Visuospatial contextual processing: Illusions, hidden figures and autistic traits

Elizabeth Walter

Dassonville Lab

I. Visuospatial contextual processing

-real world phenomena

-laboratory tasks

II. Contextual processing ability as cognitive style

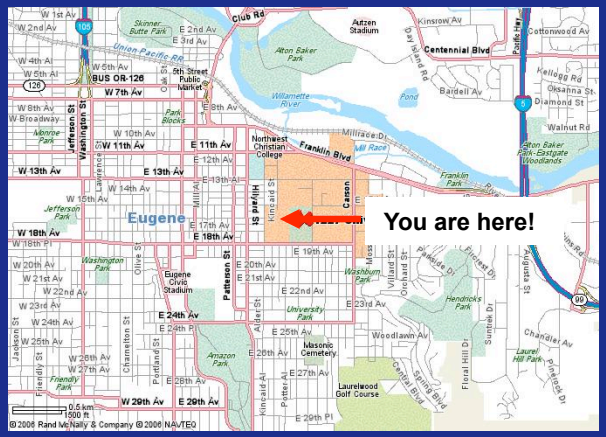
III. Contextual processing ability is correlated with autistic traits

IV. Neural underpinnings of visuospatial contextual processing

-Roelofs fMRI study

-Hidden Figures fMRI study

V. What does it all mean?



Contextual Cues in the Real World

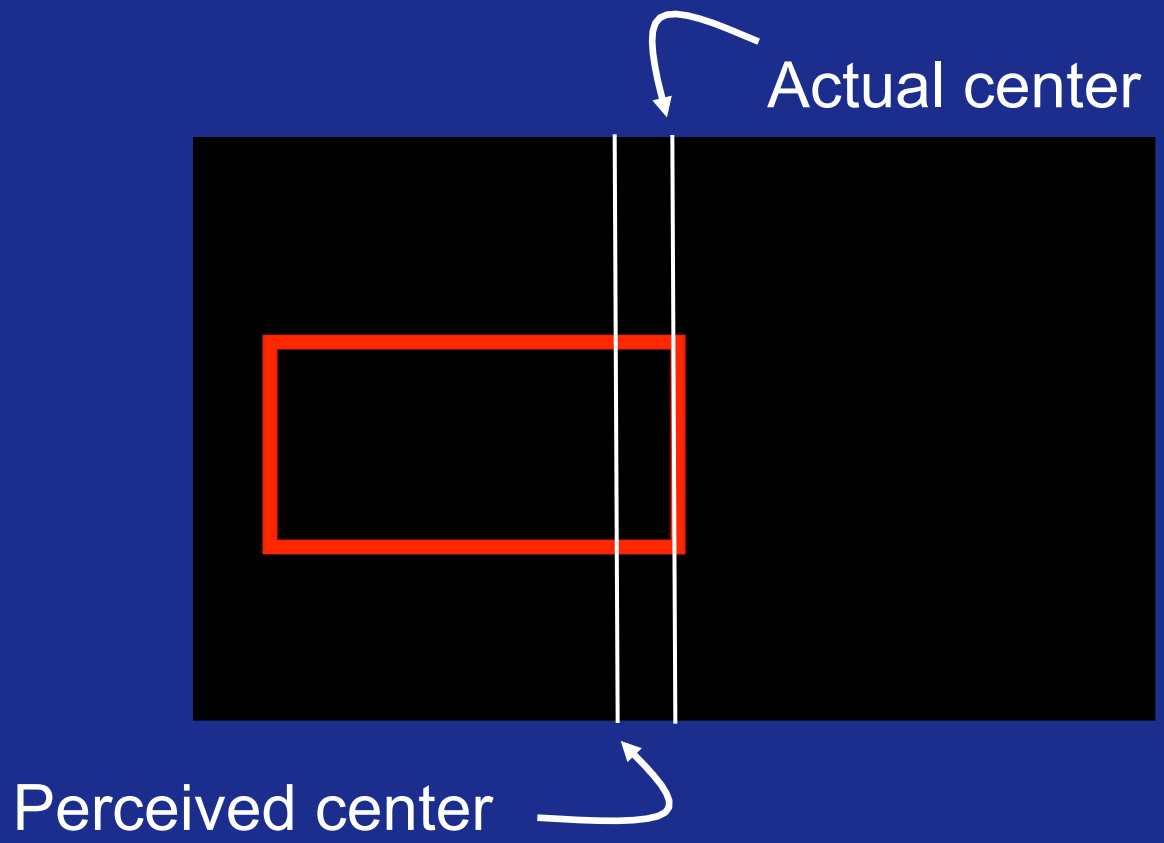
Relative size gives cues as to actual size (and identity)

Misperceptions of size occasionally arise in the real world…


Oregon Vortex
http://oregonvortex.com

The Roelofs Effect (Roelofs, 1935)

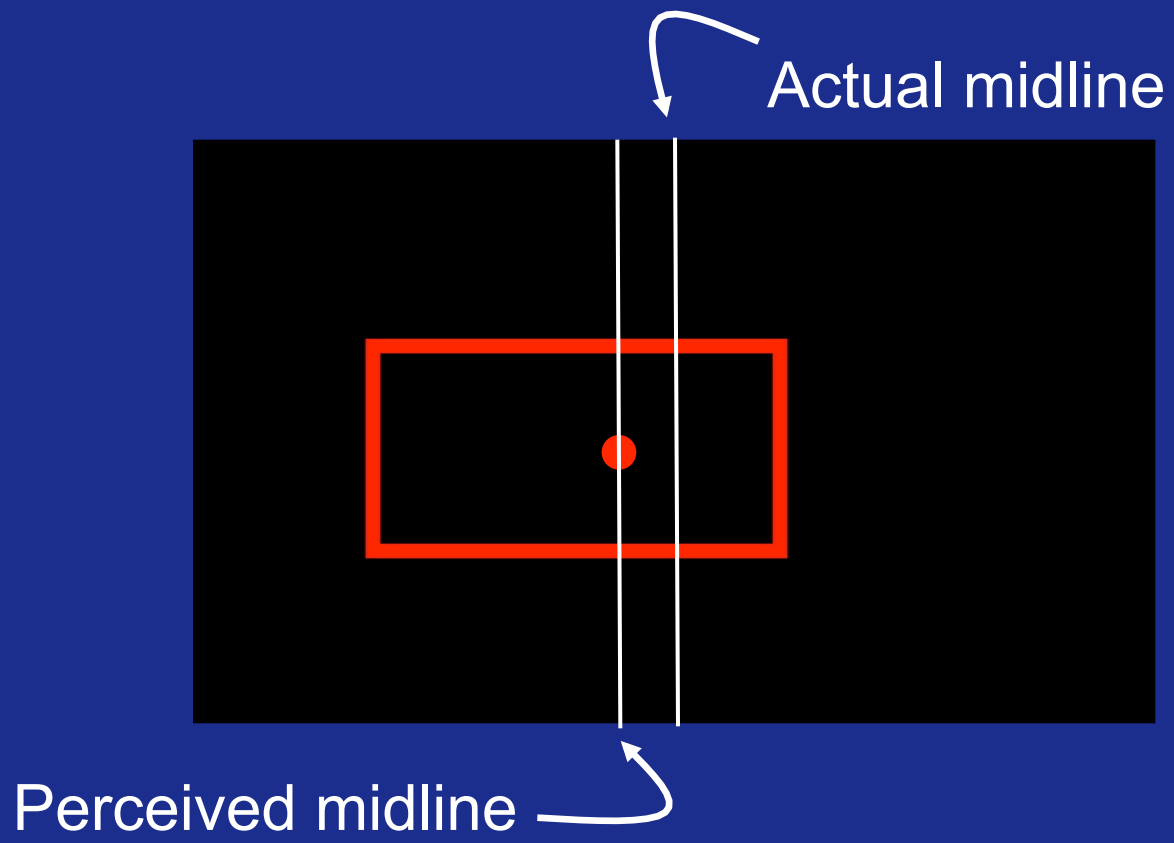
Tendency to misperceive position of the edge of a large target presented in unstructured field.



Rectangle edge perceived as right of center, though it is actually presented at midline.

