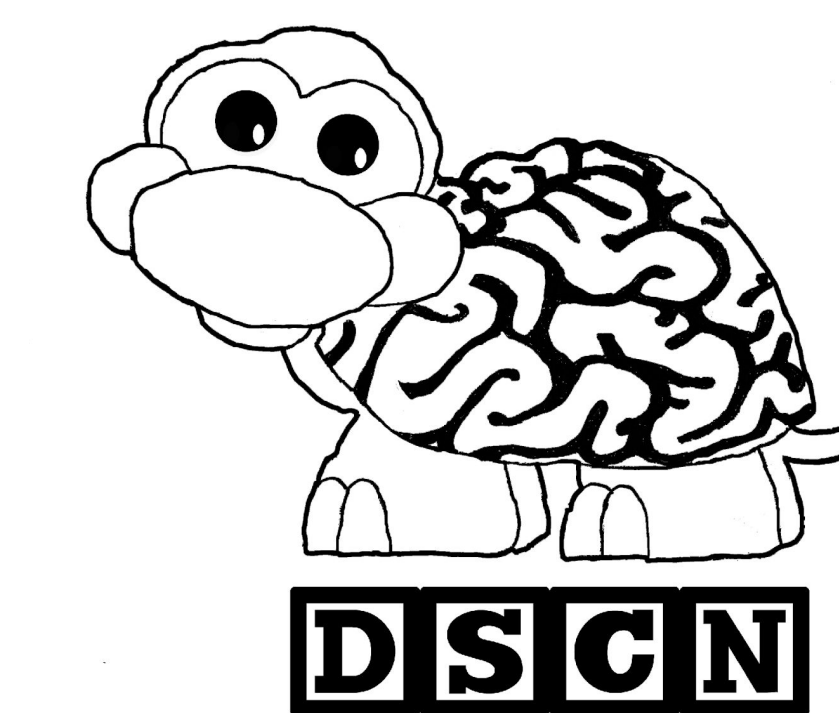




fMRI Meta-Analysis of Social Interaction via Joint Attention Paradigms

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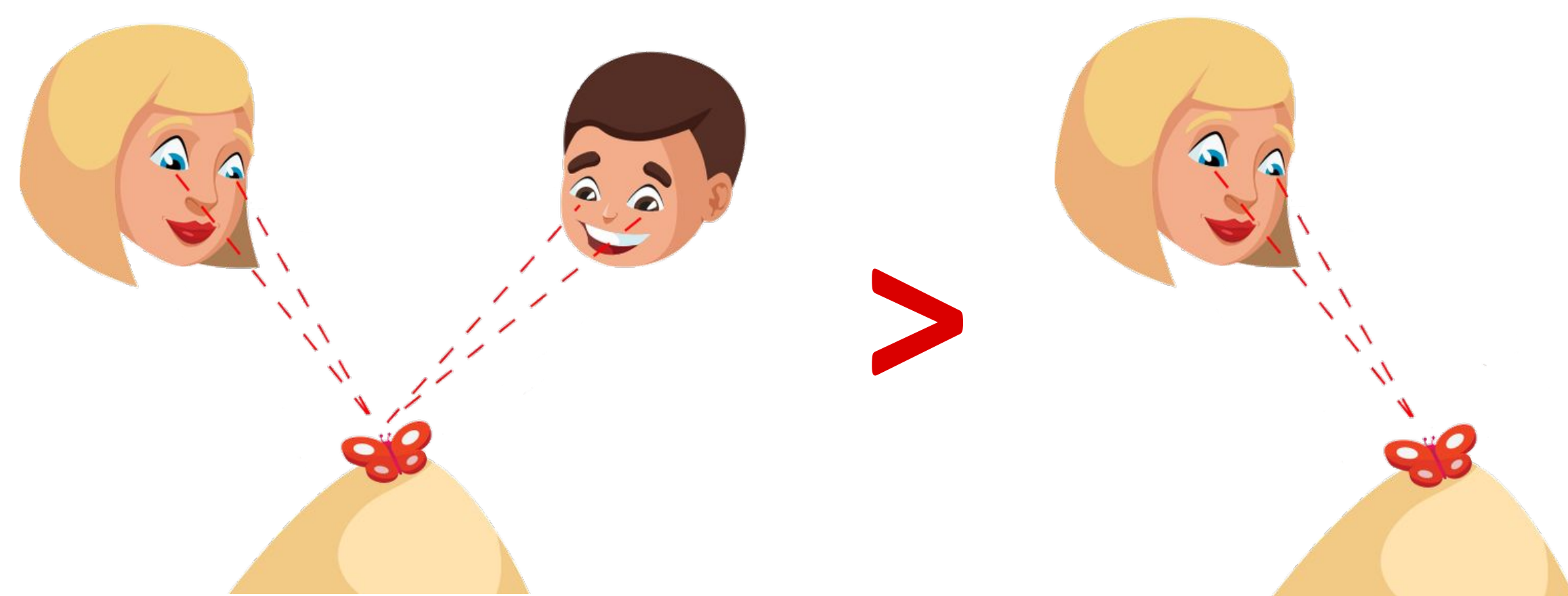


