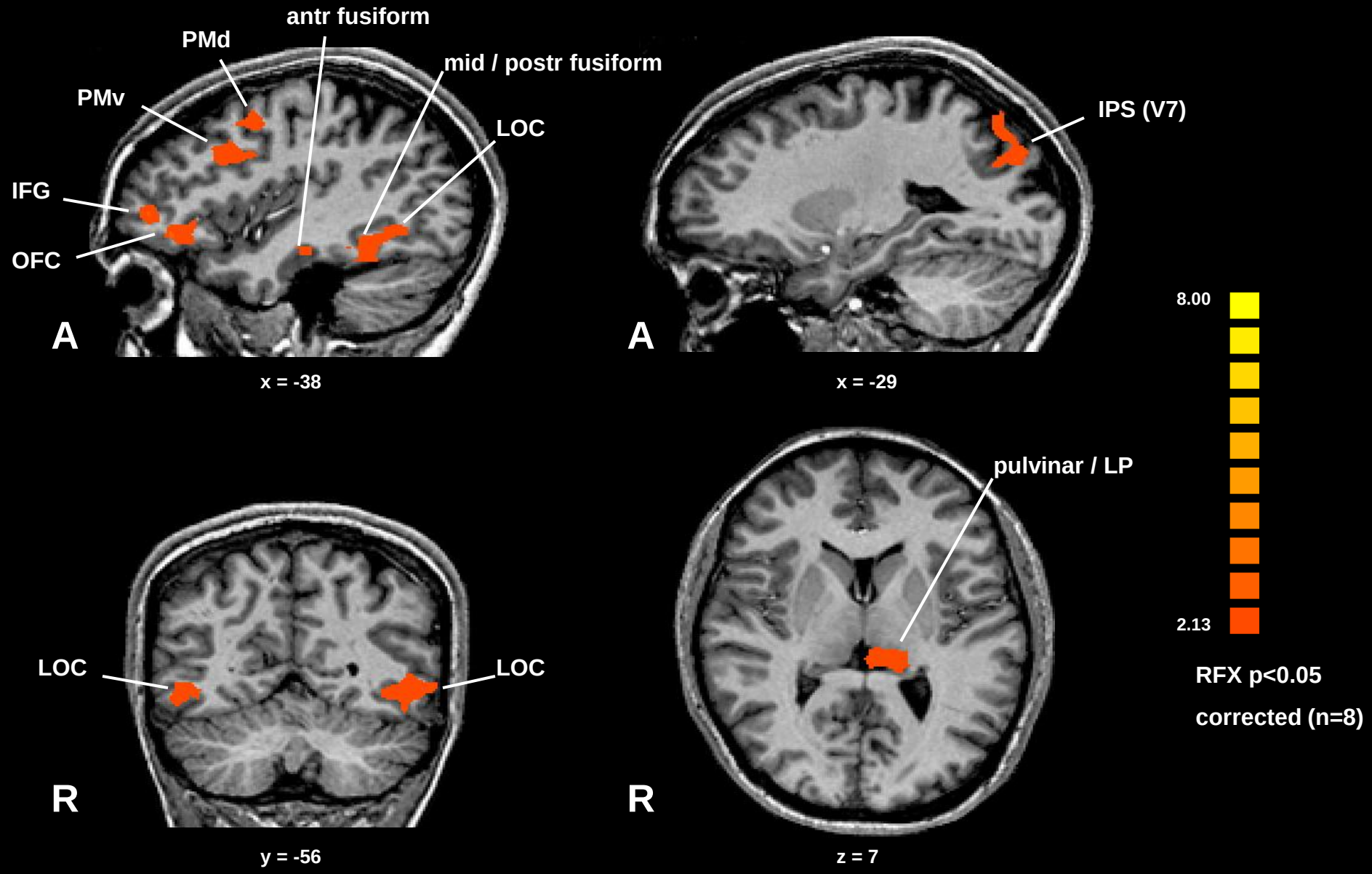
Haptic Shape
(Familiar objects)

Haptic Texture



Haptic runs: 6 (5 sec) trials/block; 4 sec exploration, 1 sec response (ISI);
one-back comparison: same or different
2 runs right hand only

Conjunction of activations for VI and HS (familiar objects)



