Abstract

We investigated whether chimpanzees can use self-experience to infer what another sees in two studies. 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.

Keywords: Chimpanzee, experience projection, perspective taking, social cognition, theory of mind
The goggles experiment: Can chimpanzees use self-experience to infer what a competitor can see?

Mentalising, 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 non-human primates is still highly controversial. Advocates of great apes’ mentalising 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, skeptics 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 mentalising 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 mentalise, 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, such that 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 little attempts to implement
the study. Penn and Povinelli report negative results for chimpanzees 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 through the
“trick-blindfolds” one could see when close to one’s eyes, whereas the others were
opaque and one could not see through them, even when 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 to 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’ mentalising 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 close to the eyes. In the test, a masked experimenter looked to a target
object to her left or right, and we measured the subject’s gaze-following response. We
hypothesised 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 study, 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
compared to cooperative contexts (Hare & Tomasello 2004). We thus hypothesised
that it might be easier for chimpanzees to predict the other’s perspective in this
paradigm.

EXPERIMENT 1

Methods

Subjects

Subjects were 25 chimpanzees (Pan troglodytes; 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 (50x100 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 away from the subject, on 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 x 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 x 26 cm) on a handle bar (15 cm long, 4 cm diameter) and an opaque or fly screen inner layer (21x21 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 maximise 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 colourful small toys (7x11 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.
Procedure and Design

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

**Experience Phase.** Subjects could gain experience with the properties of one mask type for eight minutes; 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 the black board between them. When the subject fixated the object, the experimenter interposed the mask between the object and the subject’s eyes, such that the subject could learn about the mask’s properties (opaque/transparent, depending on condition). Subjects did not avoid looking at the mask and generally maintained their gaze direction after the mask was interposed, resulting in them looking at the mask. Multiple object exemplars in multiple spatial locations on the board were used to demonstrate that the screen mask did not block vision, and that the opaque one did. At the beginning of the experience phase, the experimenter held the mask close to the object, approximately 40 cm from the subject’s eyes. In the course of the eight minutes, she decreased the distance between the mask and the subject’s eyes up to a distance of about 10 cm. Even when the mask was close to the chimpanzees’ eyes, they sat still and maintained their general gaze direction, thus not showing signs of an avoidance reaction to the mask.

**Test Phase.** After the experience phase, we tested the chimpanzee’s understanding of the effect of the experienced mask type on the experimenter’s sight in a gaze-following task. First, the experimenter started an electronic device that gave an acoustic signal every second to keep track of the time. At the beginning of each
trial, the experimenter approached first the right, then the left camera and examined
the plastic toys to draw the subject’s attention to them. She then sat down opposite the
chimpanzee and fed her, with the mask lying on the black board in front of her. After
about one minute, she picked up the mask, held it close to her face, turned her masked
face (and head) 90 degrees towards the left or right camera (according to a predefined
scheme, never to the same side more than twice in a row, and left and right side
counterbalanced), and remained with her face aligned with the camera for 7 seconds.
Next, she laid down the mask and fed one to three more pieces of food to the subject
before the next trial started. Crucially, in the test phase, the opaque inner layer was
always inserted in the mask, such that in both conditions the mask really was opaque
(and the experimenter was just starring at the inside of the mask, but her gaze
direction aligned with the camera). We administered 8 test trials per session, with a 3-
minute repetition of the experience phase after the first 4 trials to remind the subjects
of the mask properties.
Each subject received each of the two conditions in separate sessions on two
consecutive days. Twelve of the subjects started with the opaque condition, the other
13 started with the screen condition. In each of the two condition groups, half of the
subjects started with a yellow frame, the other half with a blue frame. In their
following session, they received the other condition with the other colour. The
resulting four groups were counterbalanced for age and sex.

**Coding and Analysis**

We used the recorded data from all 3 cameras for the analysis. First, we
determined the relevant looking time intervals (the 7 seconds in which the
experimenter looked at the target) by analysing the central camera data that focused
on the experimenter’s head. We then analysed the recordings of the left and right camera separately for all looks to the camera within the 7 seconds per trial in which the experimenter looked towards the camera. Looks were coded as “camera look” when the chimpanzee lined up his or her eyes with a camera for at least 0.33 s (8 video frames). We differentiated the camera looks depending on whether the subject looked at the same camera as the experimenter (“correct look”), or at the other one (“incorrect look”). As subjects rarely looked to the cameras more than once within a 7-s trial, we coded presence or absence of at least one correct/incorrect look per trial and analysed the proportion of trials with correct and incorrect looking for each individual. In trials in which the subject’s eyes were not aligned with the camera (or in which subjects only glanced at the camera for less than 0.33 seconds), no correct or incorrect looks were coded.

