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OCCURRENT THOUGHT AND *A PRIORI* REASON IN CHIMPANZEES

ROBERT LURZ

City University of New York

Department of Philosophy

Brooklyn College

USA

rlurz@brooklyn.cuny.edu

<https://orcid.org/0000-0001-6803-343X>

SUMMARY: Drawing on recent findings in cognitive neuroscience on *aha-experiences* in humans, I develop and defend *the occurrent-thought hypothesis*, which holds that chimpanzees evolved the ability for *aha-experiences*/occurrent thoughts to make their unconscious inferential reasoning abilities more effective. I argue that the occurrent-thought hypothesis provides a better explanation than *the inference-only hypothesis* for a range of facts about chimpanzees' inferential reasoning abilities. I recommend more direct empirical tests of the hypothesis and describe three experimental protocols. I end by drawing out the philosophical implications of the hypothesis for the evolution of *a priori* reason in humans and chimpanzees.

KEYWORDS: insight, belief, memory, curiosity, inhibition

RESUMEN: Apoyándose en descubrimientos recientes de la neurociencia cognitiva sobre “experiencias ajá” (*aha-experiences*) en seres humanos, este artículo desarrolla y defiende la “hipótesis del pensamiento ocurrente”, según la cual los chimpancés adquirieron a lo largo de la evolución la habilidad para tener “experiencias ajá” o pensamientos ocurentes, que les permitieron mejorar la efectividad de sus habilidades de razonamiento inferencial inconsciente. Se argumenta que la hipótesis del pensamiento ocurrente explica mejor una serie de hechos sobre las habilidades de razonamiento inferencial de los chimpancés que la “hipótesis de la exclusividad de la inferencia” (*inference-only*). Se recomiendan más pruebas empíricas directas de la hipótesis y se describen tres protocolos experimentales. El artículo concluye con las implicaciones filosóficas de la hipótesis para la evolución del pensamiento *a priori* en seres humanos y chimpancés.

PALABRAS CLAVE: comprensión súbita (*insight*), creencia, memoria, curiosidad, inhibición

The [banana] was nailed to the roof in a corner, about two and half metres distant from the box. All six apes vainly endeavored to reach the fruit by leaping up from the ground. Sultan soon relinquished this attempt, paced restlessly up and down, suddenly stood still in front of the box, seized it, tipped it hastily toward the objective, but began to climb upon it at a (horizontal) distance of half a metre, and springing upwards with all his force, tore down the banana.

W. Köhler, *The Mentality of Apes*

1. Introduction

Do thoughts suddenly occur to chimpanzees? I believe that they do. Drawing on recent findings in cognitive neuroscience on aha-experiences in humans, I develop and defend *the occurrent-thought hypothesis*, which holds that chimpanzees evolved the ability for aha-experiences/occurrent thoughts to make their unconscious problem-solving inferences more effective than competing habit-based, stimulus-response problem-solving strategies. I compare the occurrent-thought hypothesis with its main competitor, *the inference-only hypothesis*, and argue that the occurrent-thought hypothesis predicts and explains a range of data on chimpanzees' inferential reasoning abilities better than the inference-only hypothesis. I recommend more direct empirical tests for the hypothesis and describe three experimental protocols for that purpose. I end by drawing out some philosophical implications of the hypothesis regarding the evolution of *a priori* reason in humans and chimpanzees.

2. Occurrent Thought and Some of Its Distinguishing Features

Occurrent thoughts are thoughts that suddenly occur to subjects. Verbal reports of occurrent thoughts take forms of the canonical construction, 'The thought/idea that *p* suddenly occurs to S' or 'It suddenly occurs to S that *p*'. I take 'thought' here to refer to information that can be evaluated as true or false, that can be referred to by a that-clause (e.g., that *p*), and that is not something perceived by the senses.¹ *That the peanut is hidden inside the second cup,*

¹ One can call the thoughts that occur to subjects 'propositions' provided one does not take propositions to be sentences in a public language. Although the use

for instance, is information that can be true or false, is referred to by a that-clause, is not something that is perceived by the senses, and is the sort of thing that can suddenly occur to a subject—such as in a shell game when the first cup is shown to be empty. When this information suddenly occurs to a subject, the subject has the occurrent thought that the peanut is hidden inside the second cup. Because canonical reports of occurrent thoughts involve describing a subject bearing the ‘occurs-to’ relation to a propositional content, occurrent thoughts are a type of propositional attitude.

In addition to verbal reports, occurrent thoughts have recognizable behavioral expressions. Certain exclamations (e.g., ‘Aha!’ and more dramatically ‘Eureka!’) and nonverbal behaviors (e.g., a sudden cessation of activity followed by a ponderous ‘looking at nothing’ behavior) are behavioral expressions of having or coming to have an occurrent thought.

Having an occurrent thought is a fleeting conscious event that arises suddenly and unexpectedly and is then quickly gone, making occurrent thoughts quite different from dispositional or standing mental states, such as beliefs and desires.² However, like beliefs and desires, occurrent thoughts have propositional contents, allowing them to provide justifying reasons for beliefs.

The definition of ‘occurrent thought’ that I use here accords with the dictionary definition of the phrasal verb ‘occur to’. According to the Merriam-Webster Online Dictionary, “Occur to: To be thought of

and comprehension of a public language may be required for some types of occurrent thoughts, such as logically complex occurrent thoughts or occurrent thoughts about language-dependent entities (Searle 1994), I assume here, and for good reason, that occurrent thoughts, as a kind, do not require the use or comprehension of a public language. Thought-sampling studies show that neurotypical adults routinely report non-verbalized thoughts (see Hurlburt and Akhter 2008), and there are good philosophical and common-sense reasons for not equating or reducing occurrent thoughts to internally or externally verbalized public language sentences (Swinburne 2013).

² For similar reasons, intuitions are not the same as occurrent thoughts. Intuitions, like beliefs and desires, are standing states that can arise gradually and perdure for some time after they first arise. Furthermore, coming to have the intuition that *p* often happens while one is consciously thinking about *p*. Folks come to have the Gettier intuition that justified, true belief is insufficient for knowledge, for example, while consciously thinking about the Gettier case. Coming to have the occurrent thought that *p*, on the other hand, often happens when one is *not* consciously thinking about *p*. It is only after Poincaré *stopped* consciously thinking about Fuchsian functions, for example, that it suddenly occurred to him that the transformations that defined these functions were identical to those that define non-Euclidian geometry (see case 1). For empirical work on the distinction between intuitions and insight, see Zander *et al.* 2016 and Zhang *et al.* 2016.

by (someone). [Example:] It suddenly *occurred to* her that there was a simpler way to deal with the problem.” A thought that suddenly occurs to a subject I call an ‘occurrent thought’.³ Some philosophers use the term ‘occurrent thought’ or ‘occurrent state’ a bit differently to describe a mental state as being *causally active* in producing behavior or other mental states (see Bartlett 2018). There is no conflict between these two ways of using the term ‘occurrent’, as they describe different things. One describes a mental *state* (e.g., S’s belief that *p*) or *event* (e.g., S’s guessing that *p*) as ‘occurrent’ in the sense of it being causally active; the other describes a *propositional content* (e.g., that *p*) as ‘occurrent’ when it suddenly occurs to a subject. It is important to note, however, that while ‘occurrent thought’ on the latter use of the term does not describe a mental state or event, ‘*having* an occurrent thought’ certainly does. As will be illustrated below, it suddenly occurring to a subject that *p* is a fleeting conscious event that is active (occurrent) in causing the subject to believe that *p* and subsequently engage in testing behaviors aimed at verifying that *p*.⁴

Occurrent thoughts are a pervasive part of the human experience that are routinely described in literature. Despite their recognition in literature and everyday life, occurrent thoughts have been largely ignored in contemporary philosophy of mind and epistemology and only recently given any serious investigation in cognitive psychology and neuroscience. This is unfortunate as occurrent thoughts are an important element in what makes humans and, I will argue, chimpanzees uniquely rational animals.

While this essay is about occurrent thought in chimpanzees, I begin by providing some paradigm cases of occurrent thought in humans to illustrate a few interesting features that occurrent thoughts appear to possess. I will start with a well-known historical case of the mathematician Henri Poincaré (1913):

Case 1: When we arrived at Coutances, we got into a break to go for a drive, and, just as I put my foot on the step, the idea came to me, though nothing in my former thoughts seemed to have prepared me for it, that the transformations I had used

³ See Swinburne 2013 and Malcolm 1972 for similar use of the term ‘occurrent thought’.