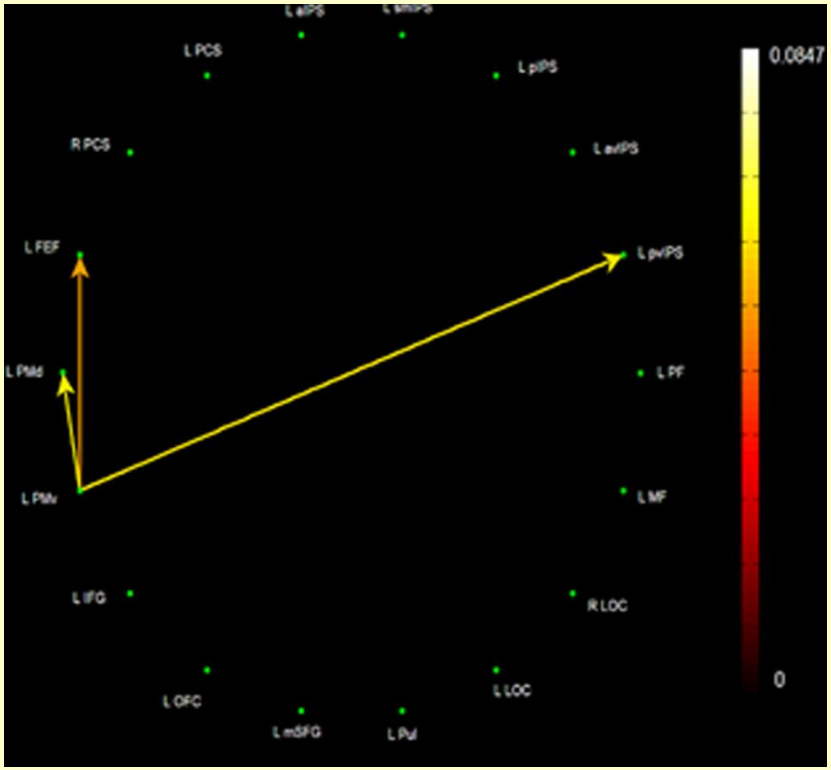
Lacey, Flueckiger, Stilla, Lava & Sathian NeuroImage 2010

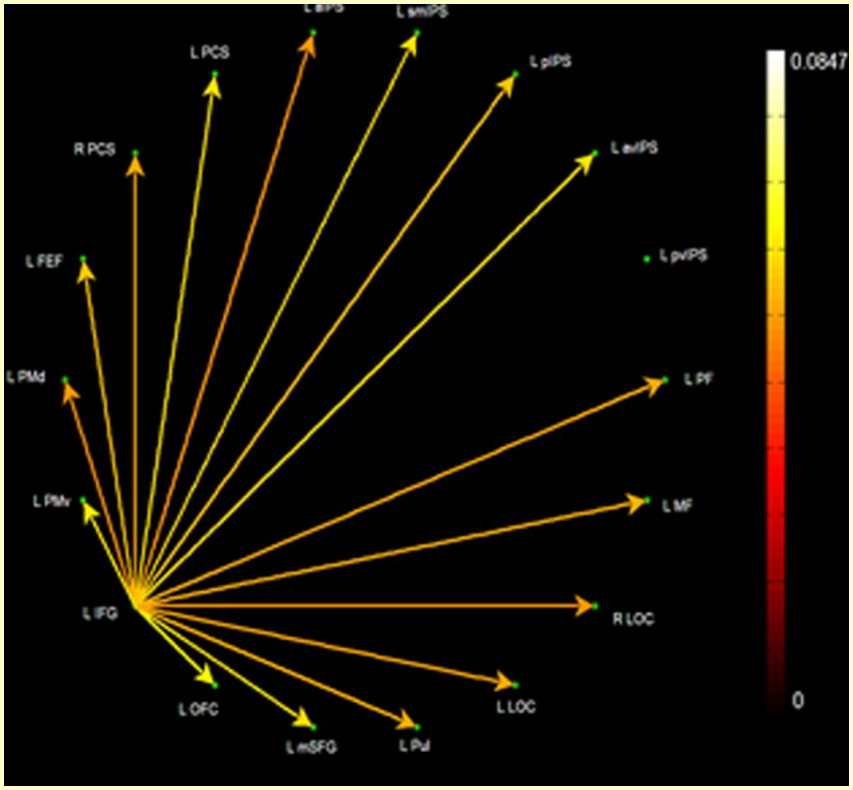
Visual object imagery/haptic shape inter-task correlations of activation magnitudes