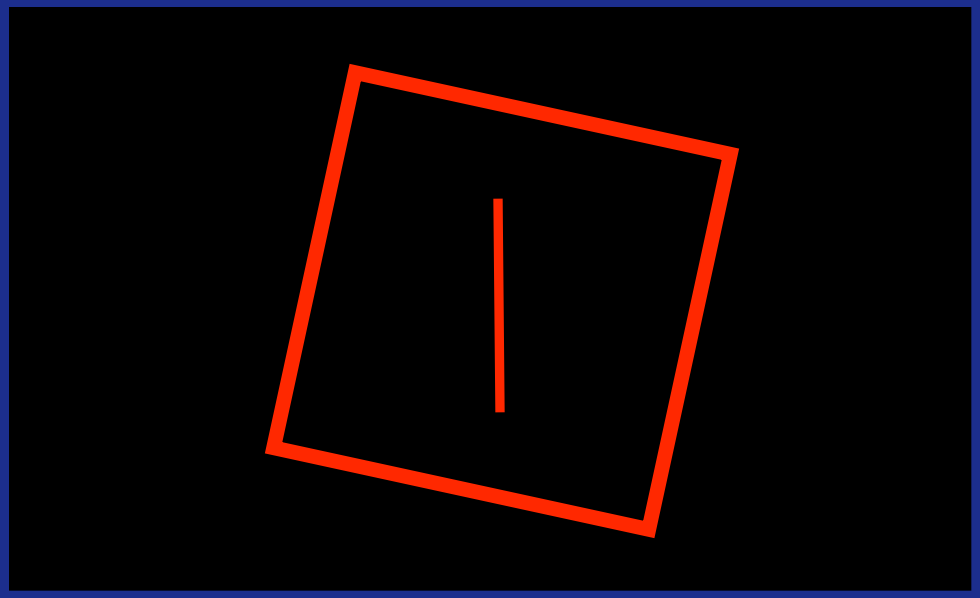
Roelofs Illusion (Dassonville Lab version)

Indicate position of midline in presence of offset frame



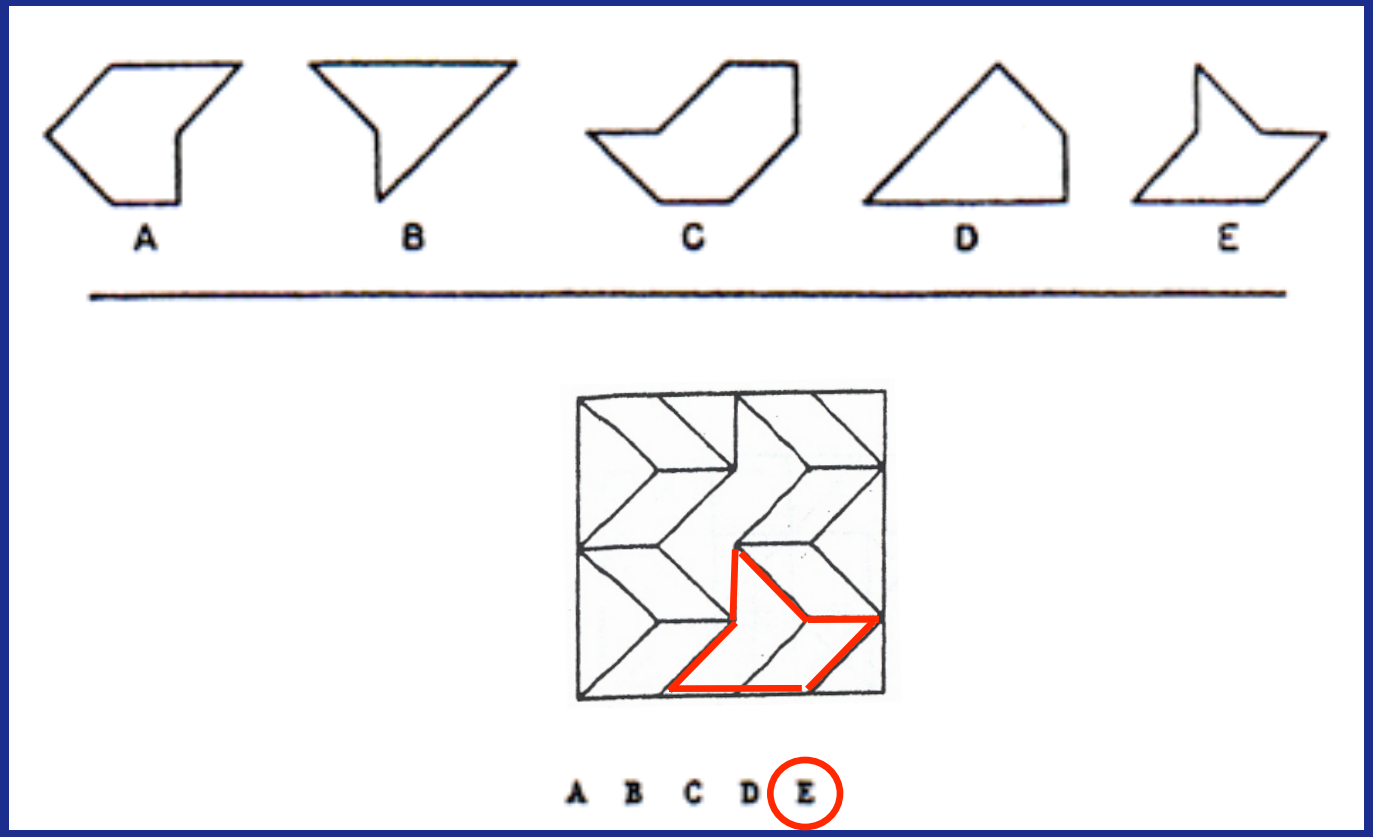
Rod-in-Frame Illusion (Witkin and Asch, 1948)

Rotate line until it is vertically oriented.



Hidden Figures Task (Ekstrom et al., 1976)
(aka: Embedded Figures Task, Witkin et al, 1954)

Decide which of five figures is embedded in the shape below. Only **one** is hidden; same orientation; same size.



Individual differences

Field dependence/independence (FDI; Witkin and Asch, 1948)

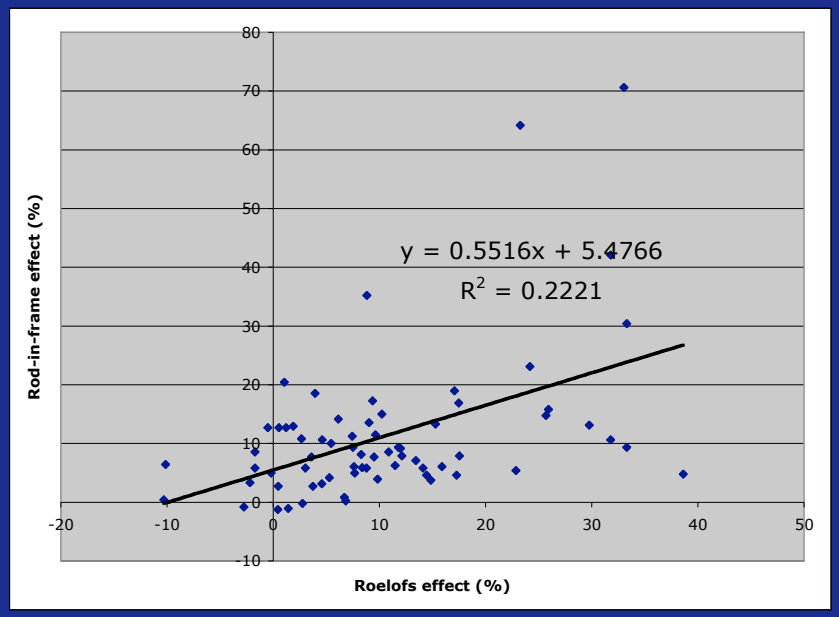
-field *dependent* individuals are strongly affected by context
-more affected by tilted frame in rod-in-frame
-worse at Hidden Figures Task

-field *independent* are not affected by context
-not affected by tilted frame in rod-in-frame
-better at Hidden Figures Task

FDI later extended to account for differences in social and educational realms, though evidence more anecdotal.