Introduction

Joint Attention (JA) is the sharing of attention on a common object or event by two or more people.

- JA is an important precursor to the development of social cognitive skills needed for more sophisticated forms of social interaction^{1,2}.
- The brain regions involved in JA during social interactive contexts are not well known because original studies of JA used tasks that are not interactive, such as engaging with the eye-gaze of a static image outside of a social interactive context.
- Recent studies have used fMRI to understand the different brain regions associated with JA in interactive contexts, but there are inconsistent findings across studies.

Therefore, this study uses meta-analytic methods to aggregate findings across JA studies using social interactive approaches to identify brain regions that are commonly activated.



Joint Attention: Two (or more) people sharing attention on an object

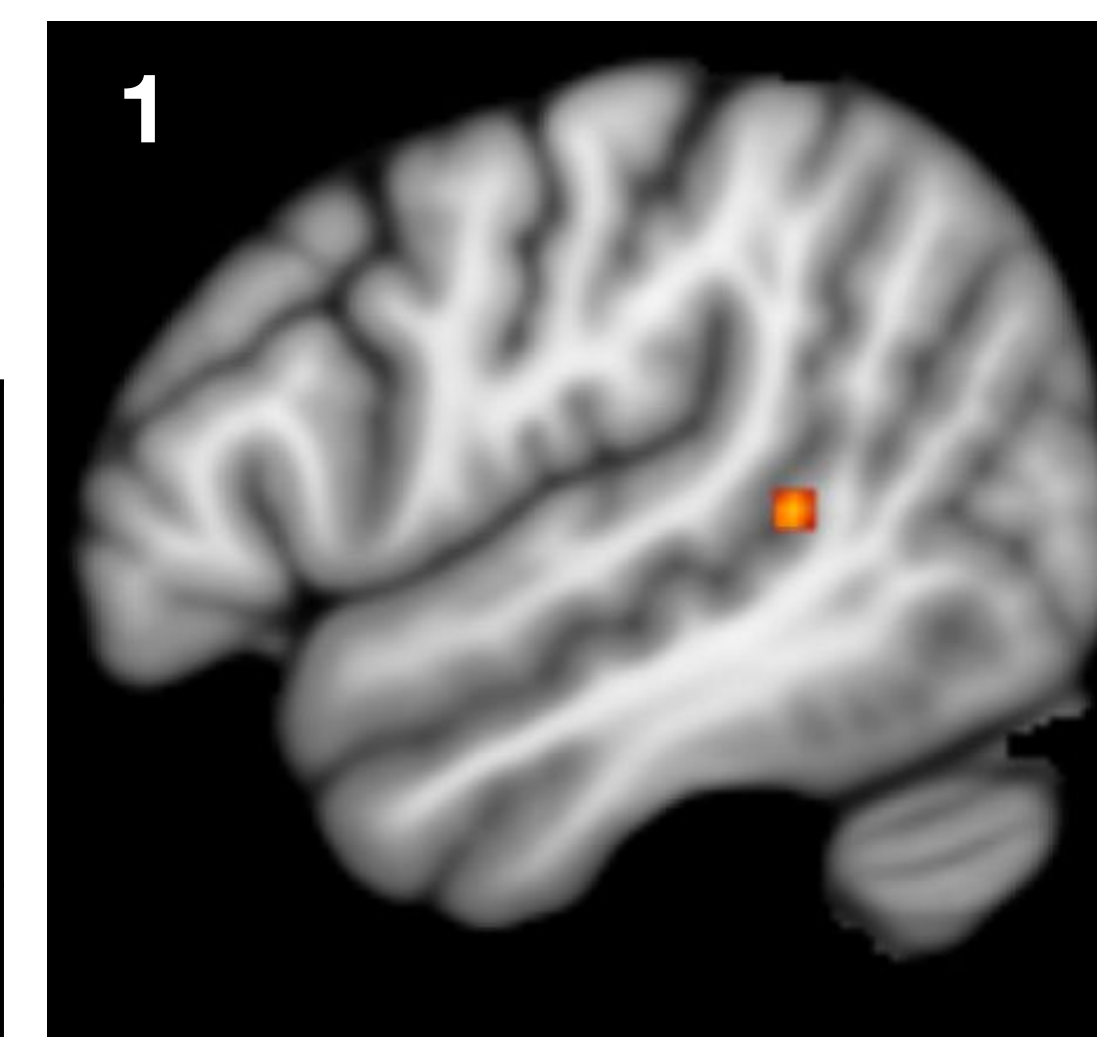
Solo Attention (SA): One person focusing attention on an object