⁴ The phenomenal properties of ‘suddenness’ and ‘fleetingness’ associated with having an occurrent thought, as we will see in section 3, are also the same phenomenal properties associated with having an aha-experience.

to define Fuchsian functions were identical with those of non-Euclidian geometry. I made no verification, and had no time to do so, since I took up the conversation again as soon as I had sat down in the break, but I felt absolutely certain at once. When I got back to Caen, I verified the result at my leisure to satisfy my conscience. (p. 53)

First, what appears to have caused Poincaré to come to believe (feel “absolutely certain”) that these mathematical transformations are identical is the thought (“idea”) that they are identical suddenly occurring to him.⁵ Had this thought not suddenly occurred to Poincaré as he put his foot on the step, it seems unlikely that he would have come to believe in the identity of these mathematical transformations at that time. It is important to stress that Poincaré’s occurrent thought appears to cause a belief (high confidence)—not a guess (low confidence)—in the identity of these mathematical transformations.

Second, its suddenly occurring to Poincaré that these mathematical transformations are identical appears to provide him with a defeasible reason for his belief.⁶ Poincaré was not being irrational in believing in the identity of these mathematical transformations when the thought of their identity suddenly occurred to him. In fact, it seems that it would have been irrational for him *not* to believe in their identity upon having this sudden thought that they are identical—unless, of course, he was aware of some reason to doubt their identity or doubt the general veracity of his occurrent thoughts at that time, which presumably he was not.

Third, Poincaré’s occurrent thought not only appears to provide him with a reason for belief, but a motivation for action. Upon the occurrence of the thought that these mathematical transformations are identical, Poincaré came to have a desire to verify their identity—a desire he subsequently satisfied back in Caen by constructing a formal proof of their identity. It seems unlikely that he would have come to have this desire to verify the identity of these mathematical

⁵ The content of Poincaré’s occurrent thought and the content of his belief are the same—namely, that the transformations that define Fuchsian functions are those of non-Euclidean geometry.

⁶ It is not simply *what* occurs to Poincaré—the content of his occurrent thought—that provides him with a justifying reason to believe in the identity of these mathematical transformations. Rather, it is the content *suddenly occurring to him* that provides him with a justifying reason to believe in the identity of these mathematical transformations.

transformations at that time had the thought about their identity not occurred to him.

Fourth, the occurrent thought that Poincaré came to have in Coutances was apparently the result of some unconscious inferential process he underwent based on other mathematical knowledge he possessed at the time. Poincaré notes that he was not aware of making any such inference at the time that would have led him to expect his suddenly having the thought that the transformation of Fuchsian functions are the same as those that define Non-Euclidean geometry.

Fifth, Poincaré did not forget the thought that occurred to him in Coutances when he arrived back in Caen, nor did he forget it later when he wrote about it in his memoir. The thought that occurred to him in Coutances obviously made a lasting impression on his memory.

There are two more cases I wish to present that illustrate two other features that occurrent thoughts can have.

Case 2: When I was in elementary school, my uncle, who was a practical jokester, asked me, “Who is buried in Grant’s tomb?” I was all prepared to say that I didn’t know when it suddenly occurred to me that this was a trick question. So I replied instead, “Grant is buried in Grant’s tomb!”

Case 2 illustrates that having an occurrent thought can be an arresting event that functions as a form of self-control, blunting the force of one’s prior inclinations. Had it not occurred to me that this was a trick question, I would have acted on my prepotent, habit-based reaction to my uncle’s question and replied, “I don’t know”.

Case 3: Jan walks into a bar and sees someone at the opposite side of the room who looks just like her. It suddenly occurs to Jan that it might just be her reflection in a mirror. To test this, she waves and sees the person wave back. Not convinced, Jan decides to do something unusual and sticks out her tongue. Seeing the person stick out her tongue at the same time and in the same way, Jan is convinced that it is just her mirror image at the opposite side of the room.

Case 3 illustrates that having an occurrent thought can provide subjects with a motivation to seek additional evidence in pursuit of knowledge. Jan’s waving her hand and sticking out her tongue are

attempts to test or verify the truth of the thought that it is her mirror reflection she sees at the end of the room. Jan's curiosity driven behavior is like Poincaré's proof-producing behavior upon returning to Caen—both are directed at satisfying a desire to know if the thought that occurred to them is true.

Cases 1–3 illustrate five features that occurrent thoughts apparently can possess: 1) they can cause and provide defeasible reasons for beliefs, 2) can be produced by unconscious reasoning processes, 3) can leave a lasting impression on one's conscious memory, 4) can inhibit prepotent responses to external stimuli, and 5) can produce a motivation to verify the truth of the occurrent thought. Recent research in cognitive neuroscience confirms and extends this list of features of occurrent thought.

3. *Occurrent Thoughts in Cognitive Neuroscience*

First, a matter of terminology. I used the Poincaré case to illustrate what I call 'occurrent thoughts'—thoughts that suddenly occur to subjects that can cause and provide justifying reasons for beliefs. Cognitive psychologists and neuroscientists use the Poincaré case to illustrate what they call 'aha-experiences' (see Schooler *et al.* 2024; Seifert *et al.* 1995; Topolinksy and Reber 2010). Topolinksy and Reber (2010) summarize the received definition of 'aha-experience' as a conscious, fleeting event that occurs when a "problem-related content comes to mind with sudden ease and provides a feeling of pleasure, the belief that the solution is true, and confidence in this belief" (p. 402). From this definition, it should be clear that the belief-inducing, conscious, sudden, fleeting event that these scientists are referring to with 'aha-experience' is the same belief-inducing, conscious, sudden, fleeting event I am referring to with having an occurrent thought, and I will use these two terms interchangeably throughout the essay.⁷ However, in this section, to avoid confusion, I will use the terminology that the researchers use (i.e., 'aha-experience') rather than 'occurrent thought' in describing their experimental findings.

⁷ Part of my reason for not calling occurrent thoughts 'aha-experiences' in the first place is suggested by remarks made by Laukkonen (2024). Laukkonen notes that the term 'aha-experience' misleadingly connotes "just a happy reaction" which fails to capture the "epistemically important" work that aha-experiences do (p. 144). Some scientists also use the term 'insight-experience'. This term is also slightly misleading. The term 'insight' is a success term, connoting knowledge and truth, but insight-experiences are not always true, nor do they always lead to knowledge (see Grimmer *et al.* 2022).

Behavioral studies of aha-experience in adults typically involve subjects solving compound remote associative (CRA) word problems⁸ and asking them afterward whether the solution popped into their heads or if they arrived at the solution by a conscious reasoning process. Behavioral studies support the view that the cognitive processes that produce aha-experience solutions in CRA problem tests are processes unconscious to subjects (Kounios *et al.* 2006; Schooler *et al.* 1993; Stuyck *et al.* 2022).

The standard procedure for studying aha-experiences in cognitive neuroscience involves subjects solving CRA problems while their brain activity is measured using EEG or fMRI. Several neuroscience studies show that subjects' brains change both in preparation of and while having an aha-experience, and that these neurological changes indicate possible adaptive advantages of aha-experiences in problem-solving situations. I list and describe below four of these possible adaptive advantages of aha-experiences that cognitive neuroscience researchers have discovered.

Inhibitory advantage: Jung-Beeman *et al.* (2004) recorded a burst of alpha-band activity (10 Hz) over subjects' visual cortices moments before they had an internally generated aha-experience in the solution of a CRA problem.⁹ Increased alpha-band oscillations over the visual cortex indicates an idling of visual processing of external stimuli. According to the sensory gating hypothesis, the idling of sensory processing facilitates an increase in neural activity in the anterior cingulate cortex (ACC) which subsequently generates the aha-experience (Jensen and Mazaheri 2010; Kounios *et al.* 2006; Subramaniam *et al.* 2009). In a similar study, Salvi *et al.* (2015) observed that moments before having an aha-experience to a CRA problem, subjects increased their rate of blinking (reducing the amount of visual information into the brain) and focused on portions of the screen away from the problem stimulus. These findings suggest that internally generated aha-experiences are preceded by a redirection of attention internally (toward the ACC) and away from external stimuli. One possible adaptive function of the damping down of sensory

⁸ E.g., what word makes a compound phrase/word from the words 'pine', 'crab', and 'sauce'? Answer: 'apple'—'pineapple', 'crabapple', and 'applesauce'.

