

How do we develop two systems for mindreading?

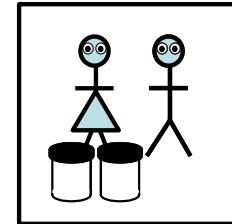
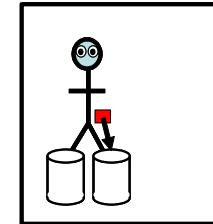
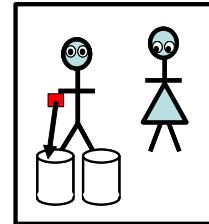
Ian Apperly



UNIVERSITY OF
BIRMINGHAM

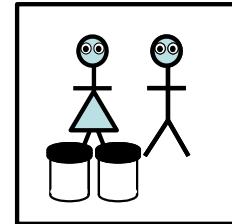
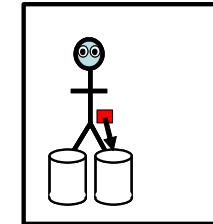
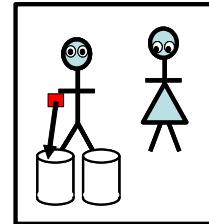
What is “Theory of Mind”?

- “Folk psychology”, “Perspective-taking”, “Social cognition”
- Essential for everyday social interaction and communication
- ***False belief tasks as a paradigm case***
- (e.g., Wimmer & Perner, 1983)
 - These tasks ensure that participant must judge from other person’s point of view



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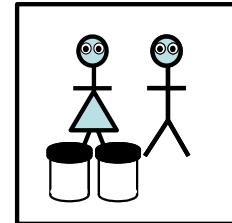
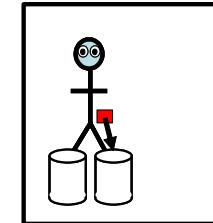
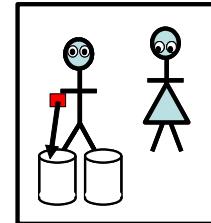


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- Disproportionately impaired in autism and several other genetic and psychiatric disorders



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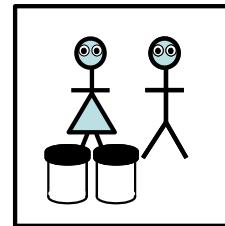
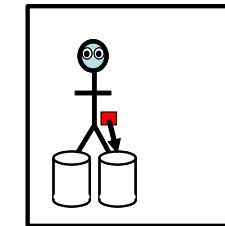
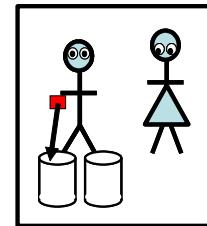


- Significant developments from infancy to early childhood
- Disproportionately impaired in autism and several other genetic and psychiatric disorders
- Existent, to a degree, in non-human animals



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- Significant developments from infancy to early childhood



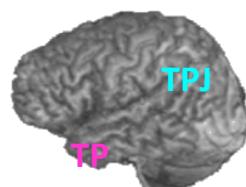
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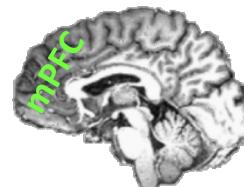
- Existent, to a degree, in non-human animals

- Identifiable neural network

■ Temporo-parietal junction / pSTS
■ Temporal pole
■ Medial prefrontal cortex



Lateral view



Medial view

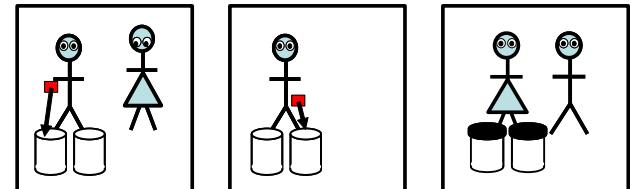
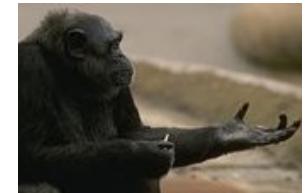


Theory of mind in adults?

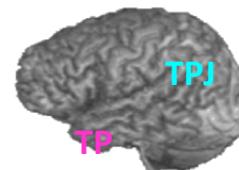
- “But don’t adults *have* a theory of mind.....?”

Theory of mind in adults?

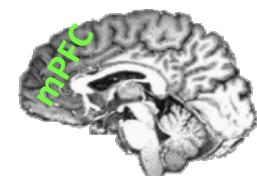
- “But don’t adults have a theory of mind.....?”
- Prevailing view:
 - ToM is a set of concepts
 - Researchers should figure out who has them (and where they are in the brain)....
 -by seeing who passes false belief tasks



■ Temporo-parietal junction / pSTS
■ Temporal pole
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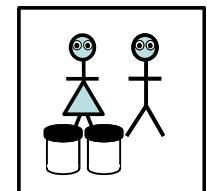
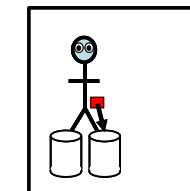
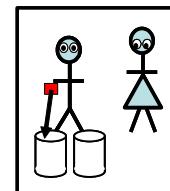
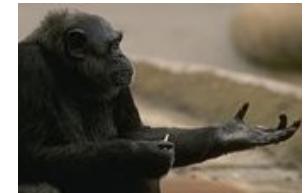
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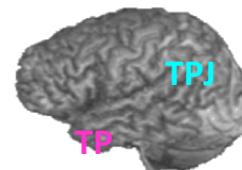
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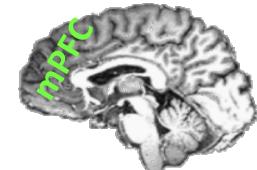
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- Prevailing view:
 - ToM is a set of concepts
 - Researchers should figure out who has them (and where they are in the brain)....
 -by seeing who passes false belief tasks
- Problems with this view:
 - No cognitive account of ToM in adults
 - Severe limitations on conceptualising extended development, neural basis and disorder
 - Little integration with the rest of cognition



■ Temporo-parietal junction / pSTS
■ Temporal pole
■ Medial prefrontal cortex



Lateral view



Medial view

“Contradictory” findings from children vs. infants and non-human animals

- **Significant developments in ToM reasoning between 2 and 7 years (e.g., Wellman, Cross & Watson, 2001)**
 - Strong links with language and executive function
- **Growing evidence of “false belief” reasoning in infants**
 - 24M (Southgate, Semju & Csibra, 2007)
 - 15M (Onishi & Baillargeon, 2005; 2010)
 - 13M (Surian, Caldi & Sperber, 2007)
 - 7M (Kovacs et al., 2010)
- **Evidence for something similar in non-human animals**
 - Hare, Call & Tomasello (2000, 2001)
 - Clayton, Dally & Emery (2007)
- **But infants and non-human animals clearly lack the language and executive resources that appear necessary for development of belief reasoning**

Today's talk:

Why should we think adults might have two systems for mindreading?

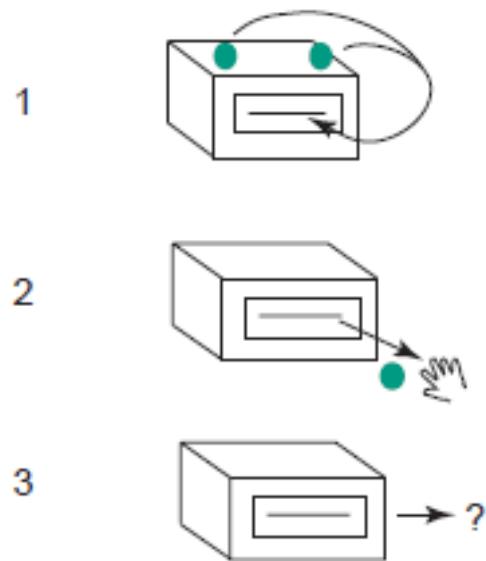
Evidence that they do

What is the relationship between the abilities of infants, children and adults?

(NB. I don't have all the answers, but I hope to indicate some of the questions we should ask!)

Example from the psychology of number

(d) Manual search experiments



- Pre-counting infants search $\sim N$ times for N items for $N < 4$

From Feigenson, Dehaene & Spelke (2004)

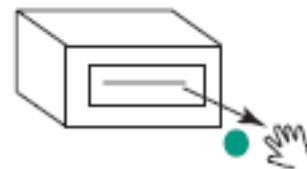
Example from the psychology of number

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1



2



3



- Pre-counting infants search $\sim N$ times for N items for $N < 4$
- People who can count are not subject to this limit....

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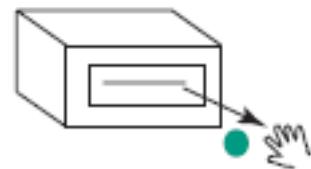
Example from the psychology of number

(d) Manual search experiments

1



2



3



- Pre-counting infants search $\sim N$ times for N items for $N < 4$
- People who can count are not subject to this limit....
-provided they have time and resources

From Feigenson, Dehaene & Spelke (2004)

Why two (or more) systems?

- Complex cognitive domains often make contradictory demands
 - We must be very efficient
 - We must be very flexible

Mindreading makes contradictory demands

ToM must be flexible

- An archetypal “central process”



ToM must be fast and efficient

- An archetypal “modular process”

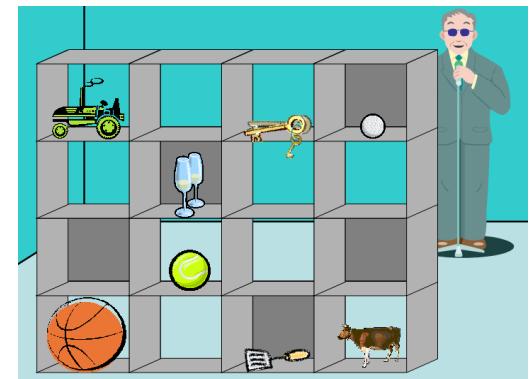
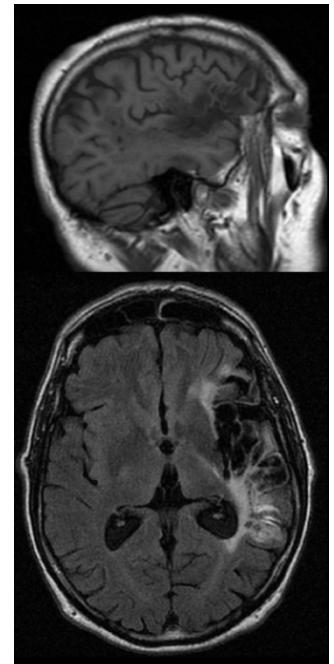


Fast &
Flexible?



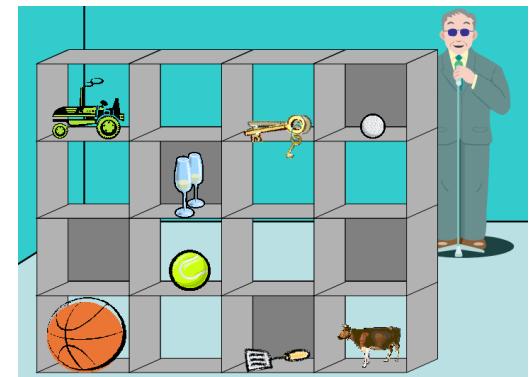
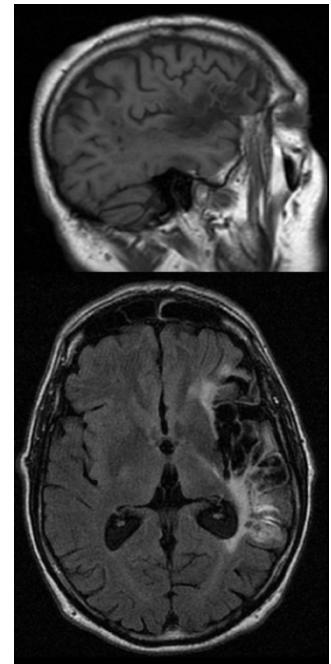
Evidence that mindreading is a flexible but demanding ability

- In Adults....
- Impaired executive processes can lead to severe egocentrism
 - (e.g., Samson, Apperly, Kathirgamanathan & Humphreys, 2005)
- Belief inferences are not *made* automatically
 - (Apperly, Samson, Riggs, Simpson & Chiavarino, 2006; Back & Apperly, 2010)
- Belief inferences are not *used* automatically
 - (e.g., Keysar, Lin & Barr, 2003; Apperly et al., 2010)
- Holding false beliefs briefly in mind has a measurable processing cost
 - (Apperly, Back et al., 2008)
- Belief reasoning requires cognitive control
 - (e.g., Bull, Philips & Conway, 2007)



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- Belief reasoning requires cognitive control
 - (e.g., Bull, Philips & Conway, 2007)
- ...and this fits with evidence from children.



