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Cognitive Processes Underlying Play and Pretend Play:

A Comparative Cross-Species Study on Degrees of Memory, Perception, Imagination, and Consciousness



ALEJANDRA WAH

Drawing on evolutionary theory, the author questions which cognitive processes underlie the capacities to play and to pretend play and the degree to which they are present in both humans and nonhuman animals. Considering cognitive capacities not all-or-nothing phenomena, she argues they are present in varying degrees in a wide range of species. Recognizing the risks involved in comparative studies, she identifies the unique features of cognition underlying pretend play while describing the broader phylogenetic sources from which they come. In the end, she finds, although play based on particular degrees of memory, perception, and consciousness can be found in many species, pretend play depends on distinctive degrees of memory, imagination, and metacognition—a cognitive process she calls “reflective imagination”—and appears characteristically human. **Keywords:** consciousness; imagination; memory; metacognition; perception; play; pretend play; reflective imagination

Introduction

IN OTHER WORKS, I have argued that distinctive degrees of imagination and consciousness—a cognitive process I refer to as “reflective imagination”—underlies the artistic experience. I take artistic experience to be the universal and characteristically human capacity to experience oneself or others in a narrative by means of music, dance, song, pantomime, drawing, pretend play, or verbal language (Wah 2017, 2019).

To analyze this human narrative capacity I have drawn on a theory proposed by Francesco Ferretti and colleagues (2017). They postulate that the cognitive mechanisms underlying the human narrative ability are global coherence (the capacity to relate events causally) and a triadic system consisting of mental

space travel (the capacity to imagine different spatial locations); mental time travel (the capacity to imagine oneself or others at different times, distinguishing between past, present, and future); and mental mind travel (the capacity to attribute mental states to oneself or others, also referred to as mind reading or theory of mind). The fact that the triadic system of mental space travel, mental time travel, and mental mind travel exists, to some extent, in nonhuman animals suggests that it precedes verbal language.

Building on evolutionary theory, I here focus on pretend play and on one of the three imaginative capacities—mental time travel. For our purposes, play includes locomotor-rotational play (jumping, leaping, twisting, swinging, swirling, running, climbing), social play (hiding, chasing, fleeing, and rough-and-tumble play, such as wrestling, grappling, fighting), and object play (carrying, dropping, biting, mouthing, manipulating, building), whereas pretend play includes role playing and sociodramatic play, both of which involve rehearsal of skill, mime, and nonlinguistic gesture and may or may not involve verbal language (Burghardt 2010; Donald 2013).

So far, research has proven that play is common among many nonhuman animals, both vertebrates and invertebrates. Play is not ubiquitous in placental mammals, but is certainly widespread. To at least some degree, it has been found in almost every order. Most groups of eutherian mammals exhibit play in the three categories I mentioned (locomotor-rotational play, social play, and object play). If only two play types are present, they are usually locomotor-rotational and social, which suggests that object play may have a different set of facilitating factors (Burghardt 2005). I will come back to these factors when discussing reflective play.

It has been stated that most species play in a stereotyped manner and do not generate truly novel patterns. Nor do they engage in imaginary games such as pretend play and role playing, as do humans (Donald 2006). However, some scholars have pointed out that, on a cognitive level, pretend play should also be evident in nonhuman animals, especially in nonhuman great apes (chimpanzees, bonobos, gorillas, and orangutans), because they have the capacity to foresee and to contemplate alternative responses to environmental circumstances. Nonetheless, these researchers have also underlined that limited evidence exists for the capacity of these apes to operate in a pretend world, a capacity which involves holding in mind distinctions between the hypothetical (the imagined) and the real (the perceived) (Whiten and Suddendorf 2007).

These researchers note that examples of pretend play in nonhuman great

apes lack frequency, richness, and complexity and appear only as relatively rare and fleeting signs of the necessary imaginative capacity rather than as an obvious everyday manifestation (Suddendorf and Whiten 2001). By contrast, other scholars point out that pretend play is a universal human trait (Smith 2010; Nielsen 2012; Lillard 2017), and that, by the time humans reach age four, they spend as much as one quarter of their free time pretending (Haight and Miller 1992; Nielsen 2012). Here, I identify the unique features of cognition underlying pretend play, while embedding these unique features into the broader phylogenetic sources from which they have arisen.

Cognitive Capacities Are Not All-or-Nothing Phenomena

To explain which cognitive processes underlie the capacities to play and to pretend play and whether these processes are present in both humans and nonhuman animals, it is important to emphasize that, from the perspective of evolutionary biology, the difference between the cognitive processes of humans and nonhuman animals is one of degree and not of kind (Darwin 1871). Cognitive capacities are not all-or-nothing phenomena; they are found in varying degrees in a wide range of species. Every species comes with a set of evolutionarily ancient components of cognition that characterizes it and makes it unique (de Waal and Ferrari 2012). For this reason, instead of a hierarchy or sequence from so-called lower to higher animals, only organism-environment adaptations exist (Gould 1977).

A basic cognitive structure found in all living organisms, including bacteria, humans, and blue whales, consists of signal integration, memory, sensing/perception, communication, behavior, learning, valence, and anticipation (Godfrey-Smith 1996; Lyon 2015). This basic cognitive structure allows all organisms to adapt and survive in the complexity of their own environments.

Specific signaling molecules have been conserved through millions of years of evolution and can be found today in both single-celled and multicellular organisms. Organisms such as worms, flies, and snails use the same molecules as humans to adjust to their environment. For example, with regard to memory, in humans as in many other multicellular organisms, the cellular basis of memory is neural. Thus, from studies conducted on the neural circuits of a type of large sea slug, we know the foundations of human memory—that repetition encourages consolidation; that, with repetition, the concentration of neurotransmitters in

synapses alters the strength of the existing connections between neurons; and that neurons grow new synaptic terminals (Kandel 1976, 2006).

In the case of perception, all organisms receive information through sensing and process this information to initiate and guide behavior. For instance, insects, frogs, and birds respond to different wavelengths of light and sound with reference to their own biological affordances (Dissanayake 2015); raptors react to tiny movements perceived many miles away (Metcalfé 2008); male bowerbirds gather brightly colored objects to attract mates (Endler 2012); and mammals, such as rats, cats, dogs, horses, and humans, respond emotionally to the perception of formal features of stimuli (Darwin 1872; Panksepp 1998).