For a better comparison to Meltzoff and Brooks’ (2008) between-subjects study with infants (who received only 4 trials each), we additionally analysed only the first 4 trials of each subject’s first session (resulting in a between-subject analysis of our originally within-subject data). Following Meltzoff and Brooks (2008), we scored the subject’s first target look for each trial as either a correct look (+1) or an incorrect look (−1). If infants did not look at either target during the 7-s trial, they received a score of 0. We then calculated a looking score for each subject as the sum of correct looks, incorrect looks, and nonlooks (as it is routinely done in gaze-following studies with children, e.g., Butler, Caron & Brooks 2000; Dunphy-Lelii & Wellman 2004).

Thus, the possible range for the looking scores across the first four trials varied from −4 to +4.

An independent observer coded a randomly selected 20% of the sessions. He was naïve to all test parameters. Interobserver agreement was assessed by Spearman’s
rho and was good for both the number of correct ($\rho = 0.78$, $P < 0.01$) and incorrect looks ($\rho = 0.89$, $P < 0.01$).

**Results**

The different experiences with the visual properties of the mask (opaque/transparent) did not affect the chimpanzees’ gaze-following behaviour towards the experimenter wearing that mask (repeated-measures ANOVA with condition, order and sex as between-subject factors: $F_{1, 21} = 0.012, P = 0.913, \eta^2 = 0.001$). In both conditions, chimpanzees looked at the correct camera in about 60% of the trials, whereas they looked at the incorrect camera in about 33% of the trials (Fig. 3).

We used a one-way ANOVA to assess the chimpanzees’ looking scores in their first 4 trials. Chimpanzees’ looking scores did not differ between the opaque and the screen condition, $F_{1, 23} = 1.03; P = 0.32$, although on average they looked less often to the target in the opaque condition ($M = 1.00, 95\% CI [-0.05, 2.05]$) compared to the screen condition ($M = 1.69, 95\% CI [0.63, 2.75]$). Overall, chimpanzees’ looking scores were higher than infants’ looking scores in both conditions (Infants: opaque condition: $M = 0.12\pm1.15$; screen condition: $M = 1.04\pm1.37$; Meltzoff & Brooks 2008).

**Discussion**

In this study, we adapted a study recently conducted with 18-month-old infants (Meltzoff & Brooks 2008) to chimpanzees to test their mentalising abilities. We did not observe any difference in chimpanzees’ gaze-following behaviour towards
an experimenter who was wearing a mask depending on whether they had
experienced that the mask was opaque or transparent. We conclude that there is no
evidence that chimpanzees in this study used their own visual experience to infer what
another can see. In contrast, 18-month old infants followed the gaze of a blindfolded
experimenter more when they had experienced that one could see through the
blindfolds, compared to having experienced that they were opaque (Meltzoff &
Brooks 2008).

This difference in the results of chimpanzees and infants could be due to a
methodological difference - we used masks instead of blindfolds. However, as the
masks covered the whole face instead of just the eyes, this should have made the
manipulation more obvious, not less.

Gaze following could also have a different ecological significance for
chimpanzees and children. Following another’s gaze in the rainforest as quickly as
possible might be a highly adaptive response with little energetic costs. The behaviour
might be more automatic and quick in chimpanzees than in humans, which could
render it unsuitable to capture higher cognitive processes like the computation of
another’s perspective. In our study, the subjects’ costs to follow the experimenter’s
gaze were particularly low as they did not have to switch position to see the gaze
target. This is reflected by the relatively high rates of gaze-following (about 60% of
trials) that chimpanzees in our study showed despite the opaque face mask in front of
the experimenter’s eyes. A study by Okamoto-Barth, Call & Tomasello (2007)
measured great apes’ gaze-following behaviour towards an experimenter who was
either looking through a window or at an opaque barrier (in 50 cm distance from the
experimenter’s face). Chimpanzees followed the experimenter’s gaze to the target
object in the window condition more (about 60%) than in the opaque condition (about
Chimpanzees in our study hence treated the face mask more like a window than an opaque barrier, but did so independent of condition. One reason for this might be that our subjects face more ecological challenges (e.g., snakes, more food competition) than the zoo animals in the study by Okamoto-Barth, Call & Tomasello (2007), and they might thus be more sensitive to gaze. It could also be that a flat barrier close to one’s face is rather rare and its effect less often experienced in everyday life (and thus more likely not be taken into account) than gaze-obscuring obstacles in some distance of another individuals’ eyes. Overall, our results also support previous findings that chimpanzees are more sensitive to the role of head movements when following gaze compared to the role of the eyes (see Tomasello, Hare, Lehmann & Call 2007).