	Familiar objects	
	r	p
R LOC	**.75**	**.03**
L LOC	**.82**	**.01**
L PMv	**.86**	**.007**
L V7	**.74**	**.03**
L IFG	**.89**	**.003**
L pulvinar	**.94**	**.001**

Lacey, Flueckiger, Stilla, Lava & Sathian, NeuroImage 2010

Effective connectivity analyses (Granger causality analyses of inferred neural time series obtained by deconvolving HRF)





objIMG & uHS

objIMG & fHS

objIMG network shares more common paths with fHS than uHS

Lacey, Stilla, Sreenivasan, Deshpande & Sathian, Neuropsychologia 2014

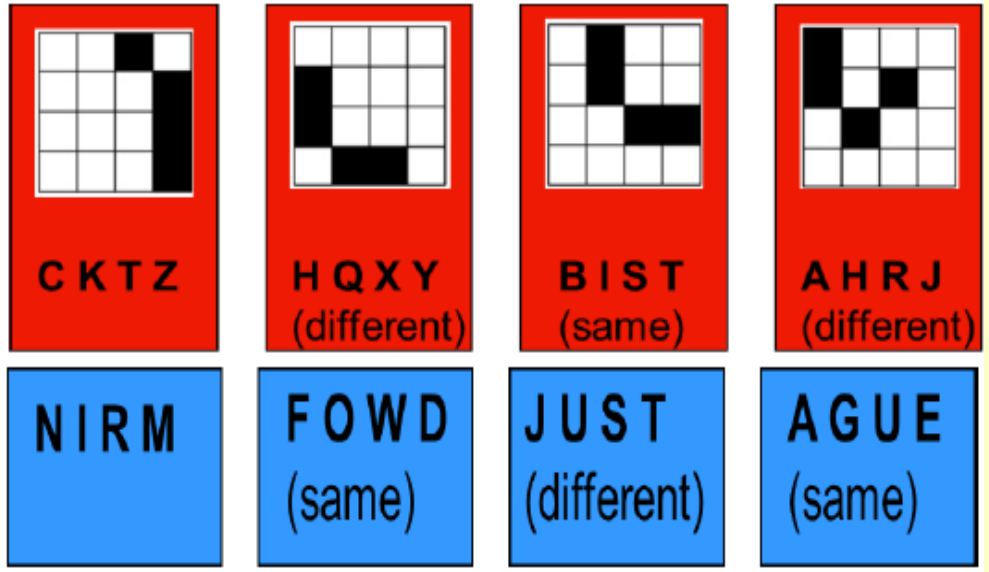
spIMG TASK

Memorize grid of letters

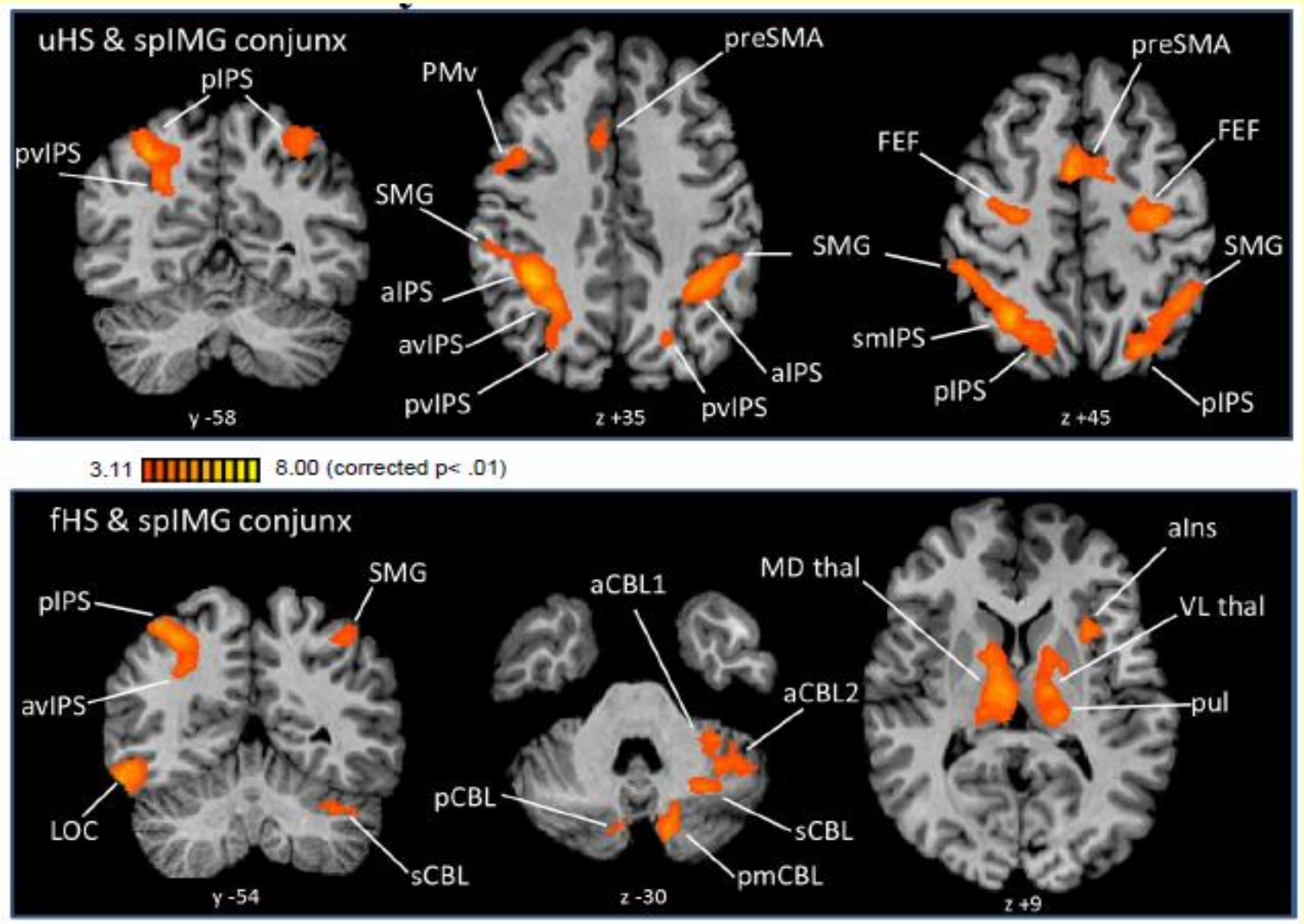
A	B	C	D
H	I	J	K
Q	R	S	T
W	X	Y	Z

In response to auditory four-letter strings, participants imagine the shape resulting from filling in the appropriate squares

The control task was to decide whether a four-letter string made a real word or non-word



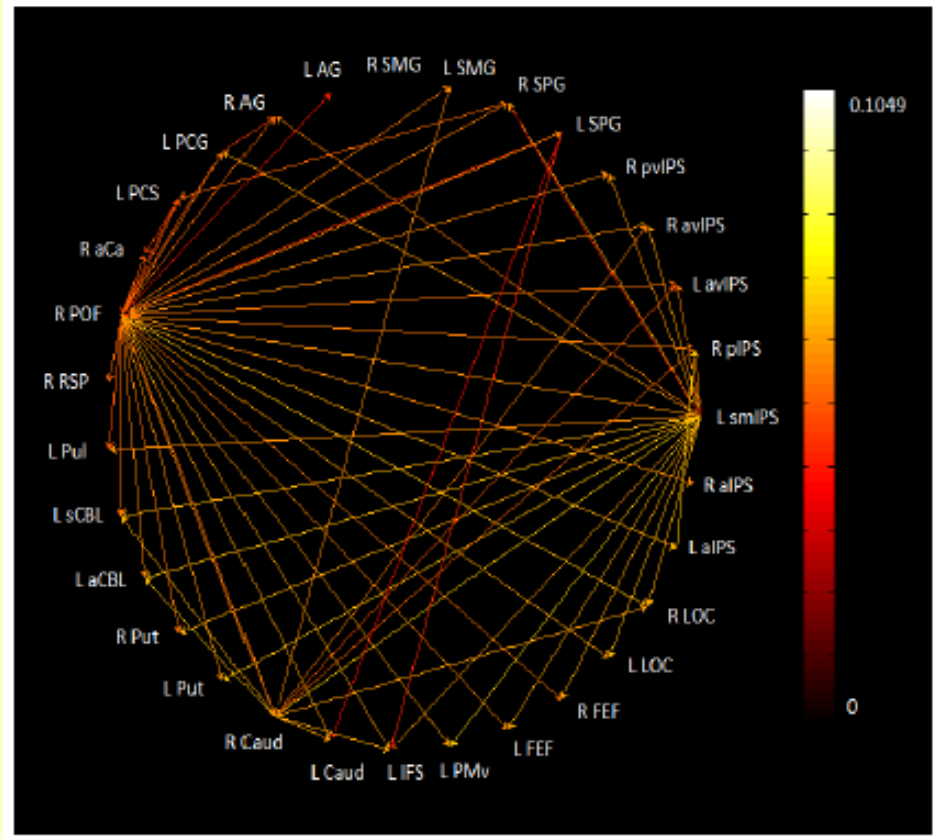
fHS, uHS as before, in separate runs in the same participants (n=12)



