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The goggles experiment: can chimpanzees use self-experience to infer what a competitor can see?

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In two experiments, we investigated whether chimpanzees, *Pan troglodytes*, can use self-experience to infer what another sees. Subjects first gained self-experience with the visual properties of an object (either opaque or see-through). In a subsequent test phase, a human experimenter interacted with the object and we tested whether chimpanzees understood that the experimenter experienced the object as opaque or as see-through. Crucially, in the test phase, the object seemed opaque to the subject in all cases (while the experimenter could see through the one that they had experienced as see-through before), such that she had to use her previous self-experience with the object to correctly infer whether the experimenter could or could not see when looking at the object. Chimpanzees did not attribute their previous self-experience with the object to the experimenter in a gaze-following task (experiment 1); however, they did so successfully in a competitive context (experiment 2). We conclude that chimpanzees successfully used their self-experience to infer what the competitor sees. We discuss our results in relation to the well-known 'goggles experiment' and address alternative explanations.

Mentalizing, or possessing a 'theory of mind', refers to the ability to ascribe unobservable mental states to oneself and others (Premack & Woodruff, 1978). Whether this ability is uniquely human or shared with nonhuman primates is still highly controversial. Advocates of great apes' mentalizing capabilities can by now list an abundance of studies that support their view (for reviews, see Andrews, 2005; Call, 2007; Call & Tomasello, 2008; Whiten, 2013). In contrast, sceptics are still not convinced and explain positive results by nonmentalistic processes, such as associative learning or inferences based on nonmentalistic categories (Heyes, 1998; Penn & Povinelli, 2007; Povinelli & Vonk, 2004). Some theorists doubt that distinguishing reasoning about another's mind from responding to behavioural cues alone will ever be possible, as inferences about another's mental state are inevitably based on their behaviour (Lurz, 2009; Purdy & Domjan, 1998; Shettleworth, 2010).

Heyes (1998) proposed one way to distinguish mentalizing skills from nonmentalistic processes. The design was later refined by Povinelli and Vonk (2003, 2004) and became known as the 'goggles experiment'. In this theoretical study, primate subjects first gain experience with two pairs of mirrored goggles in a training phase. From the outside, both goggles differ only in their rim colour. However, when wearing them, subjects experience one as opaque and the other as transparent. In the subsequent test phase, two experimenters wear the goggles such that one can see, while the other cannot. The subject is now allowed to beg for food from one of the experimenters. If primates are able to mentalize, they should use their own mental experience to infer the others' mental states, and prefer begging from the experimenter who wears the see-through goggles. Crucially, subjects never observe others interacting with the goggles, so effects from observational learning can be excluded.

Although well known and perhaps the clearest way of demonstrating mentalism in a nonverbal animal, there have since been few attempts to implement the study. Penn and Povinelli reported negative results for chimpanzees, *Pan troglodytes*, in a study in which they used (instead of goggles) buckets with opaque or see-through visors (Vonk & Povinelli, 2011). In contrast, Meltzoff and Brooks (2008) conducted a study with 18-month-old infants that resembled the goggles experiment. They provided two groups of children different experience with the view-obstructing properties of blindfolds. Both blindfold types looked opaque from the outside, but one could see through the 'trick blindfolds' when they were

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close to one's eyes, whereas the others were opaque and one could not see through them, even when they were close to one's eyes. After this experience phase, the infants' understanding of the other's sight was tested in a gaze-following task. A blindfolded experimenter sat opposite the child and looked at a target object to her left or right. The authors found that children who had experienced the opaque blindfolds followed the experimenter's gaze less than those who had experienced the trick blindfolds. Infants thus used their self-experience to infer what a blindfolded experimenter could see.

Like infants, chimpanzees follow conspecifics' and humans' gaze (e.g. Tomasello, Call, & Hare, 1998; Tomasello, Hare, & Agnetta, 1999). We thus decided to test chimpanzees' mentalizing abilities in an experiment similar to the infant study. Instead of blindfolds, we used 'face masks' that could be held in front of the eyes of the subject (experience phase) or the experimenter (test phase). One mask was opaque, the other a trick mask that looked opaque from the outside, but could be seen through when it was close to the eyes. In the test, a masked experimenter looked at a target object to her left or right, and we measured the subject's gaze-following response. We hypothesized that if chimpanzees were able to use their own experience to infer what the other can see, they would follow the experimenter's gaze less if they had experienced the opaque mask compared to the trick mask.

