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Chimpanzee Theory of Mind: A Proposal from the Armchair

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Abstract

The issue of whether Chimpanzees have a Theory of Mind is still not settled. In this paper, I look at the reasons why and make a proposal for an experimental paradigm, inspired by work on autistic children, that could settle the issue.

Introduction

The first accounts of primate tactical deception in the wild were recorded at Jane Goodall's Gombe Stream research camp in the late 60's. Goodall (1988) described the behavior of a young, low-ranking chimpanzee named Figan, who had spotted a banana placed by researchers at the top of a tree. Yummy. Only one problem - the tree was in plain view of Goliath, one of the highest ranking males. Goodall recounts, "After no more than a quick glance from the fruit to Goliath, Figan moved away and sat on the other side of the tent so that he could no longer see the fruit. Fifteen minutes later, when Goliath got up and left, Figan without a moment's hesitation went over and collected the banana." (Goodall, 1988, pp96-97) The interpretation arrived at by Goodall, well versed as she is in human Theory of Mind, was that Figan left the scene to prevent himself from gazing at the banana and attracting the attention of Goliath, who would no doubt spot it and eat it himself.

There are at least two ways one could account for behavior such as the above. The chimpanzee enthusiast would reckon Figan to be a savvy primate folk psychologist and reason as follows. Figan knew that Goliath would take the banana if he could because, ceterus paribus, Goliath always eats bananas when he can and no low-ranking male like Figan can prevent this. Figan understood that in order to take the banana, Goliath would have to know where it was, which explained why he hadn't taken it up to now. Furthermore, Figan understood that if Goliath saw him looking at the banana, he would follow his gaze and see the banana himself, which would lead him to the knowledge that there was a banana in the tree, which would cause him to desire the banana, which would cause him to go and get the banana. Finally, Figan understood that if he left the scene and was not seen by Goliath to be gazing at the banana, Goliath would not, ceterus paribus, see the banana or form any beliefs about its whereabouts. Note that to make this chain of reasoning work, Figan had to understand that there is a difference between the real state of the world and Goliath's beliefs about the state of the world. That is, Figan must have had access to a Theory of Mind (ToM) powerful enough to account for false beliefs.

But a skeptic would suggest that Figan did not have to have any kind of understanding of the mental states of other animals in order to exhibit this kind of deception. First, Figan would learn by association that high-ranking males (specifically Goliath) usually get to take food before he does. Secondly, he would have learned from past experiences that if he saw a banana and made a move towards it, or even looked at it too much in the presence of a high-ranking male, then that male (for some reason) always seemed to get the banana first. Finally, he would have learned from experience that if one stays in one place for long enough, one will eventually be alone. In the production rule style of Byrne and Whiten (1991), Figan would have learned something like this:

(banana) & (high-ranking male) => (don't look at banana)
(high-ranking male) & (need high-ranking male gone) => (wait)
(banana) & (no high-ranking male) => (get banana)

Evidence for chimpanzee ToM was initially greeted with both enthusiastic and skeptical responses. Laboratory experiments by Premack and Woodruff (1978) seemed at first to confirm the enthusiastic interpretation, but in the intervening years the enthusiasm waned to the point that even Premack (1991) now judges that the jury is still out. How to make the final judgement between the enthusiastic and skeptical points of view is the topic of this paper. I will briefly review research on normal and autistic human children to see what we have learned about human ToM and how to tease it out in experiments, then I will take an equally brief but critical look at the parallel literature dealing with ape ToM to see why it is that the conclusions must still be up in the air. Finally, I will make a proposal for a new type of experiment that could perhaps help to settle the question.

Human Theory of Mind

Normally developing humans from around age 5 onwards understand that there is a difference between the way the world is and the beliefs that people have about the world.

They understand that in order for a person to have a correct belief about some aspect of the world, that person has to somehow come by the relevant information, perhaps by perceiving the facts for themselves, perhaps by being told the relevant information, or perhaps in some other manner. Crucially, normal adult humans understand that there can be a mismatch between a person's beliefs about the world and the actual state of the world - that is, people can have *false beliefs*. But severely autistic people seem to be impaired in this regard. They always expect everyone else to believe the same things about the world that they do. Two of the strands of research that have focussed on ToM in autistic people are the research on *False Belief Ascription* and *Deception*. I will consider each separately.

