

The Marvelous Gadget.  
Review of Cognitive Gadgets by Cecilia Heyes.  
Review by Bill Rowe

The Marvelous Gadget.  
It went "Zip" when it moved  
And "Bop" when it stopped  
"Whirrr" when it stood still  
I never knew just what it was  
And I guess I never will.

So goes the chorus of Tom Paxton's charming folk song, The Marvelous Toy. The song opens with a young boy's father coming home one night with a new toy. It was a wonder to behold, we learn, with bright colors and two big buttons on the bottom that looked like big green eyes. It became his heart's delight. But the features that made the toy so marvelous were not the colors or the buttons. The toy was marvelous because of its mischievous unpredictability. It first marched left and then marched right, and then marched under a chair. But when the boy looked to where it had gone, "It wasn't even there!" And then, "I started to cry, but my daddy laughed 'cause he knew that I would find, when I turned around my marvelous toy chugging from behind."

The years went by, the song says, the child grew up, and had a little boy of his own. Then one day he gave his son the marvelous toy. It still went "Zip" when it moved, And "Bop" when it stopped, and it "Whirred" when it stood still; neither one ever learned just what it was and, happily, they never will.

In this review I will make the case that Cecilia Heyes's cognitive gadgets and Tom Paxton's marvelous toy have some things in common. Neither is required for life. Both are handed-down by other people, not passed-along by genes. One is marvelous and the other is wondrous. And none of this is obvious; which is why the author devoted 292 pages to explaining cognitive gadgets. I will try my hand at pointing to the wondrous and the marvelous part, but first ... Cecilia Heyes.

Cecilia Heyes is Senior Research Fellow in Theoretical Life Sciences All Souls College, University of Oxford. She is also a Fellow of the British Academy, and President of the British Experimental Psychology Society. She studied with the well-known and much admired social scientist Donald T. Campbell. Campbell pioneered the field of Evolutionary Epistemology which was shaped around his idea of Blind Variation and Selective Retention; a concept that he considered to be a core principle of cultural evolution. Heyes continues and expands this tradition in her writings and in her new book on the evolution of cognition. Her work is an exploration of the many ways in which culture and natural evolution intersect. In particular the

ways in which cultural influence and learning interact during development to produce our mature cognitive abilities.

### On Being Peculiar

"What makes us peculiar?" is the lead-off question that opens both the introduction and chapter one, A Question and Many Answers. This term weaves its way all through the book. At first I found it, well, peculiar. Why not "unique," for example, or "exceptional?" But as I read on I came to believe that this is, indeed, the right word. The term peculiar can have overtones that range from "strange," to "funny," to "mystifying," to "unexpected." Much like Tom Paxton's marvelous toy. So what is it about being human that is peculiar? It's the Gadgets.

Gadget: "a small mechanical or electronic device with a practical use but often thought of as a novelty." That's according to Merriam-Webster online. Some of the synonyms, however, are more revealing: "contraption," "contrivance," "gizmo," "widget." In an interview for *The Psychologist*, Heyes said that she used the term "To acknowledge a debt and mark a contrast. The debt is to evolutionary psychology, which brought together Darwinism and cognitive science about 25 years ago." A union, she notes, that depicted things like language, mindreading, causal reasoning, imitation, and moral cognition as "cognitive instincts." She agrees that these are products of Darwinian selection, but argues that the selection has been cultural rather than genetic. So these uniquely human features are, like gadgets, handed-down from person-to-person rather than passed-on gene-to-gene. And while much of human behavior is controlled by mechanisms that we have in common with other animals, these "cognitive gadgets are what make our lives so different from theirs." (*The Psychologist*, July 2018). And different they are; often in a strangely mystifying, unexpected, and peculiar ways.

The four gadgets that Heyes mostly deals with in the book are Selective Social Learning, Imitation, Mindreading, and Language. Collectively, these things create what is simultaneously the most intimate yet most illusive feature of our lives; that is, human subjective consciousness. And the pursuit of what that is has perplexed thoughtful people for a very long time. The psychologist Julian Jaynes said that: "Few questions have endured longer or traversed a more perplexing history than this." (Jaynes, 1976, p. 1). Heyes is not pretending to have solved that problem, but she is aware of the significance of her contribution. And in the opening paragraph of chapter 8 she describes the acquisition of language as the crossing of a Rubicon. "Now capable of abstract thought and subtle communication, we became radically different from all other animals - more like gods than beasts." Indeed, the ability to see ourselves objectively from a third-person point of view is a kind of transcendence, a secular transcendence to be sure, that has all the allure and wonder of divine being.

But it's not divine, it's better than that. As a metaphorical creation it can be whatever it needs to be, more Leprechaun than Olympian. And setting aside the so-called Hard Problem, (for this century anyway) the developmental arrival of reflexive self-awareness bequeaths a never-ending story whose central character is "more myself than anything I can find in a mirror." (Jaynes, 1976, p. 1). While the Divine is stuck with being, well, Divine, we are endowed with

being mischievously elusive. For, "if we press too hard to get a glimpse of ourselves "we feel a vague irritation, as if there were something that did not want to be known, some quality which to question was somehow ungrateful, like rudeness in a friendly place." (Jaynes, 1976, p. 45). But, like the boy in the song who starts to cry before turning to find his marvelous toy right behind him, we animate the nearest marvelous gadget and move on. Peculiar, huh?

### Cognitive Gadgets:

The book has 9 chapters. The first four are set-ups for the core chapters 5 through 8, each of which details a specific cognitive gadget; Selective Social Learning, Imitation, Mindreading, and Language, in that order. Chapter nine is a summary of Cultural Evolutionary Psychology. And this chapter title, Cultural Evolutionary Psychology, is the term used to distinguish her views from other previously established theories such as Evolutionary Psychology and Cultural Evolutionary Theory. Figure 1 is my adaptation of figure 1.2 in Heyes's book. The arrows in the figure depict the features of the two preceding theories that are preserved in Heyes's Cultural Evolutionary Psychology. Taking the mind as a serious "artifact" from Evolutionary Psychology, on the one hand; and social learning as a component from Cultural Evolutionary Theory, the Venn overlap of the two theories in the upper part of the figure illustrates that, in those theories, inheritance still takes place in the genes. For Heyes, the mechanism that facilitates the creation, variation, selection, and transmission of Cognitive Gadgets is definitely not genetic. A great deal of the book is dedicated to explaining this.

### Chapter 3, Starter Kit.

Cognitive gadgets are cognitive mechanisms that are learned during childhood. Examples include imitation, mindreading (also called theory of mind), language, and normative thinking. In Heyes's theory these are not part of the human genetic make-up; they are not instincts. Instead, they are the developmental products of interpersonal relationships with other people. She refers to these capabilities as "Big Special" and notes that both Evolutionary Psychology, and Cultural Evolutionary Theory suggest that they are genetically inherited. In her view, however, because their development requires attention toward and engagement with other agents, they depend upon general purpose mechanisms that are genetic. She refers to these as "Small Ordinary" and lists them by three broad categories: temperament, attentional biases, and central processors. Figure 2 graphically depicts these clusters of psychological attributes and executive functions. And chapter 3 locates these features as components of a dual process model of human cognition. "Humans have uniquely powerful central processors: mechanisms of learning, memory, and control that extract, filter, store, and use information. Each of these processors is domain-general, crunching data from all input domains." (Heyes, 2018, p 53). They will take a weakly-biased propensity to orient toward a face-like visual stimuli, for example, and mold it into what looks like a hard-wired instinct for the human face. Similarly for the shaping of an infant's tracking the human voice. A human infant has heard its mother's voice for many months in the womb. Also, during this time, the infant has been exposed to the rhythms and cadences of the language she

will be born into. These are familiarities, not instincts. They are converted into strong attractors, however, by the same general-purpose central processors that are "fully capable of honing a simple, inborn preference for primate vocalizations into a highly specific input bias favoring speech in the infant's native language." (Heyes, 2018, p 64). This theme of a general purpose processor amplifying and shaping a marginal propensity into a stable behavioral norm is pervasive throughout development. It includes the shaping of human behaviors long considered to be innately given; behaviors like imitation, joint attention, mind reading, and language. And what is that they do exactly? Basically old fashioned associative learning. And this is discussed in the last section of chapter three's Starter Kit, Cognition.

## Cognition

Figure 3 is a graphic representation of a typical dual process model of human cognition. This kind of model forms the framework for Heyes's theory. There are many of these models and they have been around since the time of William James. Although they are probably known to most people via the Nobel laureate Daniel Kahneman's book title as the components that think fast and slow. (Kahneman, 2013). As the left side of the figure shows they consist of two parts, labeled System 1 and System 2. System 1 is characterized as fast, automatic, non-conscious, and parallel. The components of System 2 are considered to be slow, conscious, serial, and effortful. These are listed in the column on the right side of figure 3. I've located Heyes's psychological attributes and executive functions between the System 1 and 2 labels on the left and the typical "fast" and "slow" descriptors on the right. And below the list of "Big Special" features I've drawn a representation of what Heyes calls a "mill." The one depicted here is called a "mindreading mill." Other kinds of "mills" are Language and Imitation. As we will see later in this review Heyes draws upon the concept of a mill to illustrate the behavior of system 2 cognitive gadgets. I've drawn a coffee grinder to represent this Mindreading mill. The metaphorical extension is that it "grinds grist," that is, mental entities like beliefs, desires, and memories, and produces new cognitive products that, in turn, can be taken as grist for further "grindings."

While there is a certain common sense logic to structures like this Heyes, in an endnote, points out that "Critics have questioned the evidence on which dual-process theory is based and identified inconsistencies among the various dual-process models on the market." (Heyes, 2018, 265). Indeed there is, and in her endnote Heyes directs the curious reader to sources for debate on this issue. Since this model is so integral to her theory, after a brief description of her version of a dual process model, I will offer a short rebuttal to some of the criticism.

The "Small Ordinary" psychological attribute, temperament, refers to the remarkable tolerance, especially compared to chimpanzees, our nearest genetic relatives, that adult humans have toward juveniles, as well as the inclination to seek out and thrive on the company of others. In later sections of Chapter 3 this is detailed under the heading of Emotion and Motivation, with sub-categories of Social Tolerance, and Social Motivation. Attentional biases are about the human infant's predilection to orient toward certain features of others such as faces and voices. This topic is elaborated under the headings of Faces and Voices. The last category, central

processors, indexes a set of functions that facilitate learning. It would be difficult to overstate the importance of this category.

The supervisory regulation of System 1, Heyes's "Big Special" executive functions, reside in System 2. Following Diamond (Executive Functions, 2013) Heyes describes three core components of System 2: inhibitory control, working memory, and cognitive flexibility. Inhibitory control is the executive function that overrides fast, intuitive, impulsive behaviors. Working memory indexes the ability to hold information in mind long enough to relate it to other factors. Heyes adds to this the processing of information about objects and events that are not currently present. Cognitive flexibility is the capacity to switch perspectives or approaches to a problem. It necessarily recruits inhibitory control since the preceding goal must be held in abeyance while a new judgment is evaluated. Also working memory is called upon as a "place" for the new goal or perspective to temporally reside.

The common sense aspect to all of this, mentioned earlier, is best seen from a developmental point of view. From birth to about seven years of age, each new skill acquired such as being able to push buttons on interesting household items or being able to throw exciting objects with increasing accuracy, needs to be modulated by executive overrides. As Heyes puts it: "System 2 acts as a more or less successful "supervisor" or "executive" with respect to System 1 ... it schedules, harnesses, and augments the activities of System 1." (Heyes, 2018, p. 67). And she adds further that it is usually assumed that System 1 is evolutionarily older and that it is System 2 that has undergone major expansion in the lead-up to Homo Sapiens.

### Grist and Mills

In addition to being peculiar and gadgety, System 1 and System 2ish, her model is also laced with grists and mills. Grist is variously described throughout the book as, "behavior, artifacts, and conceptual structures" (pp. 36-37), "ideas" (pp. 37-38), and "beliefs and skills." A few examples of mills are: "cognitive mechanisms" (p. 40), "the internal cognitive processes that grind the grist" (pp. 36-37), and "the way the mind works (pp.13-14). Interestingly, I could find no place where Heyes gives an explicit list of specific mills. They can be inferred, however, from comments she makes in passing; for example: "a mindreading mechanism (mill) is adaptive to the extent that it allows accurate prediction of behavior." (p. 205 -206); "a 'reading aloud mechanism' " (p. 38), "including the mills that enable high fidelity–high bandwidth cultural inheritance, such as metacognitive social learning strategies (Chapter 5), mindreading (Chapter 7), and language (Chapter 8)" (p. 74). And, from the last few lines of her book: "It has also shaped the mills. Distinctively human cognitive processes are products of cultural group selection. They are not cognitive instincts, but cognitive gadgets." (Heyes, 2018, p.223). From these excerpts we can conclude that grists are beliefs, skills, ideas, and behaviors. And mills are social learning mills, mindreading mills, reading aloud mills, language mills, and they are all cognitive gadgets.