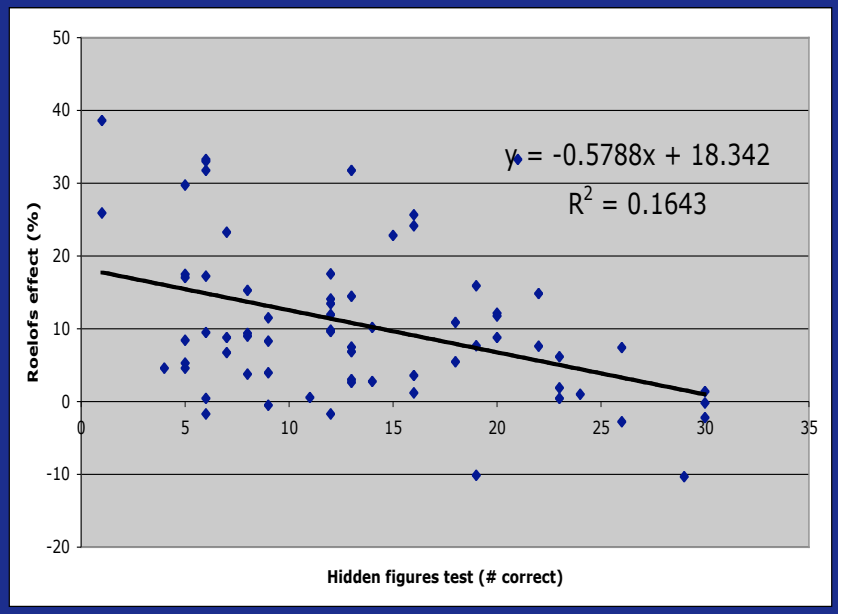
FDI extended to Roelofs effect (Dassonville Lab, unpublished data)

Rod-in-Frame



Roelofs

Roelofs



Hidden Figures

-Roelofs, Rod and Frame, and Hidden Figures Task are all correlated in general population

Clinical population

Evidence starting to suggest that different visual contextual processing may play role in autism spectrum disorders (ASD)

Autism Spectrum Disorders

Leo Kanner and Hans Asperger each described a group of children with three main deficits:

- -Social relationships
  - e.g. imitation; joint attention; face perception
- -Language
  - e.g. echolalia; pronoun reversal; concrete
- -Restricted and repetitive interests
  - e.g. ritualistic behaviors; motor repetition; need for sameness

‘Weak Central Coherence’ Hypothesis

Frith (1989) and Happé (1999)

-Core deficit of autism results from failure to process items in context:

-implications for basic perceptual processing, and problems with language and social interactions

-*explains improved performance* on HFT

-also predicts less susceptibility to visual illusions.

-Happé (1996) originally finds this

-Ropar + Mitchell (2001, 2004) find NO difference

Similar to “field independent” individuals described by FDI

…but maybe they are trying to account for too much with one dimension?

Baron-Cohen's 2-dimension account of autism:

Two traits that vary continuously in the general population:

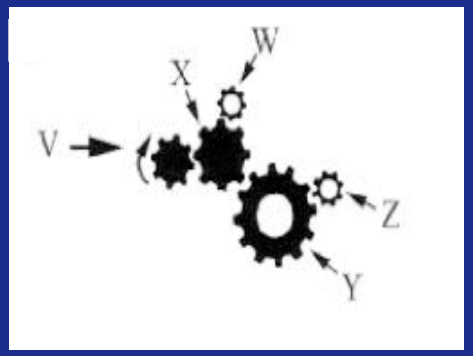
Systemizing: ability to (and predilection towards) understanding how mechanical (or other) systems work

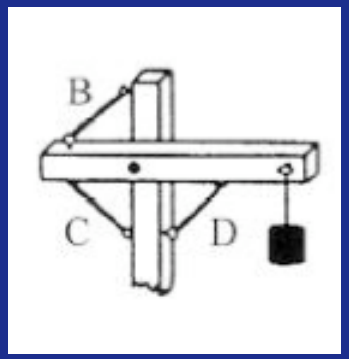
Empathizing: ability to understand emotions of others; act appropriately in social situations

Systemizing Ability

-Systemizing Quotient (SQ)

"Intuitive Physics"





Empathizing Ability

-Empathy Quotient (EQ)

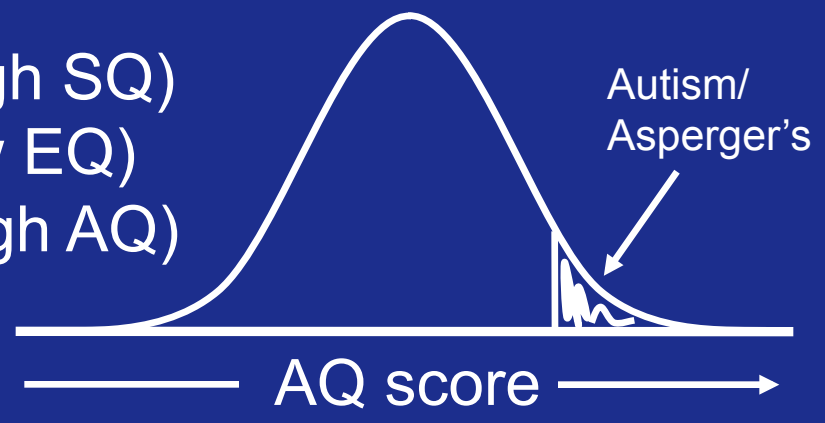
"Reading the Mind in the Eyes"

Autism is characterized by:

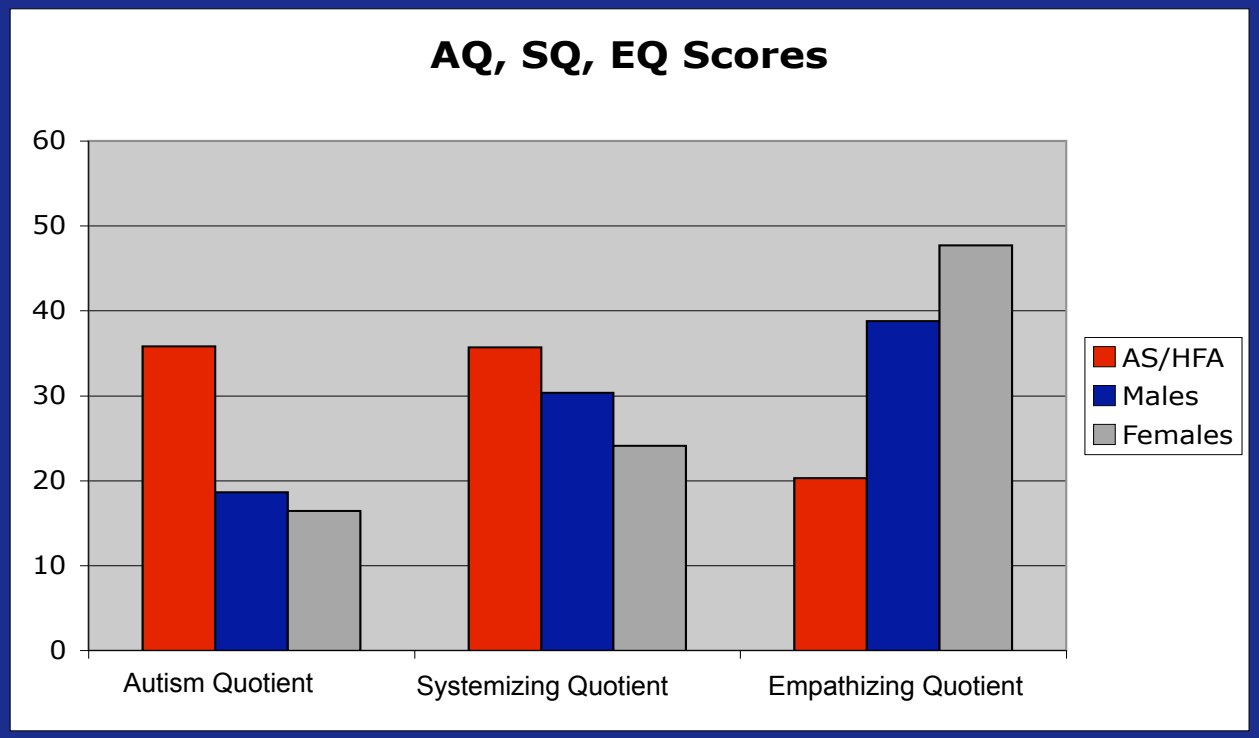
-high systemizing ability (high SQ)

-low empathizing ability (low EQ)

-high score on Autism Quotient (high AQ)



"Typical" Sample
(Baron-Cohen et al, 2003)



So far, we know …

-Typically-developing participants…

-show correlation between Roelofs and Rod-in-frame, and negative correlation between these illusions and HFT

-Participants with autism…

-do better on the HFT than general population
-may or may not be as susceptible to visual illusions
-but never tested on rod-in-frame and Roelofs

Visuospatial processing and autistic traits

Does performance on visuospatial contextual processing tasks

e.g. Rod-in-Frame, Roelofs, Hidden Figures Task (HFT), intuitive physics (IP)

…correlate with cognitive traits associated with autism?

e.g. tendency to systemize (SQ), tendency to empathize (EQ), position on spectrum of 'autistic traits' (AQ)

Factor analysis:

-technique used to discover simple patterns in pattern of relationships between many measured variables.