Efficient but inflexible processes?

- What would count as direct evidence of inflexibility and efficiency?
 - Kovacs et al. (2010) *Science*. Adults may infer false beliefs even when they do not need to.
 - Stronger evidence:
 - Process may be executed even when unnecessary or unhelpful
 - Process may not be disrupted by other tasks

Efficient but inflexible processes?

(Samson, Apperly, Braithwaite et al., 2010, *JEP:HPP*)

Self / Other Consistent

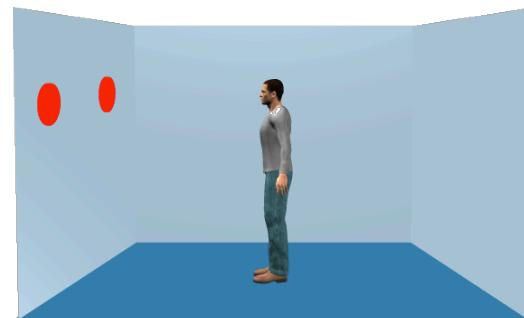
You / He



2



1,2, or 3 discs



Self / Other Inconsistent

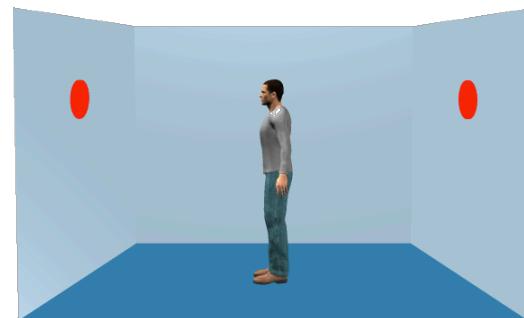
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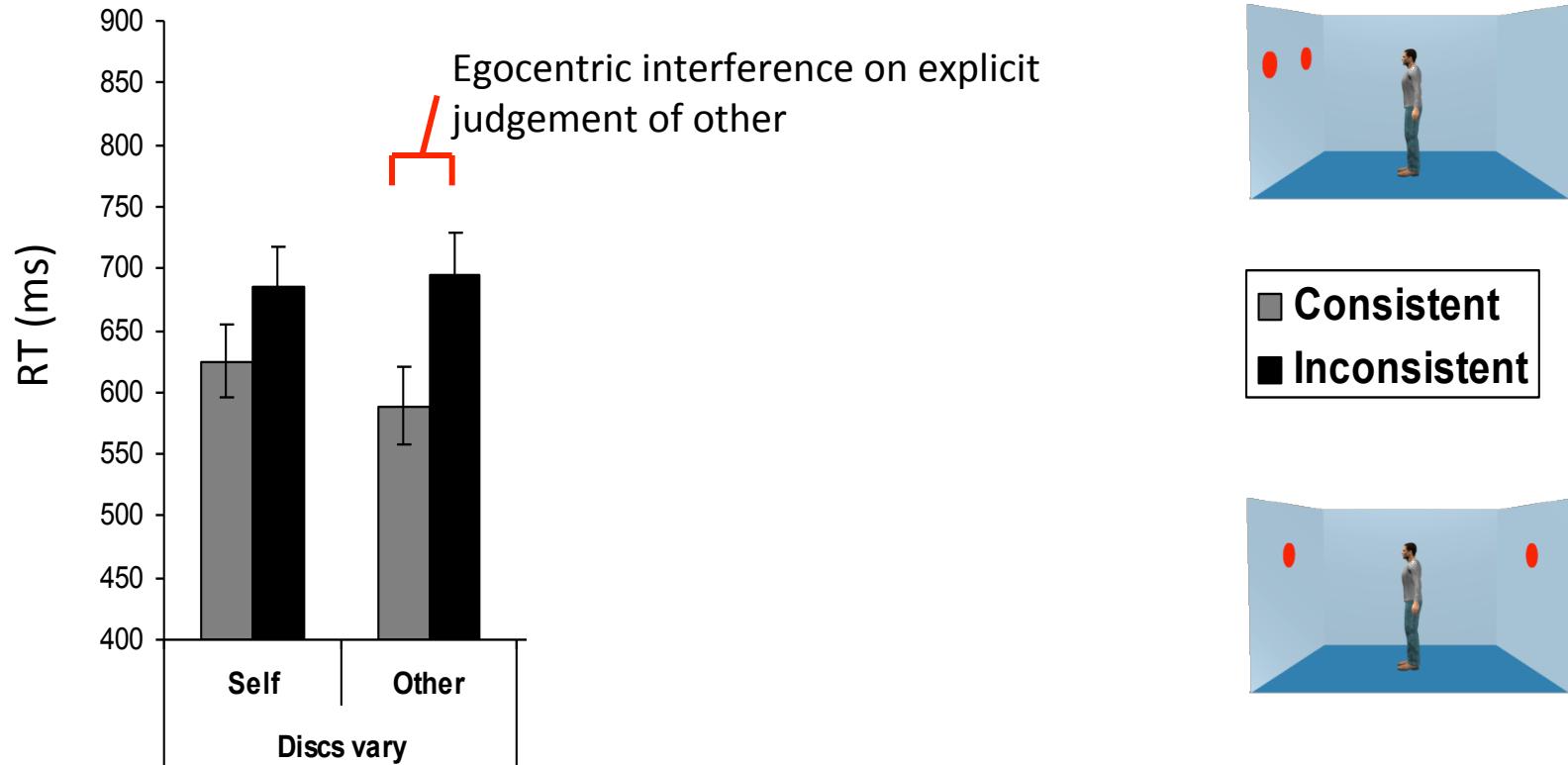


Disc position varies



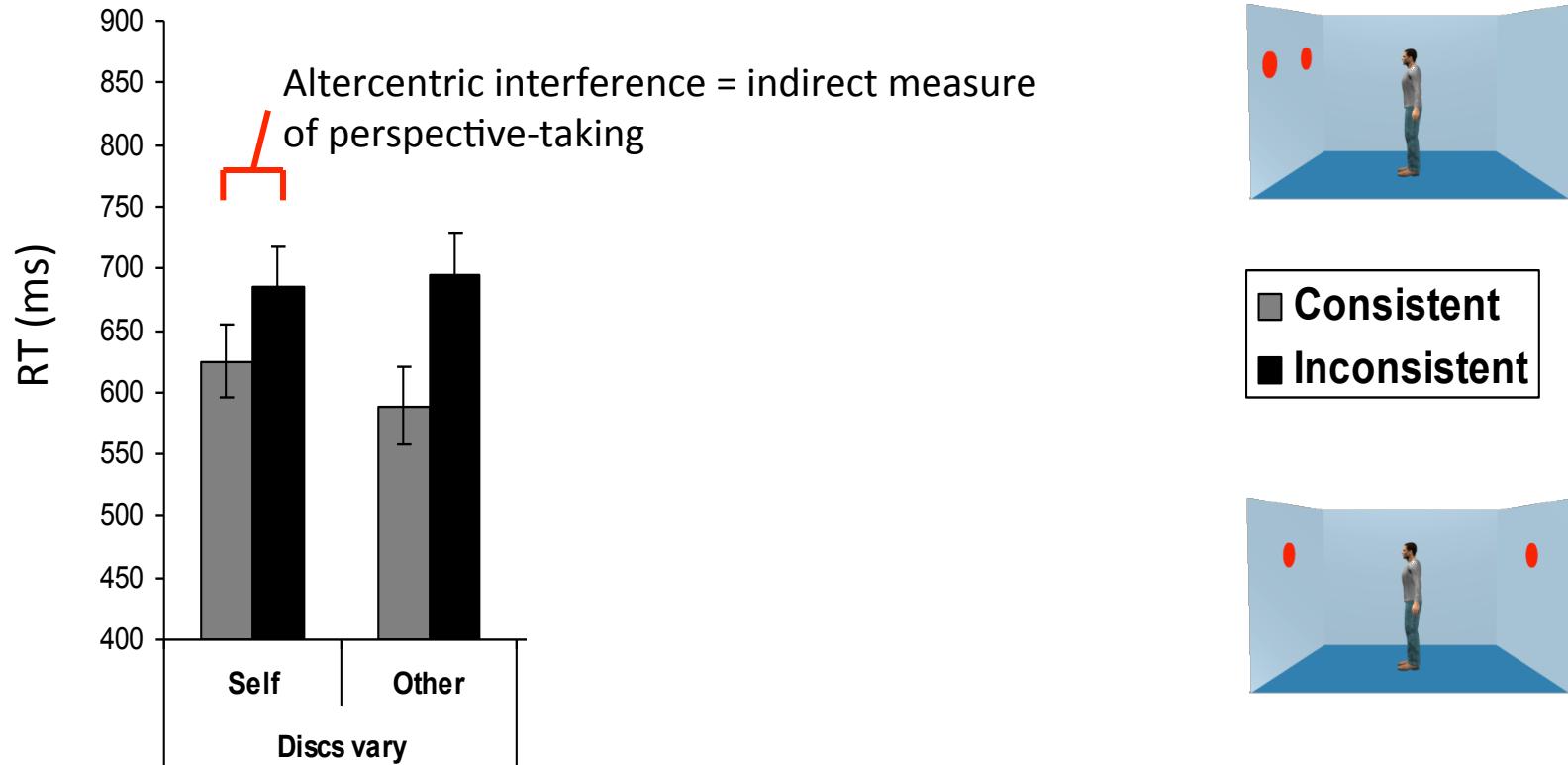
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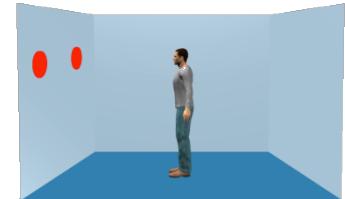
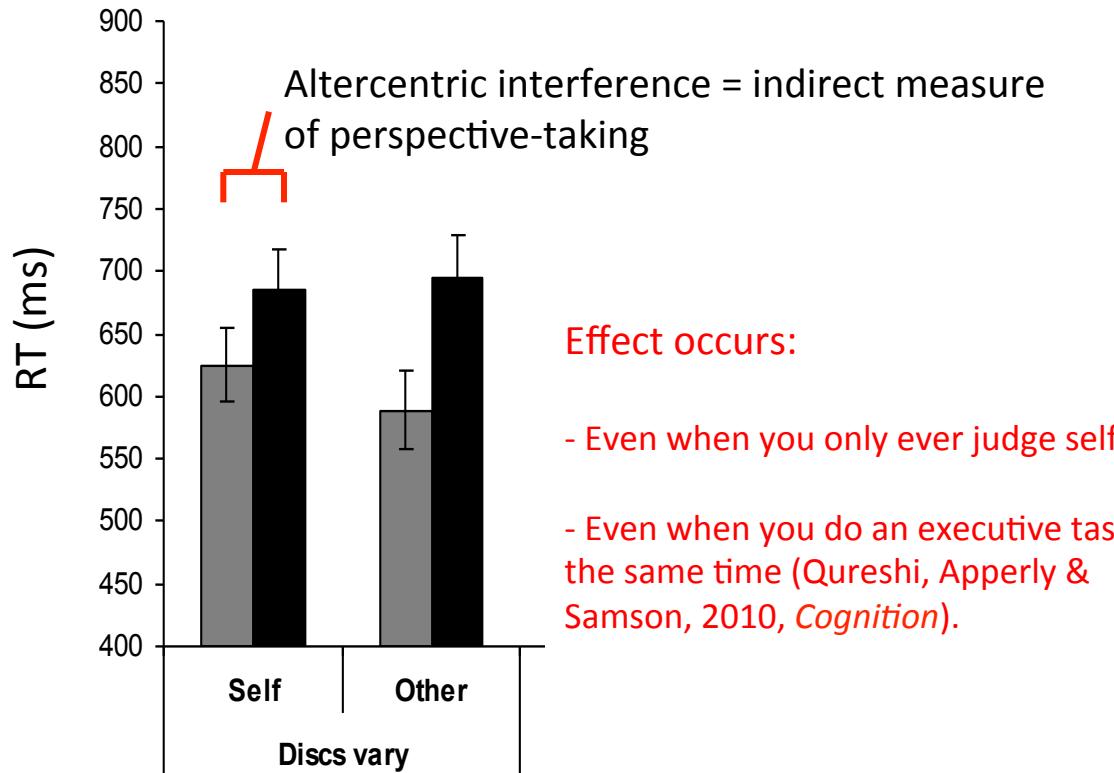
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Efficient but inflexible processes?