At first, imitative learning was thought to be characteristically human, a biological mechanism that could have brought about changes in behavior and cognition, enabling humans to save time, effort, and risk by exploiting the existing knowledge and skills of conspecifics (see Tomasello 1999). However, imitative learning has been proven to be widespread in the animal kingdom. It may be that all forms of imitation have a shared neural perception-action foundation, from the vocal mimicry of birds to the copying of feeding techniques by primates (de Waal and Ferrari 2012).

A shared basic cognitive structure has thus been widely studied, and clear evidence exists of its ubiquity in the animal kingdom. Degrees of memory, perception, imagination, and consciousness seem therefore relevant to explaining the cognitive processes underlying the capacities to play and to pretend play. However, when it comes to the cognitive processes of imagination and consciousness, less evidence seems to be available.

The evolution of imagination seems closely linked to the evolution of memory retrieval mechanisms such as semantic memory (knowing), episodic memory (self-conscious remembering), and autobiographical memory (personal memories that appear repeatedly during one's life) (see Schacter and Tulving 1994; Tulving 2005). Based on this classification, Anna Abraham and Andreja Bubic (2015) propose semantic memory as the root of all aspects of human imagination. I have argued that reflective imagination emerges from and expands beyond episodic memory, which requires—but goes beyond—the semantic memory system (Wah 2019).

A continuum between perception and imagination has also been suggested (Thomas 2014). George J. Romanes (1885) points out that imagination—the power of recalling, retaining, and manipulating mental images, no matter how rudimentary, provided that the mental images imply some dim idea of absent

objects or events—can be distinguished in four degrees in the animal kingdom. Mollusca, insecta, arachnida, crustacea, cephalopoda (such as octopuses or squids) and vertebrata (such as fish or reptiles) can recall sensuous associations and retain the memory of a sensation without direct perception of objects and events. Hymenoptera (such as ants, bees, or wasps) and mammalia (such as foxes, wolves, or rabbits) can recall and retain mental images of absent objects and events suggested by other objects and events through a process of association by contiguity. Birds (such as eagles, parrots, or canaries) and mammalia (such as cats, dogs, horses, elephants, or apes) can recall and retain mental images of absent objects and events independently of any obvious suggestion, as proven in their dreaming. However, recalling, retaining, and manipulating mental images with the set purpose of obtaining new combinations appears to be distinctively human.

The possibility to recall, retain, and manipulate mental patterns intentionally seems to require a distinctive degree of consciousness. Katherine Nelson (2005) emphasizes that consciousness has a cumulative and conservative character and that it expands both in evolution and in development. She distinguishes six degrees of consciousness in humans, from awareness of feelings to extended states. These levels emerge during the first ten years of life, with implications for the development of the self and the social and cognitive functioning, and they seem to be reflected in its evolutionary trajectory. Nonhuman animals may evolve their own different levels of conscious awareness.

Degrees of consciousness have been distinguished in the animal kingdom. The first is core consciousness, the sense of the here and now that revolves around the core self. The second is extended consciousness, which directs the autobiographical self and is self-reflective. Self-reflective consciousness constitutes metacognition. Degrees of self, or the feeling of one's own existence, have also been recognized: the nonconscious proto self, which characterizes deep sleep; the core self, which emerges in core consciousness; and the autobiographical self, which emerges in extended consciousness and is based on the experience of the integration of the here and now (perception) with the lived past (memory) and the anticipated future (imagination)—the so-called mental time travel (Damasio 1999, 2003, 2010, 2011; Metcalfe 2008).

To understand the capacity for mental time travel, Janet Metcalfe and Lisa K. Son have made a further distinction between anoetic, noetic and auto-noetic consciousness. Anoetic consciousness is a state related to implicit memory and is temporally and spatially bound to the present, which means that judgments

are related to stimuli in actual perception. Noetic consciousness is a state that is associated with semantic memory and involves internal representations regarding past facts and general knowledge, which means that judgments are related to recalled stimuli. This form of consciousness does not necessarily involve the autobiographical self. Finally, auto-noetic consciousness is a self-reflective state that involves episodic memory, which means that judgments make specific reference to the self, allowing one to recall a personal past and to imagine a personal future, thereby making mental time travel possible (Tulving 1985; Metcalfe and Son 2012). Based on this classification, I will come back to degrees of memory, perception, imagination, and consciousness when discussing perceptual play, reflective play, and reflective imaginative play. But first what do we know about the presence of mental time travel in nonhuman animals?

Phylogeny of Mental Time Travel

The possibility that nonhuman animals are endowed with the ability to recall their own past and imagine their own future has raised wide debate and controversy. According to Endel Tulving (2005) and Thomas Suddendorf and Michael C. Corballis (2007), mental time travel is the human ability to project oneself in time and implies episodic memory, episodic future planning, and auto-noetic consciousness. These accounts echo the Bischof-Köhler hypothesis (1985) suggesting nonhuman animals are stuck in the present time. However, since episodic memory and episodic future planning rely on self-reporting, it is difficult to devise tests to assess whether nonhuman animals have such abilities (Ferretti et al. 2017).

Francesco Ferretti and colleagues (2017) discuss several of the comparative studies on mental time travel conducted over the past two decades. Some of the more comprehensive behavioral data on episodic memory have come from studies of birds making use of the “what-where-when” paradigm created in reference to Tulving’s (1972) early conceptualization of episodic memory. Clayton and colleagues (1998; 2001; 2003) have tested the caching behavior and memory ability of western scrub jays. According to these researchers, that these birds remember what food items they cache, where, and when they cache them indicates they have episodic memory and episodic future planning.

Related experiments conducted with rats obtained similar results. Electroencephalography (EEG) has indicated neural activity in the rat hippocampus

when the animal explores a maze, suggesting that the hippocampus is involved in the construction and activation of cognitive maps. Such activity has also been observed in sharp-wave ripples (SWRs) after a rat has been through a maze, either during slow-wave sleep or when the animal is awake but immobile. Sometimes the replayed path does not correspond to the route the rat actually takes, which suggests the anticipation of future navigations of the maze and means that the cognitive map extends beyond actual experience (Zhou and Crystal 2009; Lu et al. 2012). The evidence that neural activity in the hippocampal regions corresponds to future navigation in rats seems to indicate subjective experience and raises the possibility of a more phylogenetically continuous view of episodic future planning in mammals (Corballis 2013).

