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EXCEPT for the Gruffalo pictures that are Copyright Julia Donaldson and Axel Scheffler.

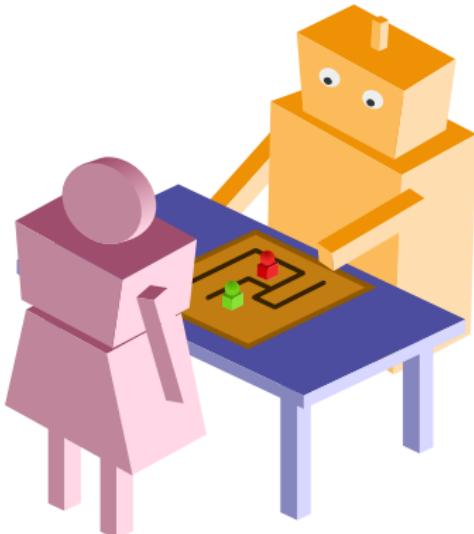


ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Mutual Modelling in Robotics

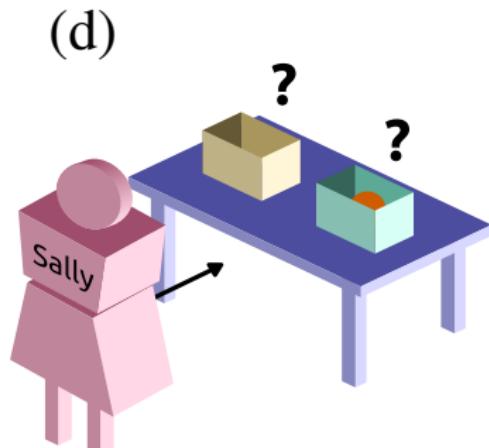
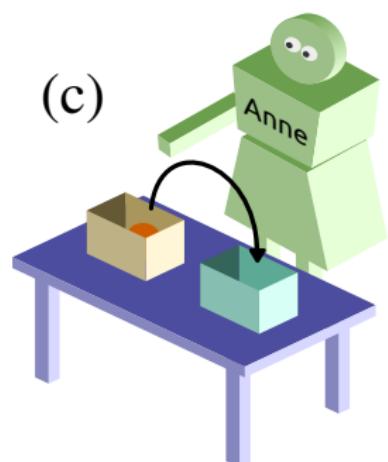
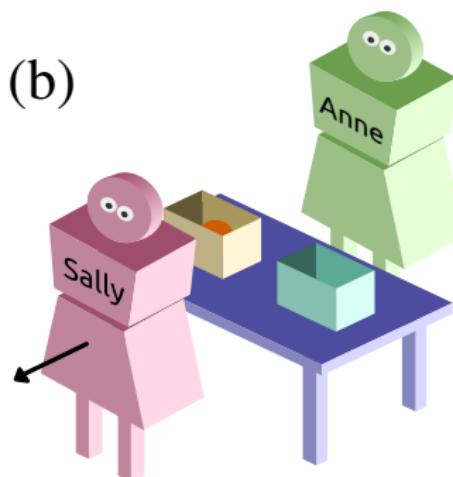
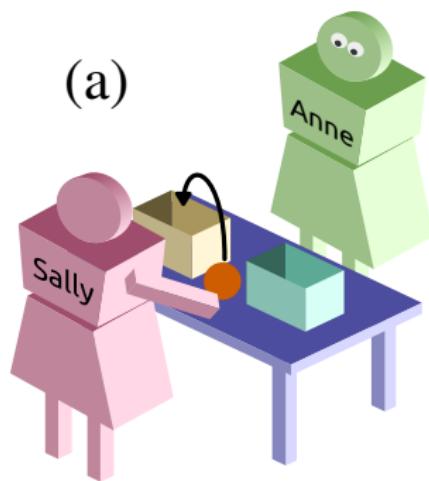
Inspiration for the Next Steps

Human-Robot Interaction, 2015, Portland



Séverin Lemaignan, Pierre Dillenbourg

Computer-Human Interaction
for Learning and Instruction **EPFL**



1- A GENTLE INTRODUCTION TO EPISTEMIC MODAL LOGIC WITH...