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■ Consistent
■ Inconsistent



Efficient but inflexible processes?

- What would count as direct evidence of inflexibility and efficiency?
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Two systems for mindreading

- These contrasting characteristics suggest separate “systems” for mindreading
- Where might they come from?



Where do adults' two systems come from?



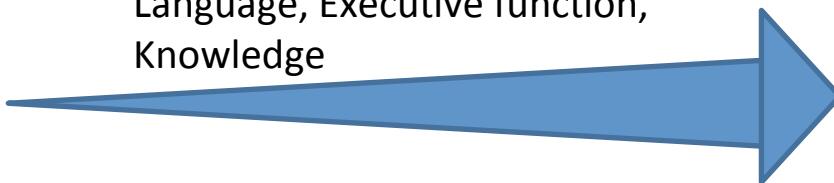
Infant system must be relatively “efficient”

Where do adults' two systems come from?

Infant
system
develops



Language, Executive function,
Knowledge



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Language, Executive function,
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Automatisation



Where do adults' two systems come from?

Infant
system
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Language, Executive function,
Knowledge



Automatisation



This is the origin of “automatic addition” (e.g., Le Fevre et al, 1988)

Where do adults' two systems come from?

Infant
system
develops



Language, Executive function,
Knowledge



Automatisation



Infant
system
preserved



Language, Executive function,
Knowledge



Where do adults' two systems come from?

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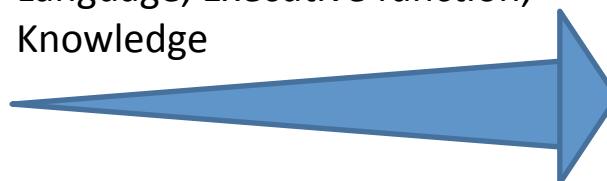
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Infant
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Language, Executive function,
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Language, Executive function,
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Automatisation



Infant system preserved



Language, Executive function,
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Where do adults' two systems come from?

Infant
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Language, Executive function,
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Automatisation



This is the Carey/Spelke view of most findings in infant cognition of number and other domains (e.g., Carey, 2009)

Infant
system
preserved



Language, Executive function,
Knowledge



Two points of investigation

Infant
system
develops



Language, Executive function,
Knowledge



Automatisation

Automatisation?



Efficient processing should be limited

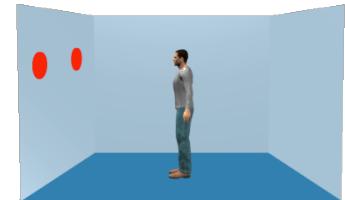
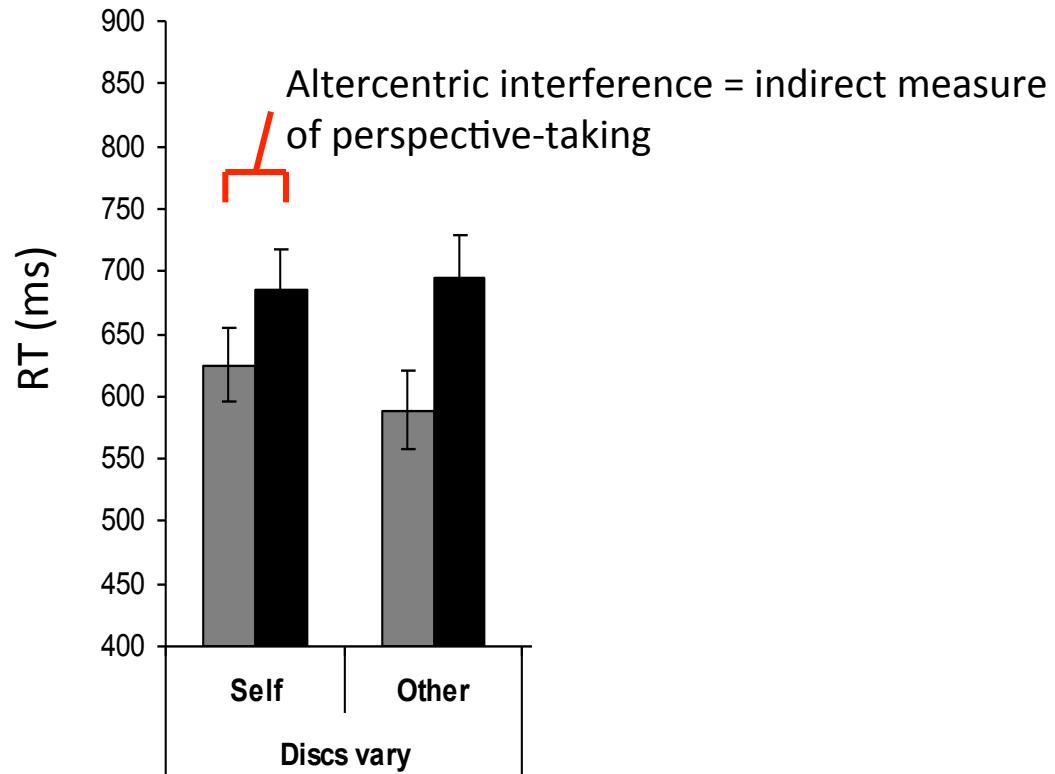
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Language, Executive function,
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What is the origin of automatic perspective-taking?



■ Consistent
■ Inconsistent



Evidence for automatisation?

Surtees & Apperly (In press) *Child Development*

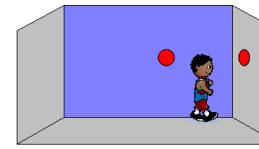
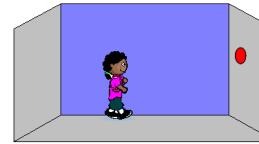
120 children aged
6-10 and adults

Expect younger
children to suffer
less interference for
self judgements.

"You see 2"

Or

"He sees 2"



Evidence for automatisation?

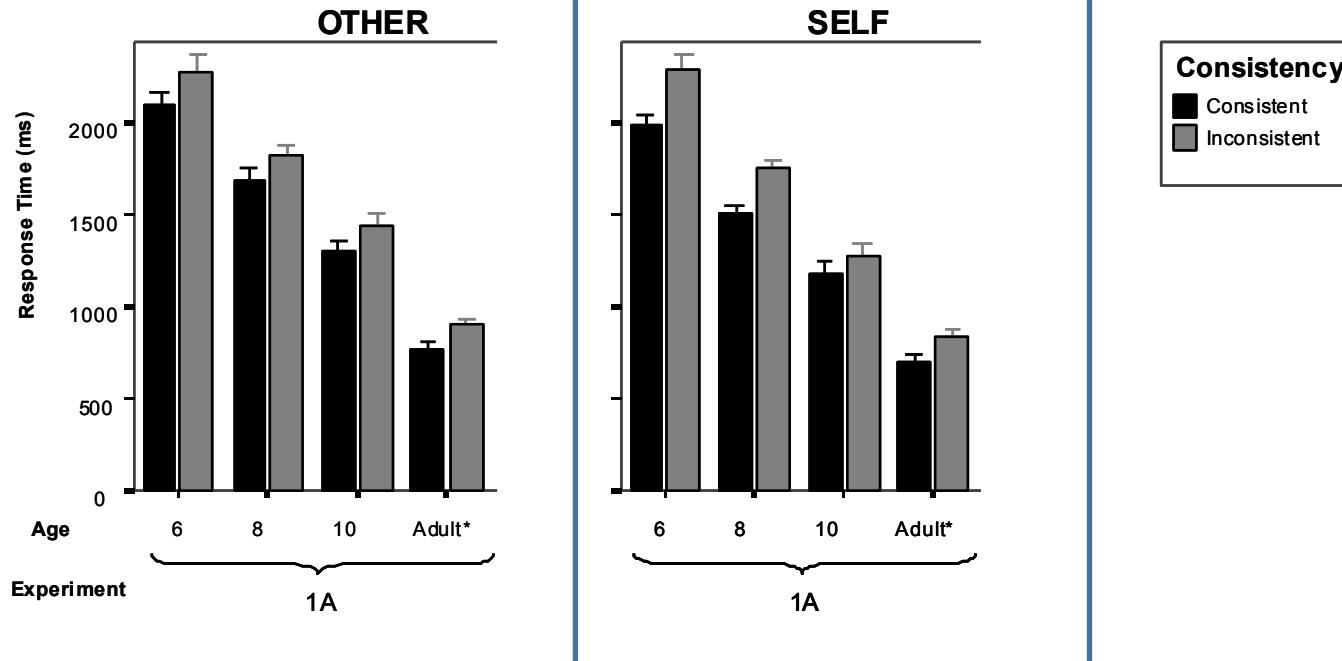
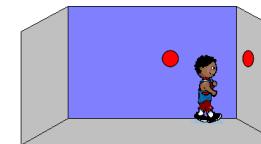
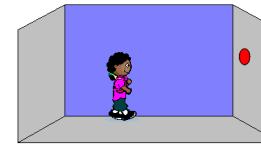
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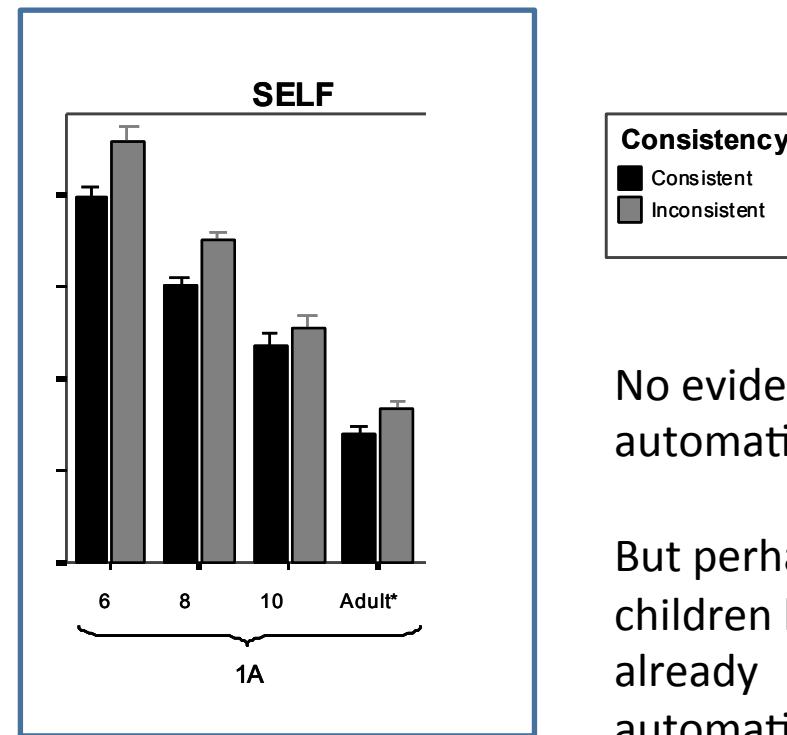
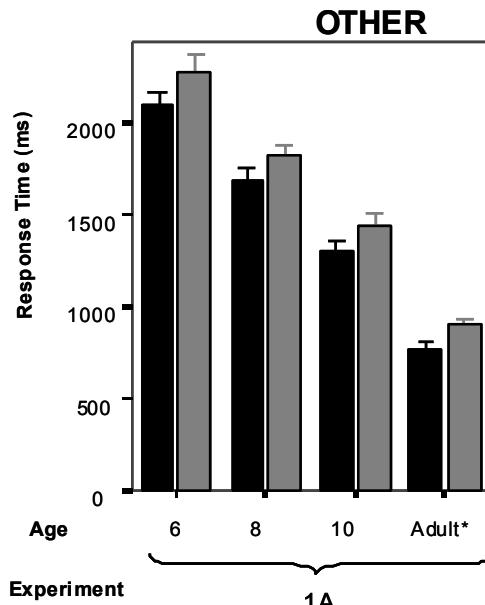
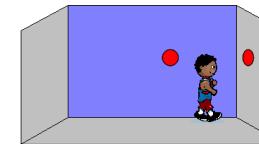
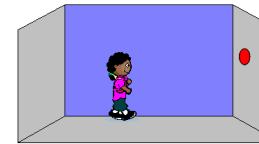
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120 children aged
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"You see 2"

Or

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Where do adults' two systems come from?

