Where do people look first when making predictions about actions based on false beliefs?

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Recent eye-tracking studies on adult Theory of Mind have found different results. Ferguson, Scheepers and Sanford (2010) asked adult participants to listen to a series of short false-belief stories while looking at static scenes. Like the children in Clements and Perner (1994), adults were able to anticipate the behaviour of a protagonist who was mistaken about a certain state of affairs without showing interference from their own knowledge of the situation. In contrast, in another recent eye-tracking study using a standard false belief task with adults, Rubio-Frenandez and Glucksberg (under review) observed that when participants were asked to predict where a character would look for a desired object that, unbeknownst to her, had been moved to a different container, they would often look first towards the current location of the object before they correcting this initial tendency.

What explains adults' looks towards the current location of the object? In this brief report we describe the progress made towards formulating hypotheses and designing experiments with the aim of answering this question.

One possibility is that these looks represent an incorrect action prediction. On this view, adults (1) are predicting where a character will go, (2) first predict that the character will go to the actual location of the object, and then (3) update their prediction to take into account the character's false belief about the location of the object. Call this the 'mistaken prediction' hypothesis.

A different explanation for why adults look towards the current location of the object involves spatial indexing (Richarson & Spivey, 2000; Hoover & Richardson, 2000). Spatial indexing occurs when information is linked to an object in such a way that, when it is necessary to recall the information, individuals will look to the object even if no information could be acquired from so doing. It is possible, then, that adults in the false belief task are attempting to recall information that is liked to the object which naturally causes them to look at this object. Call this the 'spatial indexing' hypothesis.

These hypotheses are not incompatible. It may be that two factors draw adults' eyes to the current location of the object, spatial indexing and making an incorrect action prediction. Call this the 'mixed' hypothesis.

To distinguish these two hypotheses we need to separate the actual location of the object from the location at which the character will appear. This is the purpose of the slide display schematically represented in Fig 1 below, in which the character sends an object down the slide and will then later re-appear at the top of the slide when she wants to retrieve that object. If the mistaken prediction hypothesis is correct, then participants should look to the location where the character would appear if she were going to retrieve her object in its actual

location (not the location where she believes it to be). If the spatial indexing hypothesis is correct, participants should look to the actual location of the object.
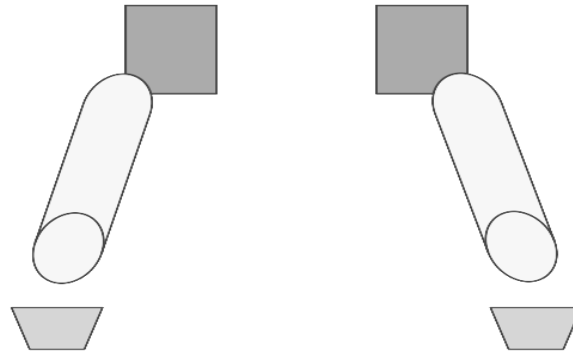
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Figure 1: Schematic representation of the modified materials for the first experiment.

Materials
False belief condition [fb]: Sally appears at B and slides her horse into C. Anne appears at A and slides her doll down to D. Anne goes home. Sally likes Anne's doll and wants to play with it, so she takes it from D and moves it to C. [This requires Sally to appear at the bottom; ideally we would not have Anne or Sally ever appear below. We will fix this by using lifts, or possibly by introducing a further character to move the doll; this detail is still under discussion.]

True belief condition [tb]: Sally appears at B and slides her horse into C. Anne was appear at A and slide her doll down to D, but because D is getting full, she decides to appear at B and slide her doll down to C (Sally's box).

The following will be counterbalanced between participants:

> 1. order of true and false belief stories

> 2. whether correct location is left or right

Method
Each participant will get a true belief trial [tb] and a false belief trial [fb]. We shall compare the location of the fixation onset in the true vs. false belief stories.

Coding
There are four regions of interest labelled A-D (see Figure 2).

FIRST FIXATIONS

PERSPECTIVE-TAKING
ACTION PREDICTION

A
(1A)

B
(1B)

EGOCENTRIC
ACTION PREDICTION

C
(2A)

D
(2B)

PERSPECTIVE-TAKING
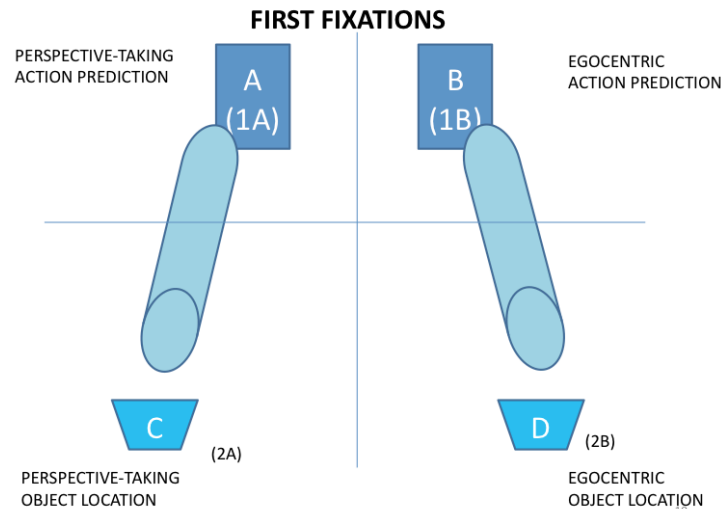OBJECT LOCATION

EGOCENTRIC
OBJECT LOCATION

Figure 2: Regions of interest

A top-left: the location the character will actually appear to retrieve her object (this applies to both tb and fb trials, as do all of the following)

B top-right: the location where the character would appear if she wanted to retrieve her object and knew where it was

C bottom-right: the actual location of the object

D bottom-left: where the character believes her object to be

For each trial, we want to know which region is the region of fixation onset.

Interpretation of results from individual participants

Our measure is a comparison between region of fixation onset in false belief vs. true belief trials.

Below the fixation onset is in region (tb, fb):

(*,A) = failure to replicate
(*,D) = failure to replicate
(A,*) = failure on true belief (can't use participant)
(D,*) = failure on true belief (can't use participant)
(B,B) = mistaken action prediction hypothesis supported, can reject spatial indexing hypothesis
(C,B) = mistaken action prediction hypothesis supported, can reject spatial indexing hypothesis
(C,C) = compatible with any hypothesis
(B,C) = spatial indexing hypothesis supported, can reject action prediction hypothesis

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If more participants exhibit on of these patterns than would be expected by chance, we can conclude that the corresponding hypothesis is supported for those participants. (So potentially we could find that some participants are making mistaken action predictions whereas others are doing spatial indexing.)