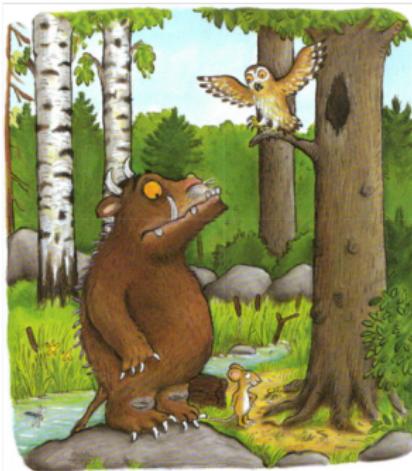


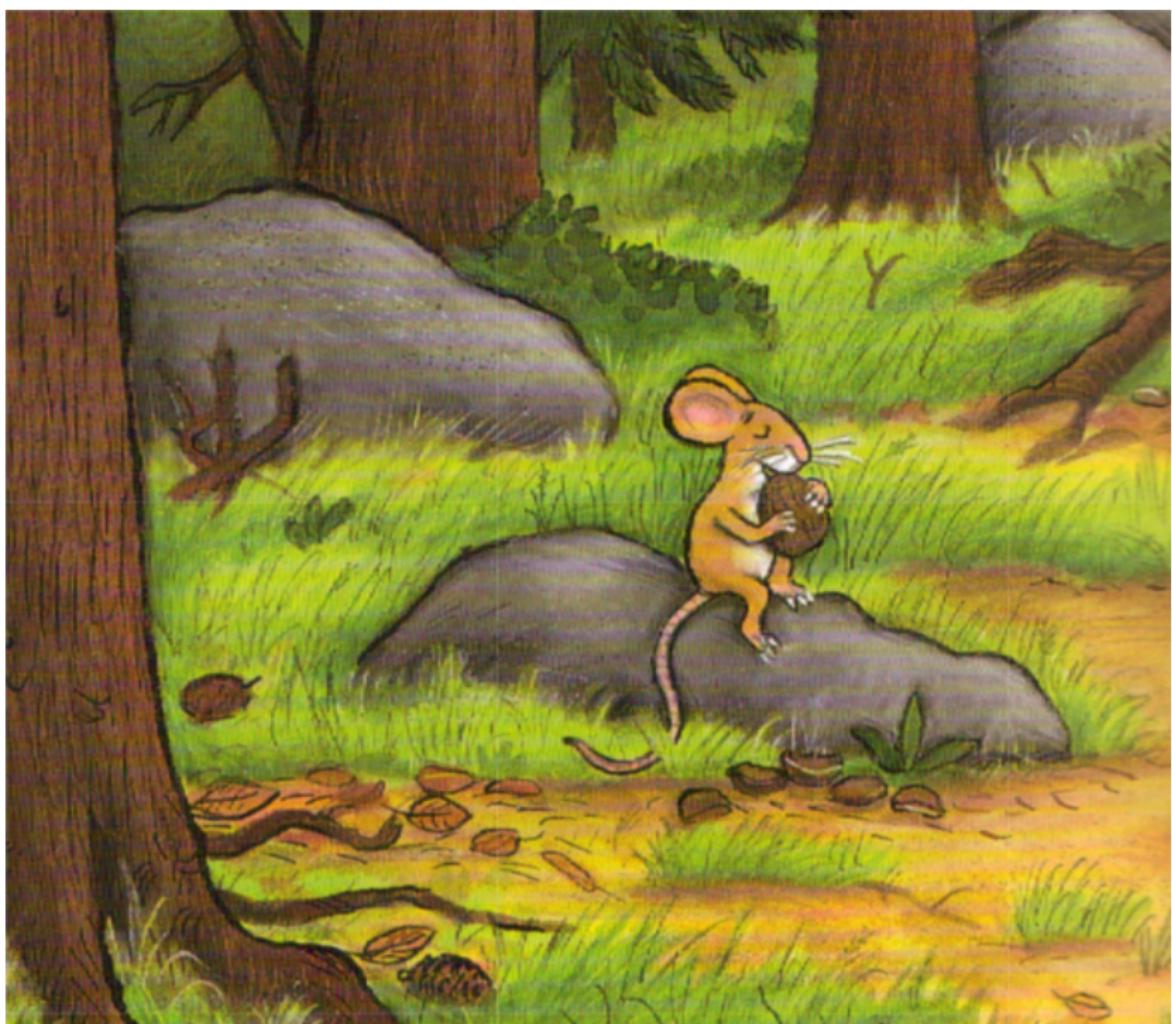




— Au secours! À l'aide!

C'est un gruffalo!





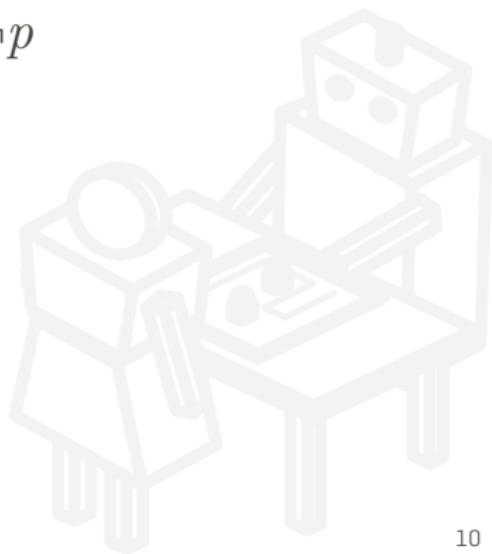
THE MOUSE IS AN EPISTEMIC LOGICIAN

K: epistemic operator "**knows**", B: doxastic operator "**believes**"