Results

Brain Regions Showing Activation

Cluster	p-Value	ALE Values	Coordinates (x,y,z)	Hemi-sphere	Brain Region
1	1.38E-06	0.0201	(50, -40, 6)	Right	pSTS
2	4.02E-06	0.0191	(-40, -64, 52)	Left	IPL
3	1.20E-05	0.0176	(6, 14, 38)	Right	MCC
4	9.43E-06	0.0179	(-6, -2, 34)	Left	MCC
5	3.16E-06	0.0194	(4, 38, 12)	Right	dACC
6	1.60E-05	0.0172	(2, -50, 28)	Left	PCC

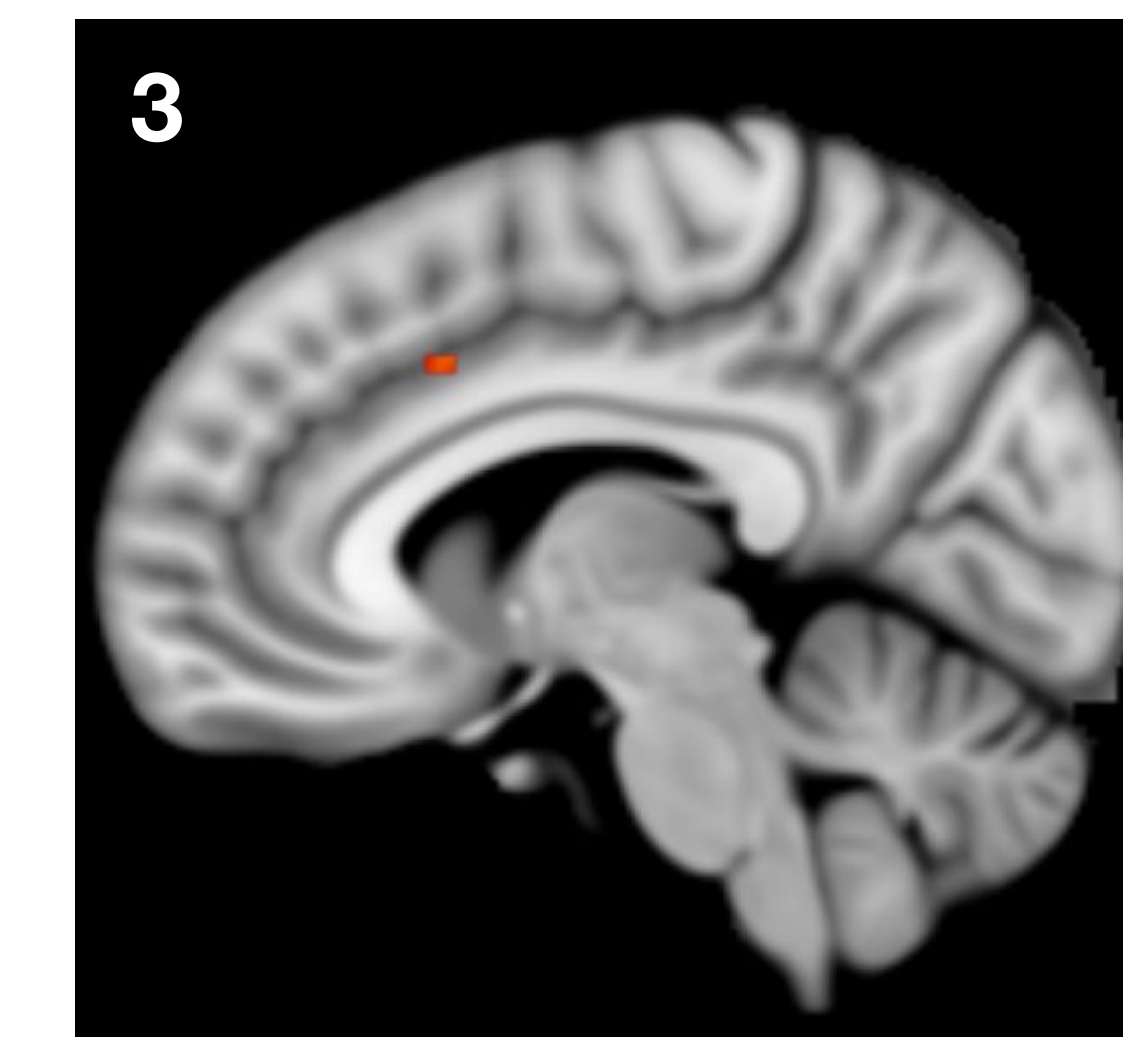
Exploration of Joint Attention vs. Solo Attention through a meta-analysis demonstrates a convergence of activations in the pSTS, IPL, MCC, PCC, and dACC regions of the brain across interactive Joint Attention studies.