So, I think it is safe to conclude that mill is a term for a specific kind of cognitive gadget such as Mindreading or Language, and that the function of mills is to grind the grist, (Heyes,

2018, pp. 36-37)." Heyes gives an example of a "reading aloud mechanism" that is capable of converting script into speech." (Heyes, 2018, pp. 38-39). And also a "mindreading mechanism (mill) is adaptive to the extent that it allows accurate prediction of behavior." (Heyes, 2018, p. 205). We see that mills function somewhat like operators in mathematics. In these cases taking sensory representations or cognitive inferences as arguments and "grinding" through the operation of producing speech in one case and prediction about what someone might do in the other. As shown in figure 3 mills are residents of System 2. But it is important to remember that they can operate on gadgets or other products of other mills and create new behaviors, ideas, thoughts, or mechanisms that, in turn, can be grist for more milling and candidates for further social Darwinian selection.

I have tried to illustrate this evolutionary process in figure 4. At time T-1 a mindreading mill processes ideas, thoughts, and procedures and produces teachings, and collaborative learning for example. These outputs or variants of them are then taken at time T-2 as grist for further milling into newer teachings, understandings, and learnings. If this rendering is correct it can be seen that there is almost no limit to the novelty and adaptability of this cultural variation and selection process. Heyes affirms this quite marvelous capacity in the last chapter of her book: "If I have this right we need not fear that our minds will be stretched too far by living conditions that depart ever farther from those of hunter-gatherer societies. On the cognitive gadgets view, rather than taxing an outdated mind, new technologies—social media, robotics, virtual reality—merely provide the stimulus for further cultural evolution of the human mind." (Heyes, 2018, pp. 218-219).

#### A note on dual process models

As mentioned earlier, Heyes informs her readers that the dual process model has its critics. As an example she cites Kruglanski and Gigerenzer's 2011 paper, "Intuitive and deliberate judgments are based on common principles." For a robust defense of the model she directs attention to Evans and Stanovitch, 2013, "Dual-process theories of higher cognition: Advancing the debate." (Heyes, 2018, p. 235). The criticisms can, indeed, sound portentous, "Dual-process theories of reasoning exemplify the backwards development from precise theories to surrogates." (Gigerenzer, 2010, p. 739). And "Evidence used to support dual theories is consistent with single-system accounts." (Osman, 2004, p. 1006). So that's all well and good, it's always informative to hear from your critics. But it gets even more interesting to hear from the supporters of dual process models; Daniel Kahneman, for example, in his book *Thinking Fast and Slow*, says: "System 1 and System 2 are so central to the story I tell in this book that I must make it absolutely clear that they are fictitious characters." (Kahneman, 2011, p.29). Say what? He goes on: "Systems 1 and 2 are not systems in the standard sense of entities with interacting aspects or parts. And there is no one part of the brain that either of the systems would call home." (Kahneman, 2011, p.29). Your first thought might just be: "With friends like this who needs critics? And then there's Evans and Stanovitch, the folks that Heyes recommends for, as she says a "robust defense." They say: "We ourselves are critics as well as supporters of dual

process theories ... we actually agree with a number of the points made in the recent critiques." (Evans and Stanovitch, 2013, 224).

The criticisms often sound more trenchant than they in fact are. And that is because they are typically not directed at any particular theory but, rather, at a class of theories. And this class can contain a rather large number of exemplars. For example, in a 2004 book, *The Robot's Rebellion*, Stanovitch found 23 different versions of dual process models, all of them differing in their characterization of features of System 1 and System 2. And in a 2008 paper Evans lists 14 different models. And among them he extracted four different cluster attributes. The shortest cluster of attributes for System 1, for example, was three; Universal, Independent of general intelligence, and Independent of working memory. The longest cluster for System 1 was eight; unconscious (preconscious), Implicit, Automatic, Low effort, Rapid, High capacity, Default process, Holistic (perceptual). All the 23 models reviewed in Stanovitch's 2004 book and the 14 models in Evans's 2008 paper differed from one-another in their clustering of attributes. So when viewed as a class of theories the dual process model can be seen as an invitation to create a smorgasbord of features within each system. And in this light, Evans and Stanovitch say: "Unfortunately, these tables of properties in the early literature have misled some theorists. The main misuse of such tables of properties is to treat them as strong statements about necessary co-occurring features. The longer the list of properties in any one table, the easier it is to create the straw-man claim that if all of these features do not always co-occur, then the dual-process view is incorrect." (Evans and Stanovitch 2013, p. 228). But then they go on to say, "In common with Kahneman ... we both favor forms of dual-process theory that are default-interventionist in form." (P. 237). What do they mean by this?

Evans and Stanovitch study reasoning and decision making, and they do not pretend to defend some generic received model that probably does not even exist. There are dual-process models in other fields like Social Psychology and Economics, for example, that will have different clusters of attributes. But there is something that unites all of these models, and that is they come into existence as an artifact of a biologically developing organism. And not just any biologically developing organism; a human infant that has the option of developing a reflective skill-set with the capacity of taking its own reactions and experiences as objects of attention. As I see it, in a typical developing context, this leaves in place a non-optional hierarchical decision-making superstructure. Something that wouldn't necessarily exist if the creature were designed from scratch by an engineer. This superstructure is some version of the well-known executive regulator of overlearned early childhood behaviors. The overlearned childhood reactions and decision-making styles do not go away just because the executive overseer comes into existence. And this is how I understand Evans and Stanovitch's default-interventionist system.

With these comments in mind I suggest that Heyes's two-system model weathers any criticism just fine. The theme of her book is a developmental one. As such she does not intend to delineate how a particular dual-process structure comes to be. Diagrams such as figure 2 with its broad list of features in each system denote the range of capabilities that this organism is capable of acquiring. Which is what the gadget theory is all about.

Figure 1 Here.

Figure 2 Here.

Figure 3 Here.

Figure 4 Here.

#### Culturally Negotiated Attention (CNA) World

Chapters 4 and 5, Cultural Learning and Selective Social Learning respectively contain the core learning concepts of Heyes's theory. But names like these, she says, can be misleading. And that the slicing and dicing of learning by different categorical names can create the illusion that there are genetically mandated systems that specialize in different mechanisms of learning. Figure 5, adapted from Heyes (Heyes, 2018. p 86), is meant to call attention to this error. The superordinate category, "Learning" indexes a very general process of encoding for long-term storage of information acquired through experience. "Social Learning," the first subordinate category, indexes learning influenced by contact with other people or constrained by social norms. "Cultural Learning," the final subordinate category, denotes learning from other people. So the issue is not necessarily what is learned but, rather, but the context of how it is learned. In chapter 5 Heyes presents evidence that most social learning is dependent upon the same cognitive mechanisms as individual learning. The inputs, other people, are different but their representations are encoded and stored by the same mechanisms as inputs from inanimate sources.

But Heyes's book is about more than cultural learning. *Cognitive Gadgets* seeks to explain how cultural inheritance works. Chapter 4 introduces this topic. "Chapter 4 examines the nature of cultural learning that enables cultural inheritance—the cultural analogue of DNA replication" (Heyes, 2018. p. 3). In the following section I would like to describe a complementary description of an analog of DNA; I suggest that it be called CNA, Culturally Negotiated Attention.

Figure 5 Here.

What is Culturally Negotiated Attention? It is a form of sustained dialogic orientation that distinguishes Cultural Learning from Social Learning and Individual Learning, without evoking any new special purpose cognitive learning mechanisms. It is Cultural because the form of the interaction tends to be culturally prescribed. It is Negotiated because the interacting parties contribute to a dynamic temporal stability. And the goal is to maintain Attention on each other, thus guaranteeing that all important time-on-task requirement for learning. The adult form of this is conversation, and conversation is crucial to Heyes's theory of cultural evolution. In her discussion of the inheritance of cognitive mills Heyes says: "things that go on between people,

rather than inside individuals' heads—such as conversation, storytelling, turn-taking, collective reminiscing, teaching, demonstrating, and engaging in synchronous drills" (Heyes, 2018. p. 203). Conversation is conventionalized negotiated attention sharing. The psycholinguist Michael Ramscar, has said that "Virtually every linguistic act – even saying, "Hello!" – is intended to reduce a listener's uncertainty, whether about the world, about the thoughts and feelings of a speaker, or a speaker's sincerity, etc." (Ramscar, p. 89). To do this the listener must acquire the skill of inhibiting action until word-by-word, or gesture-by-gesture, the message of the other person is resolved. And then the speaker becomes a listener until the meaning of the previous listener - now speaker - is resolved. How does this behavior arise?

May I have this Dance?

There is a saying in neuroscience that neurons that fire together wire together. Equivalently humans that spend time together bind together. "Speakers who tend to match each other's temporal patterns of speech see each other as warmer, as more similar, as more socially desirable, enjoy the contact more, and are found to be more interpersonally responsive or sensitive" (Beebe et al, 1985. p. 220). Beginning in the early 1970s we see the evolution of experimental techniques that quantify the development of sustained synchronous interpersonal behavior. For example, in their 1970 book, *Rhythms of Dialog*, Jaffe and Feldstein utilized a technique of coding the on-off vocal activity of two adults having a conversation. (Jaffe and Feldstein, 1970). This enabled the construction of phase diagrams showing the temporal correlation between two speakers. Figure 6 is an example of such a phase diagram. (Jaffe and Feldstein, 1970, p. 20; Jaffe et al. 2001, p. 44). The variables were the duration of speaking time, pauses during an individual's vocalization, switching pause time between speakers, interruptive simultaneous speech and non-interruptive simultaneous speech. One feature that Jaffe and Feldstein noted was a strong tendency for speakers to match the average durations of their switching pauses, that is, the length of time between the end of one speaker's vocalization and the beginning of the other's. And they commented that, "The mutual pacing is referable to a bilateral adjustment of silence intervals, and this may correlate with phenomena such as empathy or communication of mood." (Jaffe and Feldstein, 1970. p. 4). Note that the matching of switching pauses is an emergent property that arises over the course of a conversation. It is not indicated in figure 6 which, for illustrative purposes, depicts only about a 7 second event.

Figure 7 (Adapted from Figure 2 of Beebe et al. 1985) illustrates the use of this technique to explore the beginning of this skill in infancy. Here an infant of around 6 months of age and a caregiver are using make-break, gesture-hold-gesture affective shifts to negotiate sustained phasic engagements. This paper continued the work of Jaffe, Feldstein, and others under the auspices "vocal congruence," in which, "over the course of a conversation, speakers tend to match the time patterns of their speech." (Beebe et al, p. 1985). Like Jaffe and Feldstein, they note a particularly strong tendency of speakers to match the duration of their switching pauses. As with the previous diagram figure 7 depicts a short time-scale sequence, and does not attempt

to show gestural congruence which emerges over a longer duration. And figure 8 (Adapted from figure 1 of Jaffe and Anderson, 1979) illustrates what might be called the "final product," that is, an adult form of conversation socially constructed out of a nested hierarchy of rhythmic entrainments. The point of this graph is to illustrate the conjecture that what we identify as adult conversation emerges ontogenetically out of rhythmic coaction between a caregiver and the infant (Jaffe and Anderson, p. 20, 1979). This is an important issue because, as we will see later, the "conversation" is a non-optional feature of Heyes's theory of cultural inheritance. And, interestingly, the way Jaffe and Anderson, express their conjecture about the nature of this "proto-conversation" suggest a sympathy for Heyes's theory of cultural origins: "one is led to the speculation that human communication is based on an evolved capacity for the acquisition, use, and elaboration of rhythmically structured gestural systems." (Jaffe and Anderson, p. 21, 1979). Note the language of the capacity to "acquire" rhythmically structures behaviors, and not the genetically inherited mandate to do so.

Figure 6 Here.

Figure 7 Here.

## Figure 8 Here.

In 2001 researchers, including Jaffe, Feldstein and Beebe, continued the exploration of this rhythmic entrainment between infant and caregiver in a monograph called *Rhythms of Dialogue in Infancy: Coordinated Timing in Development* (Jaffe et al., 2001). Jaffe et al., used a computer system to code pauses, switching pauses, and vocalizations of the infant and the adult. Elaborating on previous work, experiments were done in the lab, in the infant's home, with a familiar person, and with a stranger. The results verified the same sort of congruence of co-regulated timings, but with variations due to the different contexts. For example, infants had shorter pauses and switching pauses when with a stranger. (Jaffe et al., 2001, figure 2). Also the adult's switching pauses were longer in the home than they were in the lab, and their vocalizations were longer in the lab. (Jaffe et al., 2001, p, 61). Despite these variations the researchers found numerous stable modes of infant-adult coupling. One of these was the average activity level of the two partners as measured by the ratio of mean durations of vocalization to pause. The infant-adult activity levels of this measure were significantly correlated in all six conditions; the three partner configurations at two sites, the home and the lab. (Jaffe, 2001, p. 91).