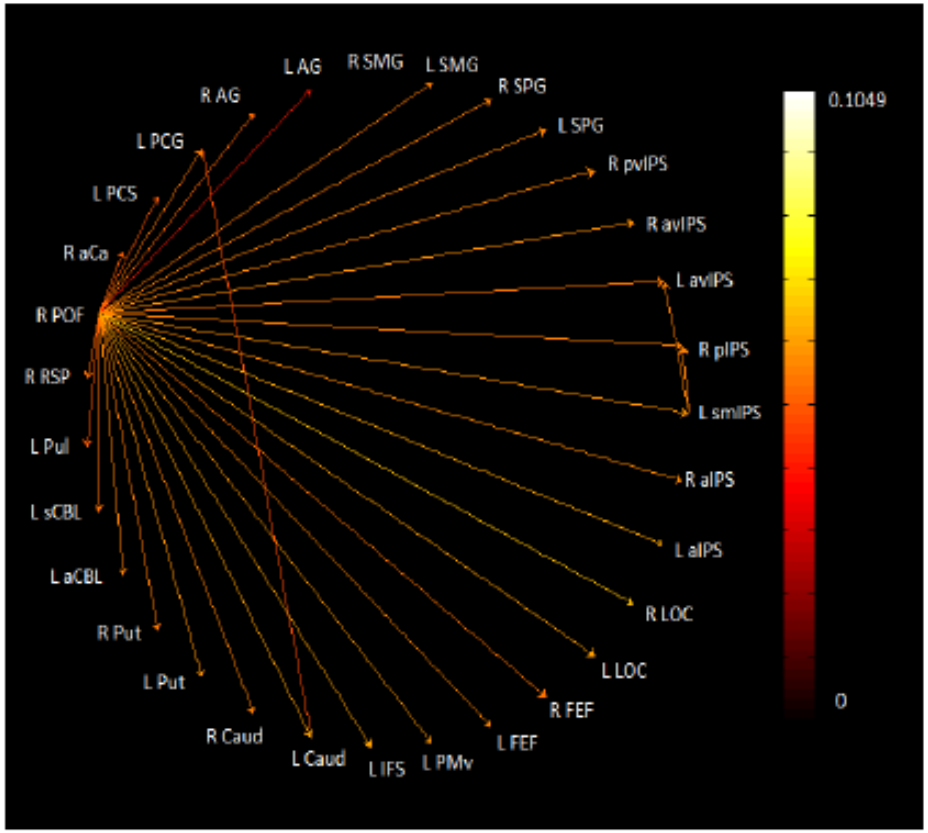
Inter-task correlations of activation magnitude were present between spIMG & both fHS and uHS, with right IPS featuring in both sets of correlations.

Lacey, Stilla, Sreenivasan, Deshpande & Sathian, Neuropsychologia 2014

Effective connectivity analyses (Granger causality analyses of inferred neural time series obtained by deconvolving HRF)