Studies on nonhuman great apes have also shown that they could pass the Bischof–Köhler test. For instance, chimpanzees have been reported to select and manufacture tools appropriate to future activity and to pick up suitable materials in advance of a need, sometimes out of sight of the place of use. They have been observed carrying stones to nut-cracking sites—even when the sites were not within view—or manufacturing probes for termite fishing from one termite nest to another (Goodall 1964; Boesch and Boesch 1984). Foresight abilities in bonobos and orangutans have also been tested using the methodological setting of Tulving’s spoon test, and subsequent studies have replicated and extended these findings (Mulcahy and Call 2006; Osvath and Osvath 2008; Osvath 2009).

All this evidence suggests that these degrees of experience are not human language-mediated processes as previously thought and that memory, perception, imagination, and consciousness are found in varying degrees in a wide range of species, including birds and mammals. Thus, de Waal and Ferrari (2012) were correct in pointing out that even if humans build cathedrals and produce symphonies this offers no reason to place them beyond comparison, because their underlying processes—such as social learning, coordination, tool use, and sense of rhythm—are shared with other animals. However, the question here is which cognitive processes and to what degree they underlie the capacities to build cathedrals and produce symphonies or—more specifically for our purposes—to play and pretend play.

Risks of Comparative Studies

Comparative theories of cognition have progressed because we now know

more about brain evolution. For instance, we can now debunk a well-established but mistaken assumption that the neocortex is a recent mammalian invention and that the so-called triune brain consists of the reptilian complex, the paleomammalian complex, and the neomammalian complex (see MacLean 1964). Even though the notion of an ancestral reptilian brain present in mammals, including humans, has been difficult to abandon, we know now that lizards, crocodiles, and birds are close cousins and all considered to be reptiles and that reptiles evolved along a different evolutionary path than mammals (Herculano-Houzel 2016).

Comparing humans with other mammals, more specifically with other great apes: chimpanzees (*Pan troglodytes* and *Pan schweinfurthii*), bonobos (*Pan paniscus*), gorillas (*Gorilla gorilla*), and orangutans (*Pongo pygmaeus*), remains, therefore, one of the more efficient and effective approaches to understanding human cognition (Pellegrini and Smith 2005). However, comparative studies risk masking six million years of an evolution that divides humans from other great apes. Even though the human family tree nests within that of the great apes, humans' closest living relatives cannot be used as "living fossils," because their lines have also evolved (Gurche 2013). Comparative studies also risk overlooking that these six million years are filled by multiple hominin species other than *Homo sapiens* (Nielsen 2012). Human cognition has not evolved in a simple linear manner, nor has it evolved in isolation but together with anatomy, diet, mating behavior, social life, and energy generation and consumption (Donald 1991, 2013).

Nonetheless, similarities in DNA show that chimpanzees and bonobos are the closest phylogenetic relatives to humans (Wrangham et al. 1996). Chimpanzees and bonobos have been posited as especially informative comparator species (McGrew 1981; de Waal and Lanting 1997). Cross-primate comparisons do remain useful because the functional anatomy of the primate brain has changed very slowly, and the basic brain design of humans remains close to that of other primates. Moreover, there is a significant overlap between their behavioral repertoires. The range of social cognitive behaviors available to humans clearly derives from equivalent behaviors in other primates (Donald 2013).

Thus, mindful of the risks involved in comparative studies and based on the previous theoretical framework, I now compare the play behaviors of humans and nonhuman great apes and distinguish between perceptual play, reflective play, and reflective imaginative play.

Perceptual Play

Locomotor-rotational play, also called exercise play, appears to be the original form of mammalian play. This type of play maintains neural development, motor control, and physical fitness and stamina (Byers and Walker 1995). Social play, including rough-and-tumble play, also constitutes a common mammalian behavior, although different species vary in the nature and frequency with which they engage in such play. This type of play has been linked to the growth of the cerebellum and neocortex (Lewis 2004; 2005). All nonhuman great apes show varied locomotor-rotational play and social play patterns (Pellegrini and Smith 2005).

Angeline Lillard (2017) suggests that a form of social play, play fighting, can be regarded as an analog of pretend play. She argues that in both cases metacommunication plays a fundamental role, as both play fighting and pretend play are issued as if they were real behaviors. There seems indeed to be continuity between social play and pretend play. However, the presence of social play in the so-called mother-infant interaction in humans suggests that, unlike pretend play, social play is an evolved predisposition that is unintentional in both baby and adult, and therefore does not require metacognition.

During human infancy, memory is nonconscious or implicit. This means that memory is evoked and instrumental but not reflective or accessible to voluntary recall. The phenomenon of infantile amnesia is attributed to this lack of memory rehearsal and undeveloped cognitive self (Nelson and Fivush 2000, 2004; Nelson 2005). Babies cannot manage more than one mental pattern at a time (Lucariello 2004). They do not yet have a conception of past and future, nor the capacity to understand another's perspective (Nelson 2005).

Ellen Dissanayake (2000, 2001, 2015) explains how the affiliative vocalizations, facial expressions, and head and body movements of the adult in the mother-infant interaction are transformed into attention-getting signals by the process of ritualization. The function of these communicative signals is to attract and sustain the attention of the infant and to trigger emotion, helping the infant achieve homeostatic equilibrium and emotional regulation. It is with reading emotions that mental mind travel begins (Corballis 2011). The tendency in adults to produce spontaneously these behavioral patterns and the sensitivities of newborns to reciprocate them suggest their primal importance (Wah 2019).

Play behaviors such as locomotor-rotational play, social play, and some examples of object play—such as manipulating branches and leaves, biting a toy,

or dropping a ball—show that perception plays a dominant role (Mitchell 2002). That these play behaviors are underlain by perception-action and are therefore temporally and spatially bound to the present, suggests that for these forms of play no metacognition or inward-directed attention is necessary. Anoetic consciousness and implicit memory seem to be sufficient. Evidence of these types of play can be found in all great apes including typically developing human infants and children younger than two years of age. We can refer to this type of play as perceptual play.

Reflective Play

Object play appears rarely in mammalian species but relatively commonly among great apes (Smith and Pellegrini 2005). Object play emerges early in human ontogeny. Babies endlessly repeat and rehearse the activities of reaching, grasping, and investigating with their eyes, hands, and mouths and begin to learn how things in the world look, sound, smell, feel, and taste (Dissanayake 2000). The first level of experiential awareness in human infants is that of a self, one that distinguishes the boundary between self and other. Midway in the first year, this boundary extends to a relation between self, other, and object (Nelson 2005). This means that the beginning of the understanding of space precedes the understanding of time (Corballis 2011). The ability for mental space travel is a property of semantic memory and a precondition for mental time travel (Tulving 2005).