One of the most significant findings, however, was a correlation between coordinated interpersonal timing at 4 months of age and both cognitive - as measured by the Mental Development Index of Bayley, and degree of attachment - as measured by the Strange Situation - at 12 months of age. The fact that such a "proto-conversational" interaction at 4 months of age predicts both cognitive and emotional outcomes at 12 months is, I think, strong support for Heyes's theory. And this is in part because, as we will see later in this review, Heyes shows us how extended rhythmic behaviors between individuals can be induced by general-purpose learning mechanisms with no need for genetically inherited programs. As Jaffe et al., say at the end of their monograph, the "Dialogic rhythms are procedures for regulating the timing of face-to-face communication at age 4 months, and are already analogues of the social-emotional dance-to-be at age 1 year, as well as an index of the infant's novelty response relevant to cognition." (Jaffe et al. 2001, p. 116).

A more recent paper found another interesting inflection point at 12 months. Hilbrink, Gattis and Levinson did a longitudinal study of the changes in speech overlaps, switching gaps, and within-person pauses between mother-infant dyads over the intervals of 3, 4, 5, 12, and 18 months (Hilbrink et al., 2015). Based on Levinson's Interaction Engine Hypothesis, (Levinson, 2006), they expected to find that children would present the temporal properties of turn-taking in

the early months of infancy but that timing turns would slow down at 12 months. And the factor behind the slowing of turns was that infants are just starting to produce their first words at around this age. As the authors say: "due to the complex nature of achieving smooth turn transitions we expected that at 12 months, i.e., around the time of the onset of language production, infant turn-timing would slow down ... and that once infants start using language their turn-timing will slow down due to the need to integrate their developing linguistic skills with the existing interactional timing skills (Levinson, 2006)" (Hilbrink et al., 2015, p. 4).

The authors also noted that based on earlier work by, for example, Anderson et al. (1977), Jasnow and Feldstein (1986), Beebe et al. (1988), and Jaffe et al. (2001) they expected to find that the observed turn-timing patterns were reciprocally structured at all ages (Hilbrink et al., 2015, p. 4). And, indeed, they found evidence that 4 month-old infants adjusted their gap duration on the basis of who they interacted with and, further, that at 9 months the maternal gap durations were influenced by infant gap durations and vice versa. This reciprocity is important, I think, because cultural learning, as Heyes defines it, requires a unique sensitivity to other people. I would now like to turn to examining the development of that unique sensitivity.

One, two, three, dance with me

Heyes, not being one to withhold credit where credit is due, shows no hesitation in acknowledging a genetic component to this development sequence. And one of these components is the surprising degree of tolerance of the young by adult humans. Citing Burkart, et al., 2009; and Silk and House, 2011, she notes that "Compared with chimpanzees, adult humans, especially males, are remarkably tolerant of one another and towards juveniles." (Heyes, 2018, p. 54). We will look at this in more detail later. But for now simply note that without this inclination toward sustained proximity there is not even the possibility of time-on-task, that non-optional requirement for the kind of social learning that is unique to human beings. The other is possession of a general purpose learning system that is able to scaffold slight bio-psychological biases into norms that are adaptable to the context. The simplicity in this view is that there is only one domain-general associative mechanism of learning. And, as Heyes points out, "There is no evidence to suggest that associative learning has undergone any major, qualitative changes in the recent past, and certainly not in the hominin line." Although there is the possibility of minor changes that are consistent with the gradualists' view of genetic evolution. "It is plausible that, compared with other apes, humans genetically inherit an enhanced capacity for associative learning. We may be genetically prepared to forge associations faster, learn more of them in parallel, and / or more readily attach associations to specific contexts." (Heyes, 2018. p. 69).

Individual Learning - doing it on your own; Social Learning - skills acquired within a setting shaped by culture; and Cultural Learning - learning directly from others; all have one thing in common and that is Time On Task. Individual learning and social learning are similar in that it is up to the individual to maintain attention on the context long enough to establish new behaviors relevant to that setting. Cultural learning is a whole new animal, literally; one with

gadgets to be precise. Apparently, evolution has found it difficult to produce organisms capable of attaining sustained attention on each other in settings other than feeding, fighting, mating, and an occasional grooming session; because, it seems, it has only happened once. The problem is stochastic attention drift. Even if two grooming primates occasionally make intimate eye contact, for example, it takes very little in terms of external sights or sounds to break that intimacy and thus, "lose the moment." Not so with humans. As the arrows in figure 7 show, either party may defocus and break-away from the current turn. But then they come back. And then they do this again. And then again. And again. The quite marvelous thing about this is that it allows mutual control over the episode. So at the sub-second level it keeps the other party "guessing," so to speak. Thus there is a low likelihood for habituation and elevated opportunities for discovery. Discovery about the other party via short-term trial and error. And equally important, discovery about oneself via prediction/confirmation and prediction/surprise episodes. Nothing like this is seen in other living creatures.

As described at the beginning of this section there have been many papers written about this dance-like coupling between infants and their caregivers. Many of these papers have used musical allusions to describe their results. For example, "duet between maestro and pupil," (Tronic, et al. 1979), and "a beautiful, rhythmic dance" (Condon, 1979). Also figure 8, from Jaffe and Anderson's "Communication Rhythms and the Evolution of Language," depicts the hierarchy of conversational rhythms. The authors of that paper say that, "The notion that conversation grows ontogenetically out of rhythmic coaction between a mother and her baby supplies us with developmental hypotheses about rhythmic interaction between two persons, both gestural and vocal, that can be tested against a large body of evidence already available from studies of adult conversation." (Jaffe and Anderson, p. 20, 1979).

So rhythmic entrainment early in infancy solves the problem of stochastic drift. And the lack of drift allows the possibility of time on task. And with time on task the infant's expanding motor skills can be put to use to further enhance the rewards of interpersonal intimacy. By six months of age the infant has become a player, almost a co-equal partner in negotiating the moment. Heyes mentions a version of this in her chapter Starter Kit. In discussing the use of pitch by mothers with their infants she says that researchers have found that, "mothers could be "shaped" by their four month old infants to increase the pitch of their vocalizations. When mothers were consistently rewarded for higher pitch by happier behavior from the infant, reinforcement learning increased the average pitch of the mothers' vocalizations." (Heyes, 2018, p. 65). This would be the kernel of what I'm calling human CNA, Culturally Negotiated Attention. It may not be dance, as alluded to by earlier commentators, but it is certainly dance-like. And it may not yet be conversation either, but it is about to be. And with this in place we have all the parts needed for the co-creation of thoughts, beliefs, grist, mills, and gadgets.

I have been making the case that there is indeed a cultural analog of DNA. And it is responsible for independent agents being able to co-create artifices that can survive the ever changing social and physical world around them. The operational unit that facilitates this is the conversation. Conversation creates virtual third entities as well as physical artifacts that

transcend the temporal and cognitive limitations of their biological creators. These entities are Heyes's grists and mills. And the elemental unit most analogous to DNA I have called CNA, Culturally Negotiated Attention. It is a species-specific mechanism present in infancy that binds two individuals together tightly enough that they can sense a view of the world around them from another perspective. But not so tight that they are unable to intentionally contribute or fortuitously stumble upon novel and unexpected solutions to common problems. The ability to do this marvelous balancing act must not be tethered to the constraints of physical DNA. It must be as fragile and as agile as the products it creates. As Heyes says: "Cultural evolutionary psychology implies that human minds are more agile, but also more fragile, than was previously thought. We are not stuck in the Pleistocene past with Stone Age minds, and well-targeted educational interventions have the potential to transform cognitive development, but we have more to lose. Wars and epidemics can wipe out not just know-how, but the means to acquire that know-how." As we have seen above, investigators have marveled at the capacity of human children to rhythmically entrain with their caregivers so early in life. But as far as I know, to date, no investigator has identified the mechanism that originates this coupling and facilitates its elaboration throughout development. I suggest that Heyes's cultural evolution model can change that.

### Prediction

In an earlier section of this review on dual processing models we saw that Heyes had located in System 1, under the heading Small Ordinary, three categories that are genetic; they are Temperament, Attentional Biases, and Central Processors. In the subsequent discussion I noted that the general purpose central processor was capable of amplifying small attentional biases and turning them into stable behaviors. As a description that was all well and good. But it does not say what "amplifying small attentional biases" means exactly. And then, in the section on CNA World, we saw that adult conversation, a requirement for cultural evolution, owed its dialog/break/dialog discourse to a previously established infant-caregiver behavior/pause/behavior entrainment pattern. Again, that was descriptive and does not specify why behavior/pause/behavior occurs in the first place, why it repeats, and why another person does a similar thing in synchrony.

There is another genetic feature that is quite general and that we share with many other animals; it's the ability to predict the future. And enjoy it! "It has been suggested that the key to human social motivation lies in our enjoyment of "response-contingent stimulation," that is, of events that are predicted by, and occur shortly after, our own actions." (Heyes, 2018, p. 58, Csibra and Gergely, 2006; Heyes, 2016b). This is the missing piece that I mentioned above that amplifies biases in System 1 and rhythmizes gestures between infant and caregiver. To some degree or another all animals that move have the ability to predict and monitor the consequences of their own actions. It would not be possible to survive if a creature had to wait until the nervous system registered and evaluated a stimulus and then organized and executed a response. But

beyond the basic opportunity to advance alive and well to the next quarter second, where is the aforementioned joy in this?

To first order there is the satisfaction of resolving the background anxiety over how well we have just predicted the consequences of an action. This is a constantly moving temporal window of something like a quarter to a half-second. Every planned movement primes proprioceptors to a length setting that will provide an optimal response to the upcoming move (Kandel, 2000, pp. 718-719). Every execution of a movements generates feedback from these proprioceptors confirming or disconfirming that the move is going well. And every contact with the world generates sensory input that we got it right ... or didn't. According to the Predictive Coding Model, if we were less than accurate in our prediction and generated an error - experienced as a surprise - then the brain updates what are called "priors." Priors are the statistically accumulated lessons from many previous trials at this particular action (Kording & Wolpert, 2006). These updated priors are then used to create statistical likelihoods of success should we decide to try that move again. I am assuming that this constantly moving window of success-and-updated-missteps is accompanied by an ongoing sense of well-being. But against that background there are other more episodic behaviors that generate new experiences of reward and failure.

Heyes describes this during a discussion of a phylogenetic change in associative learning. I think it is worth citing the whole passage. "It is likely that associations were originally formed on the basis of contiguity alone; an association was formed between the representations of any pair of events that occurred together in time. Later, in some lineages, the process became dependent on prediction error. For an association to be formed, a pair of events still had to occur close together in time, but, in addition, one event had to be predictive of the other (Rescorla and Wagner, 1972). For example, to establish an excitatory link between representations of A and B, the probability of B occurring with or shortly after A must be higher than the probability of B occurring in the absence of A. Finally, but still many millions of years ago, the process evolved such that prediction error modulated not only the rate at which associations were formed, but the "associability" of events. Representations of events that proved to be good predictors in the past were more likely to enter into associations with other events in the future (Mackintosh, 1975)." (Heyes, 2018, pp. 68-69). As an example of this Heyes describes an infant's joy - coos, smiles, laughs - at the contingencies between his or her actions and the subsequent rotation of a mobile in response. This is with respect to an inanimate object. But much of the infant's early life is with social agents. And this is where I think we see the break-point between humans and other creatures. And where we see the importance of Heyes's theoretical framework.

In a paper called Music and social being the musicologist Ian Cross opens with the claim "that music, like language, is a fundamental part of the human communicative toolkit." (Cross 2005, p. 1). With such a strong introduction it comes as something of a surprise to read later on: "So is there a general human faculty for music, and are there commonalities that can be recognized between musics cross-culturally? Evidence for a positive answer to the first part of this question is not conclusive but is strongly suggestive." (Cross 2005, p.3). "Strongly

suggestive" is not as strong an endorsement of a fundamental part of the human communicative toolkit as one might have expected. Cross does go on to explore what might be universal elements of what we call music, but he distributes qualifiers all along the way. Informing us, for example, that there are cultures that do not even have a direct lexical cognate with the term "music" as it is understood in western cultures. And, further, the kind of sounds that are used by other cultures are often dissonant and inharmonic compared to those in the standard Western musical cannon. Also the settings, the characteristics of rhythms, and the interpretations vary widely. But there are two things that stand out amidst all the qualifiers. The first is that across cultures the structure of mother-infant interactions, often in the form of lullabies, is similarly constrained. The other is that 'music' seems to be as diverse as are cultures. As I see it this makes music a Gadget! It is learned in childhood and its diversity is evidence of cultural selection.

For a book with such large aspirations Cognitive Gadgets is nevertheless compact enough for the reader to see (or sense) its significant parts in their relationships to each other. The most significant parts being the constituents listed under System 1: tolerance for the young by adult humans, the existence of only one, slightly enhanced, general-purpose learning system, and the capacity to recruit this learning system to amplify small behavioral biases. By far, in this reviewer's opinion, the most important System 1 attribute is the tolerance for the young. This is not to say that other species do not care for their young or keep them in close proximity, they do. But social intimacy in one species is not the same as social intimacy in another. Tolerance is an issue of temperament, not cognition. And all the cognitive enhancements one could imagine would not produce the typical 9 month-old human if not for the sustained shared attention with caregivers. This is the time-on-task mentioned earlier. Heyes says it well, I think: "Social tolerance and motivation get developing humans up close and personal with a wide range of adults; adults who are equipped to fill and shape their minds with culturally inherited information. Input biases ensure that, from birth, human children target their attention on these experts, ready to drink in the information they have to offer." (Heyes, 2018, p. 60).