Right Posterior Superior Temporal Sulcus (pSTS)



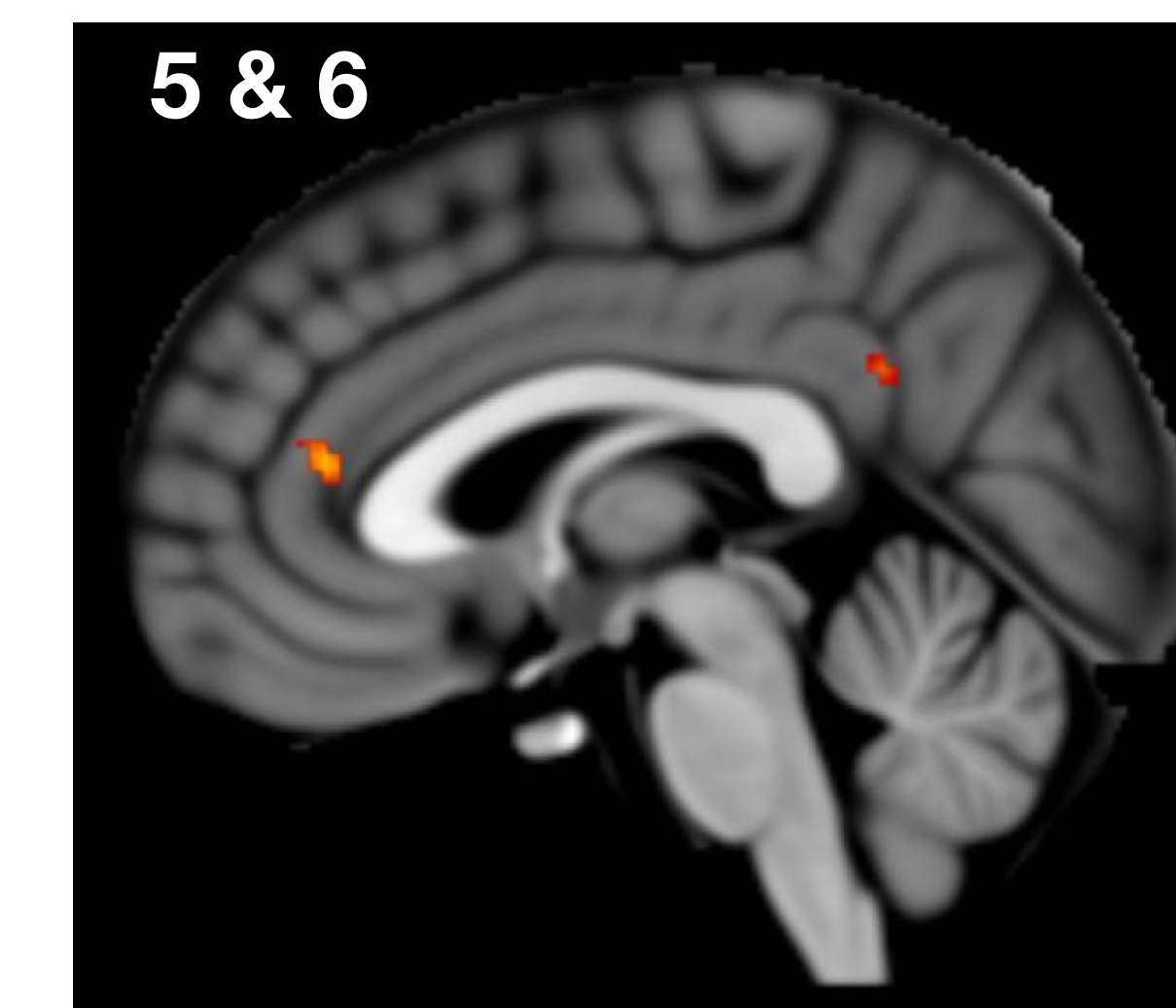
Left Inferior Parietal Lobe (IPL)