In typical development, the first recognition of the self appears near the end of the second year, once a young child passes the mirror test (the ability to recognize that one's image reflected in a mirror belongs to oneself). The cognitive self marks the beginning of memory as a recursive or metacognitive phenomenon (Tulving 2005; Corballis 2011). This ability hinges on the capacity to keep in mind two different mental patterns at the same time and is based on the development of representational systems or mappings (Bjorklund 2012). This cognitive capacity has also been demonstrated in several mammals including all nonhuman great apes, because they have all passed the mirror test (Plotnik et al. 2010; de Waal and Ferrari 2012).

Toward the end of the second year, typically developing human children begin to apply their knowledge to symbolically manipulate objects; an empty cup, for example, may be “sipped” from as if it contains hot liquid (Leslie 1987;

Harris 2000; Nielsen 2012). Children begin to handle and manipulate artifacts with increasing coordination and goal orientation, and they gradually become able to imagine their actions have an effect on objects and on others (Dissanayake 2000).

Some documented cases suggest pretend play occurs in nonhuman great apes reared by humans in a largely human environment. For instance, chimpanzee Viki briefly played with an imaginary pull toy (Hayes 1951); chimpanzee Washoe washed a doll in water in a bathtub and chimpanzee Austin used an imaginary spoon to eat food from an imaginary plate (Gómez and Martín-Andrade 2005); gorilla Koko made slurping sounds while “drinking” from an empty cup (Patterson 1980; Matevia, Patterson, and Hillix 2002); bonobo Kanzi hid and ate imaginary food (Savage-Rumbaugh 1986); and, while sleeping, orangutans in the wild held a leaf bundle compared to a doll by the authors (van Schaik et al. 2003). Nonetheless, these accounts of play behaviors hardly develop into role play, sociodramatic play, or narrative sequences (Smith 2010).

Clear parallels can be observed between the examples of object play in human children ages fifteen months to two years and juvenile nonhuman great apes. Both involve imitative abilities and actions such as eating, drinking, and cuddling a “baby.” It is important to point out that these actions do not require a full symbolic capacity. Although they are a stepping-stone to full symbolic pretend play, these forms of play often overlap with object play (Gómez and Martín-Andrade 2005; Smith and Pellegrini 2005).

Play behaviors such as the imitation of one’s own or another’s actions are based on the capacity to reenact perceived or recalled objects and events and can be classified as expressions of metacognition. This suggests that, for these forms of play, noetic consciousness and semantic memory are necessary. Evidence of these types of play is found in juvenile great apes, including typically developing human children older than fifteen-months to two years of age. We can refer to this type of play as reflective play.

Reflective Imaginative Play

The development of cognition in humans becomes evident around the third year, with considerable advances in episodic memory. These advances in episodic memory add to the ability to mental space travel the ability to mental time travel, not only into the past but, more important, also into the future (Tulving 2005).

In this period, children begin to reflect upon their experiences (or potential experiences), distinguishing between past, present, and future, and they can begin to follow a storyline (Tulving 1985; Suddendorf and Corballis 1997, 2007; Terrace and Metcalfe 2005; Nelson 2005; Ferretti et al. 2017). Through narratives, children imagine others' behaviors into internally coherent accounts. Narratives provide a resource for linking otherwise isolated events into causal, chronological wholes (Herman 2013; Ferretti et al. 2017).

Just as human children naturally start to dance, sing, mime, and draw, they also begin to engage in make-believe (Dissanayake 2000; Wah 2019). The spontaneous interaction of imitation turns into deliberate imitation as simulation or pretense (Dissanayake 2001). Pretend play invariably involves doing “as if” objects, oneself, or others were something else and had different meanings. It therefore invariably involves the use of imagination (Goldman 1998; Thomas 2014). Pretending “as if” is constrained in its themes and targets and involves pretending that one common object is more interesting than another, pretending that a person-like object is animated, pretending to be different animals, and later pretending various social roles and acting them out. All these features constitute a form of training for imaginative mind-reading capacities (Boyer 2007; Taylor, Carlson, and Shawber 2007).

Human children continue developing mental mind travel—the imaginative capacity to predict, take another's viewpoint, and understand their own and others' mental states, such as thoughts, feelings, actions, and intentions (Currie 1995; Thomas 2003; Damasio 2010). The capacity to retain and compare multiple mental patterns underlies this imaginative skill and increases dramatically between ages five and eleven (Goswami 2008). The capacity to imagine oneself or others in a different space, time, and mental state has a very important function in learning and the transmission of knowledge. The cognitive capacities for mental space travel, mental time travel, and mental mind travel underlying reflective imagination can become fully present in late childhood (Wah 2019).

Lillard (1994) has defined pretense as requiring a pretender, a reality, and a mental representation that the pretender projects onto reality with awareness and intention. According to Peter Smith (2010), this implies conscious intention and an awareness of both the actual reality and the pretend reality and, thus, some metarepresentational ability. This would rule out most nonhuman pretense. The examples of play in nonhuman great apes suggest no awareness of pretense, nor an intention to pretend or deceive (Mitchell 2007; Smith 2010). Adopting this definition also rules out pretend play in human infants and young children.

Pretend play therefore provides the greatest discontinuity between non-human great apes and humans. It seems to depend on symbolic capacities attained only by human children, as demonstrated in children three to four years old (Smith and Pellegrini 2005). In pretend play, one can step back from reality, a cognitive capacity that allows one, among other things, to be absorbed with the experience of stories (Harris 2000). By contrast, in nonhuman great apes there seems to be no evidence of narrative consciousness or of understanding anything like a story (Nelson 2005). This does not mean that nonhuman animals are incapable of complex and sophisticated forms of communication, but it does mean that one cannot accredit them storytelling skills (Ferretti et al. 2017).

Play behaviors that include the delayed imitation of one's own or another's actions depend on the capacity to reenact or re-create objects and events that are imagined instead of only perceived or recalled. This suggests that, for these forms of play, distinctive degrees of imagination and metacognition, inward-directed attention, episodic memory, and episodic future planning are necessary. Evidence of this type of play with specific reference to the self has not been found in nonhuman great apes but is found in typically developing human children older than three to four years of age. We can refer to this type of play as reflective imaginative play.

Possible Functions of Pretend Play

A predictable developmental sequence of pretend play and its universality in humans suggest an evolved behavior (Lillard 2017). Until the 1970s, the importance of pretend play was assumed without direct empirical evidence or controlled experimental studies. Nonetheless, in recent decades, several theorists have argued the benefits of pretend play for cognitive development, creative thinking, and creative problem solving (see Smith 2004; Pellegrini, Dupuis, and Smith 2007).