In all other aspects we are only marginally different from our closest genetic relatives. Now add the final piece, our enjoyment of response-contingent stimulation. There are three levels of complexity here. First is the ongoing feeling of satisfaction in the basic prediction/confirmation/updating process of successful moving in the world. This, no doubt, we share with many other creatures. Next is the pleasure of short-term action-causation behaviors such as an infant kicking a mobile, or shaking a rattle. Perhaps the neuro-chemical correlate of this pleasure is, for example, a shot of Oxytocin with each short-term response contingency. If this is the case then the intensity of the joy could be in the rapid build-up of this reward with each kick or rattle. Heyes mentions the possible role of this neuropeptide on page 60, commenting that the upregulation of oxytocin in humans may have incremental effects in extended social motivation. But the level of complexity that matters most for us is the response-contingent stimulation with another human being.

## Timing

Within a range of less than a half second, "the infant becomes conditioned to the beat: he forms temporal expectancies of when the next beat will fall and is responsive to small changes in tempo." (Stern, 1977, p. 90). "It is conceivable that on the basis of the rhythmicity of prior maternal events, the infant has built up sufficient expectation of when the mother will behave that he is in a predictive system with her" (Beebe et al., 1979, p. 28). Earlier I mentioned that humans that spend time together bind together, or at least have the opportunity to do so. And I referenced work done on adults indicating that partners who match rhythms of dialog tend to judge each other as warmer and more socially desirable. The inference I draw from this is that a similar thing happens with the infant-caregiver dialogue. The evidence cited from Heyes about the social motivation in our enjoyment of response-contingent stimulation lends support to this inference. Heyes also references studies indicating that "In the first year of life, associations are learned "exuberantly" and remembered for long periods (Heyes, 2018, p. 71). The work behind the two citations at the beginning of this section indicate that, at least for short periods of time, the infant and caregiver are phase-locked in a pattern where the onset times of the turns of one partner are too short with respect to the other partner's previous turn to be accounted for by a simple successive stimulus-response model. Thus it appears as if the dyad jointly constructs temporal expectations that are dynamically confirmed, disconfirmed, updated, or abandoned. In any case, considering the joy experienced from action/contingency moments discussed earlier, Heyes's exuberant term for these waltz-like moments between infant and caregiver is probably right-on.

## Section summary

The goal of this section has been to provide a complementary description of the developmental pathway to adult conversation. To be clear, Heyes does not need this addition. I added it in part to further illustrate the explanatory breadth and depth of her theory. And this was motivated by the observation that her model might be able to explain puzzles like the origin of rhythm and music.

To this end the primary observation is that cultural evolution is dependent on the interlocution abilities of adult humans, that is, conversation. I believe her theory is uniquely structured to accomplish this without proposing new learning mechanisms or counting on a brain region or module to show up. I did propose a neologism, which is always hazardous - CNA, Culturally Negotiated Attention, but the parts and the actions are all hers. The action takes place in a cultural milieu, the behaviors are interpersonal communications, and the result is shared attention on tasks that will lead to selectable cultural artifacts.

To support this I drew upon developmental literature that has identified species-specific couplings between infant and caregiver that some of those researchers have identified as "preverbal dialog," or "protoconversation." (Beebe et al., 1985, p. 244). Heyes supplies the prediction and expectation models that make these conversations rewarding, and also the elemental System 1 features that ensure their stability. And there you have it, a cultural analog to

DNA. An inherently creative social unit that meets Heyes's criteria for group innovation and social selection; it is inherently fragile in that it depends upon social dynamics for its endurance, but is also inherently agile in that it has only marginal allegiance to biological DNA.

Is this also the origin of rhythm and music? Well, it appears that way to me. Time will tell I suppose. But for now we return to our regularly scheduled book review.

### Selective Social Learning

Chapter 5 begins Heyes's four chapter tour of four cognitive Gadgets: Selective Social Learning, Imitation, Mindreading, and Language. It is appropriate that Selective Social Learning be first in line because the machinery of the other three depend on the skill of selecting what or who to learn from and when to do it. To solve problems with other people, to create cognitive gadgets and pass them along, one must first attend to and learn from other people. Heyes uses a dual-process model to illustrate how this is accomplished. This model assumes that all non-social learning and most social learning is accomplished by domain-general psychological processes. This is the analog of the Small Ordinary level discussed in the earlier chapters. At this level the selective part of selective social learning takes place at the input, the point of stimulus reception, and learning modulates attentional resources. Heyes calls this the "attentional approach." The other component of the dual-process model is referred to as the "strategic approach." In this case selection takes place at the output stage, where decisions about what counts as an exemplar to imitate takes place. This type of learning, Heyes illustrates, is found only in humans, and she refers to it as metacognition; cognition that is conscious, reportable, and domain specific. Metacognition would be the analog of "Big Special" in the previous dual-process model.

Heyes constructs a formidable argument in defense of this dual-process model. The bulk of her commentary and her examples support the claim that selective learning in a social context relies on the same cognitive resources that are used in non-social selective learning. For example, drawing upon studies of birds (Reader and Laland, 2002), and primates (Reader, Hager, and Laland, 2011), we see species that perform well on tests of social learning also tend to perform well on tests of asocial learning, suggesting a covariation between social and asocial learning abilities. Heyes also cites evidence showing that social and asocial learning covary across individuals within species (Boogert, Giraldeau, and Lefebvre, 2008; Bouchard, Goodyer, and Lefebvre, 2007). And, somewhat surprisingly, laboratory tests demonstrating that even animals which lead solitary lives in the wild are adept at learning from social cues. (Fiorito and Scotto, 1992; Wilkinson, Kuenstner, Mueller, and Huber, 2010).

Regarding a cognitive mechanism underwriting social and asocial learning Heyes calls attention to the role of prediction error in studies of human decision making that combine mathematical modeling with functional brain imaging. These studies found that "the same computations, based on the calculation of prediction error (the mismatch between expectation

and incoming stimulation), are involved in processing information from social partners (social learning) and personal experiences of reward" (Heyes, 2018, p.97).

Heyes cites a study by Williamson, Meltzoff, and Markman (2008, Experiment 1) on the selectivity of three-year-olds in a three-stage task consisting of a priming stage, an observation stage, and a testing stage. The experiment consisted in the opening of a set of drawers to obtain a toy, and the pulling of a toy car by a string. But we only need to look at one of these, the drawer opening task. There were two groups of children, one group, during the priming stage, experienced drawers that were easy to open, and the other group had drawers that were made hard to open by jamming them with putty. The expectations, or priors in predictive coding language, were established during this stage. Next, the observation stage, the children were encouraged to watch adults model ways of opening these same drawers. In all the adult cases these drawers that were easy to open, but the manner in which the adults opened them was different. Before opening one of the drawers the adults would first press a non-functional button on a different drawer. In the final test stage the children were again allowed to open the drawers, and in all cases these drawers were the easy to open kind. The children who had experienced the hard to open drawers in the priming stage were significantly more likely to copy the manner of the experimenter - pressing the button first - than were the children who experienced the easy to open drawers.

Williamson et al., suggested that these results implicated a strategic approach; saying that not only can young children imitate the exact actions and means used by others but they "do so flexibly, selectively, and in a rule-governed manner that we can begin to describe in some detail" (Williamson et al., 2008, p. 282). Heyes disagrees with the rule-governed part of that interpretation and, instead, notes that the results comfortably agree with the attentional approach. Rule-governed behaviors she reserves for a later developmental phase where metacognitive strategies can be called into service. Metacognitive strategies she colloquially refers to as "cook-like" indicating that they draw upon explicit domain-specific rules. And, further, Heyes comments that she has not been able to find evidence of metacognitive social learning strategies in children below the age of four or five. (Heyes, 2018, p. 108).

Use your Priors, Luke.

Yes, Obi-Wan used the word "force" but, in all likelihood, he was telling Luke to rely on those 10,000 (or more) hours of intuition building. Intuition meaning the feeling state at the confluence of my evaluation of the present situation in which I'm about to act and my expectation of how things like this have gone in the past. In other words, being sensitive to violations of expectation. The three-year-olds in the Williamson et al., study did not get 10,000 hours but, then, they weren't training to be Jedi warriors. They did, however, form expectations i.e., priors. According to current thinking in neuroscience this is what the brain does 24/7. Before it does anything else it has to get you through the next quarter second. And, if that goes well, do it again. Further, according to Daniel Wolpert and Michael Land, this sort of decision making is common to species as diverse as human, non-human primate, rats and pigeons. (Wolpert and

Landy, 2012, p. 996). This is reasonable because all creatures that move run the risk that their next move could be their last. So the most important thing about "now" is confidence about "next." And, at least to first order, this decision making mechanism is unconcerned with the context, be it static, moving, animate, inanimate, other creatures, or conspecifics; you weigh your priors against "now" and go. The bottom line being that this phylogenetically ancient mechanism underwrites learning and decision making across all mammals, across all sensory and motor modalities and, thus, meets the criteria for Heyes's generalized non-specific learning mechanism.

### Metacognitive Strategies.

All of what non-human mammals do, and most of human behavior, is managed by priors forged as expectations and weighed as likelihoods to be confirmed or updated in never-ending action/confirmation cycles. And that has always been good. But not good enough. Somewhere between the last big dinosaur and the first little arrowhead things got complicated. Whether it was with Eve or Fred Flintstone, the day arrived when it dawned on our ancestors that there was one more thing to be taken into account when forming expectations; me! Or more properly, "us." And that was good also. But still not good enough. Something more was needed. A way to take me/us into account in a context of impending decision making. Enter metacognitive strategies, also known as gadgets.

The last part of Chapter five is about that gadget and its role in cultural evolution. As mentioned earlier, metacognitive gadgets are cook-like in that they supply recipes; explicit domain-specific rules regarding decisions about who to copy from and when and how to do that. The "meta" part of metacognitions means that the copier can "see" herself and the model from a virtual third-person point of view, the me/us referred to above. This capability is a feature of theory of mind, typically not in place until age 7 or later. One feature of theory of mind is the ability to conceptualize other people and oneself in terms of mental states. Mental states are abstract common currencies such as beliefs, desires, knowledge, and memories that allow for the reduction of uncertainty regarding the intentions of other people. This is important for establishing who is trustworthy within a group. And beyond trust, conceptualizing others in terms of knowledge states makes possible better choices about who is the best person to emulate. Better choice being defined as enhanced exclusivity, specificity, and accuracy, thus yielding the highest fidelity copying behavior. This high-fidelity copying behavior is the difference maker between selective social learning and selective social learning that is adaptive for cultural evolution.

I mentioned earlier that most human behavior can be explained by the attentional model anchored in associative cognitive processes yielding what Heyes calls planetary social learning. The result can be strikingly flexible and adaptive behaviors, making it difficult, as she says, "to identify the advantages of cook-like, explicitly metacognitive social learning strategies, and thereby to spell out what it is about distinctively human selective social learning that promotes cultural evolution" (Heyes, 2018, pp 110-111). Heyes offers a three step remedy for this identification difficulty;

Step 1, metacognition leads to better social learning strategies.

An individual copying a successful social behavior via her own observational skills yields only a modest chance of being adaptive because the sampling is small. Alternatively, using explicit instructions about what to copy has the advantage of a history of payoff experiences of a larger number of people. "Thus, whereas genetically inherited social learning strategies would be broad but inflexible, and planetary social learning strategies are flexible but narrow, metacognitive social learning strategies are both broad and flexible (Heyes, 2018, p. 111).

Step 2, better social learning leads to higher fidelity copying.

Higher fidelity helps insure greater exclusivity in the sampling, enhanced specificity, and better accuracy. Examples of the kind of explicit instructions are copy the boat builder with the largest fleet, or copy the majority's boat design (Heyes, 2018, p. 112).

Step 3- higher fidelity facilitates cultural evolution.

This step is a bit thornier than the others. It involves models borrowed from evolutionary theory of both the distribution of traits - why some are more common than others, and models of the origin of those traits - how a particular trait, seal-skin canoe building, for example, came to exist in the first place. Population models can do this. Citing the philosopher of science Godfrey-Smith, Heyes notes that the success of gene-based distribution models depends upon good parent-offspring relations. But for the application of such a model to work in the cultural domain it is not sufficient that a new instance or "token" be merely alike or loosely inspired by the model. Conversely, the selectivity and high-fidelity copying inherent in Metacognition insures the required degree of resemblance. But what about the origin of a novel instance and its propagation?