In a second experiment, we used a competitive paradigm to test the same question: can chimpanzees use their self-experience to infer what the experimenter sees? Previous research has shown that chimpanzees are more skilful in competitive than cooperative contexts (Hare & Tomasello, 2004). We thus hypothesized that it might be easier for chimpanzees to predict the other's perspective in this paradigm.

EXPERIMENT 1

Methods

Subjects

Subjects were 25 chimpanzees (11 males, 14 females) living at the Ngamba Island Chimpanzee Sanctuary in Lake Victoria, Uganda (mean age 15.5 ± 3.2 years, range 8–22 years; www.ngambaisland.org). All apes came to the sanctuary as orphans as a result of the illegal bushmeat trade, were raised by humans together with peers, and at the time of testing lived in social groups. All of them had experience with experimental testing due to previous research at the sanctuary. Subjects were fed according to their regular diet and were never food or water deprived.

Apparatus

The subject was tested individually inside the holding facility. The experimenter sat opposite the subject, at a distance of about 60 cm. There was a rectangular black board on the floor (50 × 100 cm) between the experimenter and the subject (Fig. 1). Three cameras recorded the session. One was placed behind the experimenter and recorded her movements to keep track of the experimental conditions; the other two cameras were to the left and right of the experimenter, 135 cm from the subject, at a height of 150 cm, and provided a close-up of the subject's face and upper body to keep track of her looking behaviour. Two identical, colourful plastic toys (25 cm high × 15 cm wide) hung right underneath the cameras as potential gaze targets.

We used four types of 'face masks', each shaped like a hand mirror (Fig. 2). A mask consisted of a yellow or blue frame (26 × 26 cm) on a handle bar (15 cm long, 4 cm diameter) and an opaque or fly screen inner layer (21 × 21 cm), resulting in the four different mask types: opaque-yellow, opaque-blue, screen-yellow and screen-blue. One could see through the fly screen when looking straight through, but not if looking from the side. The opaque and the screen layers looked the same when placed on a black surface (see Fig. 2). To maximize the similarity between both inner layer types, we added a layer of fly screen on top of the opaque layer, so that the surface structure was the same for both mask types. In the experience phase, we used small, colourful toys (7 × 11 cm) and pieces of fruit to draw the animal's attention to the mask. We did so by first showing the animal the object (toy or fruit) and subsequently positioning the mask between the subject's eyes and the object, such that she would look at the mask.

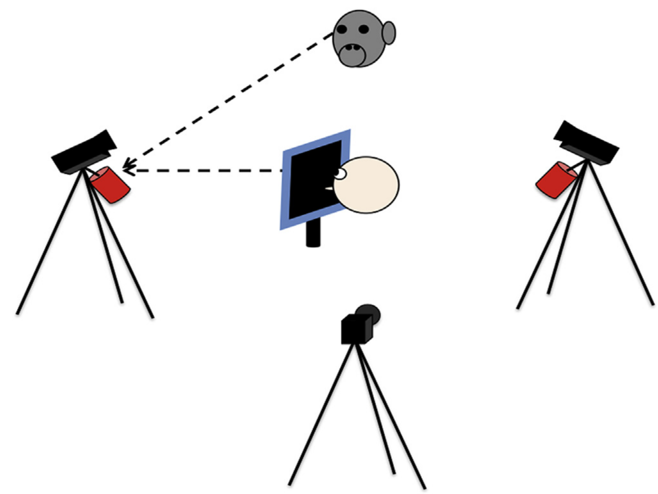

Figure 1. Set-up of experiment 1. In the test phase, the chimpanzee sat opposite the experimenter who was wearing a face mask and orienting towards a colourful object underneath the camera that recorded the subject's gaze-following behaviour.

Procedure and design

Each subject received two conditions in separate sessions on 2 consecutive days. We modelled our procedure as closely as possible on the infant study by Meltzoff and Brooks (2008). Each daily test session was split into the following two phases.

Experience phase. Subjects could gain experience with the properties of one mask type for 8 min; on the next day, she would experience the other mask type. The experimenter sat down in front of the subject and placed pieces of fruit or colourful toys on

Figure 2. Pictures of the face masks for experiment 1 as an example of the chimpanzees' experience in the training phase. On the left, the colourful toy on the black board is visible through the screen mask, whereas on the right, the toy is hidden behind the opaque mask.