False Belief Ascription: Sally and Anne

One of the most famous tests for false belief ascription is the Sally/Anne test. Sally enters a room and hides a marble in a box. Then she leaves and Anne enters. Anne moves the marble from one box to another and leaves. Then Sally returns. Where will Sally look for her marble? Autistic individuals and children under age 5 will usually incorrectly state that Sally will search for the marble in its new location. They seem unable to ascribe false beliefs to others and/or reason about these false beliefs, implying a specific representational deficit for mental states. (Baron-Cohen et al., 1985) Furthermore, there is evidence for a double dissociation of ToM from the rest of cognition. Autistic children seem to be unimpaired in performance on tasks that involve ordinary representations (of things other than mental states), whereas other types of mentally retarded individuals (e.g. those with Downs Syndrome) can pass the Sally/Anne test but fail many tests involving ordinary representations (see Baron-Cohen and Ring, 1994 for a review).

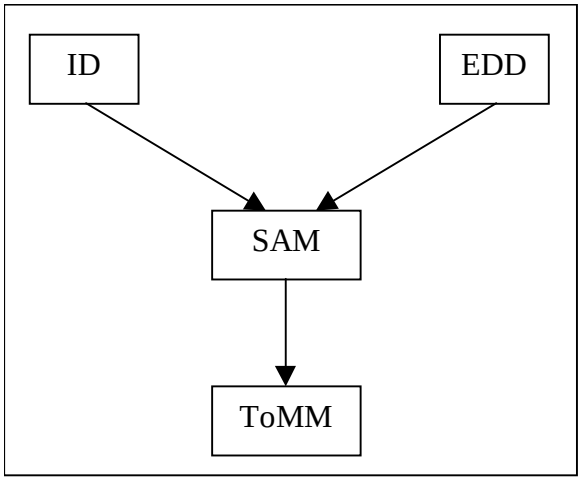

Figure 1: Baron-Cohen and Ring's (1994) model of the mechanisms involved in the formation of ToM judgements.

From this apparent double-dissociation, Autism researchers have proposed the existence of a Theory of Mind Module (ToMM) that is defective in people with Autism. A recent proposal by Baron-Cohen and Ring (1994) refines this idea by placing the ToMM in a flow chart of related mechanisms (reproduced in Figure 1). Briefly, the Intentionality Detector (ID) tags objects as intentional if they appear to be self-propelled, and is capable of attributing dyadic representations of desires and goals such as *wants(Figan, the banana)*. The Eye-Direction Detector (EDD) forms dyadic representations of the relationship of seeing based on the appearance of an individual's eyes, as in *sees(Goliath, Figan)*. The Shared Attention Mechanism (SAM) checks whether you and another individual are attending to the same thing. The SAM integrates the ID and EDD to form simple triadic representations such as *sees(Goliath, sees(self, the banana))*. Finally, the Theory of Mind Module (ToMM) is capable of interpreting the representations formed by the ID, EDD, and SAM to construct triadic representations involving all of the mental predicates (believe, think, know, pretend, imagine, etc.). In Baron-Cohen's view, it is the SAM and the ToMM which are jointly impaired in Autism.[1]

The correctness of the details of Baron-Cohen's model is beyond the scope of this paper, but the model is potentially quite helpful in suggesting what might be some of the issues in the debate over ape ToM. For the story of Figan, the skeptic could concede that a chimpanzee can form the dyadic representations of the ID and EDD, and possibly even the triadic representations of the SAM. Baron-Cohen and Ring's model raises the possibility that an individual that can recognize intentionality (ID), can follow another's gaze (EDD), can recognize shared attention (SAM) and can use these mechanisms to form some of the possible dyadic and triadic representations of mental states without having the full-blown mindreading ability that the ToMM would provide to reason in detail about another individual's psychology.

Another interesting feature of the model is that it ties the question of ape self-awareness to the question of ape ToM. The ID and EDD do not require self-representation, but the SAM, and by extension the ToMM, does. According to this model, it is possible for a non-self-aware organism to use the ID and EDD to ascribe to other individuals simple dyadic predicates involving goals, desires, and perceptions. But that individual will be unable to form the triadic representations of the SAM and ToMM, which require self-awareness. This is not an implausible idea, as Gopnik and Meltzoff (1994) have independently sketched a developmental story linking self-awareness to the development of ToM. In their view, the child's developing ToM is equally applicable to the self and to others. So if skeptics wish to grant a chimpanzee equivalent of the SAM, as it appears they would have to in Baron-Cohen's framework, then they would also be granting chimpanzee self-awareness.