Origin explanations, for obvious reasons, are not as dependent upon such a strong parent-offspring relationship. What is required, however, is that each incidence of variation be small and that it co-exist within the previous cultural background long enough to spread horizontally, that is to agents unrelated by family, clan, tribe or class. This ensures that there are numerous independent opportunities for further innovation of this novelty, again, in small steps. Once again, the fine-grained ability of metacognitive selection allows for adjustments to small features of this new cultural landscape; a slight change in the manner of curing the hides for a seal-skin canoe for example. As Heyes puts it: "Specificity—copying at a fine- rather than a coarse-grain—helps to keep innovations small. Accuracy—copying with a minimum of random error or changes based on asocial learning—helps to ensure that small innovations proliferate intact to many agents within the population" (Heyes, 2018, pp. 113 -114).

Earlier I said that Obi-Wan was telling Luke to trust his intuition and that the use of the word "force" was more of a manner-of-speaking. But both actually work because early in her book Heyes emphasizes that her theory is a "force" theory. Her cognitive gadgets theory "is a force theory rather than a narrative theory of human evolution" (Heyes, 2018, p.22). It is like

evolutionary psychology in that it focuses on the mind, and it is also akin to cultural evolutionary theory with its emphasis on social learning and culture. It departs from these theories however with the addition of radically different ways of thinking; employing cognitive mechanisms that are constructed by cultural evolution instead of genetic inheritance. The metacognitive mechanisms we have just looked at are the forces that drive cultural innovation and subsequent selection. They are able to take their own products as the objects of further innovation; this is selective social learning that creates its own future or its own failure, or, as Obi-Wan said: "Do or do not, there is no try."

### The Three Metacognateers

Imitation, Mindreading, and Language (Chapters 6, 7, and 8) are among the major cognitive gadgets that constitute metacognition. Language is a requirement for the high-fidelity transmission of various behaviors, which is necessary for cultural evolution. And mindreading is required for high-fidelity teaching and learning. With it other people can be understood in terms of the absence or presence of knowledge; knowledge that can be added-to, subtracted-from, or corrected. But imitation has a unique status because without the ability to imitate none of these other metacognitions would get off the ground. So what is imitation and where does it come from? Heyes has thought about these questions and contributed to answering them. Her contribution even has a name.

### The Heyes Rebellion

There comes a time in every parent's life when they need to have "that conversation" with their child. It can be different in different families. And the age of the child can vary widely from 6 to sixteen. But, sooner or later, someone has to tell them that there is no Santa Claus.

It almost seems like Cecelia Heyes is in a similar position with respect to much of the scientific community regarding the issue of imitation. Imitation may not be a mythical sacred cow (or Claus) but it is hallowed ground. Heyes is aware of this. And for someone who is questioning so many established ideas in behavioral science her writing is remarkably calm, deliberate, and non-confrontational. But there is one moment in her book when she bursts fourth and calmly exclaims that, "My rebellious streak comes out only in relation to the question of where imitation comes from. Offering an original theory of the mechanisms mediating imitation, and a wide range of empirical evidence in support of that theory, I argue that the capacity to imitate is acquired through sociocultural experience" (Hayes, 2018. p. 5). Well, I'm convinced. All the same, we should probably look at the details.

"Imitation occurs when an observer copies the topography of a model's action; observing the way that parts of a model's body move relative to one another causes the observer to produce movements in which the parts of his or her own body move in a similar way" (Heyes, 2018. p. 4). That's pretty much the received view of imitation. We watch someone move in a certain way and we duplicate it. And that's fine, especially in cases when we can observe our own bodily movements and can verify that we are, in fact, reproducing the other person's actions. But, what

about the cases in which we cannot see our own body parts? Duplicating a smile, for example, or a frown, or an eyebrow raise? And, further, what about the times when you're just a few hours old and a stranger is a few inches from your face making an assortment of smiles, frowns, sounds, tongue protrusions, and finger movements? Normally, at birth, you would get spanked and your feet tickled! It's beginning to look like a lot of infants do what they can to get through that moment. Possibly with the thought that when they grow up they will confess that they weren't really imitating; but then they forget and never get around to publishing. Well, it seems that science, slow and cumbersome as it is, eventually catches up to things. At least according to Heyes and a clutch of babies-turned-experimentalists who feel it's time to pull back the blanket. This is the hallowed ground where the Heyes's rebellion takes place.

### The Correspondence Problem

In the beginning was the tongue protrusion. And it's Genesis was a 1977 paper by Andrew Meltzoff and M. Keith Moore called Imitation of Facial and Manual Gestures by Human Neonates. Other gestures such as mouth opening, lip protrusion, and sequential finger movements were studied also, but tongue protrusion, as we will see, has had the most enduring influence. The authors reported that infants 12 - to - 21 days-old can imitate these gestures. This was a stunning challenge to classical theories like Piaget's which suggested that imitation skills were acquired through experiences with artifacts such as mirrors and the infant's exploration of her own body as well as the bodies of others. Nevertheless the evidence was compelling and the experimental technique - comparing the frequency of a mouth opening, say, when the experimenter was modeling mouth opening, to the frequency of mouth opening when the experimenter was presenting a different gesture--was quite innovative and methodologically trustworthy. Meltzoff and Moore hypothesized that the infant possessed the ability to establish a correspondence between the seen facial movements of the experimenter and the felt movements of her own face. They called this registration of equivalence between the seen but unfelt and the felt but unseen a "supramodal" representation. And they hypothesize that this ability was not due to an innate "releasing" mechanism but, rather, by an active matching process mediated by an abstract representational system. In later papers Meltzoff and Moore referred to this as an Active Intermodal Mapping mechanism (AIM) in which the active nature of the matching process is mediated by a proprioceptive feedback loop. They say that "the perceived and produced human acts are coded within a common (supramodal) framework which enables infants to detect equivalences between their own acts and ones they see. AIM posits an intermodal mechanism for imitation, in contrast to a reflexive or a conditioned basis for generating the matching response." (Meltzoff & Moore. 1997. p. 2).

Following that seminal 1977 paper there were both replications and replication failures. In the 1997 paper just cited, Meltzoff and Moore reviewed 25 independent studies published between 1979 and 1995, and concluded that neonatal imitation had been replicated and, in fact, was broadened to include an even wider range of gestures. But Anisfeld, in 1996, evaluating

many of the same studies, reported only weak support for neonatal imitation. (Oostenbroek et al., 2013. p. 330).

In a 2011 Target Article in *Developmental Science*, Ray and Heyes listed 37 experiments produced between 1977 and 2001 that tested for neonatal imitation of 18 different gestures. (Ray and Heyes, 2011). For hand opening and closing, lip protrusion, finger movement, blinking, head movement, and facial expressions of emotion, there was about an even split between findings of positive cross-target comparison and negative cross-target comparison. It was a different story, however, for tongue protrusion and mouth opening, with 21 positive results for tongue protrusion to 11 negative and 9 positive results for mouth opening and 20 negative. So clearly, tongue protrusion and mouth opening are giving dramatically different results.

While there has been the expected back-and-forth over the years, for an issue as complex as infant imitation there is, nevertheless, a discernable trend-line. Regarding the end-points as of 2012 Heyes says it bluntly, "this review found evidence that neonates copy only one action—tongue protrusion—and that this copying does not show the specificity characteristic of imitation." (Heyes, 2012, p. 2187 ). A subsequent review paper by Oostenbroek et al. examined 11 studies published between 2001 and 2012. Four of these studies were on non-human primates, two with Chimpanzees, and two with Rhesus monkeys ( Oostenbroek et at., 2013). After a thorough review of the evidence the authors comment: "More than 30 years of research on neonatal imitation has still not resolved questions about whether the phenomenon exists, how prevalent it is and what it means." That sentence has the feel of an introduction to "that conversation." It is followed with, "This is unfortunate because neonatal imitation, if it exists, suggests that newborns have an innate capacity for communication." "If it exists!" It does seem to me that, after more than 30 years of watching the skies, and staying up all hours of the night, you might really want to hear something other than: "if it exists." Well, the authors are not dispirited and they end with: "It is time developmentalists find new ways to approach the study and interpretation of neonatal imitation ... so that we can get beyond the current state of confusion and begin to make sense of this important phenomenon." And that brings us back to the Heyes Rebellion, still in progress.

Oostenbroek and colleagues did more than casually suggest "new ways;" they delivered. And Heyes noticed. In her chapter on imitation under the sub-heading of Evidence she says: "The evidence that inspired and supported the cognitive instinct theory of imitation recently suffered a mortal blow. It has long been suspected that a subtle experimental artifact has been giving the false impression that newborn humans can imitate." Heyes continues: "That suspicion has now been confirmed by a study conducted in Brisbane with unprecedented power and rigor." (Heyes, 2018, p. 128).

Oostenbroek et al. (2016) carried out a longitudinal study with four sample points at 1, 3, 6, and 9 weeks of age with 106 infants, a statistically significant number compared to many earlier studies. And, importantly, it used the Meltzoff and Moore "gold standard" method of cross-target comparison. The 11 test gestures included four facial gestures: tongue protrusion,

mouth opening, happy face, and sad face; two non-social actions with objects simulating social gestures: a box opening and a spoon protruding through a tube; two hand gestures: index finger protrusion and grasping; and three vocal gestures, “mmm,” “eee,” and “click” sounds. This study allowed the researchers to compare the rate in which the infants produced a particular gesture when the experimenter was modeling that gesture with the rate in which the infant produced that gesture when the experimenter was modeling one of the other controls. If the infants were imitating then there would be more matching responses (infants making a tongue protrusion, for example, when the experimenter was modeling tongue protrusion) than non-matching responses (infants making a tongue protrusion when the experimenter was modeling say, a happy face). Oostenbroek et al. have made available a Supplemental Experimental Procedures document that contains the details of the data analysis as well as tables showing the results of pairwise comparisons of the gestures. I highly recommend the supplement for the interested reader.

Figure 2 of Oostenbroek et al. shows the results for 9 social gestures over the 4 time periods tested. Each of the 9 graphic panels has curves depicting the relationship of the correct matching gesture to 10 other "false positive," controls. If matching gestures indicated genetic inheritances then one might expect a few of the matching curves to be located in the upper space above the other representations. However, in none of the 9 panels do we see matching gestures uniformly separated from the control gestures. So, basically, this longitudinal study did not reveal any strong evidence for imitation.

In 2018 Meltzoff et al. responded to the 2016 Oostenbroek paper with a commentary called Re-examination of Oostenbroek et al. (2016): evidence for neonatal imitation of tongue protrusion. Oostenbroek et al. responded with a rebuttal, and later that year Meltzoff et al. responded with a rebuttal to the rebuttal. Meltzoff et al. claimed that the design of the Oostenbroek study worked against finding positive imitation results. For example, too many stimuli were used for a within-subject design and that this could lead to neonatal fatigue; the stimulus and response periods were too brief; and the unfamiliarity of the experimenter with respect to the infant. These three conditions were part of 11 "weaknesses" noted by Meltzoff et al. I can't say one way or another how valid these detailed criticisms are, but Oostenbroek and her colleagues address all of these issues. However one thing did seem strange to me. After claiming that these "flaws" can bias and thus jeopardize the results, Meltzoff et al. say "We re-analyze the authors data and find significant imitation of tongue protrusion at all four ages tested, despite the weak design." In arguing that the data do, after all, contain evidence for imitation of one gesture - tongue protrusion - Meltzoff et al. compared the frequency of tongue protrusion elicited by the experimenter to the average frequency of tongue protrusions elicited the other ten experimental conditions. This analysis showed that the frequency of matching tongue protrusions was significantly greater than the average of all the controls in all four age groups. With results like this it does not seem unreasonable for the authors to have concluded that there was strong

evidence for imitation of tongue protrusion. But Oostenbroek et al. had their own thoughts on this matter.

"Despite the concerns regarding our methods, Meltzoff et al. (2017) nevertheless argue that our data do contain evidence for imitation of one gesture, tongue protrusion (TP), based on a series of post-hoc analyses comparing the frequency of TPs elicited by the TP model to the average frequency of TPs elicited by the other ten models" (Oostenbroek, 2018. p. 3). Oostenbroek et al., defend the validity of their methodology by noting that in their original analysis they conducted separate pairwise comparisons for each of the control models and did not average over all the non-matching data points. The logic of this comparison, they say, is to, "guard against the possibility that a general category of stimuli (such as dynamic faces) is more likely to elicit a response than other types of stimuli, which of course would not be evidence of imitation." And they conclude with a reminder that "The averaging approach, on the other hand, does not account for this possibility, as it collapses across models that may yield low TP responses (e.g. manual actions) and models that may yield high TP responses." (Oostenbroek, 2018. p. 3).

In their original 2016 paper Oostenbroek et al. showed that their method of separate pairwise comparison reveals a different relationship of tongue protrusion to the controls than the one concluded by Meltzoff et al. They say, for example, "although the infants produced these gestures significantly more often when the model demonstrated them than when she demonstrated some control gestures, there were no significant differences when compared to other control gestures." ( Oostenbroek et al., 2016, p. 1335). They also say that "More of the control comparisons for tongue protrusion were significant than for any other gesture ... Yet, across time points, the frequency of infant tongue protrusion responses to the tongue protrusion model did not significantly differ from the frequencies of such responses to the mouth opening, happy face, and sad face models.( Oostenbroek et al., 2016, p. 1335). I would like to depict graphically the significance of these statements.