Pretending seems to allow humans to develop the skill to generate and reason with novel suppositions and imaginary scenarios, thereby practicing the creative process that underpins innovation (Harris and Kavanaugh 1993; Carruthers 2002, 2006; Rakoczy 2008; Nielsen 2012). Pretend play also appears to serve a self-regulatory function, including emotional regulation (Singer and Singer 1990; Dissanayake 2000; Scarlett 2004). It has also been argued that pretend play confers on humans a vast array of skills, enabling them to construct

and adapt to rules and meanings, and transmit knowledge (Nielsen 2012). More recently it has also been stated that the sensitivity to read social signals in the presentation of reality on two levels appears to enable symbolic interpretation of behavior (Lillard 2017).

Smith (2010) points out that pretend play is a characteristically juvenile form of human behavior that generally shows an inverted U curve of frequency in adults. Lillard (2017) even suggests that pretend play stops at about the age of eleven. Nonetheless, memory enhancement continues in adolescence marked by major developments in autobiographical memory. Episodic memory combined with aspects of semantic memory makes up what is known as autobiographical memory (Corballis 2011). This means that imagination does not vanish after childhood, but merely becomes more private (Singer and Singer 1990).

As children become more self-conscious, they begin to replace pretend play with daydreaming and fantasy (Singer and Singer 1990). The development of metacognition or inward-directed attention in adolescence, adulthood, and senescence makes reflective imagination more challenging to study, because its products become less accessible to direct observation—unless externalized. Even if reflective imagination becomes more private after late childhood, it will continue to develop and to play a crucial role in the adaptation to the environment (Wah 2019).

Cognitive Processes Underlying Play and Pretend Play

Mental travel appears to be tied in nonhuman animals—including nonhuman great apes—to the capacity to foresee and to contemplate alternative responses to their environmental circumstances, such as particular locations. By contrast, the mental travel present in humans includes not only the imagination of different spatial locations (mental space travel), but also distinctive degrees of the imagination of oneself or others at different times (mental time travel), and mental states (mental mind travel), giving rise to unlimited possible combinations (Corballis 2013; Wah 2019).

For better or for worse, the positive outcome of this cognitive capacity in humans is that it confers the abilities to escape being stimulus bound, that is, to project oneself outside the boundaries of one's immediate environment to foresee and evaluate personal events beforehand, to take another's viewpoint, and to reflect upon and modify one's own behaviors and actions. However, the negative outcome is that this cognitive capacity also brings about in humans

doubts about what they perceive, about meanings, and about intentions, thereby making human life an uncertain affair (Metcalf 2008; van Heusden 2009; Dis-sanayake 2009).

Humans do not only focus on the environment but also internally on action itself. Self-inward attention allows humans to focus in detail on their own actions, to evaluate them, and to reenact or re-create them on the basis of an imagined idea through rehearsal of skill, mime, and nonlinguistic gestures. Metacognition (self-reflective consciousness) and event representation (imagination) seem the neuro-cognitive mechanisms that made hominins capable of symbolic processing (Donald 1991, 2001, 2006, 2013). The distinctive degrees of memory, imagination, and metacognition present in humans appear to make possible the narrative capacity underlying pretend play. This narrative capacity seems to be the antecedent of verbal language (see Donald 1991; Boyd 2009; Zlatev 2014; Corballis 2015; Ferretti et al. 2017).

It is important to mention that most published studies on the play behaviors of nonhuman great apes focus on their juvenile stage and lack adequate information to test hypotheses of ontogenetic processes. Still needed are normative and comparative studies between nonhuman great apes, both in the wild and in captivity (Ramsey and McGrew 2005). For now, we know that neither rehearsal of skill in terms of innovation, mime in terms of reenactment or re-creation of imagined objects and events, nonlinguistic gesture in terms of pantomime, nor symbolic invention in terms of imposing different meanings to objects and events are prevalent or present in the play behaviors of nonhuman great apes or other nonhuman animals.

Drawing on the available evidence, pretend play, in contrast to play, seems characteristically human and underlain by distinctive degrees of memory, imagination, and metacognition, the cognitive process I refer to as reflective imagination (Wah 2017, 2019). This reflective imaginative ability is the one that seems to enable humans to save time, effort, and risk by exploiting the existing knowledge and skills of conspecifics, as well as to have evolved, and to develop, into the abstract thought and analysis necessary for building cathedrals and producing symphonies.

Conclusion

In this article I have investigated which cognitive processes underlie the capacities to play and to pretend play and whether these processes are present in

both humans and nonhuman animals. My aim in conducting this comparative cross-species study has been to shed light on basic processes and common denominators before exploring species-typical specializations. Bearing in mind that cognitive capacities are not all-or-nothing phenomena but are to be found in varying degrees in a wide range of species—and that risks are involved in comparative studies—I have argued that play is underlain by particular degrees of memory, perception, and consciousness and may be found in many species, whereas pretend play is underlain by distinctive degrees of memory, imagination, and metacognition. This latter, a cognitive process that I refer to as reflective imagination, seems to be characteristically human. Pointing out that the phenomenon of pretend play appears to be typically human and dependent on distinctive degrees of memory, imagination, and metacognition is important, because this helps us understand its possible adaptive functions. I find it thus worth reconsidering the role the reflective imagination has played and still plays in both human evolution and human development.