⁹ Some aha-like experiences (oh-yes experiences) can be externally generated by an external cue, such as a hint or solution, and these externally generated oh yes-experiences, as Rothmaler *et al.* (2017) report, do not show an increase in alpha-band activity over subjects' visual cortex as internally generated aha-experiences do. The inhibitory advantage of aha-experience that I argued for in this section applies to internally generated aha-experiences only.

processing prior to and during internally generated aha-experiences may be, as Salvi *et al.* (2015) suggest, the inhibition of sensory information that “would have elicited prepotent, but unhelpful” responses to solving the problem at hand (p. 1818). As an illustration, consider the scene described in the epigraph from Köhler (1925). The sight of the hanging banana apparently triggers a prepotent response (leaping at the banana) in the chimpanzees that is unhelpful in their getting the banana. If only they could engage in a problem-solving process that would internally inhibit the unhelpful prepotent response to seeing the banana, they might be able to solve the problem of getting the banana. Problem solving by having an internally generated aha-experience, given the suppression of sensory processing that occurs prior to and during the aha-experience, might well do the trick—and it might have been what allowed the chimpanzee, Sultan, to solve the problem. Similarly, in case 2 above, the neural activity (likely in my ACC) that generated my occurrent thought may have been preceded by the suppression of the auditory processing of my uncle’s question, which in turn inhibited my prepotent response (“I don’t know”) to it.

Memory advantage: As noted in case 1, Poincaré did not forget the thought that flashed before his mind in Coutances. The thought stayed with him for days and years afterward. Several studies (Danek *et al.* 2013; Danek and Wiley 2020; Kizilirmak *et al.* 2016) show that solutions to problems arrived at by having aha-experiences are better remembered later than those arrived at by conscious reasoning processes. Danek *et al.* (2013), for example, had subjects attempt to solve how magic tricks were done. Subjects were asked to report whether the solution suddenly came to mind in an aha-experience or not. One week later, they were asked to recall the solution to the magic trick. Danek *et al.* (2013) found that subjects who solved how the tricks were done by having an aha-experience were significantly more likely to remember the solution a week later compared to subjects who did not have an aha-experience. One likely neurophysiological explanation for this memory advantage is that the onset of aha-experiences produces a burst of dopamine in subjects’ brains (Oh *et al.* 2020; Tik *et al.* 2018), which has been linked to improved memory recall (Clos *et al.* 2018; Duszkievicz *et al.* 2019). The results of these studies suggest that an adaptive function of aha-experience is to create strong memory traces for the contents of aha-experiences that unconscious processes produce.

Doxastic advantage: Several studies show that subjects have a higher degree of confidence in solutions to problems when the solutions are arrived at by an aha-experience compared to when solutions

are arrived at by a conscious reasoning process (Danek and Wiley 2020; Laukkonen *et al.* 2020). Other studies have found that solutions arrived at by aha-experiences are more likely to be true compared to solutions arrived at by conscious reasoning processes (Danek and Wiley 2024; Hedne *et al.* 2016; Salvi *et al.* 2016). On a reliabilist account of epistemic justification, since aha-experiences provide subjects with reliably true information, they are appropriate sources of justifying reasons for belief (see Goldman 2008). These findings support the view that aha-experiences function as both causes and justifying reasons for belief.

An important question remains, though: Why do aha-experiences result from unconscious reasoning processes but not from conscious reasoning processes? Ruben Laukkonen (2024) has, I believe, the correct answer:

When a problem is solved analytically in a step-by-step fashion, then we know how we reached the solution, and we can assume that those logical steps provided a useful solution, and we can act on it. On the other hand, for solutions that follow “unconscious work” there’s no such process available for access. Hence, the experience of insight—particularly the feeling of truth, confidence, and the drive to act—may be the signal that permits us a quick way to determine that a new idea is useful [i.e., warrants believing in] given what we know. (p. 188)

Laukkonen’s answer is that conscious reasoning processes, by virtue of their being known to subjects, do not need aha-experiences to cause and justify belief in a solution, but unconscious reasoning processes, by virtue of their being unknown to subjects, need aha-experiences to cause and justify belief in a solution. On Laukkonen’s proposal, aha-experiences function to cause and justify beliefs in solutions that were produced by unconscious reasoning processes.

Curiosity-2 advantage: Aha-experiences cause subjects to have beliefs, but they also cause subjects to act. Danek and Wiley (2017) report that people who have aha-experience typically describe themselves as having a drive to continue working on solving problems. The aha-experience, one subject reported, “gives me wings that make me continue working on the problem which I had not been able to solve before” (p. 4). A recent neurophysiological study (Oh *et al.* 2020) shows that aha-experiences are typically followed by a burst of gamma-band activity in the anterior prefrontal cortex that is associated with subjective experiences of pleasure, which may explain at the neural level why people often find aha-experiences pleasurable.

Oh *et al.* (2020) speculate that the feeling of pleasure that follows aha-experiences “may be regarded as an evolutionarily advantageous adaptation that motivates curiosity, exploration, learning, and creativity in the absence of immediate external rewards such as food or survival” (p. 13). Jacobs and Metcalfe (2024) call this kind of curiosity that is internally motivated and “unrelated to [external] reward”, *curiosity-2* (p. 122). Curiosity that is externally “reward-driven”, they call *curiosity-1* (p. 116). Jacobs and Metcalfe argue that people (and maybe chimpanzees) have both curiosity-1 and curiosity-2 systems, that the former system is an evolutionarily older problem-solving system than the latter, and that solving insight problems by having aha-experiences involves “switching” from using one’s curiosity-1 system (which typically leads to failure and functional fixedness) to using one’s curiosity-2 system (p. 121).

One way to satisfy the internally motivated form of curiosity generated by an aha-experience is to engage in testing behaviors that aim to verify the truth of the aha-experience. This is precisely what Poincaré appears to do with his mathematical proof in Caen, and what Jan does with her silly behavior in front of the mirror in case 2. Neither of these behaviors were performed because of some expected external reward. They were done to verify the truth of an aha-experience/occurrent thought. Seifert *et al.* (1995) note that the desire to verify the truth of an aha-experience by engaging in novel testing or verification behaviors is not unique to Poincaré’s famous case. “Numerous compendiums of introspective reports by other innovative mathematicians, scientists, artists, and musicians”, Seifert *et al.* (1995) write, “document [...] desirable new cognitive products” (e.g., proofs, scores, artworks) that were produced to test the truth of a preceding aha-experience (p. 76). If aha-experiences were selected to produce curiosity-2, and testing behaviors are a way to satisfy curiosity-2, then animals that evolved to solve problems by having aha-experiences are expected to engage in testing behaviors—knowledge-seeking behaviors performed in the absence of immediate external rewards.

The overall picture emerging from the cognitive neuroscientific research is that a possible adaptive advantage of internally generated aha-experiences is to enhance the effectiveness of unconscious reasoning processes in problem solving—specifically, to enable unconscious reasoning processes to cause and justify beliefs in solutions that are memorable, that can inhibit unhelpful prepotent stimulus-response (S-R) strategies, and can produce an internally motivated form of

curiosity (curiosity-2) that leads to knowledge-seeking behaviors in the absence of immediate external rewards.

4. *The Occurrent-Thought Hypothesis*

Here is a just-so story about the evolution of primate intelligence that is consistent with the three main hypotheses in the field—the social intelligence, technical intelligence, and cognitive buffer hypotheses (see Vonk and Edge 2022). Evolutionarily early primate species solved physical and social problems largely by means of instinctive behaviors and behaviors produced by classical and operant conditioning, S-R mechanisms—what Jacobs and Metcalfe (2024) call the curiosity-1 system. Evolutionarily later primate species were confronted with physical and social problems that were more effectively solved by unconscious inferential reasoning processes. These inferential reasoning processes were, as a result, selected, but the curiosity-1 system was retained, creating a lasting tension between these two, sometimes-competing, problem-solving processes. The unconscious inferential reasoning processes at this time were able to produce reliably correct guesses but not beliefs (high degree of confidence) in the solutions to problems. These reliable guesses were sometimes overridden by strong prepotent tendencies driven by instinctive/conditioned responses to external stimuli generated by the curiosity-1 system, preventing the unconscious inferential reasoning processes from being optimal.