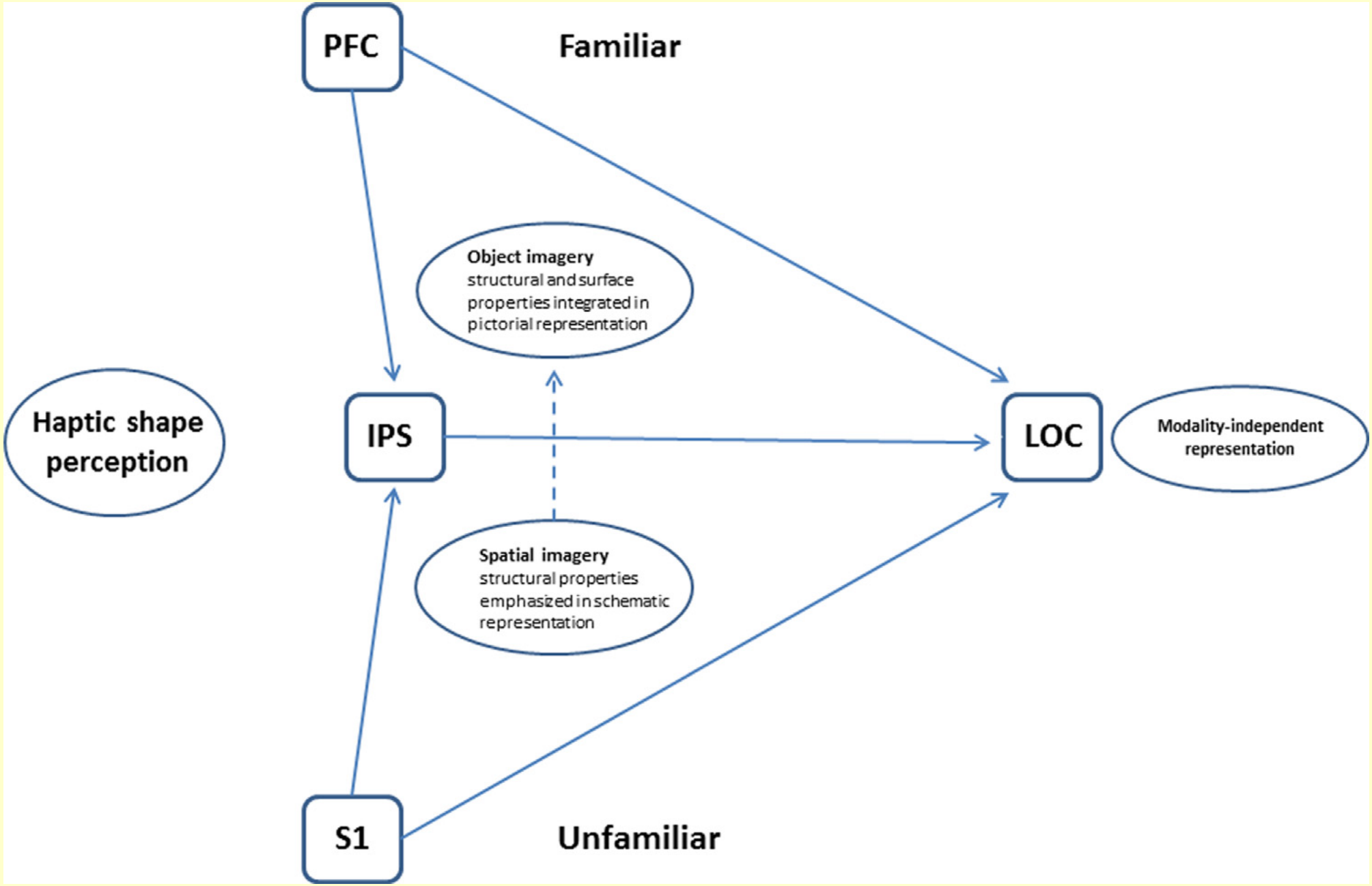
spIMG & uHS



spIMG & fHS

spIMG network has paths in common with both fHS and uHS, but more with uHS, esp paths involving IPS, bilateral LOC and S1.