m stands for the mouse, f for the fox, g for the Gruffalo

p stands for $\exists g$

$$K_m \neg p \wedge K_m \neg K_f \neg p$$



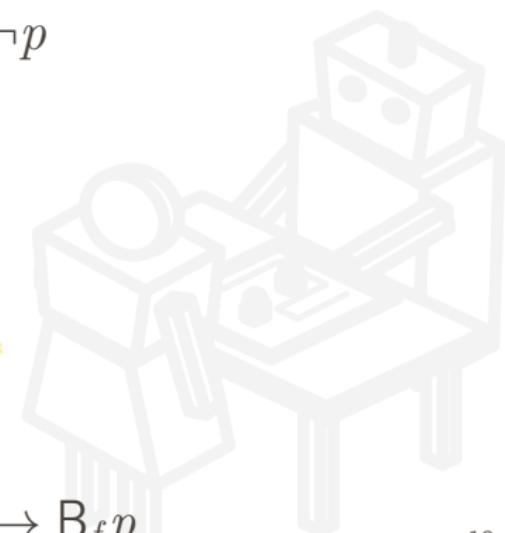
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m performs action $\rightarrow B_f p$

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p stands!



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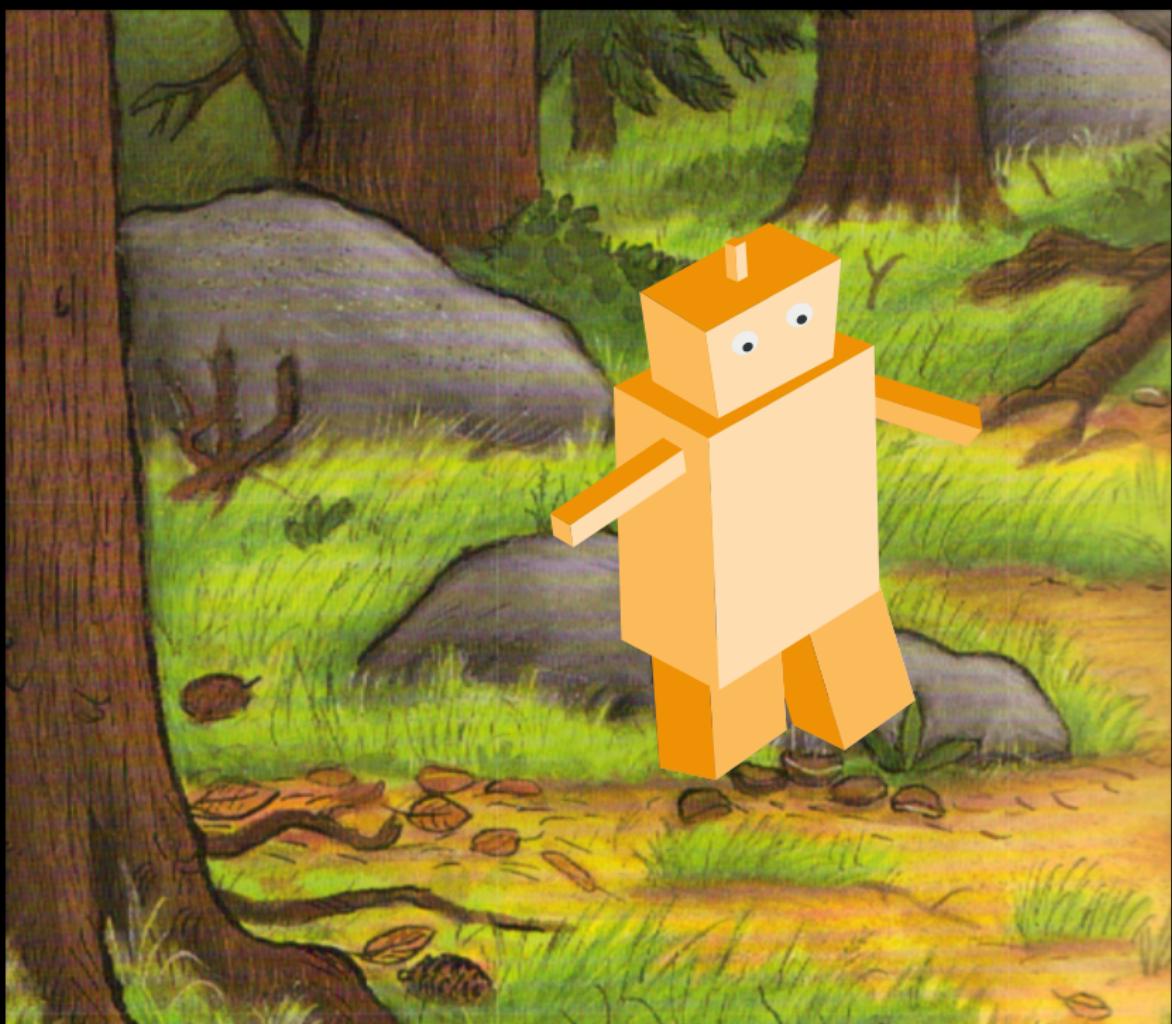
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K_{SEVERIN}(¬FUNNY)