About 5 million years ago, during the time of the last common ancestor of humans and great apes, the tension between these two competing problem-solving processes began to ease by the introduction of a mechanism that produces occurrent thoughts/aha-experiences. This new mechanism took the proposed solutions (conclusions) of unconscious inferences as inputs and outputted those proposed solutions as occurrent thoughts. Because of the doxastic and inhibitory advantages of occurrent thoughts, the unconscious inferential reasoning processes in the ancestors of humans and great apes were more resistant to the competing curiosity-1 system responses, making these unconscious inferential reasoning process more effective in solving problems. As a bonus, the introduction of occurrent-thoughts had additional benefits—it enabled these early ape species to remember the proposed solutions to problems better and provided them with an internally motivated form of curiosity—curiosity-2—that produces knowledge-seeking behaviors in the absence of immediate external rewards.

What changes occurred in the physical and social environments of these early ape species that selected for the emergence of occurrent thought? On the social intelligence hypothesis, ancestral ape groups became increasingly larger and more complex (see Dunbar 2019), putting additional pressure on the animals' unconscious social reasoning abilities to outperform and resist competing instinctive/conditioned prepotent responses to social cues. And on the technical intelligence and cognitive buffer hypotheses (see Byrne 1997; Reader and Laland 2002), foraging and food extraction methods became increasingly more varied and complex, putting additional pressure on the animals' unconscious physical reasoning abilities to outperform and resist competing instinctive/conditioned prepotent responses to physical cues.

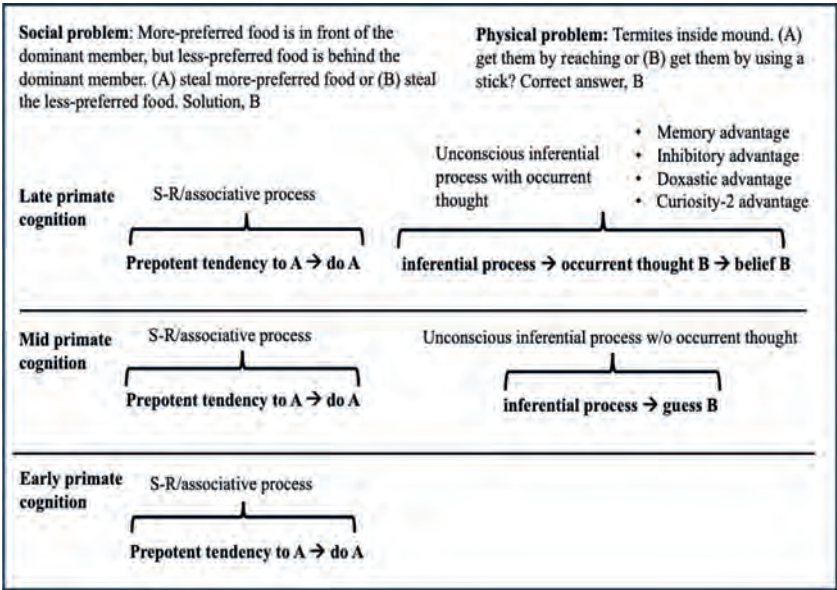


Figure 1. The evolutionary stages of primate intelligences, according to the occurrent-thought hypothesis.

The above just-so story is what I call *the occurrent-thought hypothesis* (see Figure 1). The hypothesis predicts that evidence of occurrent thought is more likely to be found in our closest living primate relative—the chimpanzee—than in more distantly related primate species, such as monkeys. Chimpanzee brains are anatomically and physiologically similar enough to human brains—specifically, in their

cellular composition, morphology, and connectivity within the anterior cingulate cortex (Amiez *et al.* 2021; Nimchinsky *et al.* 1999)—to warrant the realistic speculation that their brains can produce occurrent thoughts/aha-experiences. In addition, of all the living primate species, chimpanzees have demonstrated a robust ability to solve physical and social problems by inference rather than by associative processes or pre-existing S-R biases (see Call 2022; Lurz *et al.* 2018; Krupenye *et al.* 2016; Premack and Premack 1994; Völter and Call 2017). Some studies do not show a strong qualitative difference in the inferential problem-solving abilities of great apes and monkeys (see Tomasello and Call 1997; Schmitt *et al.* 2012). Although the occurrent-thought hypothesis predicts certain types of performance differences in the inferential problem-solving abilities of chimpanzees and monkeys, it does not predict a qualitative break in these abilities between these two primate species. Consistent with the hypothesis is the real possibility that both chimpanzees and some monkey species can solve the same range of physical and social problems using unconscious inferential processes. What the occurrent-thought hypothesis predicts is certain telltale signs of the advantages of occurrent thoughts in chimpanzees' inferential problem-solving abilities that are not found in the similar inferential problem-solving abilities of monkeys.

The occurrent-thought hypothesis is not the first to posit a unique form of problem-solving ability in chimpanzees. Arguably, Köhler's (1925) hypothesis that chimpanzees solve problems by *Einsicht* was the first. What Köhler meant by 'Einsicht' is a bit contested, but recent scholars understand him to be referring, in part, to what are now called 'aha-experiences' (Cheesebrough *et al.* 2024; Shettleworth 2013). On this interpretation, I take the occurrent-thought hypothesis to be an extension of Köhler's original hypothesis about chimpanzees' unique problem-solving abilities.

Köhler's *Einsicht* hypothesis of chimpanzee intelligence has been roundly criticized in the past (see Shettleworth 1998, pp. 465–566; Shupe 2024). Partially because of the criticism, the currently accepted view of chimpanzees' intelligence in the field is the *inference-only hypothesis*. This hypothesis holds that chimpanzees' unique problem-solving abilities are fully explainable in terms of unconscious inferential reasoning processes without any explanatory need to attribute aha-experiences or occurrent thoughts to them. This view is succinctly expressed by Richard Byrne (2016) in his criticism of Köhler's explanation of how the chimpanzee, Sultan, solved a problem by apparently having an aha-experience:

Sultan happened to push two sticks together—and they held, making a longer stick. Sultan suddenly became animated, took the sticks across to the out-of-reach food, and used his new, combined tool to reach it, with immediate success! That is insight, as described in many psychology tests: the ‘Ah ha! moment’. The trouble is, it’s not quite clear what took place for Sultan to give him the insight [...] [W]hat actually happens in that ‘Ah ha!’ moment, anyway? It smacks of unconscious thought, and ‘explaining’ an observed phenomenon with something even more mysterious is not satisfying. (p. 2)

Byrne’s point is that Sultan’s solution to the problem can and should be explained simply in terms of unconscious inferential processes—simply in terms of Sultan unconsciously “comput[ing] a solution to the problem” (p. 2). There is no need to bring in “mysterious” and explanatorily irrelevant aha-experience/occurrent thought in addition to the unconscious inferential processes.

A similar sentiment appears to be held by another prominent researcher of primate cognition. In a recent essay on inferential reasoning in primates, Josep Call (2022) argues that all cases of ‘insightful’ problem solving in apes and monkeys are explainable in terms of different kinds of unconscious inferential reasoning processes.¹⁰ However, in none of the inferential-reasoning explanations of these problem-solving abilities does Call ever once appeal to aha-experiences/occurrent thoughts. Like Byrne, he continues to use the words ‘insight’ and ‘insightful’ to label the inferential problems solving abilities of apes and monkeys, but the words are not meant to refer to consciousness, aha-experiences, or occurrent thoughts.

In a recent article on insight in animals, Shupe (2024) makes explicit the rationale for the inference-only hypothesis and acknowledges its wide acceptance among researchers. “Why not set ‘insight’ in nonhuman animals aside”, he suggests, “and more parsimoniously let causal cognition, means-end reasoning, and other ancillary capaci-

¹⁰ While Call (2022) never explicitly says that the inferential processes primates engage in are unconscious, he also never explicitly says that they are conscious, either. Byrne (2016) explicitly states that the “computational processes” that apes use to solve problems insightfully do not even have a “whiff of consciousness” about them (p. 12). Since I am principally concerned here with contrasting the occurrent-thought hypothesis with an *actual* rival hypothesis held by researchers in the field of primate cognition, not with a theoretically possible rival hypothesis, it is more charitable to take Call, Byrne, and other researchers in the field as holding the more conservative hypothesis that primates use unconscious inferential processes to solve problems than the less-conservative hypothesis that they use conscious inferential processes.

ties do the bulk of the explanatory work, as many researchers already seem inclined to do?" (p. 16).