Several studies have shown that chimpanzees take into account the geometric constellation of the looker and the object (Okamoto-Barth, Call & Tomasello 2007; Tomasello et al. 1999) and that adult, but not infant chimpanzees habituate when confronted with an experimenter who repeatedly looks towards nothing (Tomasello, Hare & Fogleman 2001). These results suggest that there is at least some degree of flexibility in chimpanzees’ gaze-following behaviour.

EXPERIMENT 2

In a second study, we used a competitive game to test the same question as in experiment 1, since competitive contexts have been quite successful in uncovering cognitive skills of chimpanzees (Hare & Tomasello 2004). Our set-up and procedure was inspired by a study from Melis, Call, and Tomasello (2006). We first established a competitive context by taking away food that the chimpanzee was trying to obtain and that the experimenter could see. In the subsequent test phase, the experimenter sat
opposite the chimpanzee with food in boxes to her left and right side. The boxes had
different lid types: opaque, transparent or screen. The opaque and the transparent lids
did not change their visual properties between their opened and their closed position.
In contrast, subjects could see through the screen in its open position, but not when it
was closed (the experimenter could, from her perspective, see through the screen in
both its open and its closed position). Subjects were first familiarised with the visual
properties of the lids; then the lids were closed and the subject could choose to steal
food from one of the two boxes – opaque vs. transparent box (transparent condition)
or opaque vs. screen box (screen condition). In a nonsocial control, we tested
chimpanzees’ general preference to reach into the opaque box (compared to a
transparent box), independent of the presence of a human competitor.

Melis et al.’s procedure was basically the same, but with tunnels instead of
boxes, and only two different tunnel types: opaque vs. transparent. The subject could
then reach the food either through an opaque tunnel that hid her approaching hand, or
through a transparent tunnel that did not prevent the experimenter from observing the
reach. Subjects had a significant preference for reaching through the opaque tunnel,
but such preference disappeared in a nonsocial control. While our transparent
condition basically replicated Melis et al.’s experiment, the screen condition was the
key to test chimpanzees’ mentalising abilities. We hypothesised that if subjects were
able to use their experience with the lid properties to infer what the experimenter sees,
they would prefer to steal from the opaque box, in which their hand was hidden from
the experimenter’s view. They would not show such a preference when the human
competitor was absent.

Methods
Subjects

Subjects were 19 semi-free ranging chimpanzees (Pan troglodytes) at the Ngamba Island Chimpanzee Sanctuary in Lake Victoria, Uganda (www.ngambaisland.org) (9 females, 10 males; age range 8 – 17 years, $M = 14.3$ years). All but one young male (Rambo, 8 years) had participated in experiment 1 before. All except one male (Kisembo, 14 years) passed the criterion that ensured that they understood the competitive nature of the game, such that 18 chimpanzees proceeded to the test. Subjects were fed according to their regular diet and were never food or water deprived.

Apparatus

The experimenter sat opposite the subject, 50 cm from the enclosure (Fig. 4). The bars between the experimenter and the subject were occluded (60 cm high, 100 cm wide).

There were two boxes to the experimenter’s left and right side (40x13 cm, 25 cm high on subject’s side; 65 cm apart from each other). Two sliding food trays could be inserted in the boxes and moved away from or closer to the subject by a handle bar. The subject could reach the food by sliding up a transparent trap door (10x8 cm) at the box side facing her and then reaching through a hole into the box (6.5 cm diameter). The boxes had exchangeable lids, so that they could either be transparent, opaque or covered with four layers of black fly screen. To maximise the similarity in surface structure between the opaque and the screen lid, we fixed a layer of fly screen on the opaque lid. The lids could be brought into a stable open position (40 degrees above horizontal), such that the subject would have a good view of the visual properties of the lids, in particular to experience the screen as see-through. When the
lids were closed, the subjects could still see through the transparent lid, and could not see through the opaque lid. However, the screen lid changed its apparent properties: the subject could now not see through it any more (see Fig. 5, for pictures). In contrast, the experimenter was still able to see through the screen from her perspective.

**Procedure and Design**

Each subject first had to pass a criterion training and, if successful, received three conditions in randomised order: the nonsocial control, the transparent and the screen condition. Subjects received each condition in two consecutive sessions with 12 trials each, summing up to 24 trials per condition and 72 trials in total.