-discovers whether observed variables can be explained in terms of smaller number of underlying (latent) variables called **factors**

-i.e. take correlation matrix and look for patterns!

Factor Analysis (n = 301; 177 female)

	Component		
	"FDI"	"Speed of Processing"	
Hidden Figures	**-0.353**	**0.629**	
Intuitive Physics	**-0.638**	0.277	
Digit-Symbol Coding	0.158	**0.814**	
Rod-in-Frame	**0.684**	-0.076	
Roelofs	**0.690**	0.160	
			Total Variance:
Variance Explained:	30.0%	23.3%	53.3%

Two components: "Field Dependence/Independence"

-HFT, Intuitive Physics, rod-in-frame, Roelofs

"Speed of Processing"

-Digit-symbol coding, HFT (also timed task)

Correlations between autistic traits (AQ, EQ, SQ) and two factors

	"FDI" Factor	"Speed" Factor
E Q	0.042	0.029
S Q	-0.278**	0.092
A Q	-0.02	0.091
Social Skill	-0.034	0.099
Attention Switchin g	0.015	0.016
Attention to Detail	-0.048	0.108
Commununicatio n	-0.011	0.059
Imaginatio n	0.023	-0.016

* indicates $p < 0.05$; **indicates $p < 0.001$

Interim Conclusions…

"Field dependence" construct extended to other tasks

-performance in Roelofs and rod-in-frame negatively correlated with performance on Intuitive Physics and HFT

Systemizing correlated with "FDI" factor

-suggests that the visuospatial aspect of FDI is very similar to notion of systemizing

Autism quotient (AQ) ***not*** correlated with "FDI" factor

-suggests that individuals with autism show differences in visuospatial processing specifically because of generally elevated <u>systemizing</u> ability

-suggests that it may be more useful to look for cognitive correlates of autistic <u>traits</u>, rather than studying individuals with autism as indivisible group

Neural correlates of autism

Behavioral differences seen in individuals with autism suggest possible brain differences in many regions.

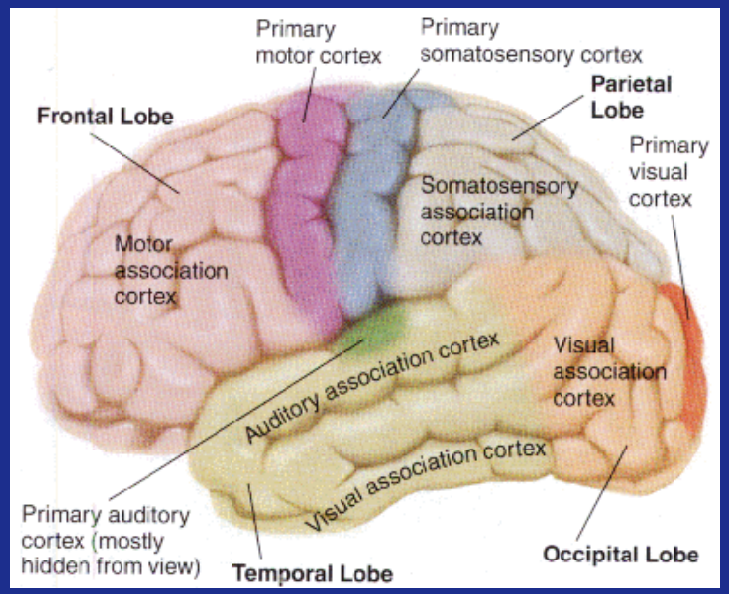
e.g. face processing regions, emotional processing (limbic), early sensory cortices, language regions…

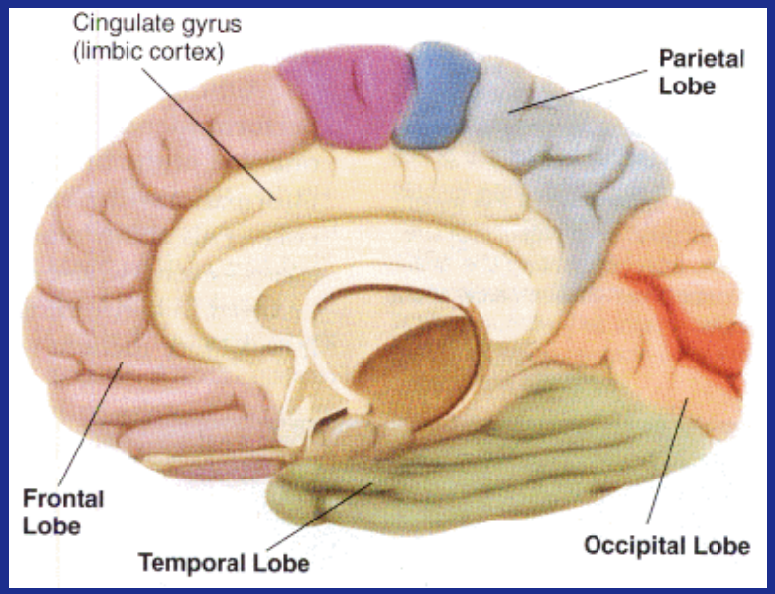
Neural correlates of visuospatial contextual processing ability have not yet been described

-though previous studies suggest ASD show differences in parietal + temporal activation during HFT (e.g. Ring et al, 1999)

Neural correlates of visuospatial contextual processing

Much of the brain is involved in visual processing



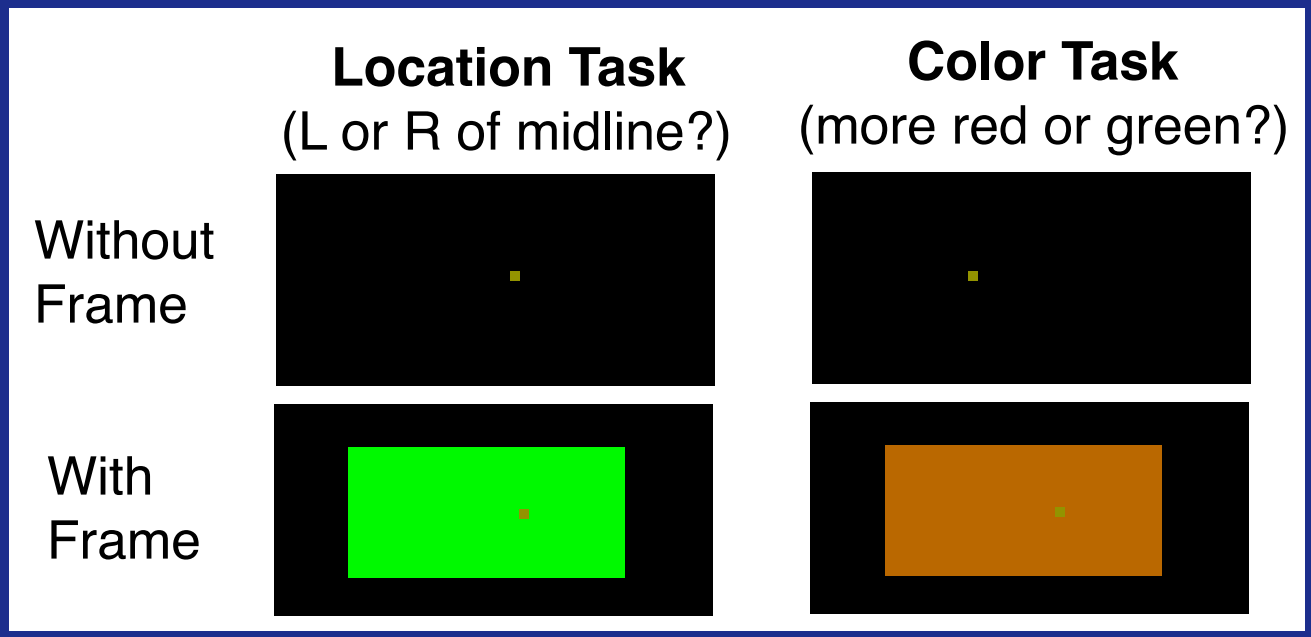


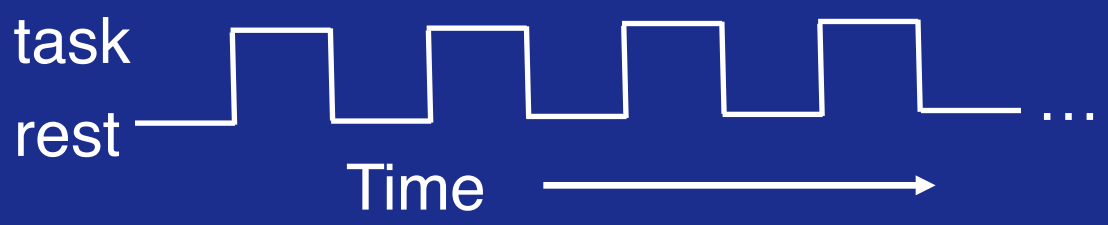
Which portions are important for processing *visuospatial contextual information*?