In the next sections, I aim to answer Shupe's question by showing that the occurrent-thought hypothesis provides a more unifying and less *ad hoc* explanation of the performance differences between chimpanzees and monkeys on inferential problem-solving tests than the more parsimonious inference-only hypothesis. Setting aside occurrent thoughts for the sake of simplicity, I argue, only weakens our understanding of some of the unique features of chimpanzees' rational intelligence.

5. *Learning Sets and Possible Occurrent Thought in Chimpanzees*

The ability to form learning sets, according to Harlow (1949), distinguishes a "conditioned response robot" from a "reasonably rational creature" (p. 51). Learning sets experiments are relatively simple. An experimenter hides a piece of food in one of two wells (holes) in a sliding board and then covers each well with a different kind of material (e.g., one well might be covered by a white piece of paper while the other well is covered by a red cloth). The board is then presented to the animal, and it is allowed to displace one of the covers to locate the food. If the animal chooses the baited well, it gets to eat the food; if it chooses the empty well, it does not get any food. The animal is then given a series of similar problem sets with different pairs of covering materials for the wells.

The animal's selection of wells on the first trial of a new problem set is, of course, a guess, as it does not have any reason to think that one well has the food any more than the other. However, after making a guess on the first trial of a learning set and seeing the results of its guess, the animal, if it is a "reasonably rational creature", should infer where the food will be located on the second trial. For example, if on the first trial the well with the white paper is chosen and it has food, then the animal should infer that the white-paper well will have food in the second trial; but if the well with white paper is chosen and it is empty, then the animal should infer that the red-cloth well will have food in the second trial. Thus, it is expected that if the animal is making its selection of wells on second trials due to such a rational inference, its success rate of selecting the baited well on second trials should increase over a series of learning sets problems.

Harlow (1949) discovered that monkeys' rate of selecting the baited well on second trials increased exponentially over many learning sets problems. By the end of the 100th problem set, Harlow's

monkeys were nearly 80% correct in selecting the baited well on second trials, and by the end of the 312th problem set, they were nearly 100% correct. The results are taken as evidence that the monkeys were learning to infer the location of the food on second trials from the results of their first trial choices by following something like the rule of inference 'win stay-lose switch' (Shettleworth 1998, p. 212).

Hayes *et al.* (1953) ran a learning sets experiment with chimpanzees and compared the results of a typical chimpanzee in their study, Kathy, with the data from Harlow's monkeys.

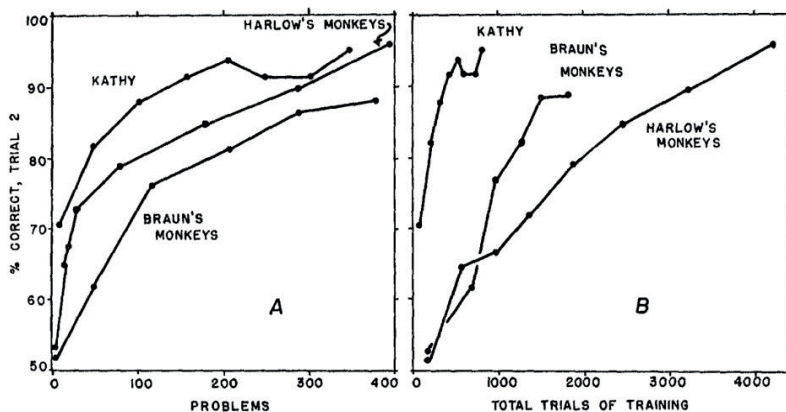


Figure 2. Learning sets development as a function of the number of problem sets (A) and the number of trials (B). From Hayes *et al.* (1953).

As Figure 2 shows, it took Kathy fewer problem sets and fewer trials to reach (say) 80% accuracy on second trials than Harlow's monkeys. Both Kathy and the monkeys learned to infer the location of the food on second trials, but Kathy was notably faster.

The question is why was Kathy faster at forming learning sets than the monkeys? The occurrent-thought hypothesis has a plausible answer. Kathy's inferences produced occurrent thoughts about the location of the food, whereas the monkeys' inferences did not. Because of the doxastic and memory advantages of occurrent thoughts, Kathy was more confident about and better able to remember which food well would be baited on the second trial than the monkeys. Furthermore, because of the curiosity-2 advantage, Kathy's occurrent thought generated an internally motivated form of curiosity that caused her to produce behaviors aimed at testing her occurrent thought (e.g., selecting the baited well on the second trial) which she

was not externally reinforced to do. The monkeys' confidence and memory about the location of the food on second trials apparently grew in strength over repeated trials and came to match Kathy's, but Kathy's confidence in and memory of the location of the food on the second trials got an internal boost from her occurrent thought about which food well was baited on the second trial, explaining why she required fewer problem sets and fewer trials per set to reach 80% accuracy on second trials compared to the monkeys.

The inference-only hypothesis can, of course, provide an explanation for the difference in Kathy's and the monkeys' performance. However, unlike the occurrent-thought hypothesis, the inference-only hypothesis is forced to appeal to auxiliary assumptions that are external to the hypothesis itself, such as that chimpanzees' memories are, for some reason independent of the hypothesis itself, better than monkeys; or that chimpanzees are, for some reason independent of the hypothesis itself, more confident in the solutions generated by their unconscious inferences than monkeys. The inference-only hypothesis on its own does not predict or explain why Kathy's confidence and memory would be expected to be stronger than the monkeys on learning sets tests; however, the occurrent-thought hypothesis does, making it a better, less *ad hoc*, explanation of the findings (see Leplin 1975; Lipton 2005).

6. *Reversal Discrimination and Possible Occurrent Thought in Chimpanzees*

Hayes *et al.* (1953) and Harlow's (1949) studies show that chimpanzees and monkeys employ a 'win stay-lose switch' inferential strategy to solve learning sets problems. Rumbaugh and Pate (1984) showed that when such inferences are pitted against competing S-R tendencies, only chimpanzees' inferences continue to be effective; monkeys' inferences appear to be overridden by the competing S-R tendencies. Rumbaugh and Pate ran a series of reversal discrimination tests with apes and monkeys and found that apes solved reversal tests faster—had higher transfer index scores—than monkeys. Rumbaugh and Pate argued that the difference in apes' and monkeys' transfer index scores was best explained by crediting apes with a more effective "mediating process [...] of an inferential nature" (p. 579).

Reversal discrimination tasks are similar to learning sets tasks except that in the reversal discrimination tasks, the animal's 'win stay-lose switch' inferential strategy is pitted against a prepotent S-R

tendency. In a reversal discrimination task, the animal must choose between two cups (e.g., a red cup and a blue cup), one of which has a piece of food hidden inside. Prior to presenting the cups to the animal, an experimenter hides food in one of the cups (e.g., the red cup) and then presents both cups to the animal. If the animal selects the baited cup, it gets to eat the food; if it selects the empty cup, it does not. On *pre-reversal tests*, the same cup (e.g., the red cup) is baited throughout. The animal is then given several pre-reversal trials until it reaches a certain level of success at selecting the baited cup (e.g., 67% or 84% success), called the criterial level. Once the animal has reached the criterial level, it is given a *reversal test* consisting of 10 trials where the food is hidden in the opposite cup (e.g., the blue cup). The animal is then given a series of 10 pre-reversal–reversal problem tests with different pairs of cups.

On a reversal test, the animal will have a prepotent S-R tendency to select the empty cup since it has been positively reinforced to select that cup in the pre-reversal trials. In pre-reversal tests in which the criterial level is 84%, the animal will have a stronger prepotent S-R tendency to select the empty cup than in pre-reversal tests in which the criterial level is 67%. Because of its prepotent tendency to select the empty cup on trial one of a reversal test, the animal is likely to choose the empty cup. However, if the animal is “reasonably rational”, it should come to learn, over several reversal problem tests, to infer which cup is baited on second trials using the ‘win stay-lose switch’ inferential strategy and, as a result, should have a higher percentage of correct choices in the reversal tests compared to the pre-reversal tests. A higher percentage correct on reversal tests compared to pre-reversal tests translates to a transfer index score greater than 1.0, indicating, according to Rumbaugh and Pate, an effective use of the ‘win stay-lose switch’ inferential strategy.

