Do robots have goals? How agent's morphology influences goal attribution in marmoset monkeys

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Introduction

The understanding of goals is a basic precondition for interpretation and prediction of actions of other individuals and for planning one's own action [1]. In young infants, goal attribution to inanimate agents seems to be coupled to presence of human-like features. Likewise, infants attribute goals to humans [2], humanoid robots [3] and puppets [4], but not to geometrical shapes [3], or mechanical devices [2].

The purpose of our study was to investigate the role of agent's appearance for the goal attribution mechanism in monkeys. We used the expectancy violation method used in preverbal studies with infants [2] to test whether common marmosets (*Callithrix jacchus*) (s. Fig 1) attribute goals to their conspecifics (experiment 1), monkey-like robots (experiment 2) and abstract geometrical shapes (experiment 3).

Experiment 1

Previous experiments have shown that common marmosets understand the goal-directedness of simple motor actions of human actors [5]. In our first experiment. we replaced the human actor by a conspecific and live presentation by videos thus standardizing the procedure and excluding cues coming from the experimenter (s Fig. 2).

Experiment 2

Human infants can extend their goal-attribution mechanism to human-like inanimate objects like humanoid robots [3] and puppets [4]. To test this ability in marmosets, in the second experiment (s. Fig 3), we replaced the conspecific agent by a monkey-like robot (modified version of Wow Wee 8096 - Robopet (s. Fig 4)

Experiment 3

Although preverbal infants attribute intentions to living agents, they are not necessarily able to do so when observing a mechanical device [2, 6]. We investigated, whether marmoset monkeys behave in the same way when they encounter inanimate entities, e.g. a moving box, which show no resemblance to a familiar actor (s. Fig. 5)

Methods

Stimuli Experiment 1

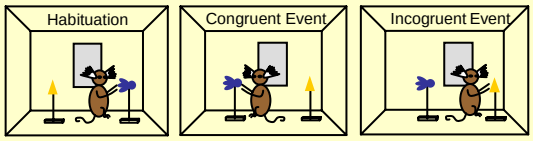


Fig 2: Three Conditions used in the experimental setting of experiment 1

Three Habituations	Repeated approaching of a certain object
Congrunent test event	Approaching the same object, different path
Incongruent test event	Approaching a different object, same path

Table 1: After three habituations, the subjects were presented with the congruent and the incongruent test events in a randomized order

Fig 1: Marmoset monkey

Fig 4: The robot used in the experiment

Fig3: **Stimuli Experiment 2**

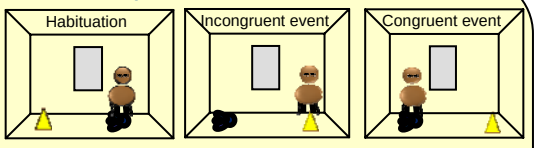
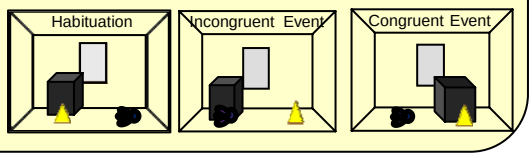


Fig5: **Stimuli Experiment 3**



Results

In the first and the second experiments, the monkeys looked longer at the incongruent test event than at the congruent test event (Repeated measures ANOVA: $F(1,2)=27$, $p<0.001$ and $F(1,2)=5,7$ $p<0.044$) respectively. Thus, the monkeys seemed to habituate to the goal of action, and not to its peripheral properties (e.g. path) (s. Fig 6, right, middle).

In the third experiment (s. Fig 6, left), the monkeys looked longer at the congruent event (ANOVAF$(1,2)=6.87$; $p<0.026$], suggesting that they did not attribute goals to the moving box.

In all three experiments, we could demonstrate a decrease of looking times over three habituation trials: [$F(1,2) = 68$; $P<0.001$], [$F(1,2) = 7,6$; $P<0.03$] and [$F(1,2)=7.8$ $p<0.003$] respectively.

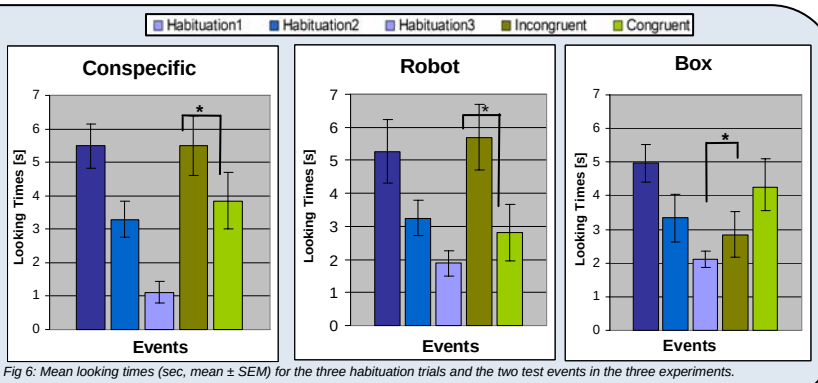


Fig 6: Mean looking times (sec, mean ± SEM) for the three habituation trials and the two test events in the three experiments.

Discussion and Outlook

The data from the first experiment confirmed the results from a previous study with human agents [5], providing additional evidence that common marmosets might be endowed with a capability to recognize goals. Although this capacity can be extended to non-human entities which exhibit human-like features or human-like behaviour in older infants and adults [6, 7], in preverbal infants, this mechanism fails if the actions are performed by inanimate objects with abstract features [2, 8].

Results from the second experiment suggest, that this extension of psychological reasoning works also for non-human primates, at least if the inanimate actors show animal-like features (like quadruped motion). The third experiment demonstrated, that in spite of self-propelled movement, the generalization mechanism for goal attribution requires at least some resemblance to a conspecific. Together with previous studies [3, 4, 6] our results provide indications that robots designed for human-robot interaction should exhibit at least some human-like features. A certain degree of anthropomorphism will enable people to use their experience from social interaction with other people and make their interaction with robots more intuitive.

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