Participants performed version of the Roelofs task and Hidden Figures Task while in the MR scanner.

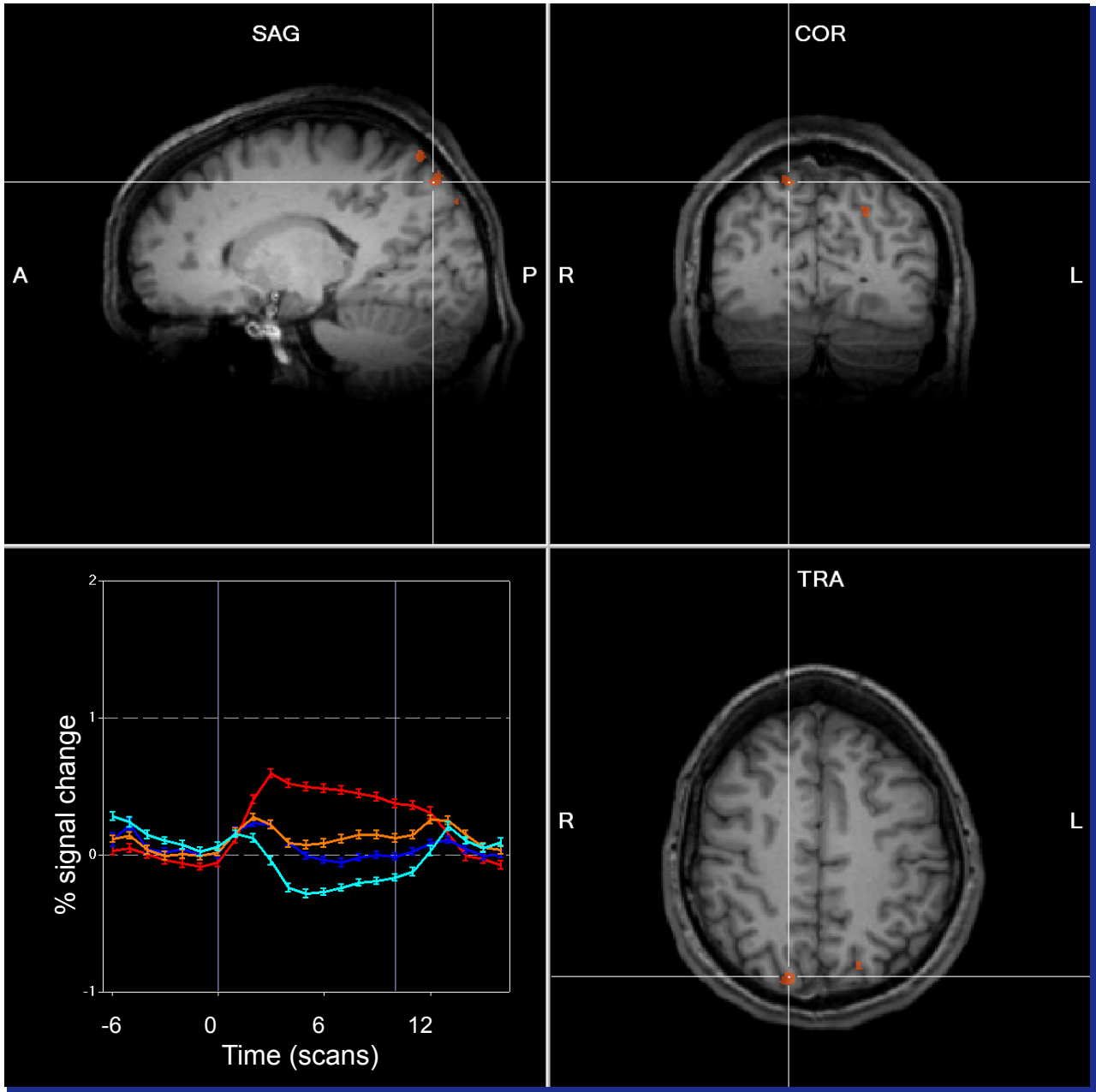
Roelofs fMRI Study

Block design; four block types; random-effects model (n=16)





Roelofs activations = "Location w/Frame" -
["Location w/o Frame" + Color w/Frame"]



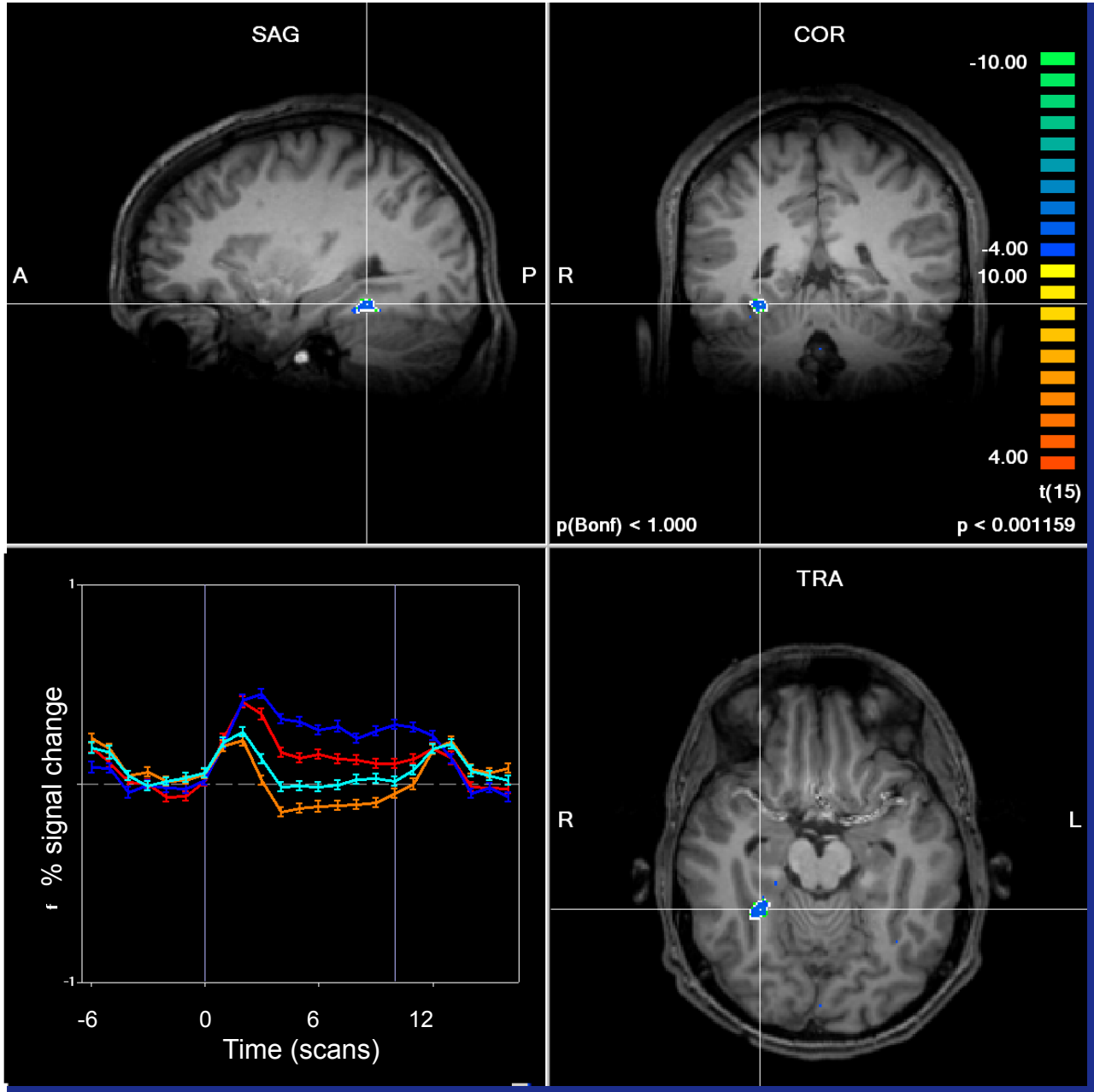
Roelofs activations

- Location w/Frame
- Location w/o Frame
- Color w/Frame
- Color w/o Frame

"Roelofs area" (BA7/19)