**Training.** To familiarise subjects with the competitive nature of the task, subjects learnt that the experimenter would retrieve the food if she could see the subject reaching for it. The experimenter sat opposite the subject, with the two boxes to her left and right side. Both box lids were transparent and, at the beginning of each session, open. To demonstrate the transparency of the lids, the experimenter showed the subject 5 peanuts through each of the lids, starting on her right side and then taking turns. Next, the experimenter closed the lids. The trial started with the experimenter baiting the boxes, with the food out of reach of the subject. She centered the subject by placing some peanuts between the boxes, 160 cm above the ground. While the subject was climbing up to get the peanuts, the experimenter pushed the food towards the trap doors and turned with her head and body towards one of the boxes (left and right side counterbalanced within a session, with the constraint that the orientation could not be the same in more than two consecutive trials), so she could see the food item she was oriented towards, but not the other. When the subject climbed back down, she could see both food items through the transparent trap doors.
However, when the subject tried to grab the food item that the experimenter was looking at, the experimenter pulled it back. When the subject tried to grab the other piece, she was allowed to obtain it. After the subject had made a decision, both trays were pulled back, and the next trial started. Each session included 12 trials. Subjects had to choose the correct side in at least 10 out of 12 trials in two consecutive sessions to proceed to the test. If they did not succeed within 10 sessions, they were dropped from the study.

**Test phase.** Each test session started with 6 warm-up trials as in the training. They served to ensure the motivation of the subject on the testing day. The subjects proceeded to the actual test trials only if they chose the correct side in at least 5 out of 6 warm-up trials (only two subjects failed and successfully restarted their session on the following day). Each test trial started with opening the lids, and demonstrating the lid properties that differed between the sides (transparent/opaque/screen) to the subject by showing her a peanut, moving it behind the lid and back to the center. The peanut was then given to the subject. Two peanuts were presented on each side, always starting with the right side and then taking turns. Then the lids were closed and the trays baited. The experimenter centered the subject as in the training. While the subject was climbing up to get the peanuts, the experimenter pushed the food towards the trap doors. She remained with her upper body and head centered, so that she could observe both boxes. When the subject tried to reach for the food underneath the transparent or the screen lid, the experimenter could see her hand and pulled back the food. If the subject chose the opaque side, on which her hand was hidden from the experimenter’s view, she was allowed to take it. Note that the bars between the chimpanzee and the experimenter were occluded up to a height of 60 cm, so that the subject could hide her approach from the experimenter. The three conditions differed
in the following way:

*Transparent*. One lid was opaque, the other transparent.

*Screen*. One lid was opaque, the other a fly screen. Subjects could learn about the see-through properties of the screen while the lids were open. As soon as the lids were closed, both sides looked opaque to the subject, while the experimenter could still see through the screen. To help the subjects discriminate between the two closed lids, one of them had a green frame (whether the green frame was attached to the opaque or the screen lid was counterbalanced between subjects).

*Control*. To check for a general preference to choose the food underneath the opaque lid, we administered a nonsocial control. Everything was as in the transparent condition, with the only difference that the experimenter left the room after pushing the food towards the subject. The subject could then choose her preferred side independent of the presence of the human competitor. The experimenter returned after 10 seconds. If the subject was quick enough, she could get both food items.

We guarded against potential cueing by having the experimenter keep her body centered, her hands in her lap and look down in the middle between the boxes when the subject was approaching to choose. The subject could not see the experimenter’s eyes, and the experimenter could not see the subject’s body when it was close to the barrier.

**Coding and Analysis**

All trials were recorded by two cameras that focused on the boxes. For each trial, we coded which box the subject chose first by lifting the trap door (opaque/transparent/screen). An independent observer, naïve to all test parameters, coded a randomly selected 20% of the sessions. Interobserver agreement was
excellent \((\text{Cohen's kappa} = 0.99, P < 0.001)\). We ran a logistic regression in the R Statistical Computing Environment, using the glm function (with a binomial link function) in the lme4 package. We included trial number and order group as covariates, and we included condition as a factor.

Results

Subjects passed the training on average after 6 sessions (72 trials) (95% Confidence Interval \([5.21, 6.90]\), range 4-10 sessions). Only one male chimpanzee (14 years old) did not reach the criterion after 10 sessions (120 trials) and did not proceed to the test phase.

In the test, subjects selected the opaque box more frequently in the screen and transparent conditions than in the control condition (Fig. 6). Our primary analysis (see Table 1) included the control condition as the reference level of the Condition factor (which includes three levels: control, screen, and transparent). This models how behavior changes by moving from the control condition (i.e., the reference level) to the screen and transparent conditions. Results show that the estimates for the screen and the transparent condition were both positive, indicating that animals are more likely to choose the opaque box in both of these conditions than they are likely to choose the opaque box in the control condition. This difference is significant for both screen and transparent conditions, as the 95% confidence intervals for these estimates do not include zero, and the p-values for the for both were less than .05 (transparent-control: \(P = 0.04\); screen-control: \(P = 0.01\)). To explore the difference between the screen and the transparent condition, we used the same model but re-leveled the Condition factor so that screen was now the reference level (see Table A1). Now, examining the estimate for the transparent condition tells us whether animals are more
likely to choose the opaque box in the transparent condition than in the screen condition. The results show that there is not a substantial difference between the screen and transparent conditions because the estimate for the transparent condition is small, the 95% confidence interval includes zero, and the p-value is greater than 0.05 ($P = 0.63$).