Infant system develops



Language, Executive function,
Knowledge

No evidence of automatization



Automatisation



Infant system preserved



Language, Executive function,
Knowledge



Limits on “efficient” mindreading?

Infant
system
develops



Language, Executive function,
Knowledge



Automatisation

Cognitive efficiency does not
come for free

Infant
system
preserved



Language, Executive function,
Knowledge



Limits on “efficient” mindreading?

Infant system develops



Language, Executive function,
Knowledge



Automatisation



Cognitive efficiency does not
come for free

Infant system preserved



Language, Executive function,
Knowledge



Limits on “efficient” mindreading?

Infant system develops



Language, Executive function,
Knowledge



Automatisation



Cognitive efficiency does not
come for free...

Infant system preserved



Only this account predict
analogous limits.
(As seen for number....)



Language, Executive function,
Knowledge

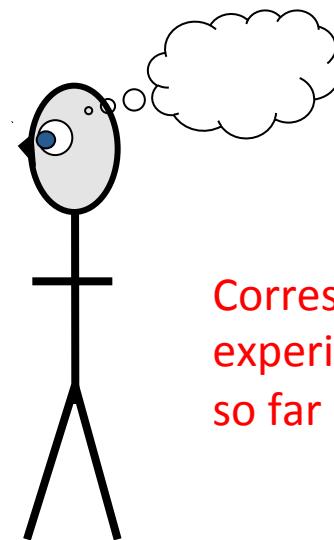
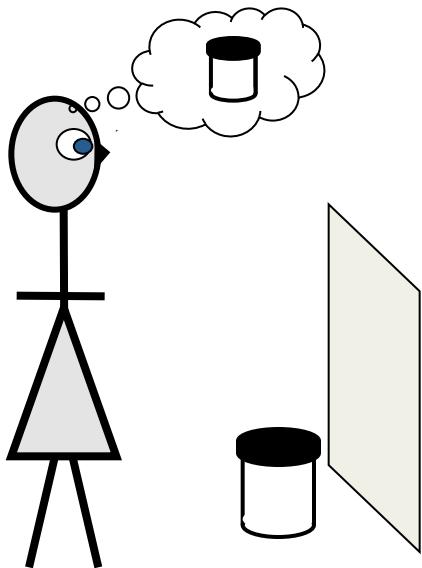


Flavell et al (1981)

Level-1

Age~2

representation of:
agent-object

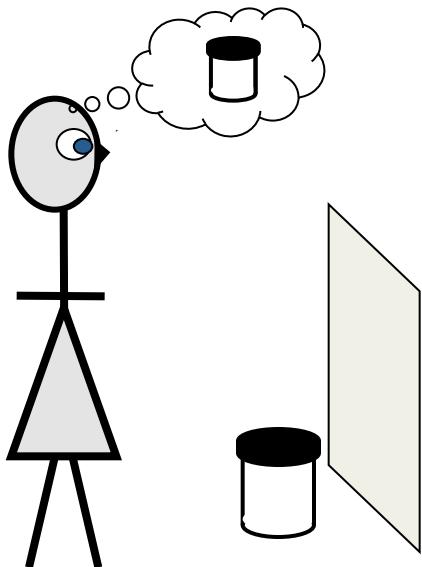


Corresponds to the
experiments described
so far

Level-1

Age~2

representation of:
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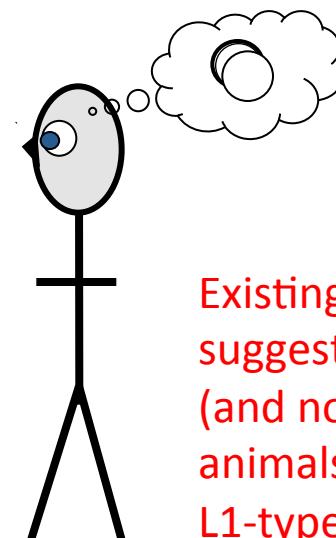
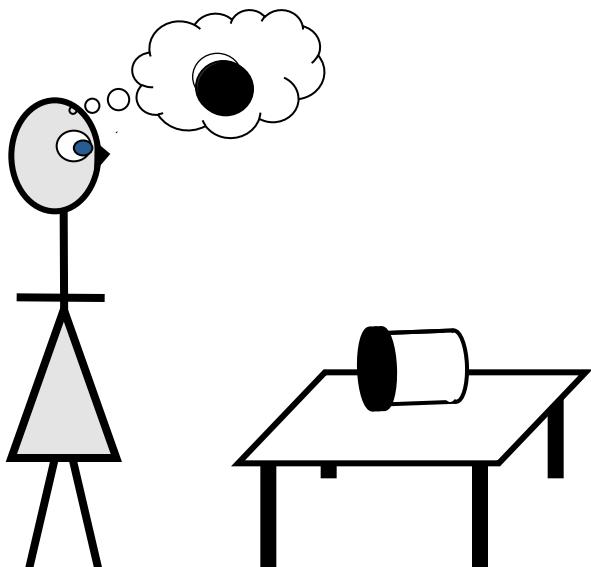


Corresponds to the
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Level-2

Age~4

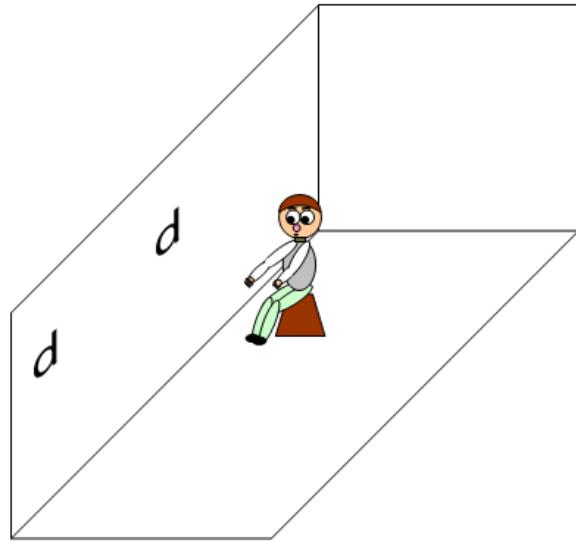
representation of: agent-
proposition



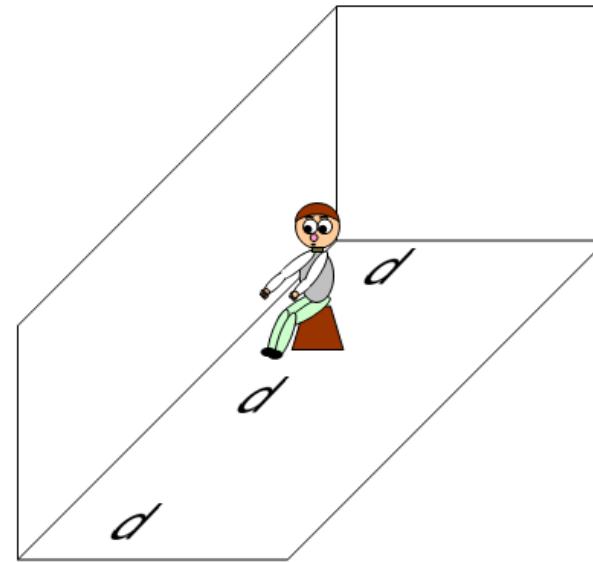
Existing evidence
suggests that infants
(and non-human
animals) are limited to
L1-type problems.



Surtees & Apperly (submitted)
Surtees, Butterfill & Apperly (submitted)



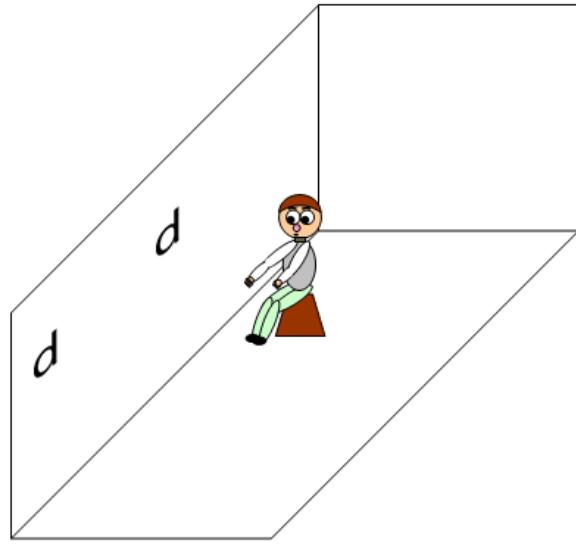
Consistent perspectives



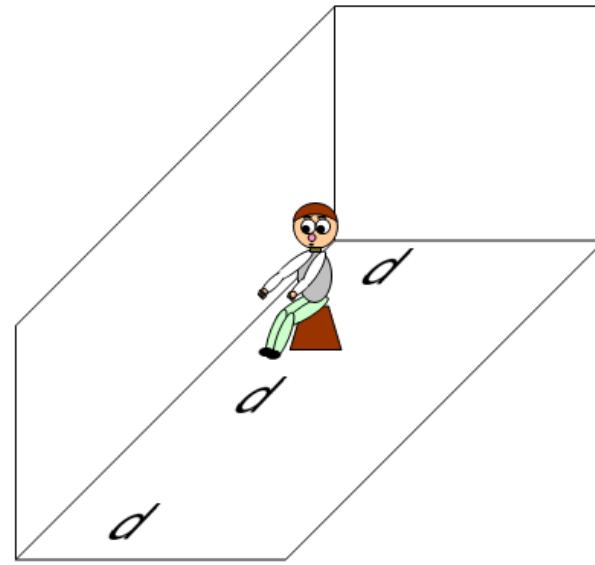
Inconsistent perspectives

L1 perspective-difference:
He sees 2 vs. you see 3

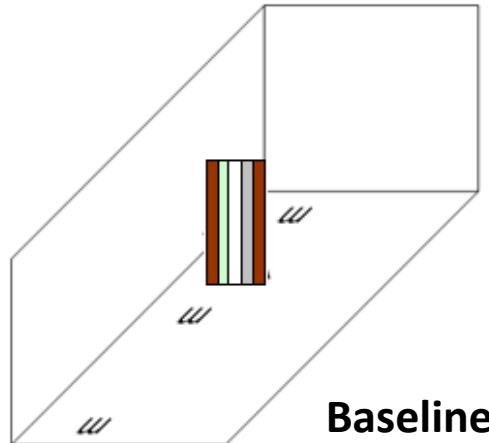
L2 perspective difference
He sees "p" vs. you see "d"