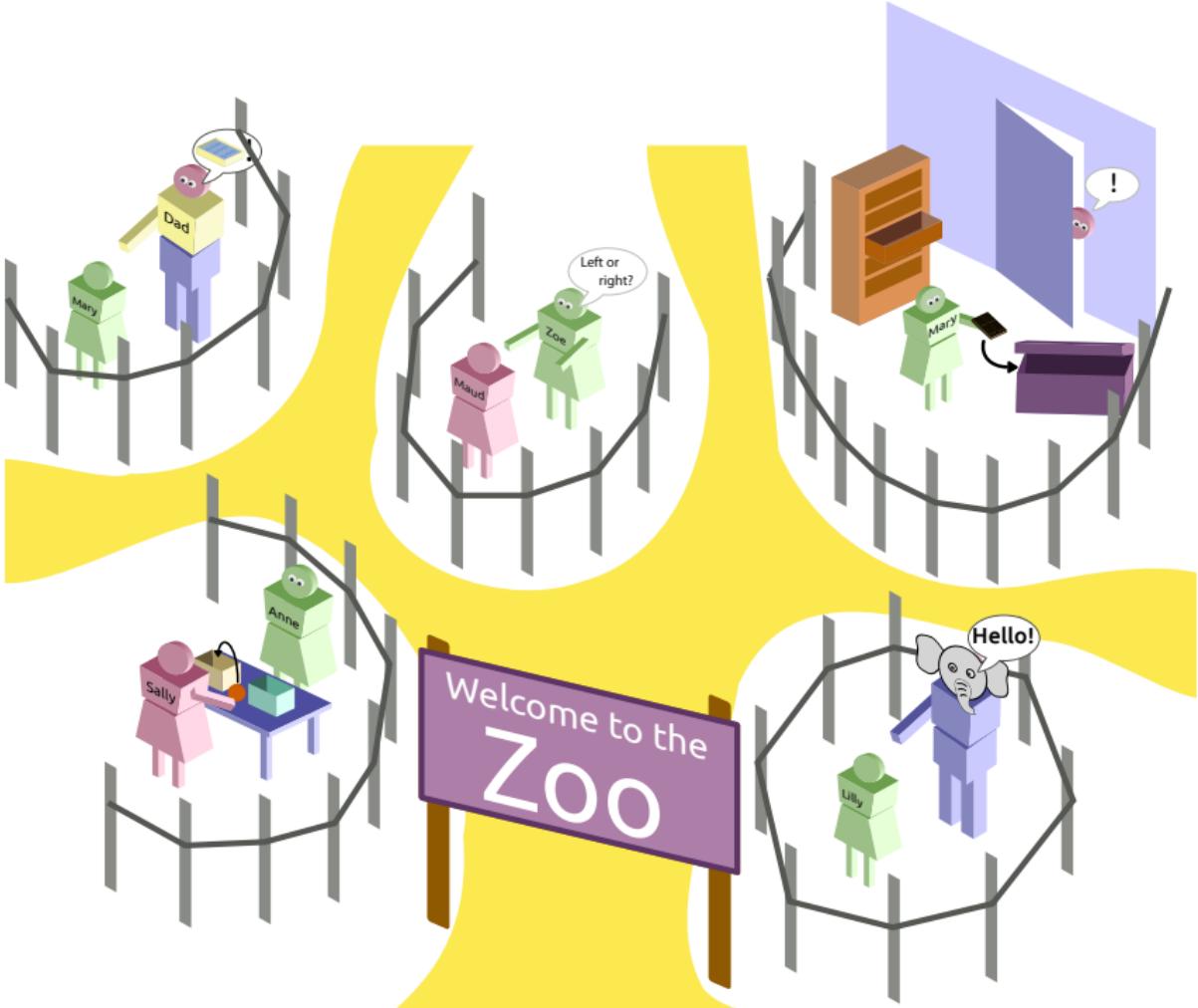
SHOPPING LIST FOR HRI?