We were also interested in whether chimpanzees’ choices were different from chance. We conducted one-sample t-tests and found that chimpanzees’ choice of the opaque box was significantly different above chance in the transparent ($t_{17} = 2.58$, $P = 0.020$) and in the screen condition ($t_{17} = 2.28$, $P = 0.036$), but not in the control ($t_{17} = 0.940$, $P = 0.36$).

When looking at individual performances, six (out of 18) subjects performed (non-significantly) above chance (50% choice of opaque box) in both the transparent and the screen condition, four subjects performed above chance in the transparent, but not in the screen condition, and four subjects performed above chance in the screen, but not in the transparent condition.

To assess learning over the course of testing, we compared each subject’s performance in the first and second session of the transparent and the screen condition to each other (Fig. A1), and in the first and last trial in these conditions (in the control, both lid types were rewarded, so there was no learning opportunity). We did not observe a change in subject’s choices of the opaque box between first and second session (paired-samples t-tests; transparent: $t_{17} = -1.25$, $P = 0.23$; screen: $t_{17} = 0.59$, $P = 0.56$) or between first and last trial within condition (related-samples McNemar Test; transparent: $P = 0.77$; screen: $P = 1.0$). As the choice of the opaque box was rewarded in the experimental conditions, we were interested in possible carry-over effects to the control. We thus conducted a between-subjects one-way ANOVA to
compare the effect of zero, one or two preceding experimental conditions on the
number of choices of the opaque box in the control. Without any previous experience,
subjects’ choice was close to chance with $M = 52.0\%$ (95% CI [45.5, 58.7]), and this
did not change significantly in control conditions after one or two preceding
experimental conditions; $F(2, 15) = 1.18, P = 0.33$ (control second: $M = 46.5\%$ (95%
CI [37.2, 55.9]); control last: $M = 46.5\%$ (95% CI [40.1, 53.0]).

Discussion

In this study, chimpanzees were allowed to steal food from an experimenter if
the experimenter could not see the stealing attempt. We found that chimpanzees
preferred to steal food from an opaque box when choosing either between an opaque
and a transparent box (transparent condition) or between an opaque box and a box
with a screen lid, that looked opaque from their, but not from the experimenter’s
perspective, but that they had experienced to be see-through earlier from a different
perspective (screen condition). Interestingly, subjects performed above chance in both
conditions, but not better in the (seemingly easier) transparent condition. In contrast,
chimpanzees did not show a preference for the opaque box when choosing between
opaque and transparent in a nonsocial control in which the experimenter was not
present at the time of stealing.

These results demonstrate that chimpanzees were able to use their own
experience with the visual properties of the lids to later infer in which box their
approaching hand would be hidden from the experimenter. Crucially, in the moment
of choice in the screen condition, both box lids appeared opaque from their
perspective (and both had a screen surface), but they had experienced earlier that one
could see through the screen from a different angle, but not through the opaque lid.
The results of our study confirm previous results by Melis et al. (2006) and extend them in important ways. First, we confirmed that chimpanzees conceal visual information by preferring the obscured approach route to the food over the exposed route when a human competitor is present. Notably, this preference was small both in our study (choice rate of opaque box: $M = 56\%$) and in Melis et al.’s study ($M = 57\%$), probably because our task is “at the limit of what chimpanzees are capable of” (Melis et al. 2006, p. 157). Chimpanzees did not maintain the same high level of performance in the test compared to the end of the training (at least 83\% correct); this was probably due to the higher cognitive challenge in the test, in which subjects could not rely on the experimenter’s body orientation, but had to use their own experience with the visual properties of the lids, compared to the training (in which they could rely solely on the salient cue of the experimenter’s body orientation), resulting in an additional memory problem. On top of that, subjects did not get training with the exact test situation (while they received an average of 6 sessions of experience with the requirements in the training). However, together with previous results (Hare, Call & Tomasello 2006; Okamoto-Barth et al. 2007; Tomasello et al. 1999) these studies consistently support the view that chimpanzees know what others can and cannot see in various situations, and that they can use this knowledge strategically in competitive or food begging contexts (see also Bräuer, Call & Tomasello 2005, 2007; Bulloch, Boysen & Furlong 2008; Hostetter, Cantero & Hopkins 2001; Hostetter, Russell, Freeman & Hopkins 2007; Tempelmann, Kaminski & Liebal 2011).