REFERENCES

- Abraham, Anna, and Andreja Bubic. 2015. "Semantic Memory as the Root of Imagination." *Frontiers in Psychology* 6:1–5. doi:10.3389/fpsyg.2015.00325.
- Bischof-Köhler, Doris. 1985. "Zur Phylogenese Menschlicher Motivation." [On the phylogeny of human motivation.] In *Emotion und Reflexivität*, edited by Lutz H. Eckensberger and Ernst-D. Lantermann, 3–47.
- Bjorklund, David F. 2012. *Children's Thinking: Cognitive Development and Individual Differences*. 5th ed.
- Boesch, Christophe, and Hedwige Boesch. 1984. "Mental Map in Wild Chimpanzees: An Analysis of Hammer Transports for Nut Cracking." *Primates* 25:160–70. doi.org/10.1007/BF02382388.
- Boyd, Brian. 2009. *On the Origin of Stories: Evolution, Cognition, and Fiction*.
- Boyer, Pascal. 2007. "Specialized Inference Engines as Precursors of Creative Imagination?" In *Proceedings of the British Academy (Imaginative Minds)*, Vol. 147, edited by Ilona Roth, 239–54. doi.org/10.5871/bacad/9780197264195.003.0011.
- Burghardt, Gordon M. 2005. *The Genesis of Animal Play: Testing the Limits*.
- . 2010. "The Comparative Reach of Play and Brain: Perspective, Evidence, and Implications." *American Journal of Play* 2:338–56.
- Byers, John A., and Curt Walker. 1995. "Refining the Motor Training Hypothesis for the Evolution of Play." *American Naturalist* 146:25–40.
- Carruthers, Peter. 2002. "Human Creativity: Its Cognitive Basis, Its Evolution, and Its

- Connections with Childhood Pretence." *British Journal for the Philosophy of Science* 53:225–49. <https://doi.org/10.1093/bjps/53.2.225>.
- . 2006. *The Architecture of the Mind: Massive Modularity and the Flexibility of Thought*.
- Clayton, Nicola S., and Anthony Dickinson. 1998. "Episodic-Like Memory During Cache Recovery by Scrub Jays." *Nature* 395:272–74. <https://doi.org/10.1038/26216>.
- Clayton, Nicola S., Timothy J. Bussey, and Anthony Dickinson. 2003. "Can Animals Recall the Past and Plan for the Future?" *Nature Reviews Neuroscience* 4:685–91. <https://doi.org/10.1038/nrn1180>.
- Clayton, Nicola S., Kara Shirley Yu, and Anthony Dickinson. 2001. "Scrub Jays (*Aphelocoma coerulescens*) Form Integrated Memories of the Multiple Features of Caching Episodes." *Journal of Experimental Psychology: Animal Behavior Processes* 27:17–29. <https://doi.org/10.1037/0097-7403.27.1.17>.
- Corballis, Michael C. 2011. *The Recursive Mind: The Origins of Human Language, Thought, and Civilization*.
- . 2013. "Mental Time Travel: A Case for Evolutionary Continuity." *Trends in Cognitive Sciences* 17:5–6. <https://doi.org/10.1016/j.tics.2012.10.009>.
- . 2015. *The Wandering Mind: What the Brain Does When You're Not Looking*.
- Currie, Gregory. 1995. "Visual Imagery as the Simulation of Vision." *Mind and Language* 10:25–44. <https://doi.org/10.1111/j.1468-0017.1995.tb00004.x>.
- Damasio, Antonio. 2000. *The Feeling of What Happens: Body, Emotion, and The Making of Consciousness*.
- . 2003. *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*.
- . 2010. *Self Comes to Mind: Constructing the Conscious Brain*.
- . 2011. "The Quest to Understand Consciousness." Filmed March 2. TED video, 18:36. Posted March 2011. https://www.ted.com/talks/antonio_damasio_the_quest_to_understand_consciousness.
- Darwin, Charles. 1871. *The Descent of Man and Selection in Relation to Sex*.
- . 1872. *The Expression of the Emotions in Man and Animals*.
- De Waal, Frans, and Frans Lanting. 1997. *Bonobo: The Forgotten Ape*.
- De Waal, Frans B. M., and Pier Francesco Ferrari, eds. 2012. *The Primate Mind: Built to Connect with Other Minds*.
- Dissanayake, Ellen. 2000. *Art and Intimacy: How the Arts Began*.
- . 2001. "Becoming Homo Aestheticus: Sources of Aesthetic Imagination in Mother-Infant Interactions." *SubStance* 30:85–103. <https://doi.org/10.1353/sub.2001.0005>.
- . 2009. "The Artification Hypothesis and Its Relevance to Cognitive Science, Evolutionary Aesthetics, and Neuroaesthetics." *Cognitive Semiotics* 5:136–58. <https://doi.org/10.1515/cogsem.2009.5.fall2009.136>.
- . 2015. "'Aesthetic Primitives': Fundamental Biological Elements of a Naturalistic Aesthetics." *Aisthesis: Pratiche, Linguaggi e Saperi dell'Estetico* 8:5–24. <https://oajournals.fupress.net/index.php/aisthesis/article/view/855>.
- Donald, Merlin. 1991. *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*.

- . 2001. *A Mind So Rare: The Evolution of Human Consciousness*.
- . 2006. "Art and Cognitive Evolution." In *The Artful Mind: Cognitive Science and the Riddle of Human Creativity*, edited by Mark Turner, 3–20.
- . 2013. "Mimesis Theory Re-Examined, Twenty Years After the Fact." In *Evolution of Mind, Brain, and Culture*, edited by Gary Hatfield and Holly Pittman, 169–92.
- Endler, John A. 2012. "Bowerbirds, Art, and Aesthetics: Are Bowerbirds Artists and Do They Have an Aesthetic Sense?" *Communicative & Integrative Biology* 5:281–83. <https://doi.org/10.4161/cib.19481>.
- Ferretti, Francesco, Ines Adornetti, Alessandra Chiera, Serena Nicchiarelli, Rita Magni, Giovanni Valeri, and Andrea Marini. 2017. "Mental Time Travel and Language Evolution: A Narrative Account of the Origins of Human Communication." *Language Sciences* 63:105–118. <https://doi.org/10.1016/j.langsci.2017.01.002>.
- Godfrey-Smith, Peter. 1996. *Complexity and the Function of Mind in Nature*.
- Goldman, Laurence R. 1998. *Child's Play: Myth, Mimesis, and Make-Believe*.
- Gómez, Juan-Carlos, and Beatriz Martín-Andrade. 2005. "Fantasy Play in Apes." In *The Nature of Play: Great Apes and Humans*, edited by Anthony D. Pellegrini and Peter K. Smith, 139–72.
- Goodall, Jane. 1964. "Tool Using and Aimed Throwing in a Community of Free-Living Chimpanzees." *Nature* 201:1264–66. <https://doi.org/10.1038/2011264a0>.
- Goswami, Usha. 2008. *Cognitive Development: The Learning Brain*.
- Gould, Stephen Jay. 1977. *Ontogeny and Phylogeny*.
- Gurche, John. 2013. *Shaping Humanity: How Science, Art, and Imagination Help Us Understand Our Origins*.
- Haight, Wendy, and Peggy J. Miller. 1992. "The Development of Everyday Pretend Play: A Longitudinal Study of Mothers' Participation." *Merrill-Palmer Quarterly* 38:331–49.
- Harris, Paul L. 2000. *The Work of the Imagination*.
- Harris, Paul L., and Robert D. Kavanaugh. 1993. "Young Children's Understanding of Pretense." *Monographs of the Society for Research in Child Development* 58:v–107. <https://doi.org/10.2307/1166074>.
- Hayes, Cathy. 1951. *The Ape in Our House*.
- Herculano-Houzel, Suzana. 2016. *The Human Advantage: A New Understanding of How Our Brain Became Remarkable*.
- Herman, David. 2013. *Storytelling and the Sciences of Mind*.
- Kandel, Eric R. 1976. *Cellular Basis of Behavior: An Introduction to Behavioral Neurobiology*.
- . 2006. *In Search of Memory: The Emergence of a New Science of Mind*.
- Leslie, Alan M. 1987. "Pretence and Representation: The Origins of 'Theory of Mind.'" *Psychological Review* 94:412–26. <https://doi.org/10.1037/0033-295X.94.4.412>.
- Lewis, Kerrie P. 2005. "Social Play in the Great Apes." In *The Nature of Play: Great Apes and Humans*, edited by Anthony D. Pellegrini and Peter K. Smith, 27–53.
- Lewis, Kerrie P., and Robert A. Barton. 2004. "Playing for Keeps." *Human Nature* 15:5–21. <https://doi.org/10.1007/s12110-004-1001-0>.
- Lillard, Angeline S. 1994. "Making Sense of Pretence." In *Children's Early Understanding*