In the HRI fridge...	To buy...
Instrumental gestures	Expressive gestures
Using person as tool	Using person as receiver of information
Talking about desires and emotions	Talking about beliefs and ideas
Showing "active" sociability	Showing "interactive" sociability
Elicited structured play	Spontaneous pretend play

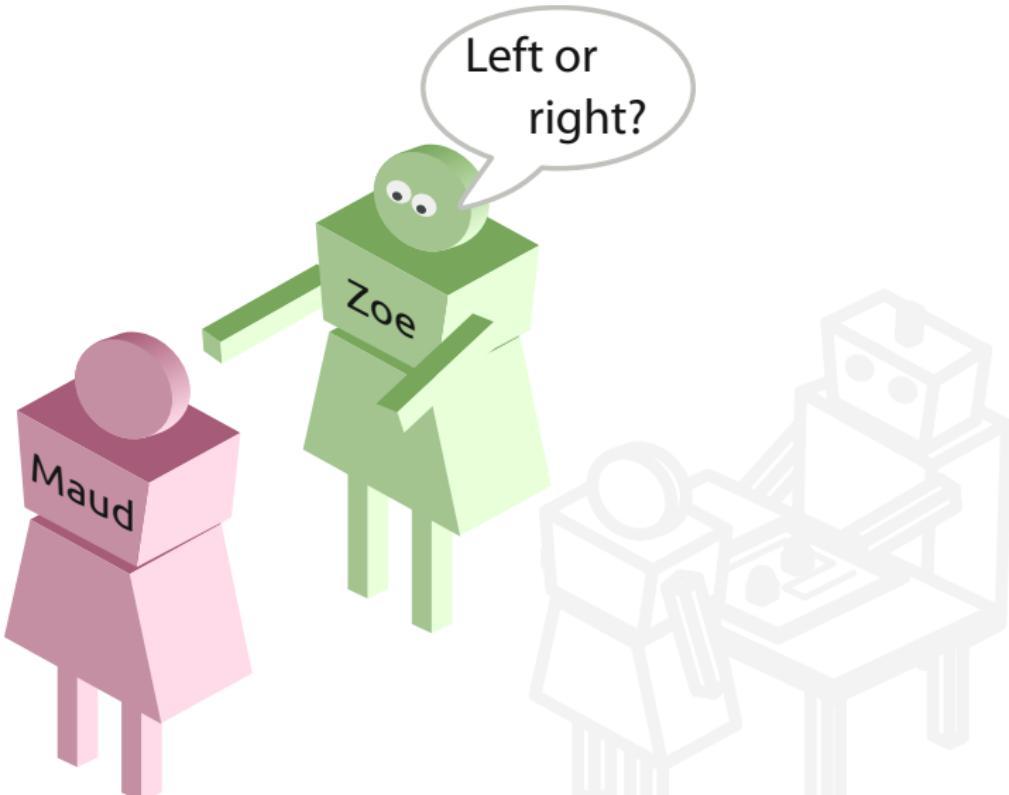
AUTISTIC ASSETS AND DEFICITS OBSERVED IN REAL LIFE

Assets	Deficits
Instrumental gestures	Expressive gestures
Using person as tool	Using person as receiver of information
Talking about desires and emotions	Talking about beliefs and ideas
Showing "active" sociability	Showing "interactive" sociability
Elicited structured play	Spontaneous pretend play