Consistent perspectives



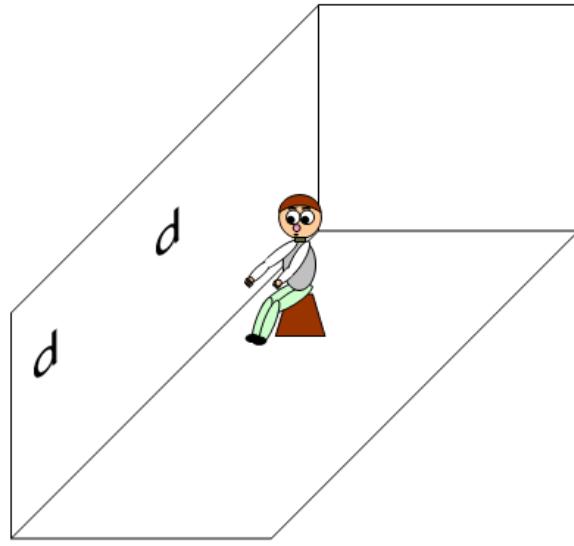
Inconsistent perspectives



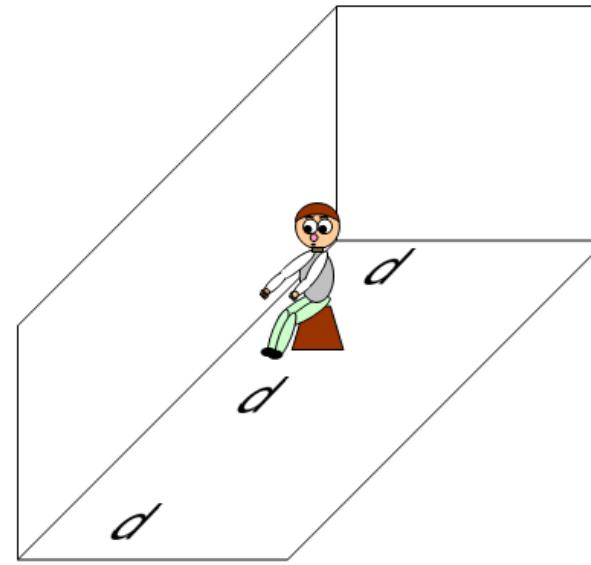
Baseline

L1 perspective-difference:
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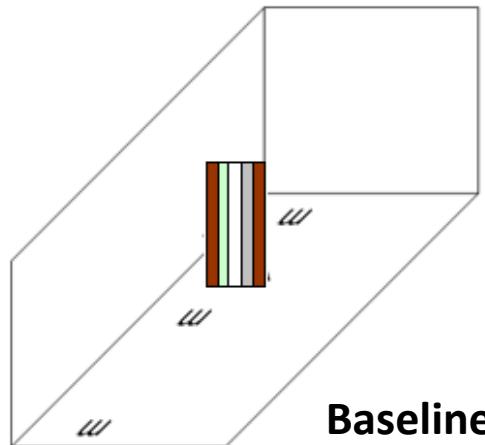
L2 perspective difference
He sees "p" vs. you see "d"



Consistent perspectives



Inconsistent perspectives



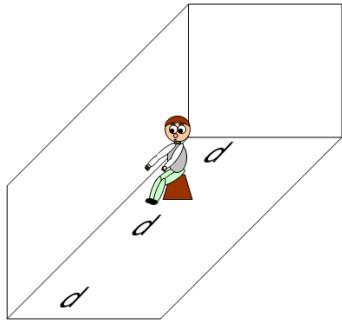
Baseline

Critical Question;

For Self judgements, compared to baseline,
does the presence of an irrelevant perspective
make any difference to L1 or L2 judgements?

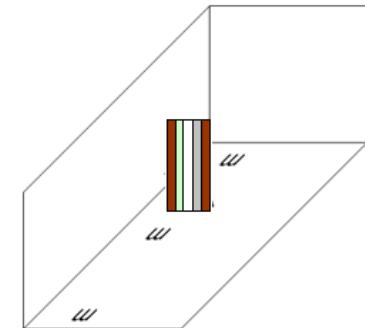
L1 shows automaticity

Surtees & Apperly (in prep)

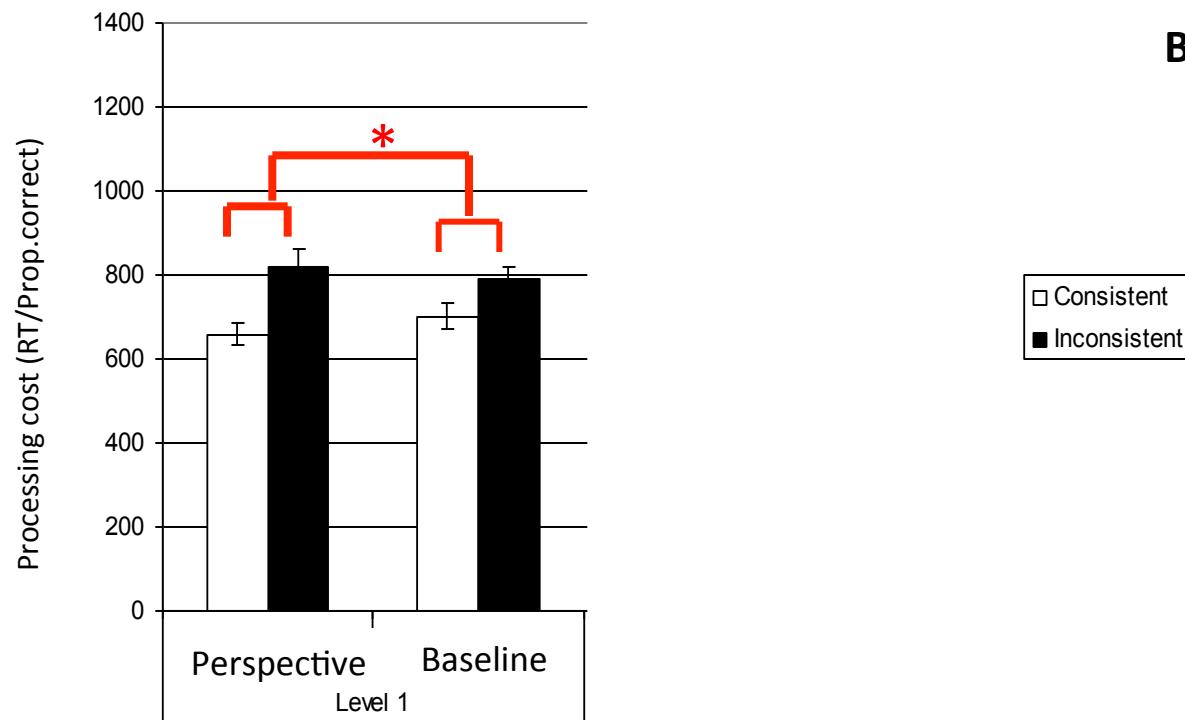


Perspective

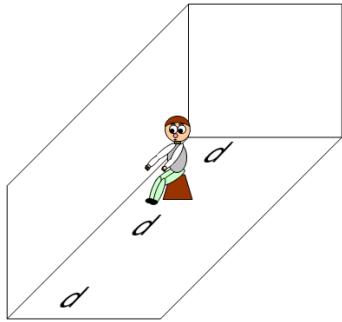
For “Self” judgements



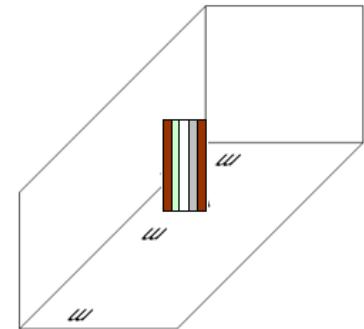
Baseline



L1 shows automaticity L2 does not

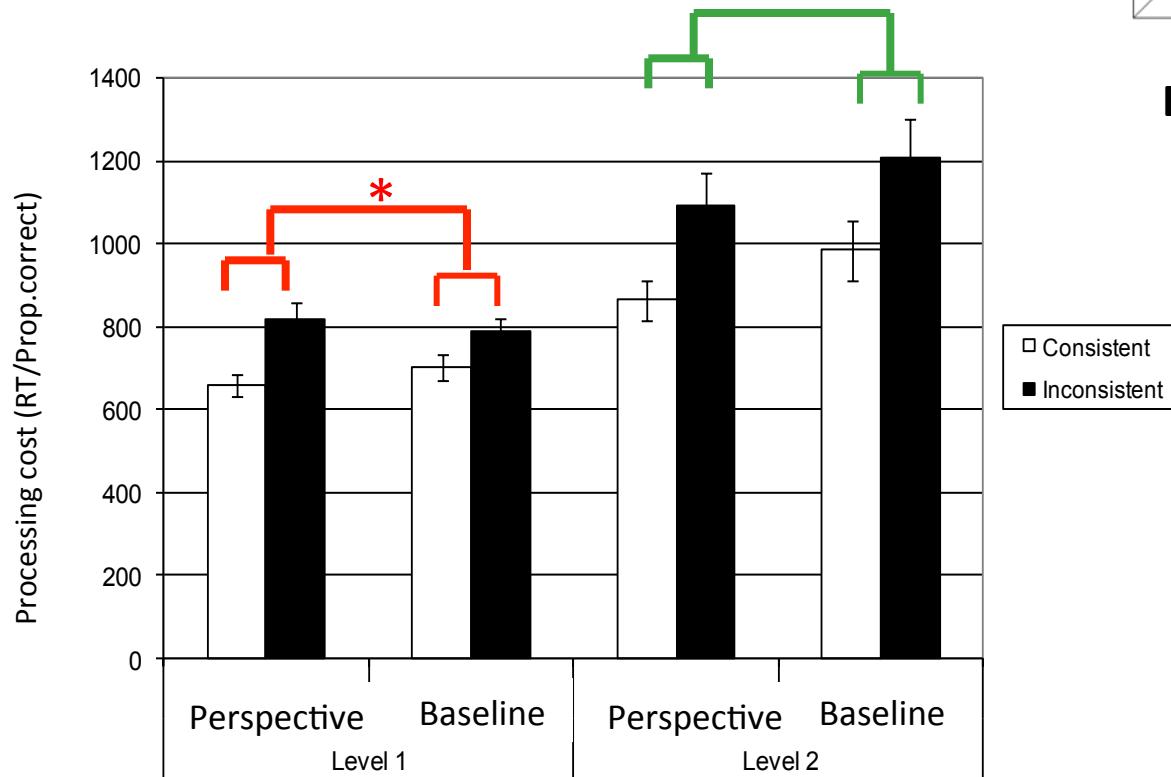


Perspective



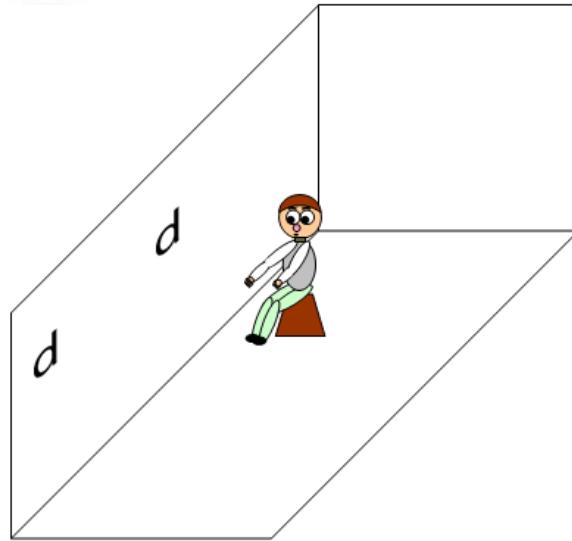
Baseline

For “Self” judgements

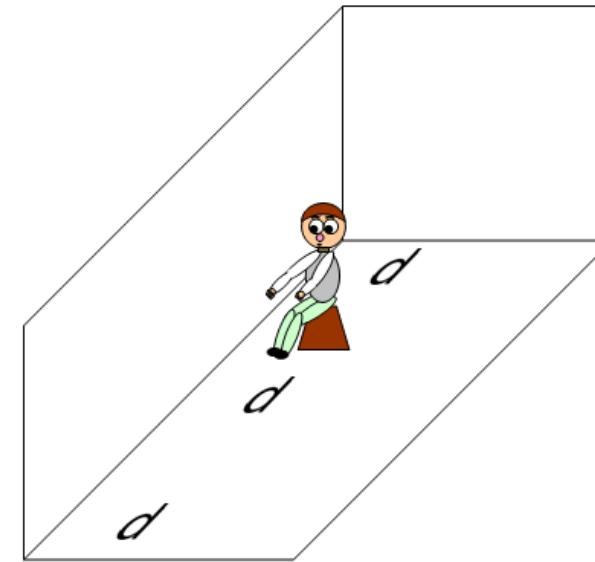




Surtees & Apperly (submitted)
Surtees, Butterfill & Apperly (submitted)