Figure 9 shows the data separated into side-by-side panels. The matching tongue protrusion, represented by the dotted line, is present in both displays, but the control stimuli have been segregated in order to illustrate the differential response of tongue protrusion to selective control stimuli. Indeed, we see in the left-hand panel that the frequency of matching tongue protrusion is significantly greater than all of the controls. However, in the right-hand panel, we see tongue protrusion nestled rather comfortably with three other gestures, happy face, mouth opening, and sad face. This is what Oostenbroek et al. are referring to when they say that the frequency of tongue protrusion is greater for some but not other gestures. And while the relationship of tongue protrusion to the other models in the right-hand panel may not be obvious to the eye, the supplementary analysis confirms what the authors said above, that over the course of 9 weeks the frequency of matching tongue protrusion does not significantly differ from the frequencies of mouth opening, happy face, and sad face models. This brief summary illustrates the experimental basis upon which the authors conclude that "there is no evidence infants were imitating the specific model." (Oostenbroek et al., 2016, p. 1335).

## Figure 9 Here.

There is another thing that these side-by-side panels make clear, the infants do not respond the same way to all facial stimuli. As seen in the right-hand panel, happy face, sad face, and mouth opening encourage a propensity to protrude the tongue. But, as the left-hand panel shows, mmm sounds and eee sounds, also produced by the face, do not. (Unfortunately, Oostenbroek do not provide pictures of these two stimuli, and it is possible that the face moved very little during their presentation.) In two places, the body of the text and at the end of the supplement, Oostenbroek et al. speculate about this difference. In both places they point out that the stimuli that evoke tongue protrusion are non-verbal active faces yet, in both places, they resist the temptation to draw a strong conclusion. They do tender the notion that it is the active aspect of faces that trigger tongue protrusion but qualify that supposition by saying that this "begs the question of why infants did not respond in a similar manner to the vocal gestures." (Oostenbroek, 2016, p. 1335). I won't pretend to speak for Heyes on this matter but my guess is that she would say that it is the activity of the face that matters. For example Heyes does comment that the tendency of tongue protrusion is actually non-specific and, citing Jones's study of music on 4-week-old infants, says that "babies also protrude their tongues when exposed to other arousing stimuli, such as flashing lights and lively music" (Heyes, 2018, p. 128). As for me, an outsider looking over the the fence at the imitation debates, I am going to risk everything and just say that I think it is the dynamics of the human face that evokes the propensity to protrude.

I've dwelt on this narrow topic because it is an origin issue, as opposed to a developmental one, and it is always wise to understand initial conditions. Further It is critically important to understand these starting conditions if one is to think clearly about Heyes's cognitive gadgets. Is the issue settled? My guess is that there will still be a few more rounds. And, while guessing, I will conjecture that it looks like things are going the way of the Heyes and the Oostenbroeks of the world. It's been over 40 years and we seem to be down to one imitative gesture. And even that seems to spend about half its time lingering in the shadows other gesture's error bars.

That does not mean that the Meltzoff school has not made major advances in this arena. With this in mind I will suggest a particular harmonization between Meltzoff and Heyes. Although, just be clear, by harmonies I'm not suggesting perfect fourths and fifths, but more like all parties recognizably humming the same tune.

Can we all get along?

The harmony I am suggesting involves the involvement of proprioception in both theories. As can be seen in Figure 10 A, Meltzoff and Moore's AIM, "Active Intermodal

Mapping" model includes a proprioceptive feedback loop, but Heyes's model, what she calls ASL, or Associative Sequence Learning model, shown in Figure 10 B, does not. On one hand I'm suggesting that the proprioception part of Meltzoff and Moore's model is incomplete and, in addition to that, does not need to be thought of as genetically honed for imitation. Heyes's theory on the other hand, while not having a proprioceptive component, nevertheless has a natural place for it to be; see the box labeled "stimuli" in Figure 10 B. The issue at hand for both models is the correspondence problem, that is, how the infant knows to select a certain body part for movement that matches the movements of something observed in the world.

Proprioception is a non-trivial sensory system. It is not only involved in sensing the consequences of ongoing movements, but also in the planning and execution of those movements. Proprioceptors are located within the muscles, joints, and tendons throughout the body. They inform the mover about movement itself; velocity, acceleration, force loads and extension limits of the limbs. The term "feedback" is often used to describe proprioception, but this does not do justice to all that is going on. Tiny muscles called "spindles" embedded within the skeletal muscles are, via spinal loops, constantly maintaining muscle tone during both dynamic and static intervals. But this postural dynamic can be modulated by top-down cerebral "overrides" that were acquired during infancy and by skill acquisition over the lifespan. In making these adjustments the nervous system must make "best-guesses" about adjusting the length of the tiny spindles so that they can send-back the most faithful rendition about the ongoing movement. This dynamic is essential for acquiring the kind of "mirroring" that imitation requires. The very term itself, proprioception, from the Latin proprius, belonging to oneself, hints at the fundamental self-intimacy of this sensory modality. Thus, I think, the obvious connection to the ability to integrate the felt but unseen movements of the self with the seen but unfelt movements of the other. (See Lethin, *How do we embody intentionality?* 2002. Also Kandel, 2000, pp 718-719).

With these considerations in mind we can see that Meltzoff and Moore come up short in that their model has only the feedback component. And Heyes's model is problematic in the sense that you can't turn proprioception off; it is going to be informative in every move that is made. So, given this, it seems that her model should include this ever-present sensory component. Fortunately, in my opinion, both models can easily accommodate the necessary implementation.

Meltzoff and Moore's AIM model suggests an intermodal mechanism. In explaining their adherence to what they call starting-state nativism Meltzoff and Moore use the term "innate equipment" to refer to the capacity of newborns to detect equivalences between observed and executed acts. (Meltzoff and Moore, 2007, p. 9). This equivalence, as briefly described earlier, is said to consist of a common "supramodal code" mediated by a proprioceptive feedback loop. Heyes rejects Meltzoff and Moore's model as part of a misguided orthodoxy and challenges its ability to integrate the felt but unseen movements of the self with the seen but unfelt movements of the other. She claims that "the model does not propose computations that would allow organ relations to be derived from observed body movements or to be cashed out as executed actions."

And, further, she says that the AIM model posits "an inborn thing inside the imitator that solves the correspondence problem, but it doesn't tell us how the thing works." (p. 120).

Heyes's alternative model does not include innate equipment that is specifically for imitation. Rather she proposes capacities that allow imitation skills to be acquired through sociocultural experience. In her model there are lines of excitation between the sensory and the motor areas of the brain that she calls Matching Vertical Associations, (Figure 10 B) and they indicate "direct, excitatory connections between visual and motor representations of action; between 'mental images' of what an action 'looks like' and what it 'feels like' to perform the action" (Heyes, 2012, p. 2185). Mechanisms like this, in the course of cultural-specific forms of synchronous behaviors, facilitate the learning of new skills such as "mimicry" or "response facilitation," skills necessary for imitation. And the specificity of her model also allows for the computations that she says are absent in Meltzoff & Moore's theory. This is her solution to the the Correspondence Problem. With these understandings in mind how do we get the AIM and the ASL to read from the same hymnbook? I think that Meltzoff and Moore could easily drop the "innate equipment" language and it would do no harm to their theory's ability to establish a correspondence between the seen but unfelt and the felt but unseen. And Heyes could adopt proprioception as a "stimulus" and I think it would do no harm to her theory. In this sense we are adopting the best of both theories with, as I see it, with no losses.

Regarding Meltzoff and Moore, the language that they use in their 1977 paper suggests that an adjustment is plausible: "Our recent observations of facial imitation in six newborns - one only 60 minutes old - suggest to us that the ability to use intermodal equivalences is an innate ability of humans" (Meltzoff and Moore, 1977, p. 78). This seems to indicate an option to recruit another system that is innate, but not that the recruited system itself is inherently for imitation. Also Meltzoff and Moore have explicitly acknowledged a role for learning. In a section of their 1997 paper called Imitation and Nativism they say: "Facial imitation is demonstrated by newborns, but it is not completely explained by nativism. We propose important roles for learning and cognition." (Meltzoff and Moore, 1997, p. 9). I think these provisos provide some overlap with Heyes who has said in other places that, "the ASL model does not deny that some vertical associations may be inborn or easier to learn than others, and that this could be owing to genetic evolution" (p. 2187. of Grist of Mills).

In Heyes's papers, but not in her book, she illustrates and discusses a second source of stimulation that is parallel to her vertical lines of interaction, the boxes labeled "Stimuli" in Figure 10, B. And she gives "words" as an example of this stimuli that can mediate acquired equivalence learning. (Ray and Heyes, 2011, Figure 1, p. 97). "A word such as 'frown', heard on some occasions when the child sees another frowning, and on other occasions when she is herself frowning, is an ideal bridge between observed and executed action." (Ray and Heyes, 2011, p. 99). So her model has the flexibility that one would expect of a cognitive gadget capable of calling in assistance from any source independent of its genetic origins. Thus, the inclusion of proprioception as another stimulus affecting sensory experience would be a trivial adjustment.

Well, I don't know if my proprioception pitch has had the Kumbayah effect I was trying for, but I've been inspired by Heyes's tone and measured approach. And even though Obi-Wan did say it's do or do not, there is no try ... sometimes you try.

Figure 10 Here.

## Chapter 8, Language

We've seen Heyes's rebellious side with regard to infant imitation. In the next section, concerning the nature of language, we see her perplexed side. The issue itself is not new; is language a genetic endowment or a culturally acquired skill? What is new is the accumulation of evidence seemingly supporting the culturally acquired view. As Heyes describes it: "Starting as a psychology student around 1980, whenever I peeped over the fence at what was happening in the language sciences it struck me as alien. And it wasn't just the jargon; it was the odd character of the ground rules. It seemed that very little weight was given to the information one would expect to be crucial in explaining language. 'The Big Questions, she says 'were about 'Universal Grammar,' and they were being addressed not by studying minds, but by studying sentences. More puzzling still, although the hunt was for universals, most of the sentences were in English." (Heyes, 2018, p. 170). But Heyes persisted. And after thirty-five years of visits to the fences and a lot of reading in between she finds herself penning a chapter on language that she calls a guide for the perplexed, "for people outside the language sciences who, like me, have been wondering what has been going on over there." (Heyes, 2018, p. 170).

### A guide for the perplexed.

There are two games in town, Heyes tells us, one that promotes genetic theories of the origin of language and one that promotes cultural origins. The genetic theories are a family of models that are, for the most part, the intellectual descendants of Noam Chomsky's ideas of Universal Grammar. These are nativist theories asserting that the core elements that make language 'language' are there at birth, and carried forward by the genes. The cultural origins view, often referred to as constructivist, asserts that very little of what can be identified as 'language' is genetic. These constructivist theories hold that the formal structures found in languages are derived from biological constraints imposed on individual gestures as well as common interests that all cultures have concerning interpersonal communication.

The guideposts, so to speak, for those who have been wondering what is going on over there, are five contentious issues. And the journey consists in evaluating the evidence from these issues for or against nativism or cultural origins. The five issues that Heyes explores are first, the search for linguistic universals; second, evaluating the claims for critical periods of language acquisition; third is a look at the neurological evidence for modular vs distributed functionality; the fourth is an examination of sequential learning; and fifth, the role of social shaping in language acquisition.

There are some unexpected bumps along the road of this guided tour. I was expecting a series "victory laps" as Heyes escorts us through chapter 8. After all she had been knocking it out of the park for the previous seven chapters. The unexpected bumps just mentioned are certain qualifiers that Heyes attaches to what might seem like "slam dunks" in a sequence of arguments. Take universals, for example. As the quote from Heyes above indicates, those proposing a Universal Grammar were very much interested in revealing universal features that could be

found in all languages. Contrary to those expectations Heyes shows that evidence for a lack of universality is not hard to find. In a 2009 Behavioral and Brain Sciences article actually called The Myth of Language Universals, Evans and Levinson point to a stunning degree of diversity in phonemes, morphology, semantics, and syntax. Beyond that, other references point to languages that have no adverbs and some that have no adjectives. There are languages in which tones have meaning and languages in which they don't. And, citing evidence from comparative linguistics, Evans and Levinson challenge the universality of things like "rules of linear order," "verb affixes," "auxillaries," and "wh-movement." So this has been pretty easy going for the constructivists. Where are the bumps?