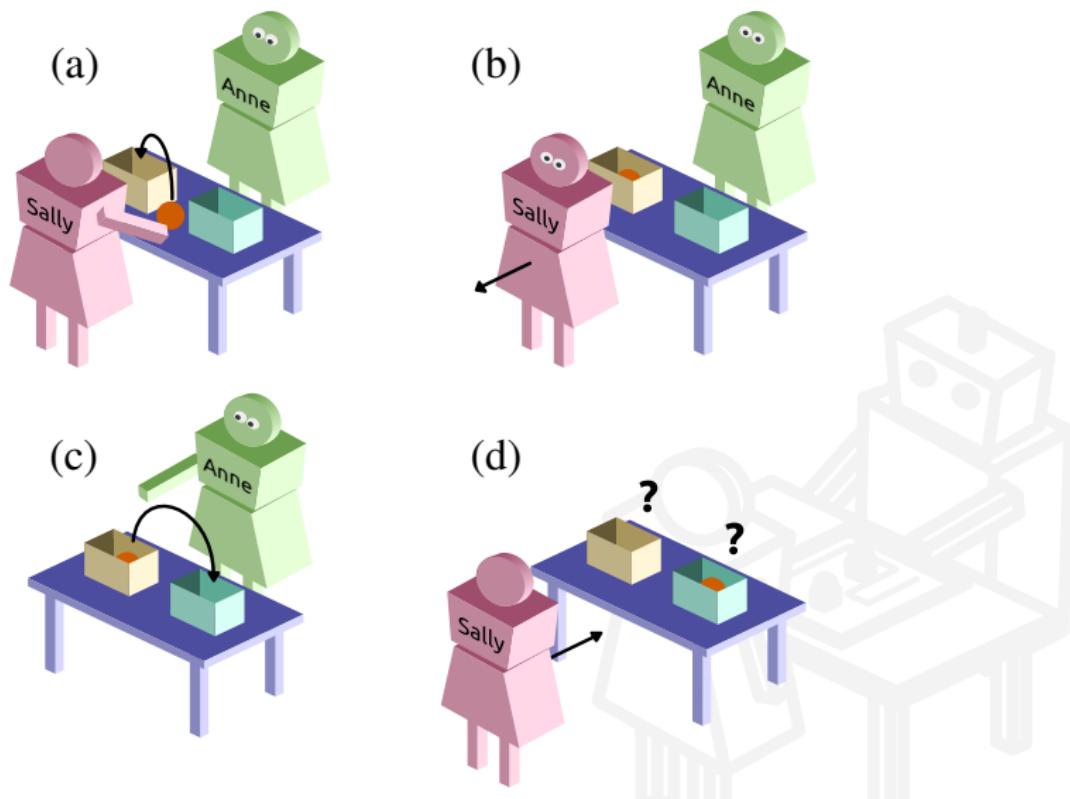
2- THE TASKS' ZOO



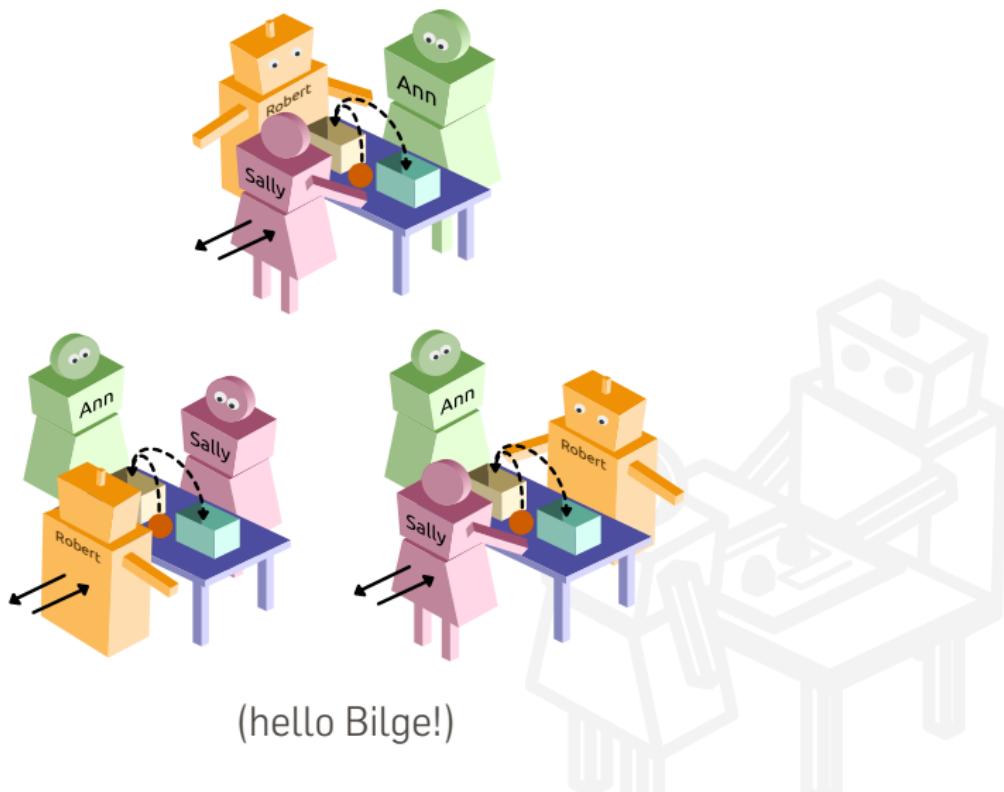
OBJECT OCCLUSION VS INFORMATION OCCLUSION



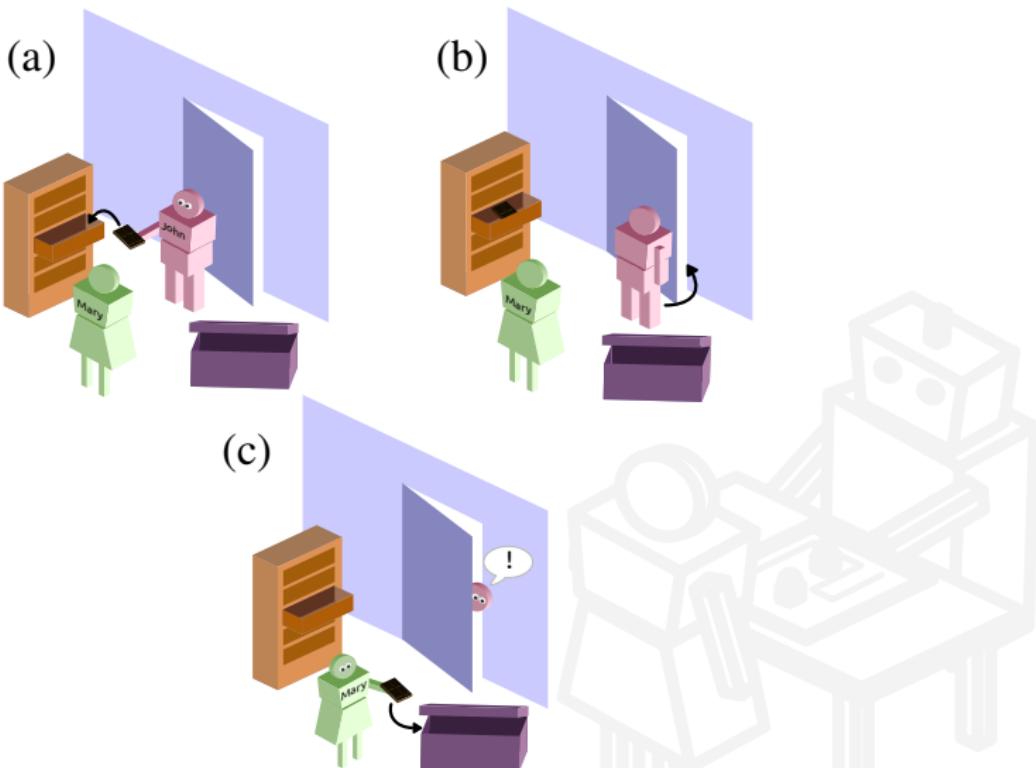
1ST ORDER TOM: THE FALSE-BELIEF EXPERIMENT



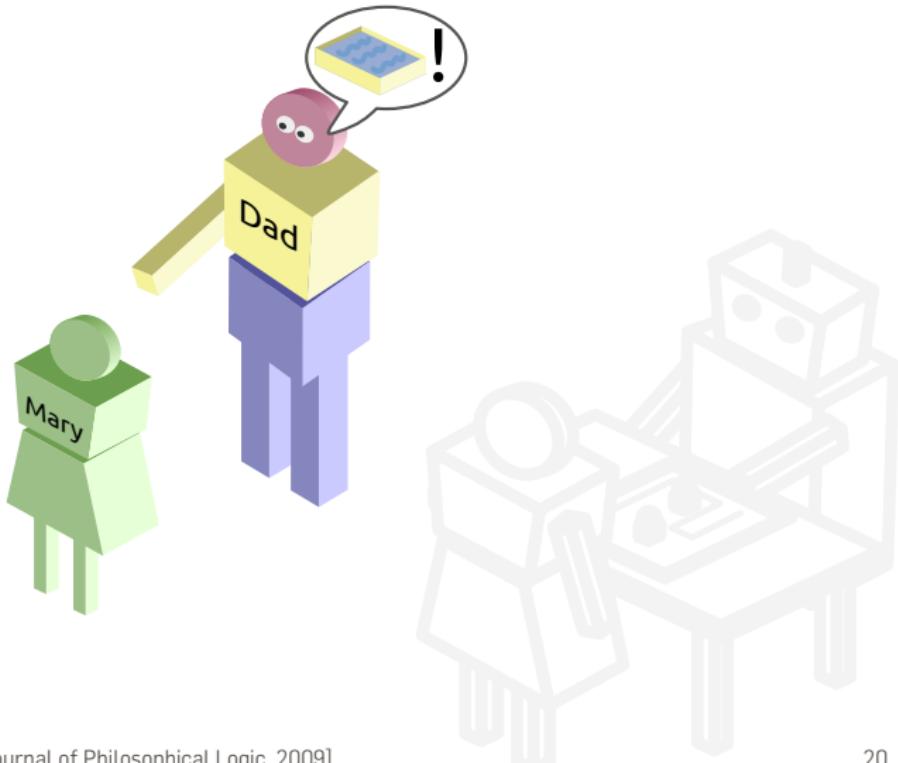
1ST ORDER TOM: THE FALSE-BELIEF EXPERIMENT



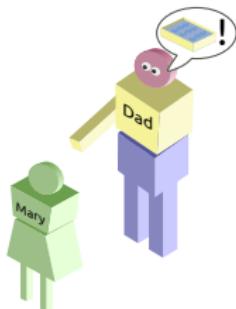
2ND ORDER TOM: THE CHOCOLATE BAR EXPERIMENT



AGREEMENT AS ∞ -ORDER TOM



AGREEMENT AS ∞ -ORDER TOM



Shared knowledge

$$EK_J\varphi \leftrightarrow \bigwedge_{i \in J} K_i\varphi$$



AGREEMENT AS ∞ -ORDER TOM



Shared knowledge

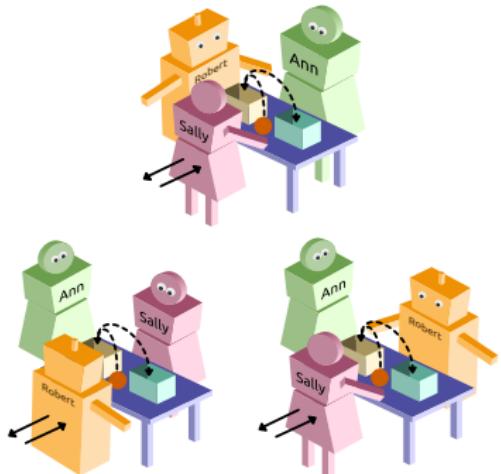
$$EK_J\varphi \leftrightarrow \bigwedge_{i \in J} K_i\varphi$$