Lacey, Stilla, Sreenivasan, Deshpande & Sathian, Neuropsychologia 2014



Lacey, Stilla, Sreenivasan, Deshpande & Sathian, Neuropsychologia 2014

Melody 1 Loudness pattern 1

Melody 2 Loudness pattern 2

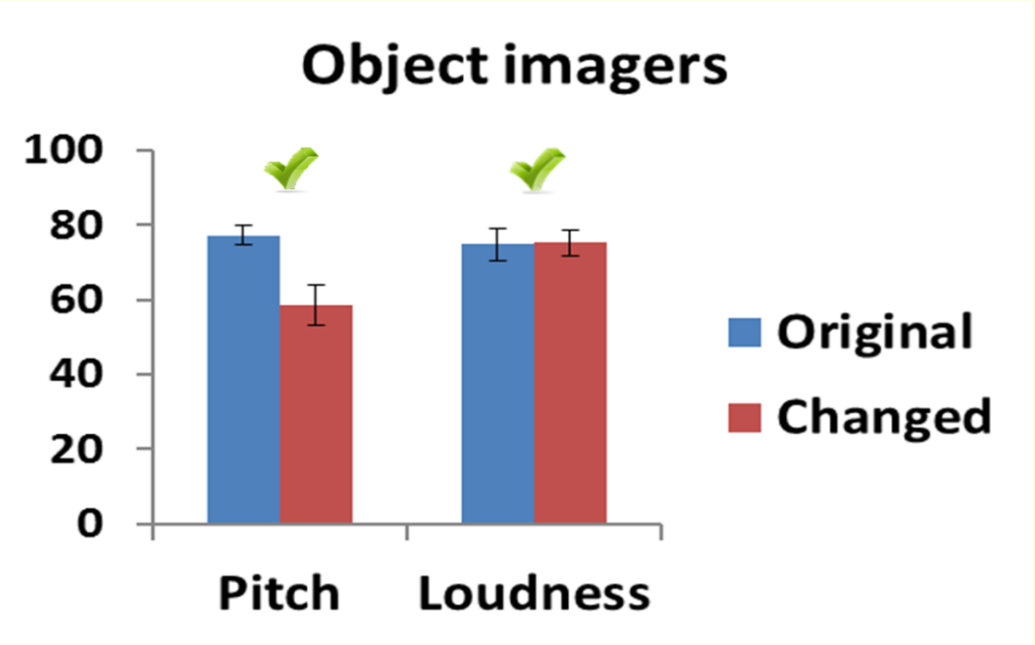
Melody 1 Loudness pattern 2

Melody 2 Loudness pattern 1

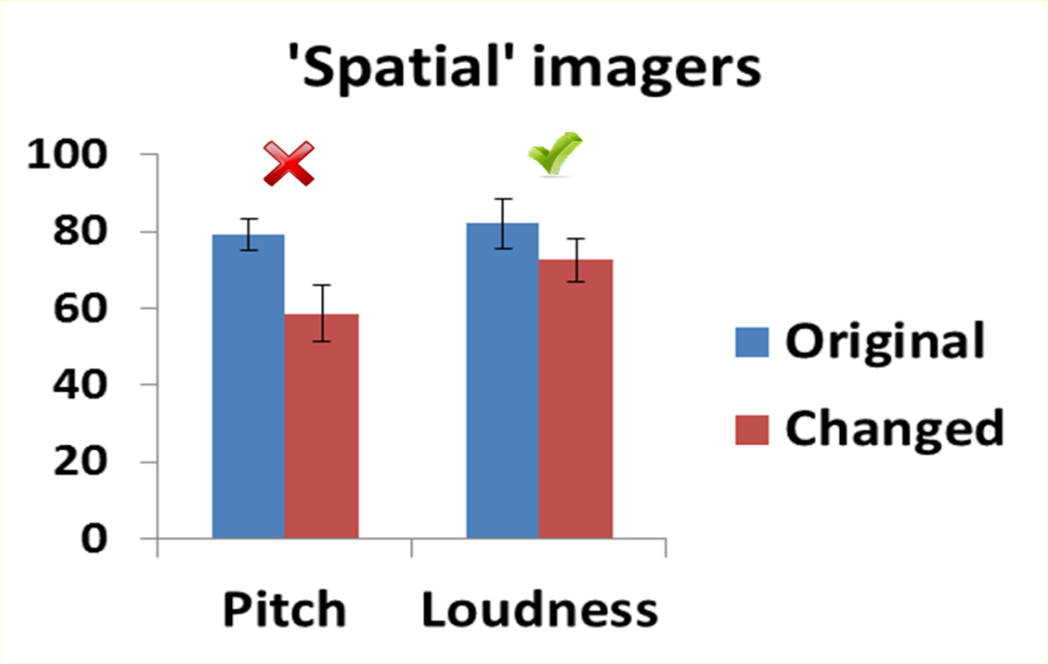
AUDITORY REPRESENTATIONS

Structural task: Identify melody, disregarding loudness pattern

Surface task: Identify loudness pattern, disregarding melody



Object imagers could discriminate loudness across pitch changes but not vice versa; consistent with the integration of structural and surface properties in object imagery.



Spatial imagers could not discriminate loudness across pitch changes but nor could they discriminate pitch across loudness changes – this is only partially consistent with the abstraction of structural properties in spatial imagery.