[1] In an unfortunate twist of terminology, Theory of Mind (ToM) is now located only partly in the so-called Theory of Mind Module (ToMM). Part of ToM is located in the SAM.

Deception: The Penny and the Smarty Thief

A separate strand of research on humans aims at investigating how children and autistic individuals are or are not able to use a ToM to engage in deceptive behavior. Understanding and intentionally exhibiting deceptive behavior involves more than just ascription of false belief. In deception, the agent is actively concealing the truth and/or actively misleading another individual. The agent must be able to reason about mental states well enough to realize what kinds of behavior will accomplish the desired deception. Deception is an intrinsically more difficult task than the ascription of false belief.

Sodian and Frith (1992) tested autistic, mentally retarded, and normal children for their ability to deceive another individual. In their task, the children are given some Smarties and are introduced to two puppet characters. One puppet is a friend who, if he finds their Smarties, will give them even more, and the other is a thief who, if he finds their Smarties, will steal them. The Smarties are then placed in a box that the children have been shown is capable of being locked. The box is closed but not locked and then one of the two puppets approaches. The experiment has two conditions. In the *deception* condition, the children are asked whether they will tell the puppet that the box is locked or unlocked, while in the *sabotage* condition they are given the choice of locking or not locking the box.

The rather incredible result of this study was that autistic children succeeded in obstructing the thief on the sabotage condition, but failed on the deception condition whereas normal and mentally retarded children successfully used both deception and sabotage to obstruct the thief. Autistic children understood the situation well enough to physically prevent the thief from taking the Smarties, but not well enough to lie to the thief and tell him that the box was locked. Physical obstruction of an opponent is within the grasp of autistic children, but *information obstruction*, designed to create false beliefs, is not.

A follow-up study was performed by Baron-Cohen (1992) to correct for the relatively high linguistic demands placed on the children in the Sodian and Frith experiment. In Baron-Cohen's experiment, the children play a penny-hiding game with the experimenter. The *hider* conceals the penny in one of his or her hands, and the *guesser* has to choose the correct hand. The revealing finding was that autistic children, when playing the role of the hider, failed by several measures to conceal the location of the penny from the guesser. They either failed to hide their hands while concealing the penny, left the hand without the penny open, or simply showed the guesser where the penny was significantly more often than normal and retarded controls. Note that they did "hide" the penny, in the sense that it was concealed in their hand, but they failed at what Baron-Cohen calls *information occlusion*. They left out the important parts of the routine that would make penny-hiding an interesting game.

Ape Theory of Mind

Premack and Woodruff (1978, described in Premack and Dasser, 1991) conducted an experiment in which a female chimpanzee, named Sarah, was shown films of humans trying to solve problems. In one case a man was shown jumping up and down to try to reach some bananas. Sarah's task was to select from a series of photographs the one which showed the man solving the problem - in this case, the man standing on a chair to reach the fruit. The chimpanzee chose the correct picture on the first trial in almost all cases. Premack and Woodruff's original interpretation was that this task demonstrated chimpanzee ToM. The animal would have to perceive the human as "having the *intention* of getting the bananas, as *wanting* the bananas, as *trying* to get them" (Premack and Dasser, 1991, p259). However, this interpretation did not stand up to some of the challenges that were thrown at it, and Premack and Dasser now believe that all Sarah required to perform well was the perception of an agent attempting to solve a problem. In terms of the ToM model above, all the chimpanzee needed was the ID and possibly the EDD.

Gómez (1991) tells a very nice story about the development of the ability of a young gorilla to relate to people as intentional systems. The gorilla was tested repeatedly in a zoo nursery between the ages of 6 to 30 months. The task was to open a door by undoing a latch placed high up beyond her reach. The only other objects in the room were a box (which if the gorilla stood on it would enable her to reach the latch) and an adult human experimenter. By the end of the first year, the gorilla had figured out that she could move the box over to the door and climb on it to reach the latch. Very soon after this cognitive breakthrough, she began to use the human as a box, pushing and pulling roughly until he was near the door, and then climbing him to reach the latch. Finally, at about 18 months, the gorilla began communicating with the human. She would lead him gently by the hand over to the door (gently compared to the force she used during the "human as box" phase), where she would extend his hand towards the latch and repeatedly look from his eyes to the latch and back again as though asking him to open the door. The remarkable thing about this experiment was that it appeared to have captured the progression of a young gorilla from an autism-like state to one in which at least the ID, EDD, and SAM were fully functional. But once again, the enthusiastic interpretation may not hold up against a skeptical analysis. Gómez argues that the gorilla does not necessarily need any concept of mind or self to have learned how to use the attention of others to solve problems. So even the SAM is ruled out, but the behavior of the animal (leading rather than pushing the human, making eye contact, etc.) still seems to show at least the involvement of the ID and EDD. So both gorillas and chimpanzees are capable of attributing a simple form of intentionality, even if they don't have the full-blown ToM necessary to really understand what intentionality entails.