#### Bump number one

At the bottom of page 179 Heyes says: "Surprisingly, however, given that the genetic account of the evolution of language is founded on 'Universal Grammar,' the lack of features common to all languages does not count in favor of the cultural over the genetic account." At this point in the reading I made full use of the "wh-movement" capabilities of English! But Heyes explains. First, she notes that the cultural evolutionary account does not necessarily predict diversity. Reluctantly, I accepted that. There could be any number of reasons, from a lingering "founder effect" to a domain-general convergence force that produces invariance features of some sort. But the most interesting "jolt" in this "bump" is the fact that the Universal Grammar people do not mean by Universal Grammar what most people mean by Universal Grammar. They do not use "linguistic universals" in a straightforward manner. As Heyes says, "they are features of a genetically inherited language of thought, not of natural languages." She goes on, "A universal in this sense need not be present in all or even most natural languages, and a feature that was found to be present in all languages would not necessarily be a universal" (Heyes, 2018, p. 180). Heyes accepts this. It is, after all, one of the strange "ground rules" that she noticed as she peered over the fence years ago. But she doesn't accept this without comment. She observes that this view of what constitutes a linguistic universal is a vivid example of immunity from empirical testing; at least, "in any way that a cognitive scientist would recognize" (Heyes, 2018, p. 180).

#### Bump number two.

Critical Periods. Heyes introduces this topic by noting how difficult most people find learning a second language is compared to learning the first. If language is genetic why not just go on to learn a second or third or even more languages with the same ease? She explains that supporters of the genetic view addressed this issue long ago. There is a "critical period" the theory posits, in which "the genes make Universal Grammar available to guide language learning only for a limited period in development. The window opens shortly after birth and shuts around puberty" (Heyes, 2018, p. 181). Heyes begins her critique of this explanation by noting that birdsong and imprinting, the paradigmatic animal model for critical periods, are actually not so paradigmatic, and that the ease of song acquisition is more experience-dependent than

genetically programmed. She also, significantly, comments that the evolutionary advantages of turning off access to Universal Grammar at puberty are far from obvious. Heyes goes on to cite evidence from second language acquisition of migrants into a new country. The evidence suggests that proficiency in their new language correlates more with the amount of exposure they have to the new language rather than whether they arrived before or after puberty. (Birdsong and Molis, 2001; Flege, Yeni-Komshian, and Liu, 1999; Hakuta, Bialystok, and Wiley, 2003).

With her usual breadth and depth Heyes continues to cite evidence that would normally create a For Whom the Bells Toll moment for any theory. But then comes the next bump. Just when you might expect a "We sadly announce the demise of a valiant yet flawed theory of language" Heyes says: "Thus, the critical period debate has not yielded evidence supporting the cultural over the genetic account of the evolution of language" (Heyes, 2018. p. 183). Okay. Next.

Bump number three

Neural localization. This time it happens even faster. After only 165 words we have: "But the discovery that language, rather than being localized, depends on scattered, multi-functional brain areas does not undermine the genetic account of the evolution of language." One reason that this is surprising is that those 165 words are loaded with evidence against the localization of linguistic function in the brain. Citations, for example, like a meta-analysis of over than 450 fMRI studies indicating that neural activity during language processing was more distributed across the brain than during any other kind of task including memory, mental imagery, emotion, and attention. And further, in a different meta-analysis, that activity in Broca's area, widely understood to be essential for speech production, showed-up in only 19 percent of the 869 studies. All of this, and more, against a backdrop of repeated claims by well-known nativists such as Lenneberg, (Lenneberg, 1967) and, at least by implication, Stephen Pinker, (Pinker, 1994) that localization of linguistic function would support the genetic account of language evolution. "Something's happening here but you don't know what it is, do you, Mr. Jones." I was Mr. Jones to Heyes's Bob Dylan. It was becoming clear to me that there was more going on here than simple refutation, and that there was more for me to learn than I had previously thought. So, I kept on reading.

Sequence learning and Social Shaping.

The guideposts along this stretch signaled a little smoother going. Sequence learning heralds a return to familiar territories of domain-general processes of associative learning, with social shaping providing the mechanism by which the statistical properties of lexical and syntactic forms are acquired.

Heyes demonstrates the generality of sequential learning with examples from areas such as computer simulation, adults learning artificial grammars, studies of typically developing children, and children diagnosed with Specific Language Impairment (SLI). Computer programs, for example, based on a simple recurrent network architecture demonstrated the ability to process

complex grammatical constructions without any built-in features. Furthermore adults were shown to be able to learn the regularities of an "artificial grammar" based on an arbitrary set of rules used to generate sequences of stimuli such as colors, locations, letters, and pictograms. And typically developing children's ability to learn a non-linguistic ordering of events demonstrated a correlation of this new skill with the ability to process linguistic forms like passives and object-relative clauses. Similarly the specific part of a specific language impairment turns-out to be not so specific. Heyes comments: "However, recent studies with careful controls have shown that, relative to typically developing individuals of the same age, children and adolescents with SLI are impaired in a range of sequence processing tasks (Hsu and Bishop, 2014; Hsu, Tomblin, and Christiansen, 2014; Tomblin, Mainela-Arnold, and Zhang, 2007)." (Heyes, 2018. pp. 185-186). Heyes also looks at claims made about the so-called "language gene" FOXP2. But recent work, she points out, shows that mutations in FOXP2 interfere with neurological elements that are concerned with sequence learning, a deficit which would present itself as a deficit in speech production. (Heyes, 2018. p. 187).

Social shaping issues are related to the Chomsky's well-known claim regarding the so-called "poverty of the stimulus." Chomsky felt that an inborn Universal Grammar was necessary for language acquisition because he did not think typical children were exposed to a sufficient number of both positive and negative input instances. Chomsky was influenced by Brown and Hanlon's 1970 report of the child "Eve's" interaction with her caregivers which indicated that she did not receive negative feedback. A 1991 re-analysis of those transcripts by E. L. Moerk, however, found numerous instances in which Eve's semantic and syntactic errors corrected by her caregivers (Moerk, 1991). Other transcript analyses have found that during their interactions with their parents about one-third of all phonological and syntactic errors received negative feedback (Bohannon and Stanowicz. 1988). Also, Demetras, Post, and Snow (1986), found that a child's incorrect sentences were considerably less likely to be repeated by parents than correct sentences. Heyes reports on more recent longitudinal studies of mothers and their children that "found evidence that a mother's spontaneous tendency to 'expand' her child's utterances—to repeat the meaning while supplying missing syntactic information—contributed to vocabulary learning (Heyes, 2018. p. 189)."

Heyes's guided tour through chapter 8 was a bumpy one for me. But it turns out that what doesn't thrill you makes you smarter. Or, in my case, better informed. Her qualifiers on things like linguistic universals, critical periods, and neurological locations are cautionary reminders, at least for me, to be careful about your confidence in your understanding of other people's theories. The later sections on general-purpose sequence learning was a smoother journey with strong support from computer simulations, and adult studies, Specific Language Impairments in children, genetics, and social shaping. All things considered, this looking over the fence led Heyes to conclude that language is not a cognitive instinct. "For what it is worth," she says, "this outsider has not been convinced. (Heyes, 2018, p. 196).

So, you would think that would be "The End," right? Not so fast! On the last page of chapter 8, just 16 lines from Heyes's "for what it's worth" speech is the following: "However,

those who are committed to a firm distinction between competence and performance can argue that all of these findings bear on the externalization of language, but not on whether there is a genetically inherited language of thought." (Heyes, 2018. p. 196). "Language of thought"? "Externalization of language"? "Competence vs performance"? "And then a miracle occurs"? What are these things? Okay, there is no "And then a miracle occurs," but there is a nearly supernatural ability of the cognitive instinct model to stay alive long after life support has ceased. Or, in Heyes's gentler prose: "I find the genetic account very puzzling. It seems that any other theory would have lost credibility long ago." Under the heading of "Broad Arguments" Heyes devotes four and half pages to addressing this puzzle. That's 16 percent of chapter 8, more space than for any other single topic. What does she want us to understand?

In the opening paragraph of Broad Arguments, after reviewing all the evidence that we have just looked at, Heyes says: "However, in spite of what appears to be a long series of empirical defeats, the genetic account has not fallen." (Heyes, 2018. p. 190). If the reader is not yet envisioning the King Arthur vs the Black Knight at the bridge-crossing scene in Monty Python and the Holy Grail, I suggest a viewing or, perhaps, asking a friend to help jog your memory. In this short coda to the review of chapter 8, I will briefly pass on three major reasons Heyes gives for the resilience of the genetic account.

First, there is the heterogeneous, moving-target nature of the theory. It is simply not one theory. Regarding its origin, for example, some supporters see it as having arisen gradually while others propose a sudden origination. And the moving-target aspect can be seen in its reconfiguration from an initial model of transformations to what became a "principles and parameters," theory, to the current version often referred to as the "minimal program." Second is a competence and performance conceptualization. This has been there from the beginning and it effectively isolates the genetically inherited "language of thought" from any "externalization," that is behavior, also called competence. Thus, any experimentally based bit of evidence against nativism can be dismissed as simply an "externalization." Features like this are probably what Elizabeth Bates had in mind when she referred to the Chomsky model as "a 'scorched earth' policy in which unintelligibility to other disciplines is considered a virtue. (Cited from Tomasello, 1995, Language is Not an Instinct. p. 136). Heyes doesn't talk this way but she does say that "it threatens to insulate hypotheses about Universal Grammar from evaluation by cognitive scientists." (Heyes, 2018, p. 192). And third and last, is related to how Heyes opened chapter 8: "Language is often regarded as a rubicon, a shining threshold in the evolution of human cognition." (Heyes, 2018, p. 169). I drew upon that same paragraph in my opening to this review wondering if, with language, we became more like gods than beasts. The message Heyes draws from this is that we all have deeply held convictions about the role of language in our understanding of human nature.

## Mindreading

Language is a kind of Rubicon, (Heyes, 2018. p.169) and no other creature, as far as we know, has made that crossing. But crossing a Rubicon is one thing, what you do on the other side is something else. This section is about one of the many post-crossing options; what Heyes calls mindreading. Mindreading, which also goes by the name Theory of Mind, is an almost unbelievable achievement. Without ever leaving the body we can "observe" ourselves from a third-person point-of-view. We can take our own actions as objects of attention. Narrate our own experience as if telling a story about someone else. Or tell a story about someone else as if it were our own experience. That's some river crossing!

Chapter 7, called Mindreading, is about one of these post-crossing achievements. This cognitive gadget is a crucial player in the process of Cultural Evolutionary Psychology because without it there is no cultural inheritance; at least not the kind that is at the core of Heyes's book. Mindreading allows a form of teaching that cannot be matched by behaviors like emulation, or miming. It does this because it enables the accuracy and precision that, as we saw in earlier sections, are required for passing on subtle variations of previously acquired skills. Mindreading allows the teacher to know what the novice knows or does not know. And language, which is already in place for mindreading to happen, is employed to direct the attentions and actions of the novice to the features of the world and the manipulations of those features that will become the next cultural norm.

The arc of chapter 7 is similar to that of other chapters; cognitive instincts vs cognitive gadgets. In defending mindreading as a cognitive gadget Heyes evokes an interesting and evocative analogy; print reading. The goal in doing this is to exploit the obvious and uncontentious fact that print reading must be taught, it is not "in" the genes. Likewise mindreading is an acquired skill. And, just for the record, mindreading is not the supernatural thought transfer that the term can potentially imply. Heyes defines mindreading as the "process of ascribing mental states, thoughts and feelings, to oneself and others." (Heyes, 2018. p. 144).

The following are some of the similarities with print reading. In print reading conventionalized signs in some medium represent objects and events in the world. In a similar fashion, facial expressions, body movements, and utterances represent culturally named internal states. In both cases the representational relationship is interpretive and must be taught. This might sound strange at first. But we've known for some time that there are wide cultural variations in the categorization of mental and emotional states. See Angeline Lillard's *Ethnopsychologies*, cross cultural variations in theories of mind, for examples. And recent research on the social aspects of emotional states of arousal is adding cognitive and neurological evidence; further supporting the cultural origins of mindreading. (Barrett, 2017).

Both print reading and mindreading are cognitively demanding and slow to develop. Heyes notes that research using scalp electrodes show that event potentials associated with print reading are slower in teenagers than in adults. (Brem et al., 2006). Similarly, studies in the last ten years or so reveal that neurological systems associated with processes such as perspective-

taking, emotion recognition, and pretense-detection are still developing into adulthood. (Dumontheil et al. 2010).

Neurological studies have also demonstrated that acquiring reading skills organizes cortical regions into areas specialized for reading. For example, in adults there is an area appropriately called the "visual word form area" that is more active when people are viewing words than non-word stimuli. Analogously, neuroimaging data has identified cortical circuits such as the medial prefrontal cortex and the temporo-parietal junction area which are more active when subjects are engaged in thinking about mental states as opposed to performing similar tasks but ones that do not involve mental issues.

### Submentalizing

The similarities between mindreading and print reading that we have just reviewed pose challenges for the cognitive instinct point of view, and suggest that alternative models are called for. For example, Heyes cites a 2005 twin study on the origins of individual differences in theory of mind that casts doubt on genetic contributions. In this study more than a thousand pairs of five-year-old twins - identical and non-identical - were given a comprehensive battery of mindreading tests. The correlation in performance within pairs was the same for the identical twins as for the non-identical twins. This certainly challenges the cognitive instincts view and suggest a strong environmental influence on individual differences in "theory of mind." (Heyes, 2018, p. 151).