Consistent perspectives



Inconsistent perspectives

L1 perspective-difference:
He sees 2 vs. you see 3

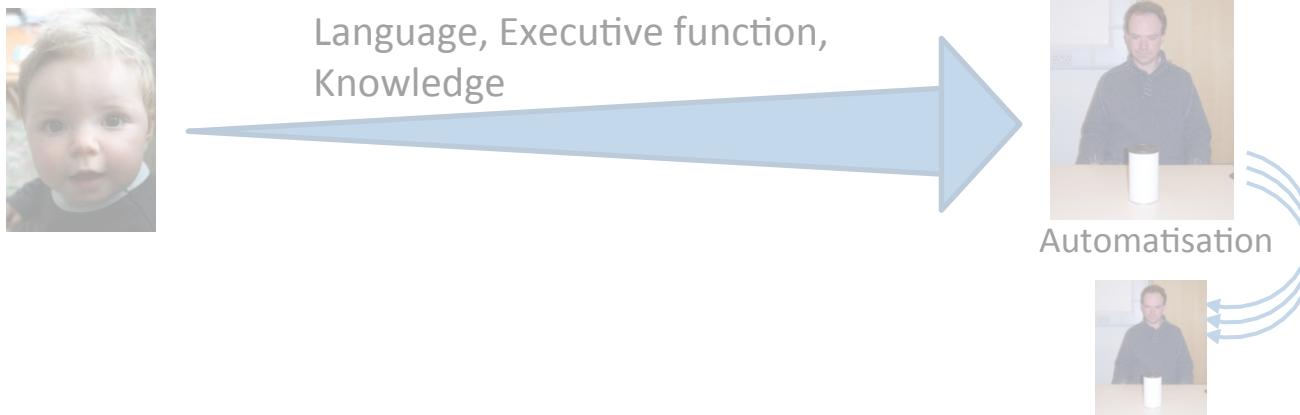
L2 perspective difference
He sees “p” vs. you see “d”

We replicate evidence of automatic,
stimulus-driven Level-1 perspective-
taking.

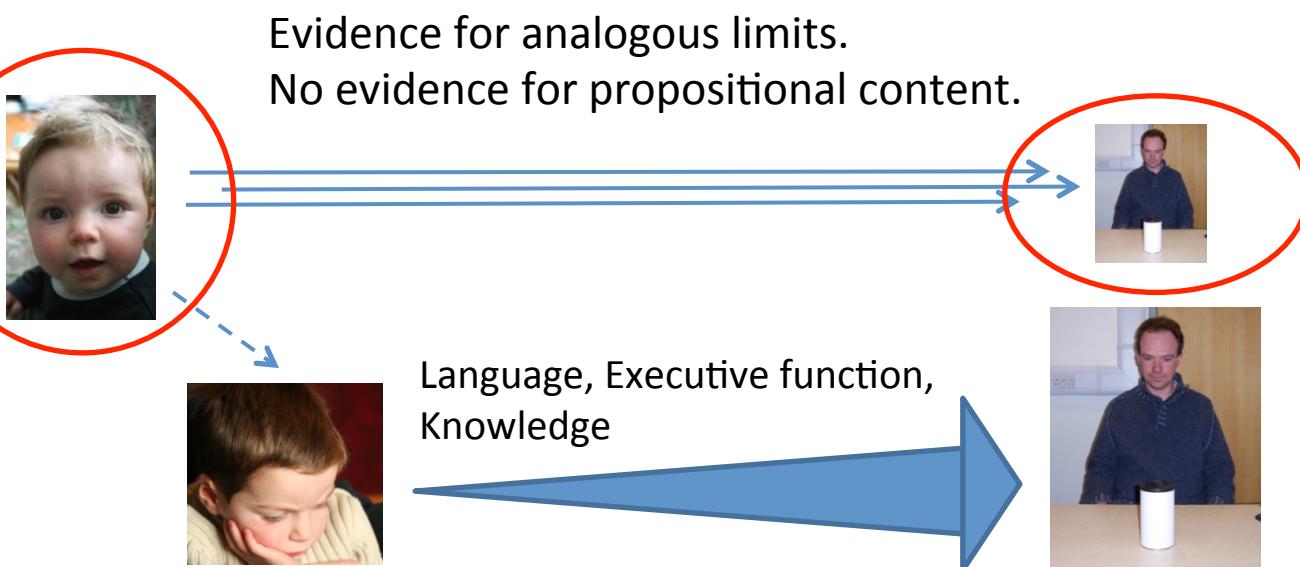
We find no evidence of automaticity
for Level-2 perspectives

Limits on “efficient” mindreading?

Infant
system
develops



Infant
system
preserved



Limits on “efficient” mindreading?

Infant system develops



Language, Executive function,
Knowledge



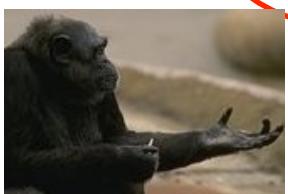
Automatisation



Infant system preserved



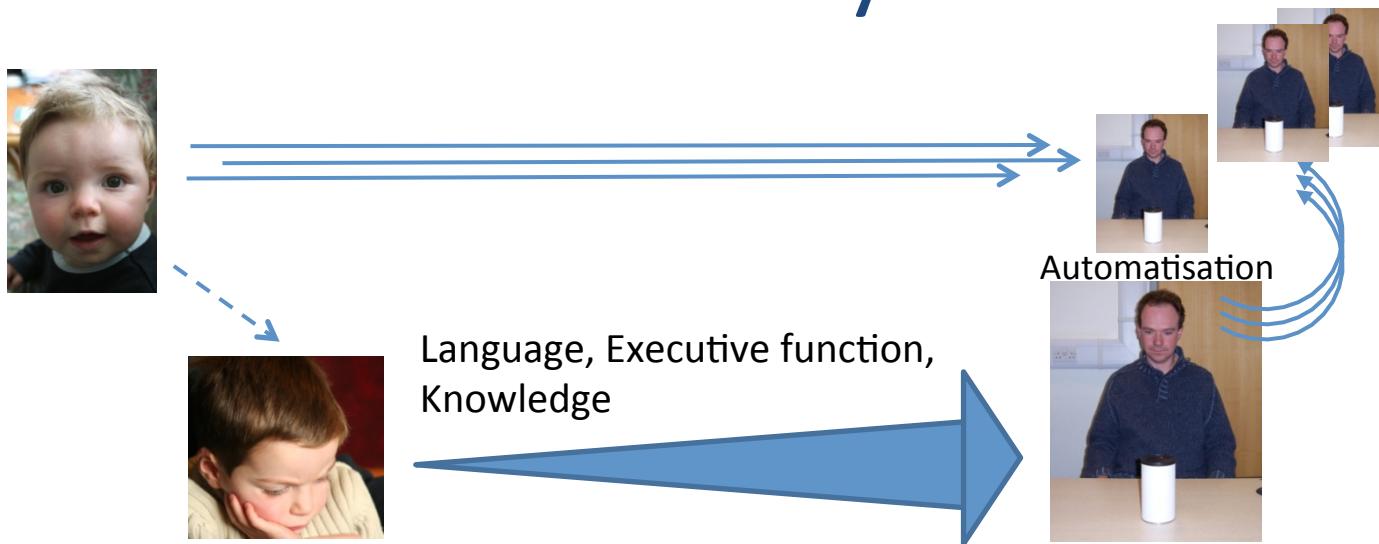
Evidence for analogous limits.
No evidence for propositional content.
(Same for infant false belief studies)



Language, Executive function,
Knowledge



Summary



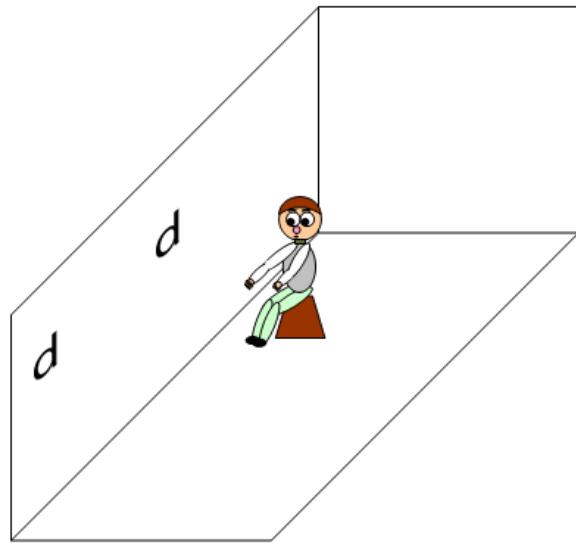
We must explain how mindreading can be both flexible and efficient.

“2-system” accounts offer a solution.

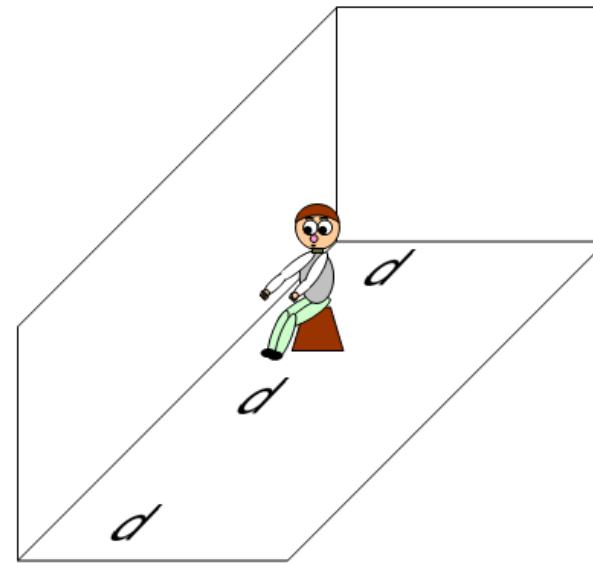
This should make us think hard about development.

There are tractable ways of testing between alternative models

Surtees & Apperly (submitted)
Surtees, Butterfill & Apperly (submitted)



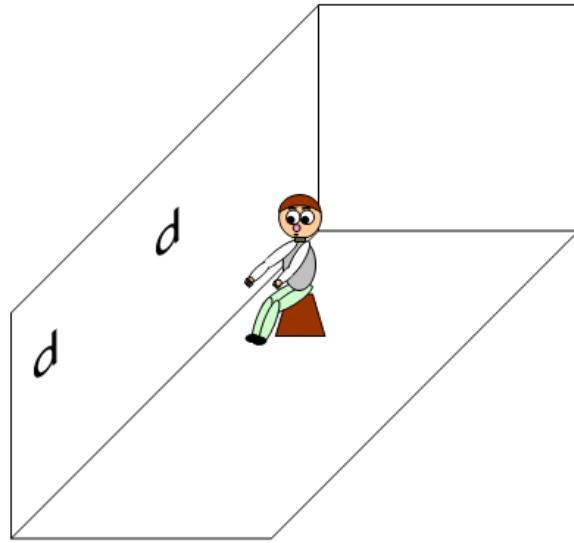
Consistent perspectives



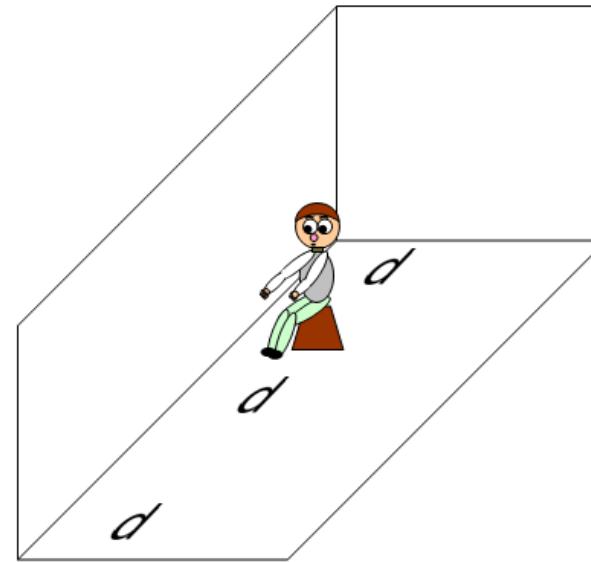
Inconsistent perspectives

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He sees 2 vs. you see 3

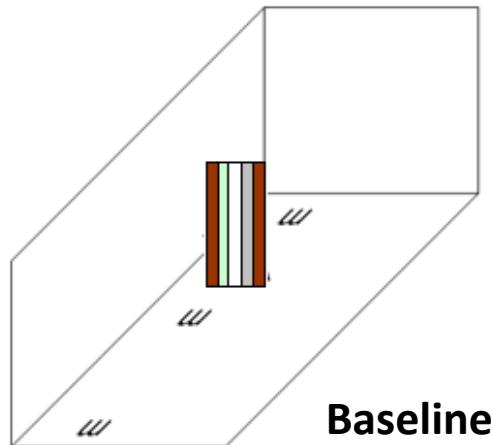
L2 perspective difference
He sees "p" vs. you see "d"