Rumbaugh and Pate (1984) found that great apes, including chimpanzees, have index scores significantly greater than 1.0 while monkeys do not. What is more, the researchers found that when the prepotent S-R tendency increased from 67% criterial level to 84% criterial level, monkeys’ transfer index scores plummeted while great apes’ index scores stayed much the same, indicating that great apes’ inferences were more resistant to the stronger prepotent S-R tendency than the monkeys’ inferences. The question is why if monkeys and chimpanzees both solve learning sets problems by means of the same ‘win stay-lose switch’ inference, chimpanzees’ inferences are more resistant to the stronger S–R tendency than monkeys’ inferences.

The occurrent-thought hypothesis has an answer. Consider a chimpanzee, for example, who is on the first trial of a reversal test. It has the prepotent tendency to select the empty cup (e.g., cup A), and as a result selects cup A. Upon observing that cup A is empty, it unconsciously infers that cup B is baited, causing it to have the occurrent thought that cup B is baited. Because of the memory advantage of occurrent thoughts, when the chimpanzee is presented with the cups again on the second trial, it again unconsciously infers cup B is baited, which again produces the occurrent thought that cup B is baited. Furthermore, because of the inhibitory advantages of occurrent thoughts, the generation of the occurrent thought that cup B is baited in the chimpanzee's ACC involves prior suppression of visual processing of seeing cup A and subsequently inhibits the chimpanzee's prepotent response to select cup A upon seeing it on the second trial. Finally, because of the doxastic and curiosity-2 advantages, the chimpanzee's occurrent thought causes it to believe (high confidence) that cup B is baited and internally motivates it to engage in testing behaviors (i.e., selecting cup B) that it was not externally rewarded to do based on its pre-reversal reinforcements history. A monkey, on the other hand, may unconsciously infer that cup B is baited upon observing cup A is empty, but because its inference does not produce an occurrent thought, the monkey is left with only a guess (low confidence) that cup B is baited, which is too weak of a signal to resist the strong prepotent S-R tendency to select cup A upon seeing the cup on second and subsequent trials of the test, resulting in a comparatively lower transfer index score.

Again, the inference-only hypothesis would need to appeal to some external, auxiliary assumption, such as that chimpanzees are for some reason better at inhibiting prepotent tendencies and at remembering the solution produced by unconscious inferences than monkeys, to explain the difference in index scores between chimpanzees and monkeys. The inference-only hypothesis on its own does not predict or explain why chimpanzees' inferences on reversal learning tests are expected to be more effective than those of monkeys, but the occurrent-thought hypothesis does, making it a better, less *ad hoc*, explanation of the data.

7. Hybrid Delay Tasks and Possible Occurrent Thoughts in Chimpanzees

The hybrid delay (HD) task is an innovative task designed to assess the level of self-control an animal has over inhibiting its prepotent

tendency to take an immediate but smaller valued food item to get a larger but later valued food item. The first stage of the task, called the choice stage, involves the animal choosing between a plate of smaller quantity of food (e.g., 4 grapes) and a plate of larger quantity of food (e.g., 12 grapes). If the animal chooses the plate of 4 grapes, it gets to eat all the grapes immediately; if it chooses the plate of 12 grapes, it is moved to the second stage of testing, called the accumulation stage. In the accumulation stage, the 12 grapes on the plate are inserted into a dispenser (e.g., a clear tube with a stopper preventing the grapes from rolling out) one at a time while the animal watches. The animal can see the grapes accumulate in the dispenser and can take them at any time in the process. However, the catch is that if the animal takes the grapes from the dispenser before they are all inserted, the animal does not get the remaining grapes on the plate. It is to the animal's advantage to resist the temptation to take the grapes in the dispenser before they are all inserted.

Animals are given three phases of the accumulation stage. In phase 1, the grapes are inserted into the dispenser every 3 seconds, in phase 2 they are inserted every 10 seconds, and in phase 3 they are inserted every 20 seconds. Obviously, the later phases of the accumulation stage require greater self-control on the animal's part than the earlier phases. The level of self-control the animal has on the test is determined by the average number of grapes it consumes during the accumulation stage. If the average number is greater than 4 (i.e., the number of grapes the animal would have received if, in the choice stage, it had taken the smaller but immediate option), then the animal demonstrates self-control. The comparative strength of animals' self-control is measured by both the difference between the average number of grapes consumed in the accumulation stage (e.g., animal A has stronger self-control than B if A's average consumption of grapes is 10 while B's is 5) and the number of later phases in which it consumes on average more than 4 grapes (e.g., animal A has stronger self-control than B if A is averaging above 4 grapes in phase 1, 2 and 3, but B is averaging above 4 grapes only in phase 1).

Beran *et al.* (2014) ran a HD test with chimpanzees and compared chimpanzees' performance with monkeys' performance on the same HD test run by Paglieri *et al.* (2013). Beran *et al.* (2014) found that while both chimpanzees and monkeys showed self-control on the task, chimpanzees' self-control was considerably stronger than monkeys' self-control. On average chimpanzees consumed 12 grapes during the accumulation stage whereas monkeys consumed on average 5

grapes. In addition, only chimpanzees were able to maintain self-control on later phases of the accumulation stage.

Another important feature of chimpanzees' performance on the HD tasks is that they are able to inhibit their prepotent tendency to take the grapes in the dispenser before it is full without employing any overt self-distraction strategies—such as covering their eyes, or covering the food in the dispenser, or looking away from the food in the dispenser (see Beran 2002; Beran and Evans 2006). On the classic marshmallow task, for example, children frequently use overt self-distraction strategies, such as covering their eyes, looking away from the marshmallow, or saying things out loud like “I like to wait”, to divert their attention away from the marshmallow and increase self-control (Mischel and Mischel 1983; Toner and Smith 1977). Beran and Evans (2006) ran a HD test with chimpanzees in which they purposively looked for overt self-distraction behaviors, such as looking away from the food in the dispenser, and found none.¹¹ The chimpanzees were apparently using some internally generated self-distraction strategy in the HD task.

There are, then, two outstanding questions about chimpanzees' performance on HD tasks that I believe the occurrent-thought hypothesis can plausibly answer. First, why do chimpanzees show greater self-control on the task than monkeys? Second, what internal processes do chimpanzees use, as they do not appear to use any overt behavioral ones, to inhibit the prepotent tendency to take the food in the dispenser before it is full?

On the HD tasks, animals that show self-control and wait for more grapes to accumulate in the dispenser need to use some cue, such as the presence of grapes on the plate, to judge that more grapes are coming. Animals that demonstrate self-control presumably use the presence of such a cue, in accordance with something like the ‘food-on-plate–more-to-come’ principle, to infer that more grapes are coming, and rely on this inference as their reason and motivation to wait. Because monkeys and chimpanzees demonstrate self-control

¹¹ In a later study, Evans and Beran (2007) found that 2 out of 4 chimpanzees in a HD task when given access to a toy, played with the toy apparently to distract themselves from the sight of the food accumulating in the dispenser. While this study shows that some chimpanzees engage in overt self-distracting behavior when provided with an attractive external object, it does not show that they engage in overt self-distracting behavior when they are *not* provided with an attractive external object. Thus, what Beran and Evans (2006) found that is relevant for my argument in this section is that when chimpanzees are *not* provided with an attractive external object to distract their attention in an HD task, they are still able to exert self-control in the task by some apparently internal form of self-distraction.

on the task, both species presumably use the ‘food-on-plate–more-to-come’ inference to determine when more food is coming. However, according to the occurrent-thought hypothesis, only the chimpanzees’ inferences produce the occurrent thought that more food is coming. Furthermore, the generation of this occurrent thought in the chimpanzees’ brains, according to the inhibitory advantage thesis, involves the prior suppression of the visual processing of the sight of the grapes piled up in the dispenser. The suppression of the visual processing acts to inhibit the chimpanzees’ prepotent response (take the grapes!) to the sight of the grapes. In effect, occurrent thoughts serve the same function of inhibiting prepotent responses to tempting visual stimuli as overt behavioral strategies, such as covering one’s eyes or looking away from the tempting stimulus (Salvi *et al.* 2015). Both reduce the amount of attention and sensory processing given to external stimuli. Thus, if chimpanzees’ inferences in HD tasks produce occurrent thoughts, we have an explanation for why they do not resort to overt behavioral strategies to inhibit their prepotent response to take the food in the dispenser. They don’t need to—their internally generated occurrent thoughts do it for them.