Second, our study adds to previous studies by confronting subjects with a situation in which they can only successfully compete if they project their self-experience with an object to the human competitor to predict what the other can see. This procedure bears the advantage that popular “lower-level” explanations for their...
success do not apply here: behaviour reading or learned behavioural rules (e.g., Heyes 1998; Penn & Povinelli 2007). We would like to address three prominent concerns.

1. Subjects could have merely reacted to behavioural cues of the experimenter, e.g., her body orientation or her gaze.

We can exclude this explanation as in the test, the experimenter’s body was oriented to the center between the boxes and her gaze direction was not visible to the subject as she looked down towards the box lids.

2. Subjects could have learnt about the effect of the lid properties on the experimenter’s vision by observing her interacting with the lids.

The experimenter treated all lid types in the same way. In addition, the lids were positioned such that the chimpanzee could never see the experimenter’s eyes through the transparent lid or the screen. However, the lid types were differentially rewarded – while subjects were allowed to steal from the box with the opaque lid, the experimenter retrieved the food from underneath the transparent or screen lid during a stealing attempt. Therefore, subjects could potentially learn to choose the opaque box in the course of the 24 trials of each experimental condition. However, we found no evidence of improvement over time. Subjects did not choose the opaque box more often in control conditions that were preceded by one or two experimental conditions, compared to naïve subjects’ choice behaviour in control conditions. Within conditions, we did not observe increased success rates in the second compared to the first session or in the first compared to the last trial. Thus, although subjects could have used e.g., the coloured frames as a learning cue, they did not improve over trials.

3. Subjects could have formed rules from observing other individuals in their natural environment and infer the experimenter’s behaviour from these rules.

For example, in a prominent set of studies (Hare, Call, Agnetta & Tomasello...
22000; Hare, Call & Tomasello 2001) subdominant chimpanzees reliably avoided food
that a dominant competitor could see or had seen in the past when competing with
him about two food items. While most other explanations could be excluded, one
potential lower-level explanation remained: In their every-day environment, subjects
could have learnt rules about the contingencies of the eyes of a competitor and
contested food, e.g., by imagining a line of sight between the competitor’s eyes and
the food (“evil eyes hypothesis”, see Povinelli & Vonk 2004). For this objection to
apply to our study, chimpanzees would need to have experienced others looking
through screens and then act as if they could see; it is unlikely that the subjects in our
study were ever exposed to such experiences as they live in a natural forest during the
day and have no previous experience with experiments involving screens or others
interacting with them. Moreover, in our study at the time of choice, the
experimenter’s line of sight seemed obstructed by the box lids from the subject’s
perspective for both the opaque and the screen lid. Only by projecting their
experience of being able to see through the screen in the training phase, subjects could
successfully avoid being caught stealing (see also Kaminski, Call & Tomasello 2008;
Schmelz, Call & Tomasello 2011).

However, we are aware of one additional alternative explanation for our
results. Following up the evil eye hypothesis, one could object that chimpanzees
imagined a line of sight between the experimenter’s eyes and the food, and imagined
the screen in the right position such that it would not block this line. Similarly, the
subjects could have learnt about the “psychological affordances” of the masks, such
as “able to be seen through” and “unable to be seen through”, instead of projecting
their visual experience to the competitor (see Meltzoff & Brooks 2008). The subject
could then use its everyday experience to avoid the food item that is unobstructed
from the competitor’s view. This explanation might require them to imagine the
screen from the experimenter’s perspective (as from their perspective, it is “unable to
be seen through” at the moment of choice), thus forming a mental representation of an
object that differs from their own. This skill, also known as level 2 perspective taking
sensu Flavell and colleagues (Flavell, Everett, Croft & Flavell 1981; Masangkay,
McCluskey, McIntyre, Sims-Knight, Vaughn & Flavell 1974) correlates highly with
classic mentalising skills such as false belief understanding and active deception in
children (even when controlling for age and language development (Bigelow &
Dugas 2009, Farrant, Fletcher & Maybery 2006). This suggests similar underlying
mechanisms, in particular the ability to envision perspectives that counter one’s own.
But even if subjects do not imagine the screen from the experimenter’s
perspective, the task at least requires them to learn about the psychological
affordances of the lids by learning how it affects themselves and applying it to others
(see Meltzoff & Brooks 2008).

GENERAL DISCUSSION

We ran two studies that tested chimpanzees’ ability to project their visual
experience with an object to a human to predict what she can see. While they failed to
do so in a non-competitive gaze-following task (experiment 1), they were successful
in a competitive context (experiment 2). In experiment 1, subjects first gained
experience with an opaque or transparent (but opaque-looking) face mask. Then we
measured their gaze-following behaviour towards a masked experimenter.
Chimpanzees did not take into account the different visual properties of the mask
while following the experimenter’s gaze. In contrast, Meltzoff and Brooks (2008)
found in a highly similar study that 18-month-old infants followed the gaze of a
blindfolded experimenter more when they had experienced the blindfolds as see-through rather than as opaque.