The two experiments above demonstrate one of the primary difficulties of research into ape ToM. There is no

doubt that apes do exhibit behavior that makes them seem like they have a ToM - the literature is packed with examples - but experimental attempts to tease out this ability tend not to stand up to criticisms from the skeptics. Nevertheless, there is a nagging feeling among many researchers that there is an ape ToM to be discovered. Consider the following dialog between Koko, a gorilla taught to communicate with simple sign language, and an experimenter.

Koko: THAT ME. (Pointing to a photo of a bird)
Exp: Is that really you?
Koko: KOKO GOOD BIRD
Exp: I thought you were a gorilla.
Koko: KOKO BIRD
…
Exp: Can you fly?
Koko: GOOD ("Good" can mean "yes")
Exp: Show me.
Koko: FAKE BIRD, CLOWN. (Koko laughs)
Exp: You're teasing me. (Koko laughs.) What are you really?
Koko: (Laughs, and after a minute signs:) GORILLA KOKO.

In this piece of dialog, reported by Patterson and Cohn (1994, p.285), Koko is clearly engaging in pretend play, a form of deception-like behavior reckoned by most researchers to require full-blown ToM mechanisms. Autistic children do not engage in pretend play (see Leslie, 1991). Unfortunately, even if Koko can be shown to have a ToM, any good skeptic will point out that we can't generalize from Koko to non-language-using apes.

False Belief Ascription

The search continues for an experimental paradigm that will settle the question of ape theory of mind, with most laboratory work focussing on false belief ascription. One such set of experiments tested chimpanzees' abilities to discriminate between an experimenter with true beliefs and an experimenter with false beliefs. Povinelli (1994) describes experiments in which the subjects had to choose the correct container to receive food. The subjects are seated behind a glass screen and watch as an experimenter baits one of the containers. The room is arranged so that the chimp cannot see which one is being baited. There are two humans involved - a guesser and a knower. The knower either places the food herself, or watches the food being placed. The guesser either leaves the room during the process, or stands in the corner with a bag over his head. When the choices are presented, the knower points to the correct container and the guesser points to the wrong one. The subject has to understand that the guesser could not know the answer and choose the container indicated by the knower.

Rhesus monkeys and three-year-old children failed this task completely, choosing strategies such as always picking the same container, or a particular experimenter. Four-year-old children performed the task almost perfectly from the first trial on. But the chimpanzees were a mixed bag. Some of them "got" the task and selected the correct container most of the time over several weeks of testing, but some of them didn't get it at all. What do we make of results like this? Povinelli is not sure what to say, an uncertainty that is reflected in the title of his paper, "What chimpanzees (might) know about the mind." The two problems are: a) the poor performance of some chimpanzees, and b) nagging doubts about how the chimpanzees solved the task. One big problem with the experiment was that each animal was exposed to many trials over several weeks - ample time to learn a strategy such as, "don't pick the experimenter with the bag over his head". In fact, this is one side of the double-edged sword of ape research. As Dennett (1988) points out, creative intelligence is hard to catch in the act - to be sure you've got it you need to have repetitions, but repetitive behavior is less likely to be the product of genuinely creative intelligence.

Deception

The other edge of Dennett's sword is represented in the literature on tactical deception in apes, which focuses on anecdotes (albeit rigorously recorded anecdotes) of ape behavior in a naturalistic setting. Researchers such as Byrne and Whiten (1991) simply collect stories in which apes appear to be engaging in deception, and then analyze them to see what's really there. In almost all cases, a given behavior is seen once and never again which, as Dennett (1988) points out, is both the hallmark of creative intelligence and the bane of serious research. Almost all such one-off activities can be explained away in terms of learned production rules that have nothing to do with mental state representations.