The inference-only hypothesis can explain the difference in performance between chimpanzees and monkeys on HD tasks on the auxiliary assumption that chimpanzees just have better self-control than monkeys. But what the inference-only hypothesis does not predict or explain is how or why chimpanzees are able to exert self-control in HD tasks without using overt behavioral strategies. The occurrent-thought hypothesis, however, predicts and explains both sets of data, making it preferable to the inference-only explanation.

8. Imitation Recognition and Possible Occurrent Thoughts in Chimpanzees

Monkeys and chimpanzees recognize when an experimenter (E) is imitating their behavior (Paukner *et al.* 2005; Nielsen *et al.* 2005; Haun and Call 2008; Pope *et al.* 2015). Imitation recognition arguably involves an inference of the form: I did X, and then E did X; therefore, E is imitating my behavior. Plausibly, both monkeys and chimpanzees use something like the imitation-recognition (IR) inferences to recognize when E is imitating their behavior. However, only chimpanzees produce ‘contingency testing behaviors’ when they recognize that E is imitating their behavior. Haun and Call (2008) define ‘contingency testing behaviors’ as

actions, performed to test the contingent relationship between two interacting individuals [...] these include either deliberately odd behaviours to test form contingencies or odd or repetitive sequences of behaviours to test timing contingencies. [...] [W]e coded testing behaviour in apes as behavioural patterns which were enacted while facing E, if they fell outside of the described repertoire of the species [...] or were combined in non-standard sequences (testing sequences) or uncharacteristically long bouts of repetitions (behaviour repetitions). (p. R288)

Two important features of chimpanzees' contingency testing behaviors are the following: First, the behaviors have an apparently knowledge-seeking aim. They are done with the apparent aim of coming to know (to test) whether E is imitating their behavior. Second, the deliberately odd behaviors the chimpanzees engage in are not behaviors that the researchers shaped or reinforced by giving the chimpanzees external rewards, such as food. Thus, contingency testing behaviors do not appear to be done out of an expectation of receiving an immediate external reward, such as food.

Why do chimpanzees produce contingency testing behaviors when they recognize that E is imitating their behavior, but monkeys do not? According to the occurrent-thought hypothesis, the answer is that only chimpanzees' IR inferences produce the occurrent thought that E is imitating their behavior. When, for instance, a chimpanzee observes E imitating its behavior, this causes the chimpanzee unconsciously to infer that E is imitating its behavior, causing the chimpanzee to have the occurrent thought that E is imitating its behavior. According to the curiosity-2 advantage thesis, the chimpanzee's occurrent thought that E is imitating its behavior causes the chimpanzee to have an internally motivated curiosity to test the occurrent thought by engaging in contingency testing behaviors. Monkeys' IR inferences, on the other hand, do not produce the occurrent-thought that E is imitating their behavior, and as a result, they do not experience curiosity-2 and thus lack the motivation to engage in contingency testing behaviors.

Again, the inference-only hypothesis does not predict or explain without some external auxiliary assumptions the observed difference in contingency testing behaviors between chimpanzees and monkeys in imitation recognition tests. The occurrent-thought hypothesis does, making it a better explanation of the data.

9. *Mirror Self-Recognition and Possible Occurrent Thoughts in Chimpanzees*

Both chimpanzees and monkeys are capable of recognizing themselves in mirrors (Chang *et al.* 2017; Gallup 1970; Rajala *et al.* 2010). However, only chimpanzees engage in contingency testing behaviors prior to mirror self-recognition (Bard *et al.* 2006; de Veer and van den Bos 1999; Lin *et al.* 1992). Since Gallup's (1970) seminal study, it has been well-documented that chimpanzees engage in contingency testing behaviors in front of the mirror prior to showing positive signs of mirror-self recognition, such as passing the mark test or engaging in self-exploratory behaviors in front of the mirror. Contingent testing behaviors include the chimpanzee repeatedly following its mirror image to the side of the mirror (where it disappears) and then looking behind the mirror (de Veer and van den Bos 1999) as well as closely watching and following its mirror image as it engages in novel head, body, and mouth movements (Lin *et al.* 1992). The testing behaviors chimpanzees perform in front of mirrors are like those they perform in front of an experimenter in IR tasks. They are odd, non-standard behaviors done while looking at another (in this case, the chimp in the mirror), which they have not been externally rewarded for doing, and which appear to be done for the purpose of testing the contingent relationship between their own behavior and that of another (in this case, the chimp in the mirror).

The type of inference that chimpanzees and monkeys use to recognize themselves in the mirror is presumably something like 'the chimp/monkey in the mirror has physical characteristics like me and is present when and only when I am in front of the mirror; therefore, that chimp/monkey in the mirror is me'. I will call this type of inference, the MSR inference. According to the occurrent-thought hypothesis, the MSR inference in chimpanzees, but not in monkeys, causes the chimpanzee to have the occurrent thought that the chimp in the mirror is me. According to the curiosity-2 advantage thesis, the chimpanzee's occurrent thought that 'the chimp in the mirror is me' provides the chimpanzee with an internal motivation to engage in behaviors it was not externally reinforced to do that aim to test the thought that 'the chimp in the mirror is me'. This motivation in turn causes the chimpanzees to engage in contingency testing behaviors in front of the mirror. Once the results of its contingency testing behaviors satisfy its curiosity-2 that 'the chimp in the mirror is me', the chimpanzee stops the testing behaviors and begins to show positive signs of mirror self-recognition. Since monkeys' MSR inferences do

not produce occurrent thoughts, monkeys are not expected to engage in contingency testing behaviors before showing positive signs of mirror self-recognition.

Again, it is difficult to see, without some additional auxiliary assumptions, how the inference-only hypothesis can explain why both chimpanzees and monkeys are capable of mirror-self recognition, but only chimpanzees engage in contingency testing behaviors prior to showing positive signs of mirror-self-recognition.

10. *More Direct Tests of the Occurrent-Thought Hypothesis*

In the last few sections, I've argued that the occurrent-thought hypothesis has some explanatory power over the inference-only hypothesis when explaining performance differences between chimpanzees and monkeys on a range of inferential problem-solving tests. If correct, this provides modest support in favor of the occurrent-thought hypothesis over the inference-only-hypothesis. It would be better still if there were more direct empirical support for the hypothesis. Alas, there is none. However, given recent findings in cognitive neuroscience on aha-experiences, more direct tests can and should be run. Below I describe three experimental protocols the positive results of which would provide more direct empirical support for the occurrent-thought hypothesis.

Priming protocol. A priming study by Laukkonen and Tangen (2017) showed that subjects who looked at a bistable figure, such as the Necker cube, were more likely to solve insight problems by having an aha-experience than subjects who looked at a stable figure. The underlying theoretical rationale of their experiment is that perception of bistable figures primes the brain for aha-experiences. When viewing a bistable figure, subjects' perception of the figure alternates between two competing representations. This alteration in competing representations involves the activation of the anterior cingulate cortex (ACC) which functions to detect representational conflicts in the brain (Botvinick *et al.* 2004). Thus, Laukkonen and Tangen (2017) hypothesized that the viewing of bistable figure may prime subjects' ACCs "to detect non-dominant—perhaps creative—solutions" during insight problem-solving tests (p. 202).