In experiment 2, we tested the same question in a competitive paradigm. Subjects could steal food from an experimenter by reaching into one of two boxes. If the experimenter saw the stealing attempt, she retrieved the food. In the key condition, both box lids seemed opaque from the subject’s perspective; however, they had experienced that from a different point of view, one of the lids (the screen) was see-through, while the other really was opaque. Chimpanzees preferred to reach for the food under the truly opaque lid, in which their approach was hidden from the experimenter, and avoided the screen lid through which the experimenter could see. In a nonsocial control condition, they did not show such a preference.

We argue that this study fulfils the requirements that skeptics propose to validly test mentalising skills in nonhuman primates (the ‘goggles experiment’, e.g., Heyes 1998; Shettleworth 2010). First, the cue on which the inference to the mental state was made was arbitrary – in the test situation, chimpanzees could discriminate between the box lids only by the frame colour or their location. Second, subjects did not have exposure to (human or non-human) others behaving in association with that cue, excluding the possibility of associative learning or “learnt behavioural rules” (and we did not find any learning effect over trials). And third, although both box lids looked opaque in the moment of choice, chimpanzees discriminated between their visual properties based on their previous self-experience, and used this knowledge appropriately to anticipate what the human competitor would be able to see. Note, however, that not all researchers accept the goggles experiment as a valid test of mental state attribution (e.g., Csibra 1998; Lurz 2009; Perner 2010). Their key point is that we do not know whether chimpanzees (and other non-human animals) experience
“seeing” as a mental state themselves, or whether they reason about “seeing” (even
their own experience of it) non-mentalistically – for instance, by experiencing seeing
as having an unobstructed line of sight on an object. Thus, even if we find that
chimpanzees project their own experience to others, some authors argue that this does
not necessarily indicate that they project mental states to others. As Csibra (1998)
puts it:
“Seeing is a mental concept if, and only if, it refers to an epistemic relation
between a mind and an object/event that is established in a particular (visual) way;
but it is not a mental concept when it refers only to the physical relations that may or
may not give rise to the epistemic relation. Accordingly, demonstrating that animals
can understand such a physical relation and can use it as a discriminatory cue to
predict the usability of people’s behaviour is not sufficient evidence for applying
mental concepts. What is needed in addition is to demonstrate that the animals
conceive the result of seeing as a representational rather than a dispositional state.”
(Csibra, 1998; p. 118)
But if chimpanzees are able to project their self-experience to others (in
whichever form), why did they not show differential gaze-following towards a
masked experimenter, depending on whether they experienced the mask as opaque or
transparent before (experiment 1) - in particular, as 18-month-old infants successfully
do so (Meltzoff & Brooks 2008)? Several factors might account for this discrepancy.
First, chimpanzees often show clearer outcomes in competitive situations, possibly
due to their highly competitive environment in hierarchically organised groups (Hare
& Tomasello 2004). In contrast, in the human world cooperation is a key feature for
successful adaptation, and human infants have a natural tendency to cooperate from
early on (Tomasello 2009). This difference in ecological demands might explain why
18-month old human infants succeeded in Meltzoff and Brooks’ (2008) study, while chimpanzees failed in our highly similar study. Second, whereas the gaze following required in experiment 1 is a quick and rather automatic response (although adult chimpanzees have demonstrated some flexibility in gaze following, e.g., they take into account the presence of barriers (Okamoto-Barth et al. 2007), and stop following the gaze of someone who repeatedly looks towards nothing (Tomasello et al. 2001), in experiment 2 chimpanzees had unlimited time to think about which box to choose. Although in humans, sociocognitive processes such as perspective taking have been proven to be fast and sometimes even involuntary (e.g., Samson, Apperly, Braithwaite, Andrews & Bodley Scott 2010; Surtees & Apperly 2012), these processes might be computed slower in great apes, and thus be captured better with more explicit behavioural measures. Third, while subjects could use only the frame colour as a cue to the visual properties of the mask in experiment 1, they could use frame colour and/or location of the lid (left/right of the experimenter) as a cue in the second study. Obviously, the location of the rewarded lid varied randomly between the trials; however, in the experience phase of each trial, they could not only learn about the frame colour, but also about the location of the (truly) opaque lid. Several studies demonstrate that chimpanzees have difficulties with quickly associating arbitrary cues such as colour with the presence of food (e.g., Call 2006; Jarvik 1953, 1956), which might account for their indiscriminate gaze-following behaviour in experiment 1. Other studies show that chimpanzees prefer location to colour as a cue to find food (e.g., Haun, Call, Janzen & Levinson 2006; Tinklepaugh 1932; but see also Kanngiesser & Call 2010, for contradicting results). The additional informative spatial feature might thus have helped chimpanzees to choose the correct box in experiment 2.
After dozens of positive findings that show that chimpanzees understand what
others see or hear (Bräuer et al. 2007; Hare et al. 2000; Melis et al. 2006), prefer
(Schmelz, Call & Tomasello 2013), know (Hare et al. 2001; Kaminski et al. 2008),
attend to (MacLean & Hare 2012), intend (Behne, Carpenter, Call & Tomasello 2005;
Buttelmann, Carpenter, Call & Tomasello 2007; Call, Hare, Carpenter & Tomasello
2004; Call & Tomasello 1998; Warneken & Tomasello 2006), and infer (Schmelz et
al. 2011), this study provides additional evidence that chimpanzees possess
mentalising capacities revealed by a different and powerful method. Because subjects
used their self-experience to infer what the competitor saw, the current results might
fit best with Meltzoff’s “Like Me” framework (2007).