Specifically active for location judgment *in presence of context*

Talairach coordinates: 15, -74, 43



Color contrast activations

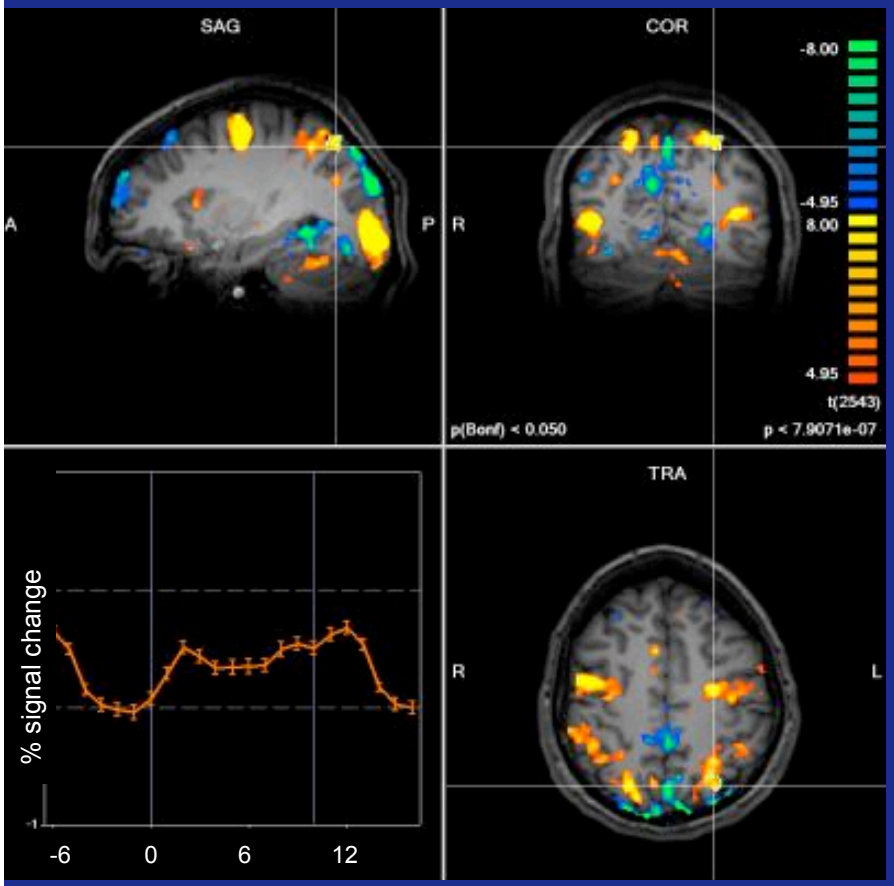
- Location w/Frame
- Location w/o Frame
- Color w/Frame
- Color w/o Frame

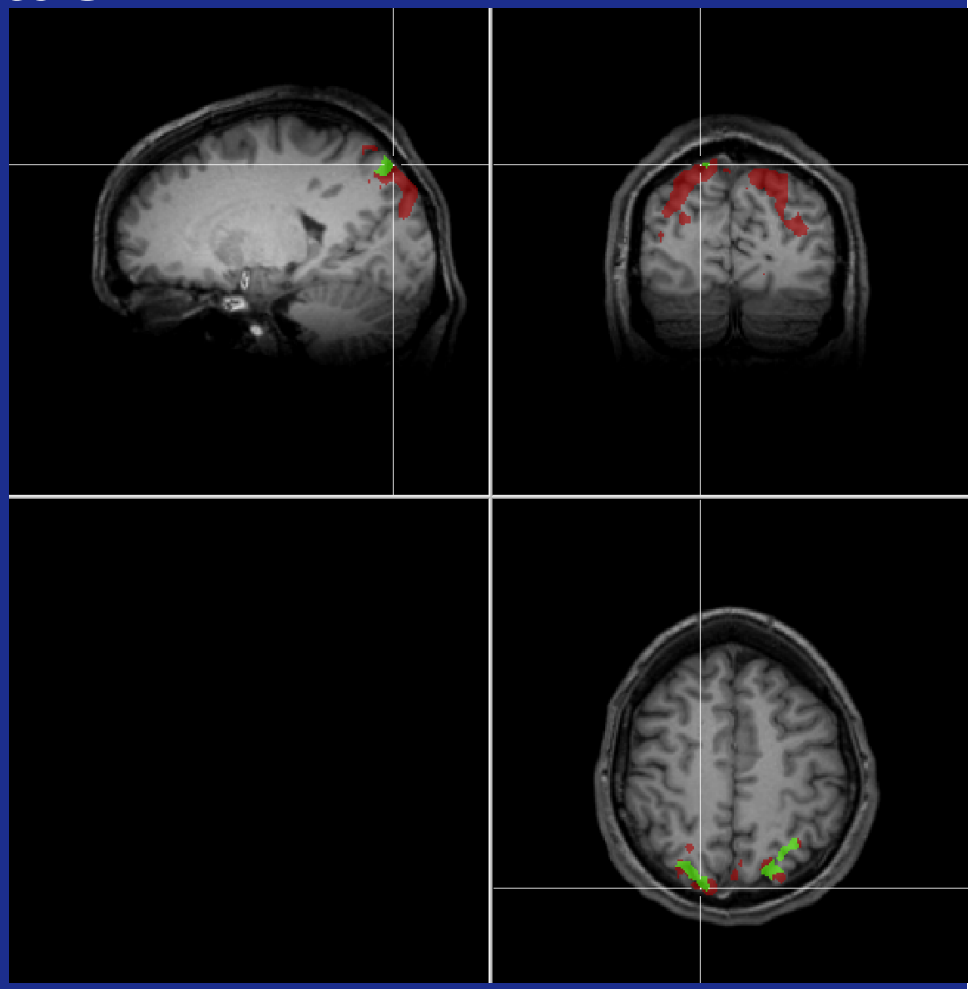
Ventral activations along fusiform gyrus (FFG)

Talairach coordinates: 28, -43, -14

Eye movements control task

Fixed effects model (n = 11)





Activations

Deactivations

Roelofs (fixed FX)

EyeMvmt + Roelofs overlap

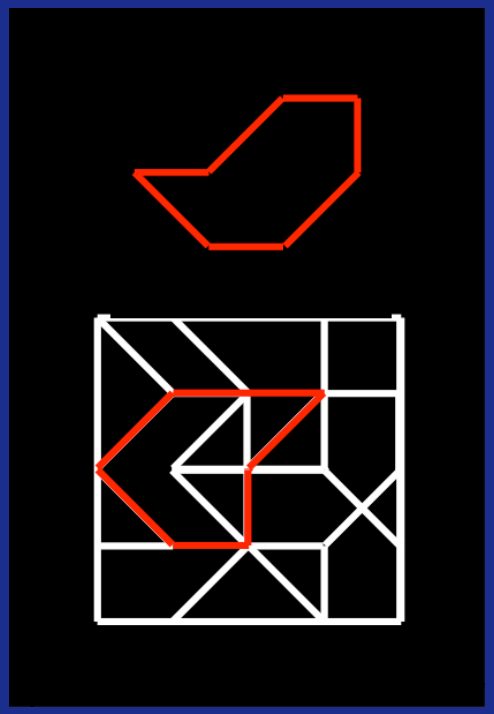
Talairach coordinates: -27, -60, 44

Talairach coordinates: 18, -77, 46

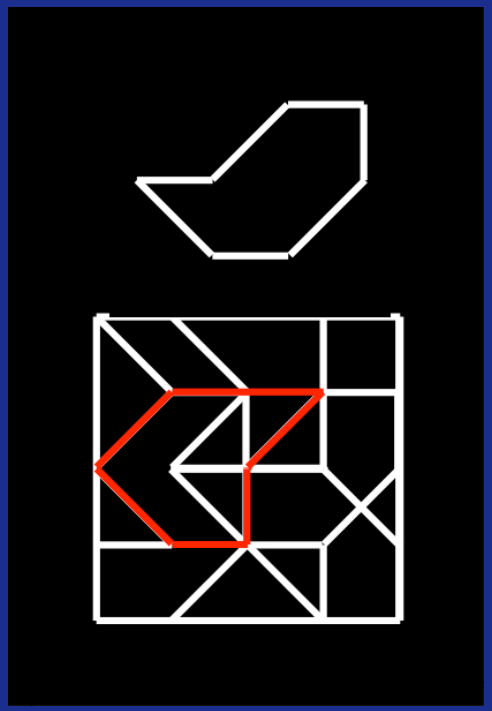
Hidden Figures fMRI Study

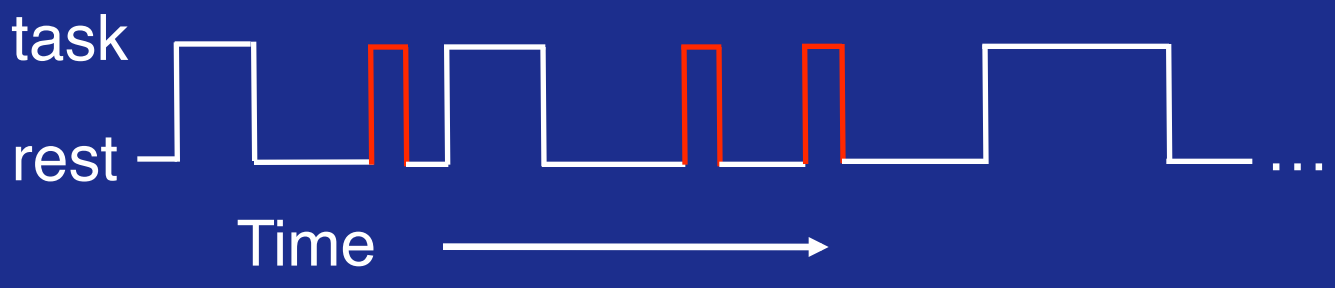
Event-related; two event types; fixed-effects model (n=12)