Consistent perspectives



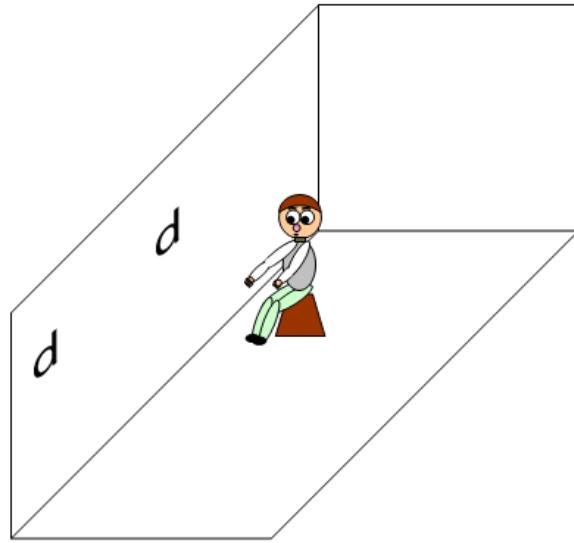
Inconsistent perspectives



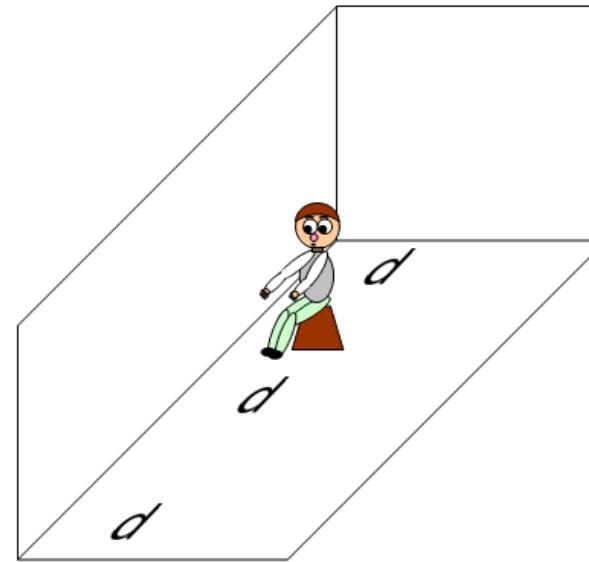
Baseline

L1 perspective-difference:
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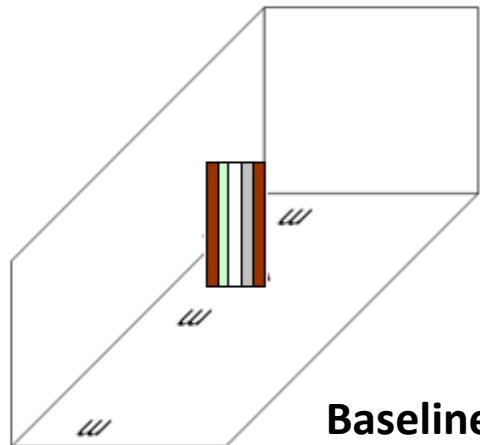
L2 perspective difference
He sees "p" vs. you see "d"



Consistent perspectives



Inconsistent perspectives

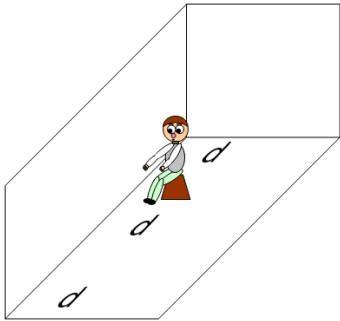


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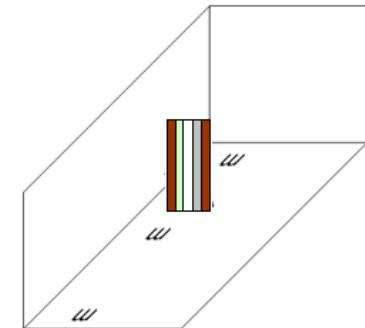
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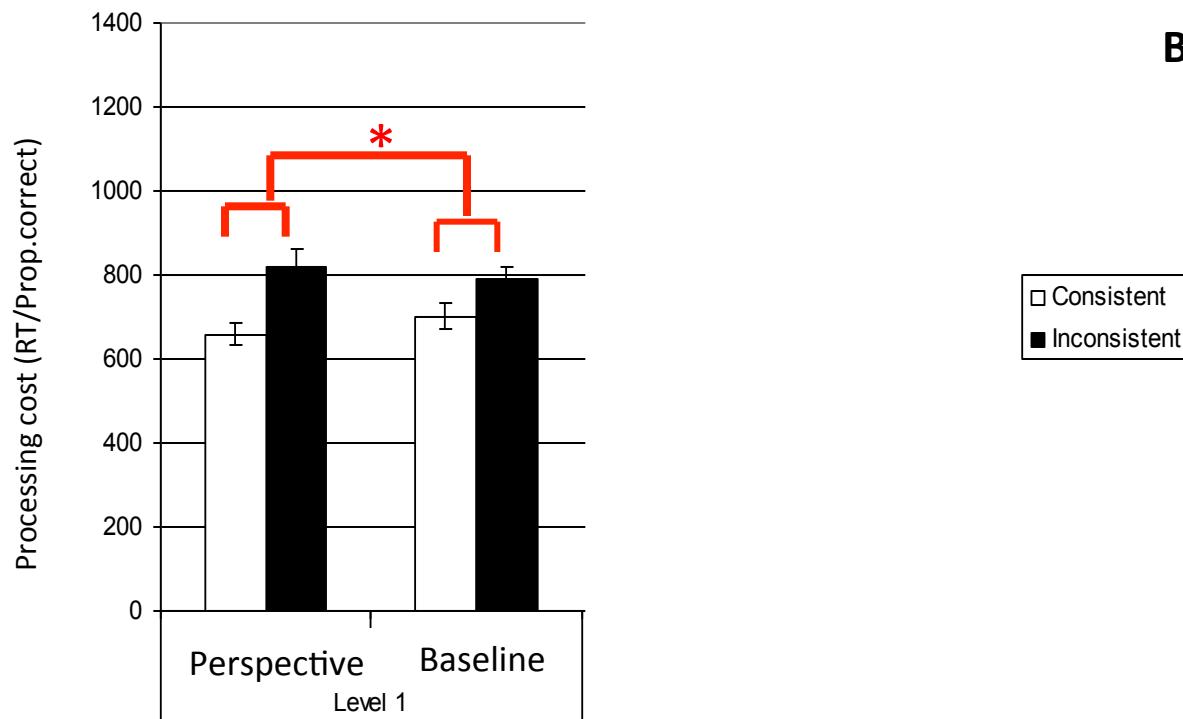