One solution is just to collect enough stories until the weight of evidence seems overwhelming and then declare a conclusion. But Byrne and Whiten (rightly) refuse to accept anything so arbitrary. The one possibility they are left with is the recording of episodes in which the behavior cannot be explained away in production-rule terms. In their paradigm example, the chimpanzee Belle was repeatedly shown where food has been hidden, but repeatedly lost it to Rock, a high-ranking male. The behavior that ensued is recounted by Byrne and Whiten (1991, pp130-131):

1. Belle stopped uncovering food if Rock was around. She sat on it until Rock left.
2. Rock figured this out and if Belle sat in any one place for more than a few seconds, he shoved her aside and searched where she was sitting, obtaining the food.
3. Belle stopped sitting right on the food. She sat close instead.
4. Rock expanded the radius of his search around the area where Belle was sitting.
5. Belle eventually sat far away, waiting until Rock looked in the opposite direction before going for the food.
6. Rock feigned disinterest until Belle started to move somewhere. On some occasions, Rock started to wander off only to wheel around suddenly precisely as Belle was about to uncover some food.
7. Belle started to lead the group away from the food, then double back to get it while Rock searched the bogus area.

In some trials, a single piece of food was hidden in a different place from the main pile, and Belle would lead Rock to the single piece before going for the big pile herself.

8. When Rock started to ignore the single piece and keep his eye on Belle, she had temper tantrums.

According to Byrne and Whiten, the key behavior here is item (6), where Rock seems savvy to Belle's deception, by appearing not to be interested but then wheeling around to catch Belle in the act. Byrne and Whiten claim that this cannot be convincingly captured in production rule terms. I think Byrne and Whiten are right that this behavior is difficult to explain without imputing ToM to Rock. But this is a weak form of argument at best. There is no *proof* that the behavior can't be accounted for any other way. This is a general problem with Byrne and Whiten's approach. A creative person could probably account for almost any single behavior in almost any way they wanted, given enough time. So the important issue remains very much a matter of opinion based on how plausible one finds the alternative explanations. Surely we can do better than this.

A Proposal from the Armchair

There are basic methodological problems with Byrne and Whiten's anecdotal approach to deception. But could deceptive behavior be tested in a laboratory? Probably not. A game like penny-hiding is probably too uninteresting for an ape. Perhaps if the object was something of interest, such as a banana, the ape could be engaged. But what would motivate the ape to play the role of the hider? With the banana in hand, the most likely behavior would be to eat it straight away. The Smarty thief task was suspected of being too linguistically demanding for children, both for the verbal responses required and for the instructions that have to be understood. It is not very likely that the task could be explained to an ape, and we can't have them learn it by example since that would raise the possibility that they are learning regularities that have nothing to do with ToM.

The false belief ascription task that Povinelli tried on chimpanzees proved to be inconclusive, and furthermore there are always nagging doubts that with multiple trials the animals are learning to solve the problem in some other, less interesting way. A third problem with these kinds of studies is that they require the ape to apply it's ToM (if it has one) to human beings. Why should we assume that chimpanzees see humans as equivalent to other chimpanzees for ToM ascriptions? True, we appear similar, but there is no guarantee that the apes will all see the similarities that we do (imagine how alien we must look to rhesus monkeys!), and therefore if they have a ToM, there is no guarantee that it occurs to all of them to apply it consistently to humans. The only really "true" test for ape ToM would be one that tested their belief ascriptions to *other apes of the same species*.

So the experiment I am looking for has a number of characteristics. (1) It should not involve repetition. That means we want a one-shot task that would be performed on many animals. Ideally the task should be motivating enough for the apes that they perform it on the first trial. So penny-hiding is out, as are the "guesser and knower" tasks of Povinelli. (2) Actually, the experiment probably shouldn't involve a "task" at all in the traditional sense, since tasks have to be learned, and that implies repetition. (3) It should measure the apes' ToM of other apes, so all the actors, including any "experimenters" that are interacting with the apes must be of the same species. This condition rules out Povinelli's tasks a second time, unless we can train apes to put bags over their heads and pretend they know where the food is (and if we could do that, we wouldn't need to test for ToM!) Finally, (4) The task must be non-linguistic. If it requires explanation, which is usually the only way around trial-and-error repetitive learning, it's probably too complicated. Better yet, for an ape subject, we should probably not require communication of any kind. So the Smarty thief task is out, and so is the Sally/Anne task.