Duration 1 Loudness pattern 1

Duration 2 Loudness pattern 2

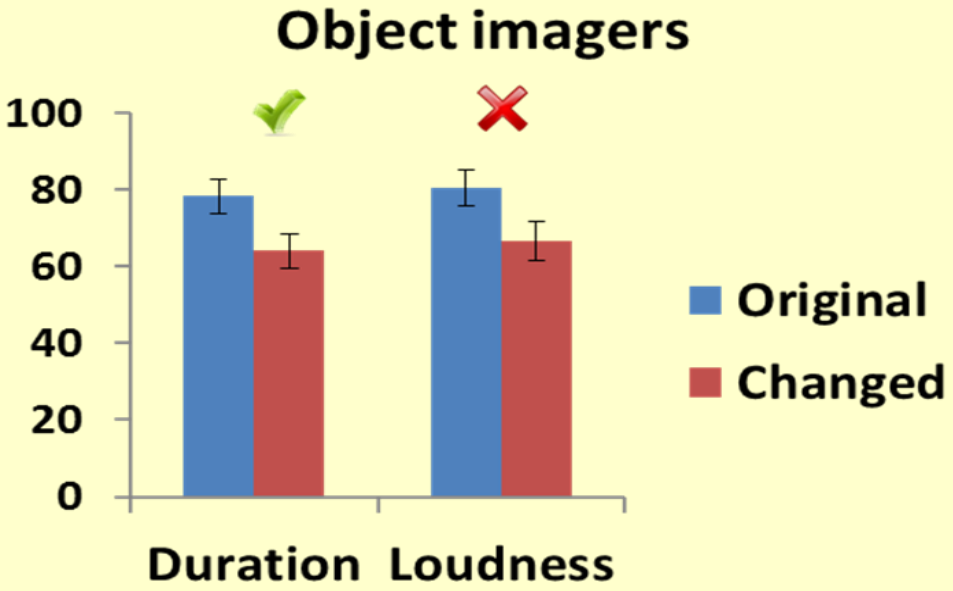
Duration 1 Loudness pattern 2

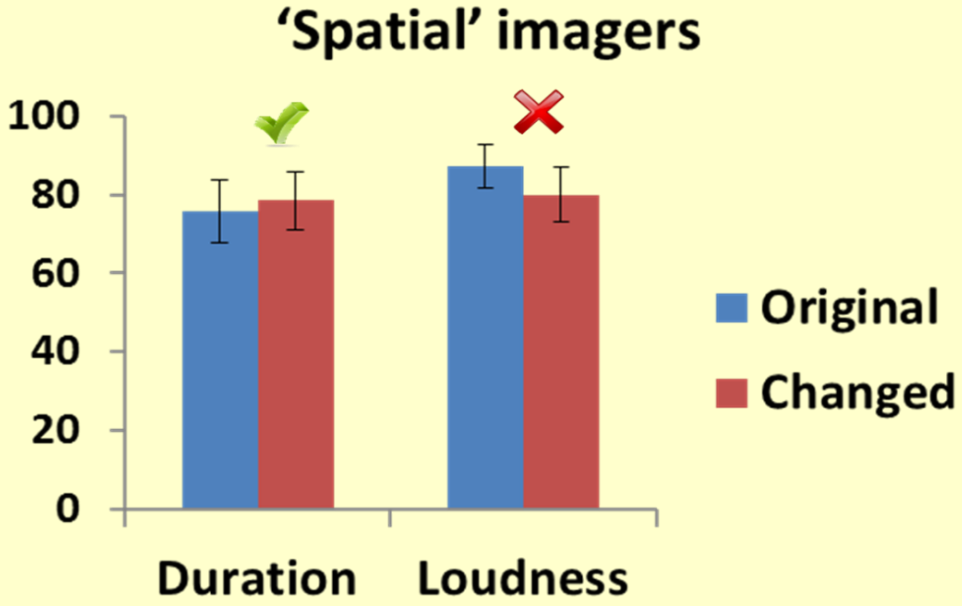
Duration 2 Loudness pattern 1

AUDITORY REPRESENTATIONS

Structural task: Identify duration, disregarding loudness pattern

Surface task: Identify loudness pattern, disregarding duration





Object imagers could not discriminate duration across changes in loudness but they also could not discriminate loudness across changes in duration.

Spatial imagers could discriminate duration across changes in loudness but they could also discriminate loudness across a change in duration (but note trend in predicted direction with small sample).

Lacey, Feng, Caesar, Landis, Bhushan, John & Sathian, IMRF 2014

Sensory substitution approaches would benefit from taking advantage of individual cognitive styles in terms of preference for schematic, structural object representations (akin to spatial imagery) vs. holistic object representations that integrate surface features (akin to object imagery).