- of Mind: Origins and Development*, edited by Charlie Lewis and Peter Mitchell, 211–234.
- . 2017. “Why Do the Children (Pretend) Play?” *Trends in Cognitive Sciences* 21:826–34. <https://doi.org/10.1016/j.tics.2017.08.001>.
- Lu, Hanbing, Qihong Zou, Hong Gu, Marcus E. Raichle, Elliot A. Stein, and Yihong Yang. 2012. “Rat Brains Also Have a Default Mode Network.” *Proceedings of the National Academy of Sciences of the United States of America* 109:3979–84. <https://doi.org/10.1073/pnas.1200506109>.
- Lucariello, Joan M. 2004. “New Insights into the Functions, Development, and Origins of Theory of Mind: The Functional Multilinear Socialization (FMS) Model.” In *The Development of the Mediated Mind: Sociocultural Context and Cognitive Development*, edited by Joan M. Lucariello, Judith A. Hudson, Robyn Fivush, and Patricia J. Bauer, 33–57.
- Lyon, Pamela. 2015. “The Cognitive Cell: Bacterial Behavior Reconsidered.” *Frontiers in Microbiology* 6:1–18. <https://doi.org/10.3389/fmicb.2015.00264>.
- MacLean, Paul D. 1964. “Man and His Animal Brains.” *Modern Medicine* 32:95–106.
- Matevia, Marilyn L., Francine G. P. Patterson, and William A. Hillix. 2002. “Pretend Play in a Signing Gorilla.” In *Pretending and Imagination in Animals and Children*, edited by Robert W. Mitchell, 285–305.
- McGrew, William C. 1981. “The Female Chimpanzee as a Human Evolutionary Prototype.” In *Woman the Gatherer*, edited by Frances Dahlberg, 35–73.
- Metcalfe, Janet. 2008. “Evolution of Metacognition.” In *Handbook of Metamemory and Memory*, edited by John Dunlosky and Robert A. Bjork, 29–46.
- Metcalfe, Janet, and Lisa K. Son. 2012. “Anoetic, Noetic, and Auto-noetic Metacognition.” In *Foundations of Metacognition*, edited by Michael J. Beran, Johannes L. Brandl, Josef Perner, and Joëlle Proust, 289–301.
- Mitchell, Robert W., ed. 2002. *Pretending and Imagination in Animals and Children*.
- . 2007. “Pretense in Animals: The Continuing Relevance of Children’s Pretense.” In *Play and Development: Evolutionary, Sociocultural, and Functional Perspectives*, edited by Artin Göncü and Suzanne Gaskins, 51–75.
- Mulcahy, Nicholas J., and Josep Call. 2006. “Apes Save Tools for Future Use.” *Science* 312:1038–40. <https://doi.org/10.1126/science.1125456>.
- Nelson, Katherine. 2005. “Emerging Levels of Consciousness in Early Human Development.” In *The Missing Link in Cognition: Origins of Self-Reflective Consciousness*, edited by Herbert S. Terrace and Janet Metcalfe, 116–41.
- Nelson, Katherine, and Robyn Fivush. 2000. “Socialization of Memory.” In *The Oxford Handbook of Memory*, edited by Endel Tulving and Fergus I. M. Craik, 283–95.
- . 2004. “The Emergence of Autobiographical Memory: A Social Cultural Developmental Theory.” *Psychological Review* 111:486–511. <https://psycnet.apa.org/doi/10.1037/0033-295X.111.2.486>.
- Nielsen, Mark. 2012. “Imitation, Pretend Play, and Childhood: Essential Elements in the Evolution of Human Culture?” *Journal of Comparative Psychology* 126:170–81. <https://doi.org/10.1037/a0025168>.