Popout Task

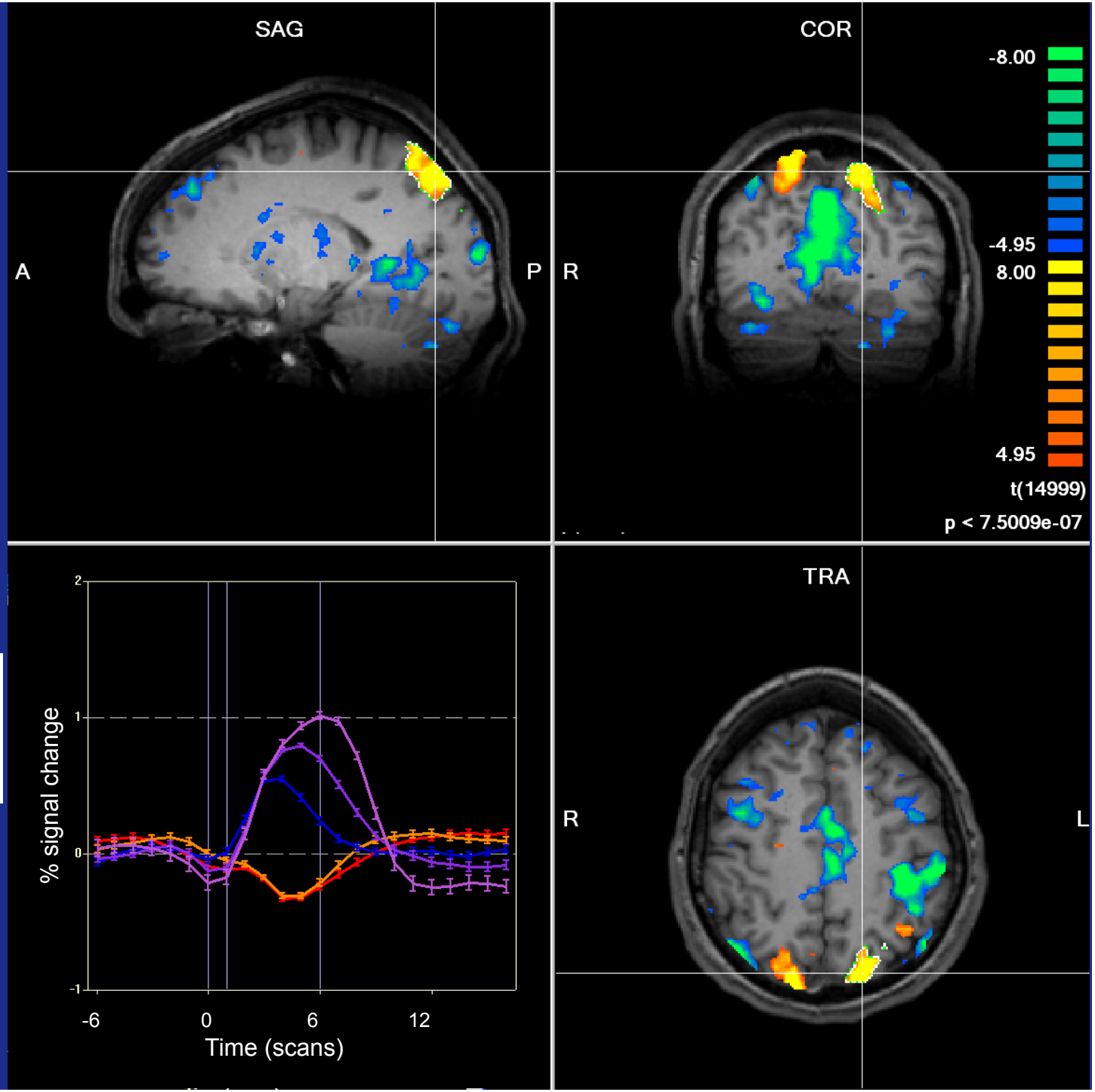


Hidden Figures Task





Search vs. Popout

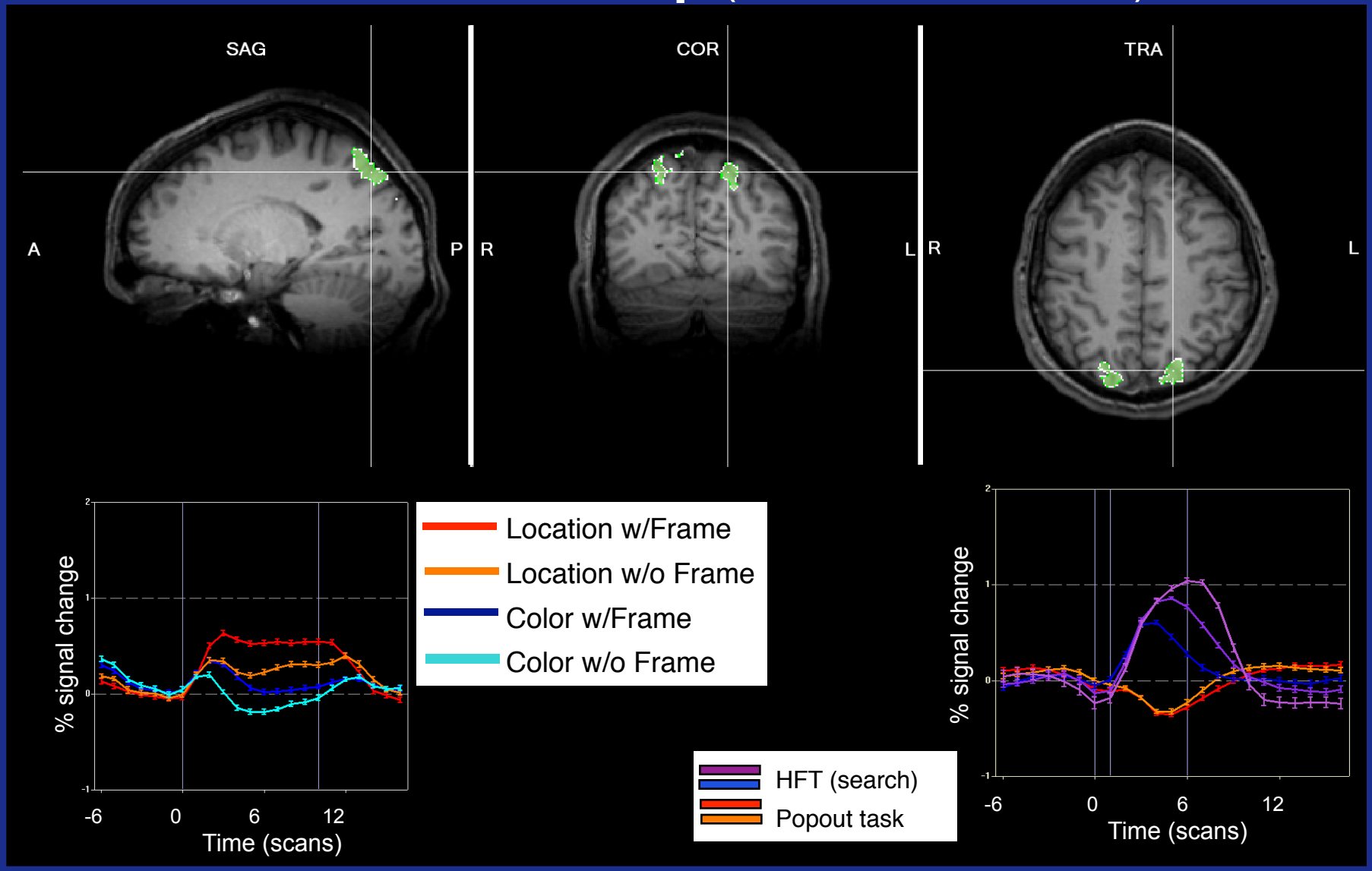


HFT (search)