Perspective

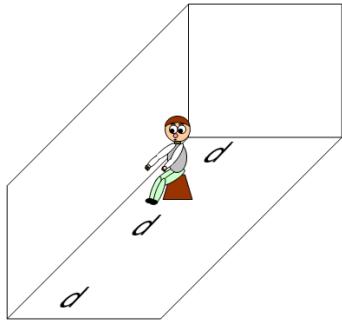
For “Self” judgements



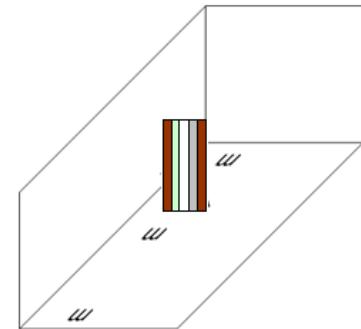
Baseline



L1 shows automaticity L2 does not

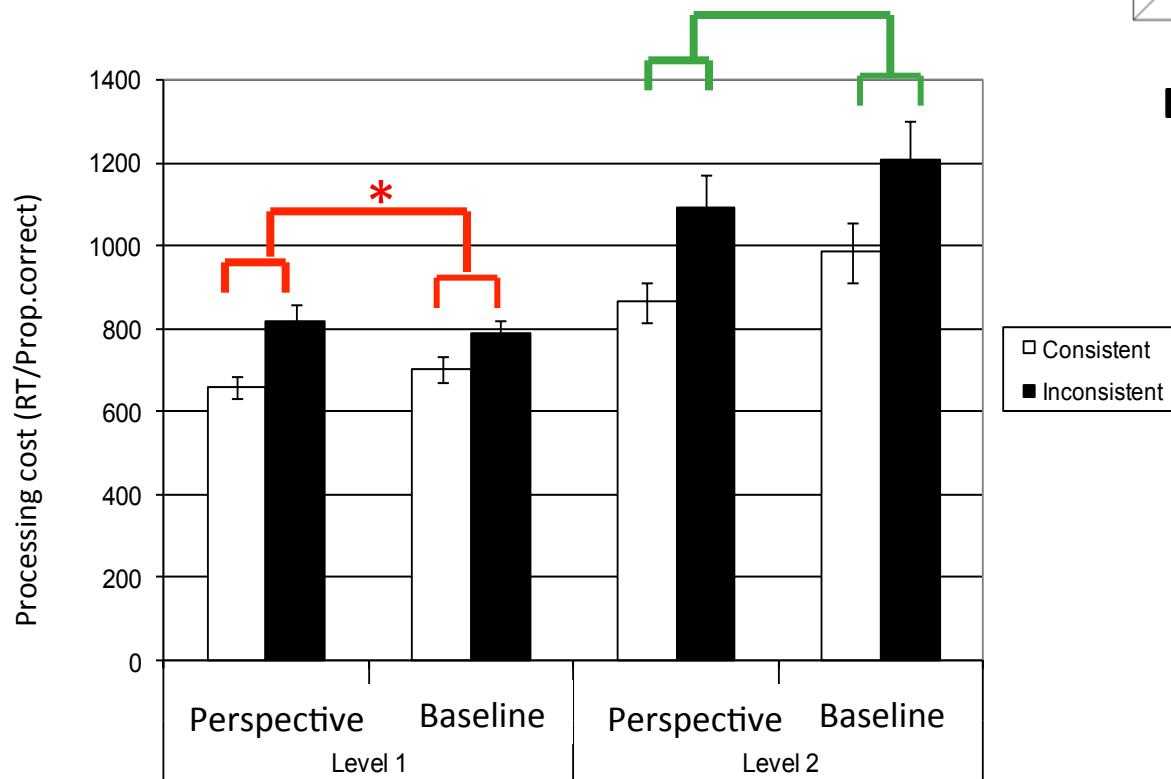


Perspective



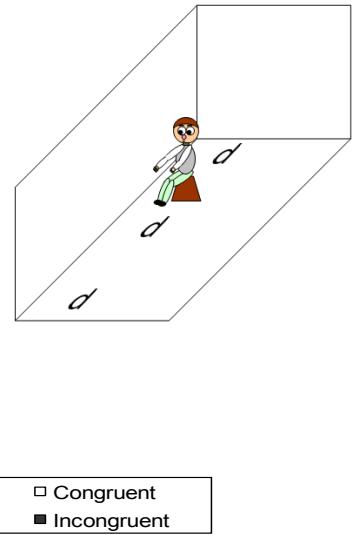
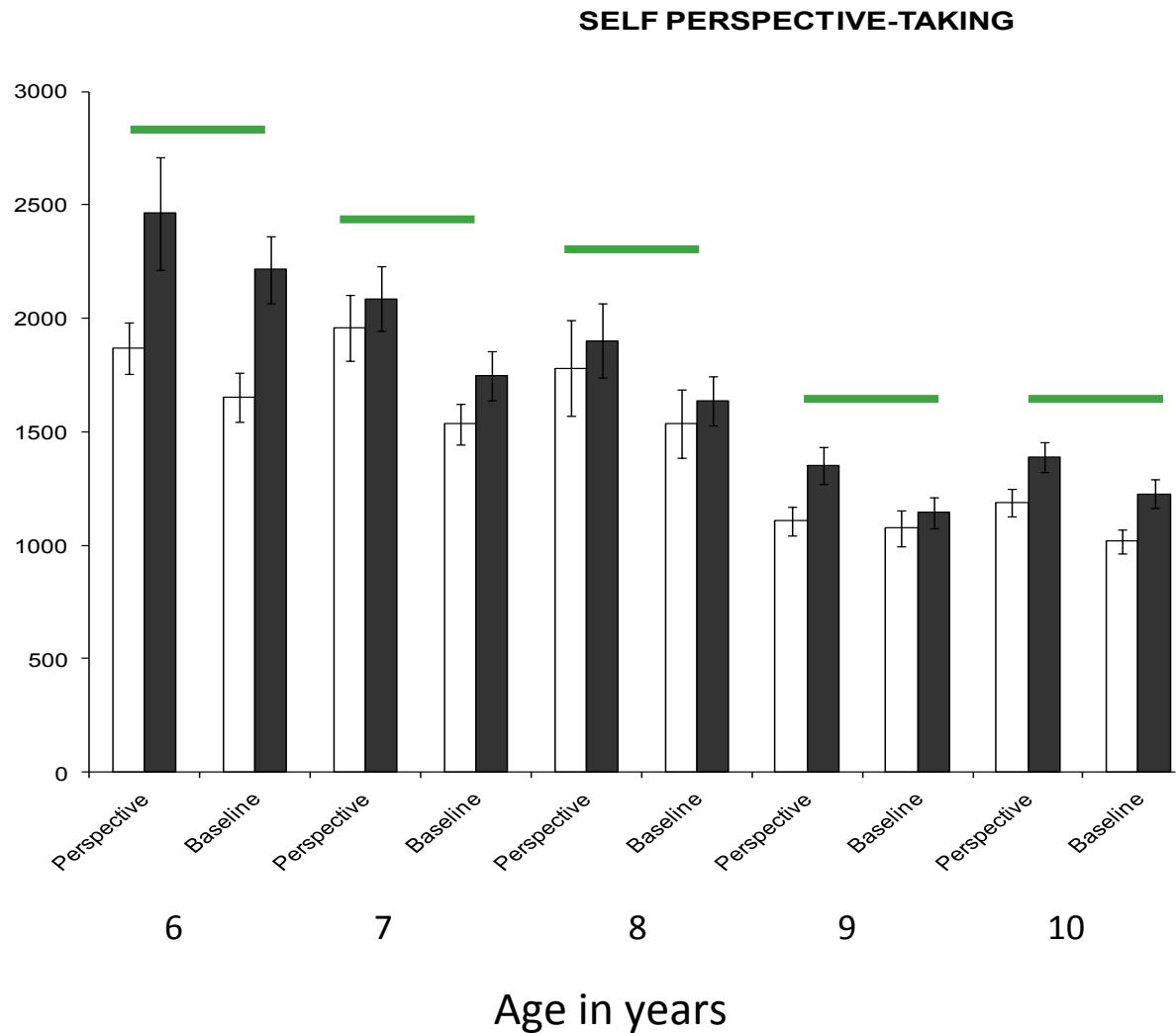
Baseline

For “Self” judgements



The same is true across a wide age range

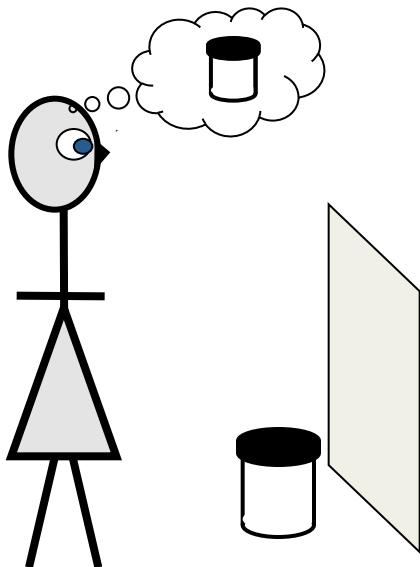
Surtees & Apperly (in prep, b)



Level-1

Age~2

representation of:
agent-object

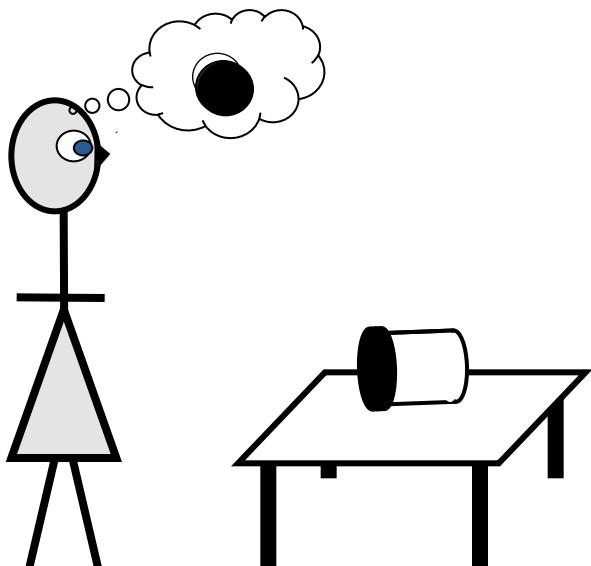


Corresponds to the
experiments described
so far

Level-2

Age~4

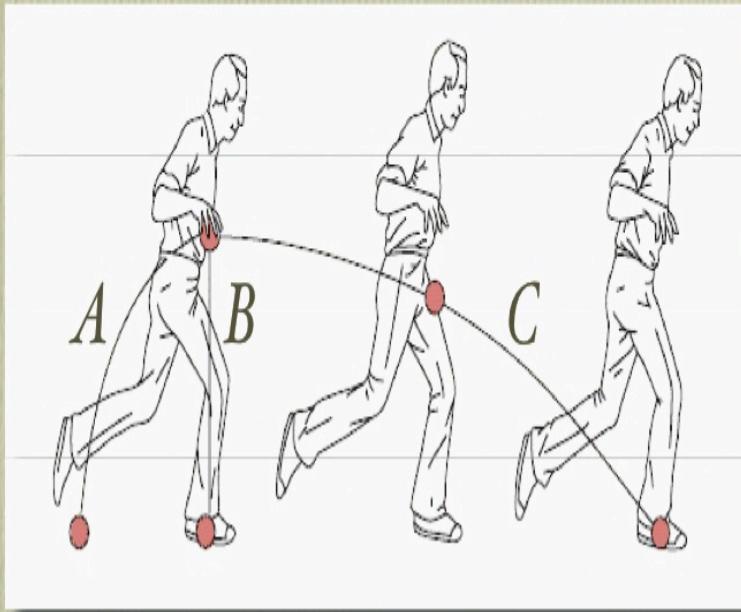
representation of: agent-
proposition



No evidence of
automaticity

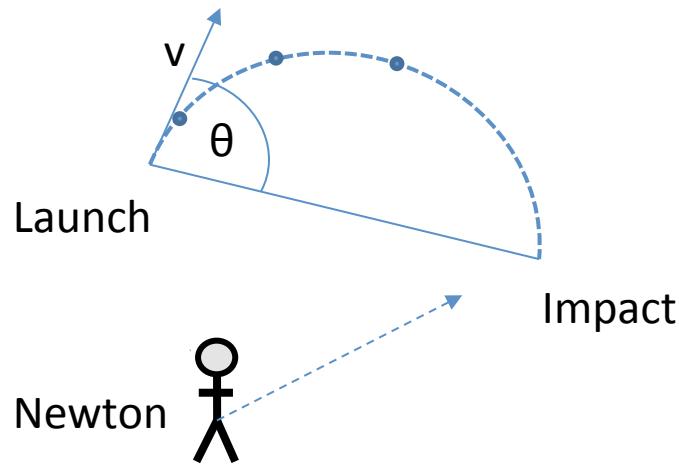
Example from the psychology of trajectories

Which of the three paths shown (*A-C*) most closely resembles the path taken by the ball?



If these judgements guided catching, we would not catch balls.

Example from the psychology of trajectories

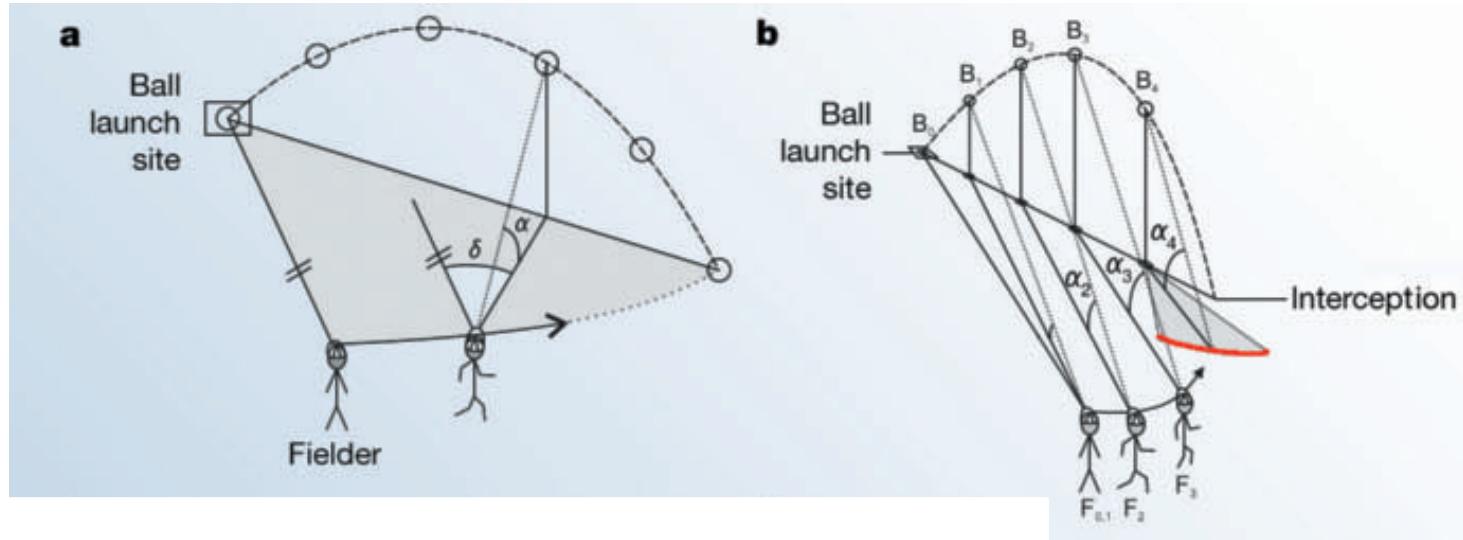


What Newton would have done.....

- A) Derive equation for trajectory of ball.
- B) Derive equation for one's own capacity to move.

Solve A and B simultaneously

Example from the psychology of trajectories



What England Cricketers do...

Fielders run so that their angle of gaze elevation to the ball increases at a decreasing rate, while their horizontal gaze angle to the ball increases at a constant rate (McLeod, Reed and Dienes, 2003)