- Osvath, Mathias. 2009. "Spontaneous Planning for Future Stone Throwing by a Male Chimpanzee." *Current Biology* 19:R190–91. <https://doi.org/10.1016/j.cub.2009.01.010>.
- Osvath, Mathias, and Helena Osvath. 2008. "Chimpanzee (*Pan Troglodytes*) and Orangutan (*Pongo Abellii*) Forethought: Self-Control and Pre-Experience in the Face of Future Tool Use." *Animal Cognition* 11:661–74. <https://doi.org/10.1007/s10071-008-0157-0>.
- Panksepp, Jaak. 1998. *Affective Neuroscience: The Foundations of Human and Animal Emotions*.
- Patterson, Francine G. 1980. "Innovative Uses of Language by a Gorilla: A Case Study." In *Children's Language*, Vol. 2, edited by Keith E. Nelson, 497–561.
- Pellegrini, Anthony D., and Peter K. Smith, eds. 2005. *The Nature of Play: Great Apes and Humans*.
- Pellegrini, Anthony D., Danielle Dupuis, and Peter K. Smith. 2007. "Play in Evolution and Development." *Developmental Review* 27:261–76. <https://doi.org/10.1016/j.dr.2006.09.001>.
- Plotnik, Joshua M., Frans B. M. de Waal, Donald Moore III, and Diana Reiss. 2010. "Self-Recognition in the Asian Elephant and Future Directions for Cognitive Research with Elephants in Zoological Settings." *Zoo Biology* 29:179–91. <https://doi.org/10.1002/zoo.20257>.
- Rakoczy, Hannes. 2008. "Pretence as Individual and Collective Intentionality." *Mind & Language* 23:499–517. <https://doi.org/10.1111/j.1468-0017.2008.00357.x>.
- Ramsey, Jacklyn K., and William C. McGrew. 2005. "Object Play in Great Apes: Studies in Nature and Captivity." In *The Nature of Play: Great Apes and Humans*, edited by Anthony D. Pellegrini and Peter K. Smith, 89–112.
- Romanes, George John. 1885. *Mental Evolution in Animals*.
- Savage-Rumbaugh, E. Sue. 1986. *Ape Language: From Conditioned Response to Symbol*.
- Scarlett, W. George, Sophie Naudeau, Dorothy Solonius-Pasternak, and Iris Ponte. 2005. *Children's Play*.
- Schacter, Daniel L., and Endel Tulving. 1994. "What Are the Memory Systems of 1994?" In *Memory Systems 1994*, edited by Daniel Schacter and Endel Tulving, 1–38.
- Schacter, Daniel L., Donna Rose Addis, and Randy L. Buckner. 2007. "Remembering the Past to Imagine the Future: The Prospective Brain." *Nature Reviews Neuroscience* 8:657–61. <https://doi.org/10.1038/nrn2213>.
- Singer, Dorothy G., and Jerome L. Singer. 1990. *The House of Make-Believe: Children's Play and the Developing Imagination*.
- Smith, Peter K. 2005. "Play: Types and Functions in Human Development." In *Origins of the Social Mind: Evolutionary Psychology and Child Development*, edited by Bruce J. Ellis and David F. Bjorklund, 271–91.
- . 2010. *Children and Play: Understanding Children's Worlds*.
- Smith, Peter K., and Anthony D. Pellegrini. 2005. "Play in Great Apes and Humans: Reflections on Continuities and Discontinuities." In *The Nature of Play: Great Apes and Humans*, edited by Anthony D. Pellegrini and Peter K. Smith, 285–298.

- Suddendorf, Thomas, and Andrew Whiten, 2001. "Mental Evolution and Development: Evidence for Secondary Representation in Children, Great Apes, and Other Animals." *Psychological Bulletin* 127:629–50. <https://doi.org/10.1037/0033-2909.127.5.629>.
- Suddendorf, Thomas, and Michael C. Corballis. 1997. "Mental Time Travel and the Evolution of the Human Mind." *Genetic, Social, and General Psychology Monographs* 123:133–67.
- . 2007. "The Evolution of Foresight: What Is Mental Time Travel, and Is It Unique to Humans?" *Behavioral and Brain Sciences* 30:299–313. <https://doi.org/10.1017/S0140525X07001975>.
- Taylor, Marjorie, Stephanie M. Carlson, and Alison B. Shawber. 2007. "Autonomy and Control in Children's Interactions with Imaginary Companions." In *Proceedings of the British Academy (Imaginative Minds)*, Vol. 147, edited by Ilona Roth, 81–100.
- Terrace, Herbert S., and Janet Metcalfe, eds. 2005. *The Missing Link in Cognition: Origins of Self-Reflective Consciousness*.
- Thomas, Nigel J. T. 2003. "Imagining Minds: Bradshaw Seminar, The Claremont Colleges, Claremont, California, 6–8 February 2003." *Journal of Consciousness Studies* 10:79–84.
- . 2014. "The Multidimensional Spectrum of Imagination: Images, Dreams, Hallucinations, and Active, Imaginative Perception." *Humanities* 3:132–84. <https://doi.org/10.3390/h3020132>.
- Tomasello, Michael. 1999. *The Cultural Origins of Human Cognition*.
- Tulving, Endel. 1972. "Episodic and Semantic Memory." In *Organization of Memory*, edited by Endel Tulving and Wayne Donaldson, 381–403.
- . 1985. *Elements of Episodic Memory*, Oxford Psychology Series, Vol. 2.
- . 2005. "Episodic Memory and Autonoesis: Uniquely Human?" In *The Missing Link in Cognition: Origins of Self-Reflective Consciousness*, edited by Herbert S. Terrace and Janet Metcalfe, 3–56.
- Van Heusden, Barend. 2009. "Semiotic Cognition and the Logic of Culture." *Pragmatics & Cognition* 17:611–27. <https://doi.org/10.1075/pc.17.3.07van>.
- Van Schaik, Carel P., Marc Ancrenaz, Gwendolyn Borgen, Birute Galdikas, Cheryl D. Knott, Ian Singleton, Akira Suzuki, Sri Suci Utami, and Michelle Merrill. 2003. "Orangutan Cultures and the Evolution of Material Culture." *Science* 299:102–105. doi: 10.1126/science.1078004.
- Wah, Alejandra. 2017. "Cognitive Processes Underlying the Artistic Experience." *Avant: Trends in Interdisciplinary Studies* VIII:45–58. doi:10.26913/80102017.0101.0003.
- . 2019. "Reflective Imagination via the Artistic Experience: Evolutionary Trajectory, Developmental Path, and Possible Functions." *Evolutionary Studies in Imaginative Culture* 3:53–72. doi:10.26613/esic/3.2.143
- Whiten, Andrew, and Thomas Suddendorf. 2007. "Great Ape Cognition and the Evolutionary Roots of Human Imagination." In *Proceedings of the British Academy (Imaginative Minds)*, Vol. 147, edited by Ilona Roth, 31–59.
- Wrangham, Richard W., Colin A. Chapman, Adam P. Clark-Arcadi, and Gilbert Isabirye-

- Basuta. 1996. "Social Ecology of Kanyawara Chimpanzees: Implications for Understanding the Costs of Great Ape Groups." In *Great Ape Societies*, edited by William C. McGrew, Linda F. Marchant, and Toshisada Nishida, 45–57.
- Zhou, Wenyi, and Jonathon D. Crystal. 2009. "Evidence for Remembering When Events Occurred in a Rodent Model of Episodic Memory." *Proceedings of the National Academy of Sciences* 106:9525–29. <https://doi.org/10.1073/pnas.0904360106>.
- Zlatev, Jordan. 2014. "Human Uniqueness, Bodily Mimesis, and the Evolution of Language." *Humana.Mente Journal of Philosophical Studies* 27:197–219.