Overall, we thus agree with Whiten’s recent evaluation of the state of the art
of the field (Whiten 2013): “Humans are not alone in computing how others see the
world”. As the methodology of the current study is based on suggestions of skeptics
in the field, it would seem to constitute especially powerful additional evidence for
this proposal.

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7687.2007.00630.x


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APPENDIX

TABLES

Table 1 Results of the General Linear Model determining whether trial number, condition order or condition influences chimpanzees’ choices of the opaque box

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
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<th>P</th>
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<tr>
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<td>0.152</td>
<td>0.880</td>
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<td>0.008</td>
<td>0.363</td>
<td>0.716</td>
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<tr>
<td>Condition Order</td>
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<td>0.068</td>
<td>-0.958</td>
<td>0.338</td>
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<tr>
<td>Screen</td>
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<td>0.137</td>
<td>2.587</td>
<td>0.010 **</td>
</tr>
<tr>
<td>Transparent</td>
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<td>0.137</td>
<td>2.110</td>
<td>0.035 *</td>
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</table>

Significance codes: ‘***’ 0.01, ‘**’ 0.05

Table A1 Results of the General Linear Model determining whether trial number, condition order or condition influences chimpanzees’ choices of the opaque box, with the screen condition as the reference level

<table>
<thead>
<tr>
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<tr>
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<td>0.008</td>
<td>0.363</td>
<td>0.716</td>
</tr>
<tr>
<td>Condition Order</td>
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<td>0.068</td>
<td>-0.958</td>
<td>0.338</td>
</tr>
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<td>Control</td>
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<td>0.137</td>
<td>-2.587</td>
<td>0.010 **</td>
</tr>
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<td>0.137</td>
<td>-0.480</td>
<td>0.631</td>
</tr>
</tbody>
</table>

Significance codes: ‘***’ 0.01
FIGURE CAPTIONS

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

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

Fig. 3 Mean percentages of trials with at least one correct (grey bars) or one incorrect look (white bars) in the opaque and screen conditions. Error bars refer to 95% CI.

Fig. 4 Set-up of experiment 2. (a) Apparatus with open lids from the experimenter’s perspective. (b) Training phase. The chimpanzee can see the peanuts through the screen lid on his left side, but not through the opaque lid on his right side. (c) Test phase. Both lids are closed and now appear opaque to the subject, whereas the experimenter can still see through the screen. The chimp can now decide to lift and reach through one of the trap doors to steal a banana piece. Note that the space between the chimpanzee and the experimenter was occluded up to a height of 60 cm (lower breast height of the experimenter; not depicted in the picture) such that the experimenter could not see which side the chimpanzee chose until observing the subject’s hand in one of the boxes.

Fig. 5 Pictures of the box lids in the screen condition in their open (above) and their closed position (below) from the subjects’ perspective. The screen lid is on the left, the opaque lid on the right side.
Fig. 6 Mean percentages of trials with the choice of the opaque box across the three conditions. In the transparent condition, one lid was opaque, the other transparent. In the screen condition, one lid was a screen, the other opaque. The control was like the transparent condition, but without the experimenter’s presence at the time of choice. Error bars indicate 95% CI, ‘*’ indicates $P < 0.05$, ‘**’ indicates $P < 0.01$.

Fig. A1 Comparison of the chimpanzees’ choices of the opaque box in the first (white bars) and second session (grey bars) of the transparent and the screen condition in experiment 2. Error bars indicate 95% CI.
Fig. 1
Fig. 2
Fig. 3
Fig. 4
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Fig. 6
Fig. A1