Popout task

(Talairach coordinates: -27, -60, 44)

Roelofs and HFT overlap (fixed effects; n=10)



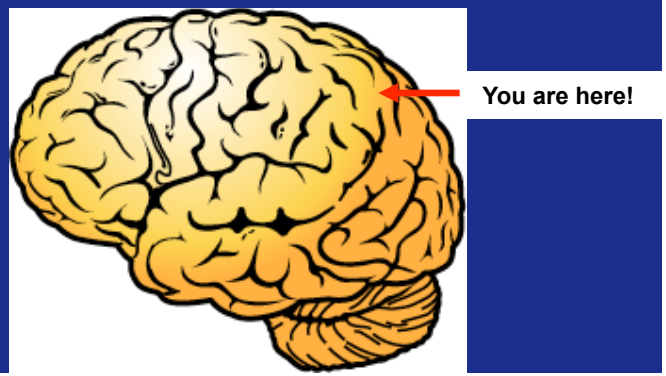
Talairach coordinates: -17, -71, 43

Conclusions

Posterior parietal cortex area (BA 7/19) responsible for visuospatial contextual processing:

- -active during Roelofs task (Location judgment w/frame)
  - -but not during Color judgment with same stimulus
- -active during Hidden Figures search
  - -but not during Popout task
- -not active during Eye Movement control task

Indicates potential site of interest for future investigations regarding neural underpinnings of autism spectrum disorders



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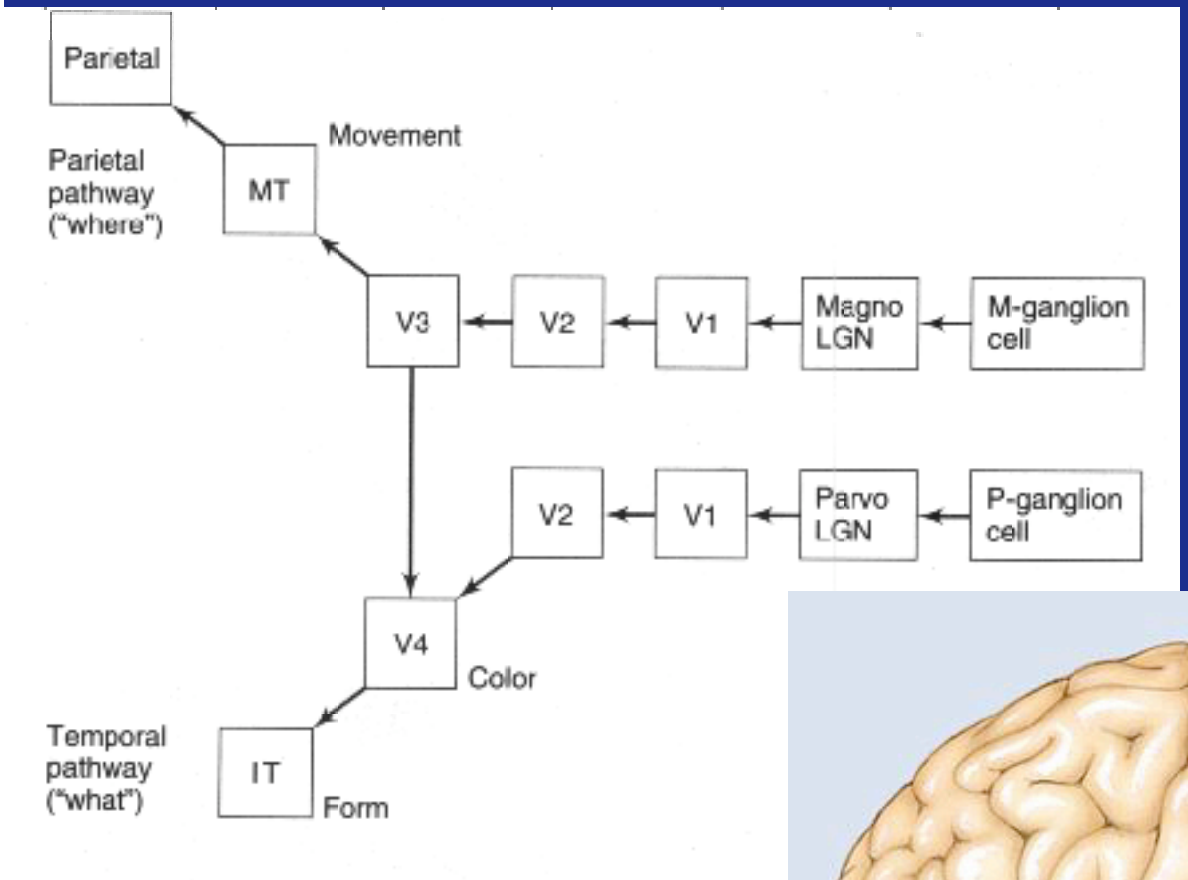
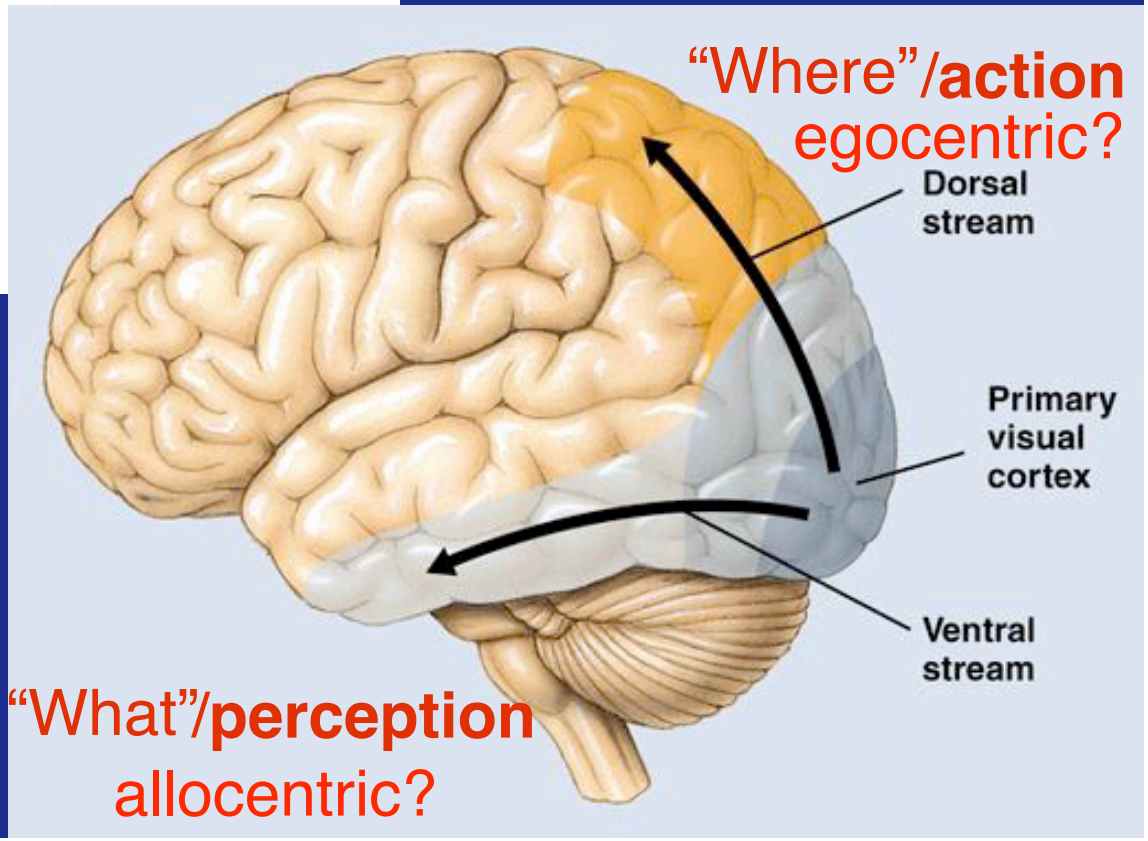
Visual Processing Streams





Goodale/Milner (1995):
Object & spatial information being processed by both streams, but for **different purposes**.

Dorsal = for action control
Ventral = for object perception

Perception in comics