A similar priming experiment could be run with chimpanzees to test the occurrent-thought hypothesis. Using a modified version of the reversal discrimination test (see section 6) with a touchscreen monitor and eye tracker, chimpanzees could be given a series of reversal discrimination tests on the computer monitor. Half the chim-

panzees would be presented with a bistable image on the monitor before each reversal discrimination test, while the other half would be presented with a complementary stable image. Since perceptual switching between competing representations of a bistable image is what is causally relevant for priming the brain for aha-experiences, pupil dilation of the chimpanzees' viewing the images can be recorded by the eye tracker. Studies show that sudden pupil dilation is an indicator of perceptual representational switching of bistable images (Einhäuser *et al.* 2008; Hupé *et al.* 2009; Lamirel *et al.* 2008; Salvi *et al.* 2020). The occurrent-thought hypothesis predicts that the bistable group should have more occurrent thoughts than the stable group on reversal discrimination tests and should subsequently have higher index scores than the stable group. A similar test can be run using the learning sets paradigm (see section 5) and comparing the success rates on second trials of the two groups. The occurrent-thought hypothesis predicts that the bistable group should have higher success rates on second trials than the stable group.

Behavioral markers protocol. Salvi *et al.* (2015 and 2020) found reliable oculomotor markers of aha-experiences in humans during insight tests. These researchers found that aha-experiences are preceded by increased eye blinking and foveation on parts of the screen away from the problem stimulus area approximately 2 seconds prior to problem presentation (Salvi *et al.* 2015), and that subjects' pupils dilated approximately 500 milliseconds prior to their having an aha-experience (Salvi *et al.* 2020). Using the modified reversal discrimination/learning sets paradigm just described (*sans* bistable images), one could test whether chimpanzees with higher index scores/higher second trial scores showed greater frequencies of these oculomotor markers than chimpanzees with lower index scores/second trial scores. The occurrent-thought hypothesis predicts that the frequencies of these oculomotor behaviors should predict index scores/second trial scores on reversal discrimination/learning sets tests.

Noninvasive neurological protocol. As noted above, several brain imaging studies (Kounios *et al.* 2006; Luo *et al.* 2004; Shen *et al.* 2018; Subramaniam *et al.* 2009) investigating the neural correlates of aha-experiences in humans have found that neural activity in the anterior cingulate cortex (ACC) plays an important role in producing aha-experiences. As noted above, chimpanzees' brains share several anatomical and physiological similarities with human brains—in particular, the ACC in chimpanzees is remarkably similar in anatomy and physiology to the human ACC (Amiez *et al.* 2021; Nimchinsky *et al.* 1999). While brain imaging studies in chimpanzees are rare,

it is in practice possible to use existing brain scans of chimpanzees (e.g., Hopkins *et al.* 2007; Latzman *et al.* 2015) to test the neurological implications of the occurrent-thought hypothesis. A group of chimpanzees for which there are brain scans can be given the modified reversal discrimination/learning sets tasks described above. The occurrent-thought hypothesis predicts that chimpanzees with higher index scores/second trial scores should have a greater frequency of occurrent thoughts compared to chimpanzees with lower index/second trial scores, which should be physically manifested by neurophysiological differences in the ACCs of the two groups. One relevant difference would be in white matter connectivity in the ACC, as white matter connectivity is associated with greater neuronal connections and processing. Measurements of white matter volume can be assessed from the brain images using standard manual tracing procedures or voxel-based morphology. The occurrent-thought hypothesis predicts that white matter connectivity in the ACC of chimpanzees' brains should predict performance on the reversal discrimination/learning sets tasks.

11. *Objections and Replies*

The chief empirical objection to the occurrent-thought hypothesis is that attributing occurrent thoughts to chimpanzees is explanatorily unnecessary, that there is nothing the hypothesis can explain that the inference-only hypothesis cannot explain more parsimoniously. The bulk of this essay has been a response to this objection by providing several areas of chimpanzee behavior that are better explained by the occurrent-thought hypothesis than by the inference-only hypothesis.

The chief philosophical objection to the occurrent-thought hypothesis is the Cartesian objection that chimpanzees, and non-linguistic animals in general, are incapable of occurrent thoughts because they lack language. Norman Malcolm (1972) states this argument as follows:

The relevant question is whether [non-linguistic animals] *express* thoughts. I think the answer is clearly in the negative [...] In the case of a person, we can often find out whether the thought that *p* crossed his mind, either by overhearing him *say* that *p*, or by his subsequently *testifying* that the thought that *p* occurred to him. With animals we don't have either recourse. The possession of language makes the whole difference. If a dog on that slippery path moved in an equally gingerly way, we could say with propriety that dog is aware [believes] that the path is slippery. What further thing could we do to find out whether

the thought, ‘This path is slippery’, occurred to it, or crossed its mind? An undertaking of trying to find out whether the dog did or didn’t have that thought is not anything we understand. (p. 17)

Malcolm’s argument is a direct challenge to the occurrent-thought hypothesis, as the hypothesis explicitly holds that occurrent thoughts and beliefs are distinct mental events/states, with the former being a cause and epistemic basis of the latter. Taking ‘believes’ as a suitable replacement for ‘is aware’ in the description above, Malcolm’s argument is that, absent the dog verbally reporting on having an occurrent thought, there is no reason to prefer explaining its behavior in terms of an occurrent-thought-based belief that the path is slippery rather than a sensory-based (it looks/feels slippery) belief that the path is slippery. And what goes for the dog and its behavior on the path, goes for all non-linguistic animals and their behaviors.

I agree with the methodological principle that we should prefer a sensory-based belief explanation of animal behavior over an occurrent-thought-based belief explanation, all things considered. I also agree that for Malcolm’s dog, there is no good reason to prefer the occurrent-thought-based belief explanation over the sensory-based belief explanation. However, given what I’ve argued above, I believe that for chimpanzees, there *are* good reasons to prefer an occurrent-thought-based belief explanation over a sensory-based belief explanation in some cases. Chimpanzees and monkeys are capable of much the same kinds of sensory-based beliefs about the world (see Parrish and Agrillo 2022), and yet chimpanzees form learning sets faster, have higher index scores on reversal discrimination tests, show more self-control in hybrid delayed tasks, and engage in contingency testing behaviors in imitation recognition and MSR tests compared to monkeys. A sensory-based belief account is unlikely to be able to explain the differences in performance across these tests for animals whose sensory-based beliefs are likely to be the same, but the occurrent-thought-based belief explanation can. Thus, if the occurrent-thought-based belief explanation is warranted, then the behavioral performances of chimpanzees on these tests can be taken as nonverbal *expressions* of occurrent thoughts, contrary to what Malcolm argues is possible for non-linguistic animals.

12. *Philosophical Implications and Conclusion*

Kant (1787/1999) famously made the distinction between two kinds of justifying reasons for beliefs about the world: empirical (*a posteriori*) reasons and non-empirical (*a priori*) reasons. Empirical reasons

are those we get from our senses. That roses look red, for example, is an empirical reason to believe that roses are red. *A priori* reasons are usually defined in the negative, as reasons that are *not* from our senses (see BonJour 1998; Boghossian 2020). Proponents of empiricism—the view that there are only empirical reasons for beliefs about the world—have always complained that *a priori* reasons are mysterious or “obscure” or incompatible with our biological natures and should be eliminated from epistemology (see Devitt 2005). How could there be non-sensory reasons to believe in things about the empirical world? How would our brains produce such reasons? How could we have evolved to have non-sensory reasons for our beliefs from evolutionary origins that most certainly began in sensory reasons?

There are different sensory sources of empirical reasons, and so we should not be surprised if there are different non-sensory sources of *a priori* reasons. Occurrent thought, I believe, is one non-sensory source, and plausibly the earliest evolutionary source, of *a priori* reasons for beliefs about the world.¹² If, upon seeing that the first cup is empty, it suddenly occurs to you that the other cup has peanut inside, and you have no reason to doubt this or the veracity of your occurrent thoughts, then you have a defeasible reason to believe that the other cup has peanut inside. The occurrent thought that the other cup has peanut inside is not a sensory experience, it is not a state of vision, hearing, smelling, etc. Thus, the occurrent thought is not an empirical reason but an *a priori* reason to believe that the other cup has peanut inside. Cognitive neuroscience is beginning to unravel how the human brain produces occurrent thoughts/aha-experiences and, in so doing, demystifying the neurological origins of one important source of *a priori* reason in humans. If the occurrent-thought hypothesis is on the right track, it provides a similar demystifying account of the evolutionary origins of a source of *a priori* reason in humans. Of course, if chimpanzees have occurrent thoughts, as I believe they do, then they too have *a priori* reasons, as humans do, for some of their beliefs about the world.¹³

¹² Intuition is another likely source of *a priori* reason (see Boghossian 2020; and Chudnoff 2013).

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