Common knowledge

$$CK_J\varphi \leftrightarrow EK_J\varphi \wedge EK_J EK_J\varphi \wedge EK_J EK_J EK_J\varphi \wedge \dots$$



3- TRIANGLES, RECTANGLES

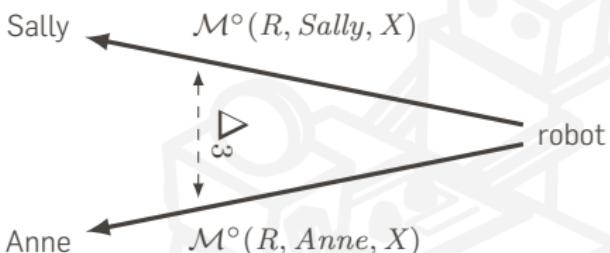
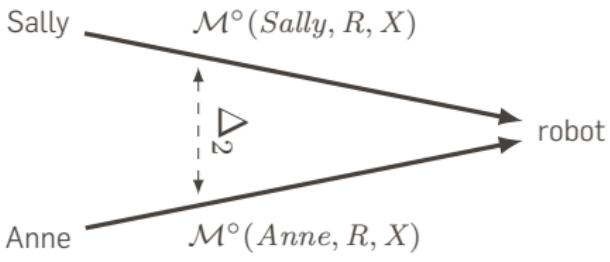
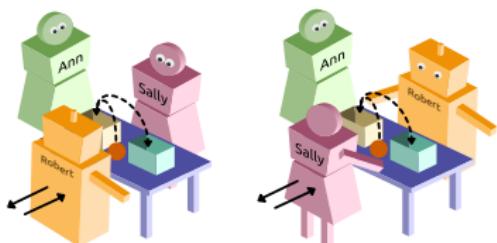


$$\mathcal{M}(A, B, X)$$

$$\mathcal{M}^\circ(A, B, X)$$

e.g. $\textcolor{teal}{\mathcal{M}}(\text{robot}, \text{Sally}, \text{plans})$





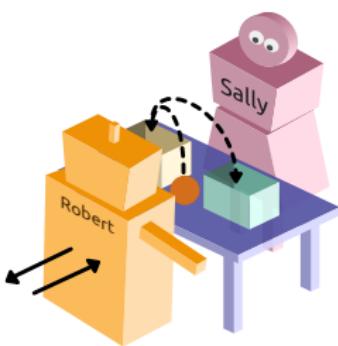
Do Sally and Anne have the same accuracy when modelling the robot?

$$\Delta_2 = \Delta(\mathcal{M}(\text{Sally}, R, X), \mathcal{M}(\text{Anne}, R, X))$$

Conversely, what may lead the robot to model more accurately Sally or Anne?

$$\Delta_3 = \Delta(\mathcal{M}(R, \text{Sally}, X), \mathcal{M}(R, \text{Anne}, X))$$

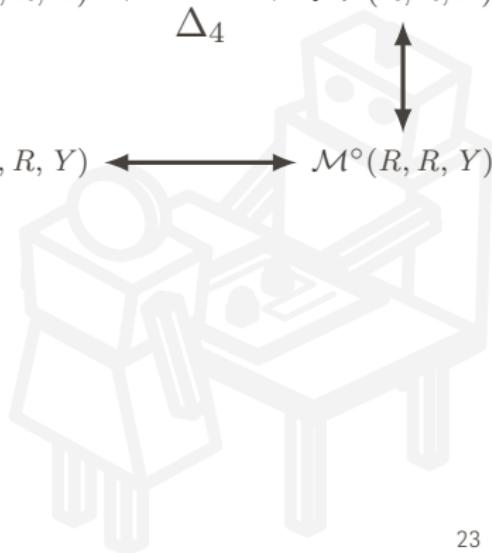




$$\mathcal{M}^\circ(Sally, R, X) \leftrightarrow \mathcal{M}^\circ(R, R, X)$$



$$\mathcal{M}^\circ(Sally, R, Y) \leftrightarrow \mathcal{M}^\circ(R, R, Y)$$



ALRIGHT, TAKE HOME MESSAGE

TAKE HOME MESSAGE

Read the litterature on autism in developmental psychology (and if only one paper, Frith and Happé's one): it certainly resonates to roboticists' ears



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The models found in CSCL raise practical questions that we may want to research too



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The models found in CSCL raise practical questions that we may want to research too

Even if deep learning is all hype, modal logics bring useful formal models to the table (and bridges to philosophy of mind as bonus).
We should give them another look.



Thank you!
severin.lemaignan@epfl.ch

— Au secours! À l'aide!
C'est un gruffalo!