Or is it? Suppose we could play a chimpanzee a film made with chimpanzee actors, professionally produced using skilled trainers so that it looks as realistic as possible. We see three rooms on the screen, connected by closed doors. One chimp is in the left room (Sally), the other is in the right room (Anne). In the center room are two boxes with lids. Sally enters, places a banana in one of the boxes, and returns to the left room. While she is placing the banana, Anne opens the door slightly and peaks at what is going on. Once Sally is gone, Anne enters, moves the banana from one box to the other, then leaves again. Then Sally re-enters (we never lose sight of Sally, she just sits in the left room waiting) and goes straight over to the box with the banana, retrieves it and begins to eat it. Assuming our chimp subject has been paying attention, and assuming she has a theory of mind, how will she react? Presumably she will be surprised or excited - an emotional response that can be measured both behaviorally and by taking measurements of autonomic response. On the other hand, if Sally had gone to the original box and failed to find the banana, the subject's reaction should be different, since Sally is doing what would be expected given her belief state.

Here are some of the issues. (1) You can only show each ape one movie. Repeating one of the movies will habituate the ape and suppress the response. Showing both movies to a subject raises the possibility that any differential response to the second movie is a product of surface differences between the two. We need the chimps to be surprised, and surprised for the right reason. That means each subject gives you one data point for one of the two conditions, and that means we need lots of subjects - probably more than you would find in any one zoo or laboratory. This problem could be overcome by inter-laboratory cooperation, but the use of so many subjects raises a second issue.

(2) Individual chimps may have different reactions to the movies. Assuming they understand what's going on, some may find it funny, others may get angry on Sally's behalf, etc.

But perhaps a baseline could be established by habituating the subjects to movies of chimpanzees entering rooms, performing various actions, leaving, re-entering, etc. After a while, the subject's responses would hopefully stabilize and then the test condition could be presented.

(3) There may be a problem convincing the apes to watch the movies at all. In order to ensure their attention, we need some motivation - perhaps a reward for watching movies attentively. This could be accomplished either by withholding the reward if the chimp was not constantly fixated on the screen, or perhaps by offering a choice of pictures and giving a reward for choosing the picture of an object that appeared in the preceding movie.

(4) There may be difficulties measuring and interpreting behavioral or autonomic responses. This is an issue that cannot be addressed from the armchair - it needs to be considered by the an ape researchers themselves. But I see no reason in principle why chimpanzee emotions could not be distinguished behaviorally, and I see no reason in principle why the habituation period mentioned in (2) could not also involve habituation to a blood pressure or skin conductance response machine.

(5) There is also the question of whether convincing Sally/Anne movies can be produced with animal actors. Again I don't know the answer to this question, but it seems possible from the armchair. I have no doubt that a movie that was convincing to humans could be produced, but this experiment requires a continuous action movie - no cuts or breaks in the action that might distract or confuse the subject. That means the important part of the production is the performance of the animal actors.

(6) Finally, before we even start with apes, we need to know whether this version of the Sally/Anne task would work on human children. First, will they notice the discrepancy on their own, or do they require special instructions to notice it? Secondly, what are the behavioral and autonomic manifestations of noticing the discrepancy? Performing the test on normal and autistic children would help establish indices to adapt and apply to the apes. But if the test does not work on humans, then the whole thing is a washout.

Final Words

Research and speculation on ape theory of mind has been going on for at least 30 years, yet we seem no closer to a definitive theory than we were when it first began. In fact, given the weakening of the strong conclusions drawn early on, it almost seems like we've lost ground. Part of this is simply to do with the difficulty of animal experimentation in general and ape experiments in particular. Apes have their own minds (even if they don't know it) They need to be convinced to participate in experiments, oriented to the relevant parts of the tasks, and usually trained to perform them. This paradigm undermines our ability to clearly document acts of creative intelligence. On the other hand, if we just wait for isolated acts of folk psychological brilliance, we end up with a bunch of stories that with a little imagination can be explained away. The proposal in this paper is in a way a combination of the two paradigms - it is the statistical study of single anecdotes. The main advantage of studying emotional response is that we don't have to train the animals. If the experimental method is defined carefully enough, it could be almost as good as if we had explicitly asked the animals "which box will Sally look in?" The disadvantage is that differences in individual chimpanzee personality, combined with the large numbers of animals required, may make the experiment quite difficult and costly to carry out.

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