Midcingulate Cortex (MCC)



Midcingulate Cortex (MCC)



Dorsal Anterior Cingulate Cortex (dACC) & Posterior Cingulate Cortex (PCC)

Methods

- Completed a search for relevant fMRI papers using the key words: 'joint attention', 'shared attention', and/or 'gaze'.
- Studies with the following criteria were included:
 - The participant is socially engaged with a live human partner.
 - There is a reciprocal exchange between the participant and their interaction partner.
 - Participants share attention on the same object, video, or image.
- 14 studies with 352 participants and 314 activation foci matched our criteria and were entered into the meta-analysis.
- To obtain brain activation likelihood estimation (ALE) map:
 - Coordinates of relevant activations were retrieved from individual studies and compiled into a file.
 - Coordinate data were entered into GingerAle and the analysis was run using a voxel threshold value of $p < .0001$ and $k = 100$ (k is the minimum number of contiguous voxels below p -value threshold to eliminate chance activations).
 - Activation Likelihood Estimates (ALE) were generated to determine the probability of activation in each voxel of the brain during JA.
 - The results were viewed in the brain activation map using Mango.
- The brain map produced from the meta-analysis visualizes the significant convergences of brain activations reported across previous fMRI studies of JA.

Studies Used in Meta-Analysis

Author, Year	Contrasts Used
Caruana et al., 2015 ⁴	RJA* > Control RJA and IJA** > Control IJA
Cavallo et al., 2015 ⁵	Look, Look > Look, No Look; Look, Look > No Look, Look; Look, Look > Look Picture; Look, Look > Look Yourself
Dziura et al., 2021 ⁶	JA > SA
Koike et al., 2019 ⁷	JA condition > Control condition
Koike et al., 2019 ⁸	LIVE condition > REPLAY condition
Oberwelland et al., 2016 ⁹	JA > Control
Oberwelland et al., 2017 ¹⁰	JA > Control
Pfeiffer et al., 2014 ¹¹	JA > No JA
Redcay et al., 2010 ¹²	JA > SA and Live>Recorded
Redcay et al., 2012 ¹³	IJA > SA blocks, RJA > SA blocks, IJA > SA events, and RJA > SA Events
Redcay et al., 2013 ¹⁴	NT: RJA > SA and NT: IJA > SA
Saito et al., 2010 ¹⁵	Effect of eye cueing
Schilbach et al., 2010 ¹⁶	JA > No JA and Other > Self
Wagner et al., 2015 ¹⁷	Shared_Emotion > Unshared_Emotion

***Responding to Joint attention (RJA):** the ability to follow the gaze and gestures of others³.

****Initiating Joint Attention (IJA):** the ability to use gestures and eye contact to direct others' attention³.

Discussion

- Right pSTS and PCC are involved in visual processing of social stimuli¹⁸ and general social cognitive processes¹⁹.
- dACC and MCC are involved in executive functioning²⁰ and monitoring others decisions²¹.
- IPL is involved in spatial attention²².
- Overall activations indicate the use of social cognitive, executive functioning, and attentional systems in the brain during JA.
- Previous fMRI research on social interactions using a wide range of interactive paradigms have also found activations in the right pSTS and left IPL¹⁴.

Future Directions

- There are a limited number of studies exploring interactive JA, therefore continuing research in JA can help establish the strength of these results.
- Further analysis of studies using a variety of interactive tasks is needed to establish brain regions that are generalizable across all social interactive approaches.

References

(Scan me!):