Given that the evidence seems to be moving in favor of the cognitive gadgets view it is quite surprising, at about a third of the way through the mindreading chapter, to come across: "Studies of infants now suggest that the development of mindreading is very different from that of print reading. Western children do not typically acquire the skill of print reading until they are five or six years old, but infants as young as seven months old seem to be capable of mindreading (Kovacs, Teglas, and Endress, 2010)." (Heyes, 2018, p. 155). Really? Heyes goes on to say that the most striking results of these studies implies that infants attribute false beliefs to agents. In other words, they understand that another person can be wrong about a situation in the world.

Despite appearances this is not the upset of the constructivist view that it may seem. Heyes is referring to a resurgence of reports that infants are capable of automatically and non-linguistically representing mental states. In 2012, for example, the *British Journal of Developmental Psychology* devoted a special issue to the topic of implicit and explicit theory of mind. And in 2014 Heyes published a paper called "Submentalizing: I am not really reading your mind," where she addresses many of the new experimentally-based claims. (Heyes, 2014a). In that paper and in parts of chapter 7 Heyes engages this literature by examining the status of explicit vs implicit theories of mind.

Submentalizing is Heyes's term for the domain-general cognitive mechanism that allows these very young subjects to appear to understand other people in terms of mental states. In Heyes's model this expression replaces a supposed implicit theory of mind concept that is

typically suggested in many of these more recent experiments. Since many of these experiments are on pre-verbal infants the assessment of false belief, for example, is done by measuring factors like looking time; longer looking time taken as an index of surprise or violation of expectation. One example that Heyes explores is a false-belief experiment by Onishi and Baillargeon with 15-month old infants. (Onishi and Baillargeon, 2005). This paper was an innovative investigation into the ability of the human infant's capacity to understand false beliefs in other people.

In this study the infants first participate in a familiarization phase which consist of three trials. In the first trial, an adult wearing a visor over her eyes, played with a toy for a few seconds and then hid it in a green box on her left. There is a similar yellow box on her right. This was followed by a second trial in which the adult reached inside the green box and paused there until the end of that trial. The third trial was the same as the second.

Then there are four experimental manipulations referred to as induction trials. One called the True-belief green condition in which the adult is present when the toy remains in the green box, and the yellow box moves right and left but remains empty. The second is called the True-belief yellow condition. Here the toy moves on its own accord from the green box to the yellow box and the adult is present to observe this. The third induction trial, called the False-belief-green condition, has the toy moving on its own accord from the green to the yellow box but the adult is not present to observe this. The last induction trial called the False-belief yellow condition has two parts; first the adult sees the toy move from the green to the yellow box, then the adult leaves and while she is gone the toy moves back to the original green box. Thus the adult could not observe the toy moving back to its original location.

In the final phase of this experiment the infant's gaze time was measured as the adult reaches for either the green or the yellow box. In the True-belief green condition, as well as the False-belief green condition the infants showed more surprise when the adult reached for the yellow box. The authors interpret this as the infant, having inferred the adult's state of knowledge from what the adult could have seen, was surprised when the adult did not reach toward where the infant thinks the adult knew the toy to be. That is, the adult could see that the toy was put in the green box in the True-belief green condition, but could not have seen it move from the green to the yellow box in the False-belief green condition. Therefore, if the infant were capable of reasoning in a mature theory of mind manner he would expect the adult to reach for the green box and, thus, be surprised at a reach toward the yellow box.

In the last trial, the False-belief yellow condition, the infants showed more surprise when the adult reached for the green box. Supposedly this is because the adult last saw the toy moved to the yellow box, but was not present to see it move back to the green one.

Heyes argues that while these experiments are "ingeniously designed and carefully implemented, they do not provide evidence of implicit mentalizing because their results could be due instead to submentalizing — domain-general cognitive mechanisms that simulate the effects of mentalizing in social contexts." (Heyes, 2014a, p. 131). Along with basic associative learning, some examples are, involuntary attentional orienting, spatial coding of response locations,

object-centered spatial coding of stimulus locations, retroactive interference, and distraction. (Heyes, 2018, p. 163). In her 2014 paper, *False Belief in Infancy: A Fresh Look*, Heyes offered a different explanation of the experiment outlined above, suggesting an involuntary attentional orienting toward low-level novelty events. (Heyes, 2014b).

It goes like this: In the True Belief-green condition, where the adult was able to observe the toy being hidden in the green box, and in the False Belief-green condition where the toy was moved from the green to the yellow box while the adult was not present, the infants who were shown an adult reaching for the yellow box looked longer than the infants who were shown an adult reaching for the green box. The reason the yellow group looked longer than the green group, says Heyes, is because the reaching toward the yellow box event was more perceptually novel compared to the reaching events the infants had observed in the preceding familiarization phase. And the reason these events were more perceptually novel is that during the familiarization phase infants had seen the adult shape move towards green box three times and no movements towards the yellow box.

Then there is the True-Belief yellow condition, where the adult saw the toy move, of its own accord, from the green to the yellow box, and the False-Belief yellow condition where the adult saw the toy move from the green box to the yellow box, but was temporally gone when the toy moved back from the yellow to the green box. In both the True-Belief yellow condition and the False-Belief yellow condition the infants looked longer when the adult reached for the green box during the test phase. Onishi and Baillargeon concluded this was because the infant surmised that the adult should believe that the toy is in the yellow box. Heyes's alternative interpretation is that the movement of the toy from the green box to the yellow box was visually similar enough to the movement of the adult's arm toward the yellow that it reduced the novelty of that gesture during the test phase.

This explanation avoids projecting adult mindreading into the infant and draws upon the known cognitive propensity of involuntary orienting toward novel events. But there is a caveat here because the infant had also seen the toy move on its own from green to the yellow box in the False-Belief green condition. The most likely explanation for why this movement did not reduce the novelty in the False-Belief green condition is a retroactive interference effect. That is, memory impairment caused by the unexpected reappearance of the agent at the beginning of the test phase.

#### Up-close-and-personal

My walk through the experiment above was meant to convey the character of current debates about the origins of mindreading and the style of experimental adjudication. Heyes details two other experiments in chapter 7 further supporting the submentalizing interpretation of implicit mindreading. I also suggest, for a little more up-close-and-personal view of the debates, spending time with Heyes's 2014 paper, *False belief in infancy: a Fresh look*, and follow that with Scott and Baillargeon's response, *How Fresh a Look? A Reply to Heyes*, and then read Heyes's reply to Scott and Baillargeon; *Rich Interpretations of Infant Behavior are Popular, But*

are they Valid? A Reply to Scott and Baillargeon. And what will the reader learn? Well, the reader will see more of the graciousness that Heyes extends toward her critics. And, further, in spite of the competence of Scott, Baillargeon, and others - or perhaps because of it - a sense that when the digital dust has settled, Heyes will win the day. The following are three examples from that exchange. (Heyes, 2014b; Scott and Baillargeon, 2014; Heyes, 2014c).

First, quite reasonably, Scott and Baillargeon appeal to the convergence of multiple experimental results over the past 20 years. Commenting that "The research on early psychological reasoning over the past 20 years makes clear that infants represent simple psychological events as 'actions on objects by agents', rather than as 'colours, shapes, and movements'" (Scott and Baillargeon, 2014, p. 660). The 'actions on objects by agents', rather than as 'colours, shapes, and movements' excerpt from Heyes's paper reflect Scott and Baillargeon's belief that adult-like categories exist in the minds of young infants. It is unfortunate that we have no easily accessible language to denote the body-related cognitions of pre-linguistic children. It is all too easy to adultapomorphize an infant when the most readily available lexicon is already loaded with biases of skills-yet-to-be-acquired.

Expressions like "the arm-shape moved in an oblique, minimum jerk trajectory towards the green cube-shape." are, in all probability, exactly what the infant is experiencing but, if used by researchers, would be hopelessly confusing. In her 2014 paper Heyes notes that that in evaluating this body of research on infant false belief it is not enough to just monitor the beliefs of the young subjects. One must also keep in mind the beliefs of the researchers. And she reminds us that in a very important sense the purpose of these experiments is "to find out whether infants appreciate that the 'arm-shape' is attached, not merely to a human body ... but to a fully-fledged agent." (Heyes, 2014b. p. 648).

I would like to note in passing that this review has had a sort of de ja vu feeling for me from a review I did of Mix, Huttenlocher and Levine's book, "Quantitative Development in Infancy and Early Childhood" called "It's the overall amount silly." (Rowe, 2004). In that review I concluded that Mix et al. successfully found colleagues of theirs such as Wynn, Gallistel, Gellman, Meek, and Markman, guilty of importing mature adult mathematical capabilities into the heads of innocent little children. Where Wynn and friends saw an incipient mathematician Mix et al., demonstrated that infants were doing pattern recognizing and invariance noting on the basis of the overall amount of things like area and outline shape. Or, updated in the language of Cecilia Heyes, utilizing low-level general purpose cognitions that when viewed from a certain intellectual altitude bear a resemblance to the skills of grown-up arithmeticians.

Second, regarding the convergence of multiple experimental results over the past 20 years, Scott and Baillargeon include a table of 36 reports from papers on false-belief understanding prior to age 4. Heyes responds to this by pointing-out that the experiments which Scott and Baillargeon draw upon are themselves subject to low-level interpretation of the kind illustrated in the implicit belief experiment described above. And regarding the number of papers with positive supporting results she notes that, "Other potential drivers include the academic

incentive structures created by high-impact, non-specialist journals with a taste for reporting precocity." (Heyes, 2014c. p. 665).

And lastly, Scott and Baillargeon say: "Many of Heyes's (2014) assumptions concerning these processes seem unlikely. For example, we know of no evidence that infants' memory of repeated events rapidly fades over a brief delay, or that infants generally view the return of an agent after a brief absence as highly disruptive."(Scott and Baillargeon. 2014. p. 661). Perhaps, at this level of detail the parties are in some way talking past each other; because examples of things like this are not hard to come by. See table 1.

## Table 1 Here.

And just to call attention to one issue, take the A not B error for example. In this task the child is allowed to see an interesting object hidden in location A a number of times. Then, still visible to the child, the object is transferred and hidden in a near-by location B. When allowed to retrieve the object after a short delay Infants tend to look in location A even though they have just witnessed the object being transferred to location B. This perseverative responding is called the A-not-B error. Heyes points out that retroactive interference contributes to the A-not-B error. "In experimental paradigms similar to those used to test for FB [False Belief] attribution in infants, a distracting event, occurring after the infant has seen an object hidden at location B, disrupts memory for this event and thereby encourages her to search at location A." (Diamond, 1990; Longo & Bertenthal, 2006. Heyes, 2014b, p. 648).

Diamond gives an example of how an action occurring after the object is transferred to location B can be disruptive. The experiment was done on 9-month-old infants using a 5-second delay between object hiding and infant search. There are two experimental manipulations; one, where after the object is transferred from well A in a table top to well B in the table, a tray simultaneously covers up both wells. In the other manipulation well B is uncovered and then re-covered after the object is placed in it. Thus in the second manipulation the last action after the hiding can be seen as drawing the infant's attention to where the object is hidden. Infants performed better when the last action before the delay drew their attention to the well where the object was hidden than when the wells were covered simultaneously. I take this to be an example of retroactive interference. (Diamond (1990).

I think that Heyes has shown that the convergent evidence highlighted by Scott and Baillargeon does not sufficiently distinguish between high-level and low-level explanations. And specifically, as she summarizes in her reply to Scott and Baillargeon, the infant false belief evidence can be better explained by low-level novelty. It seems to me that her critiques of this body of work will only help sharpen the focus and as she says: "design experiments to test rich, domain-specific accounts of infant behavior against leaner, domain-general alternatives." (Heyes, 2014c, p.665).

## Theory of Mind

In the Latin Catholic Church the sacrament of confirmation is conferred on the young no earlier than age 7. Why age 7? According to canon law, that is the age of reason. Before that the young person is not considered to be responsible for his or her self. During the last quarter of the 20th century developmental scientists checked that same box and confirmed that at around age seven most children in the western world at least could pass a canonical battery of tests under the rubric of Theory of Mind. These are standardized tests that go by the names Appearance-Reality test, Contents false-belief test, Locations false belief tests, and tests for "true deception." Studies have also shown that it is not until around age 6 that children become competent at narrating themselves in the dimension of time (Cromer, 1971). So if we take this as an index that the child can now understand his or her own behavior in terms of intentions, desires, and correct and incorrect beliefs, then it looks like the Catholic Church got it about right at age 7, throwing in an extra year for good measure. And now it is time for something completely different, Confession. That is, the ritual of narrating to someone else a time-line of, not just behaviors, but also abstractions like beliefs and intentions along with the assumed beliefs and intentions of the other person; and on top of this shared judgments but the moral value of these things. In other words the child demonstrating that he or she is now capable of sin. And perhaps most frightening of all from the adult point of view, the first sin of the child is the fruit of knowledge that grown-ups can be wrong about things!

All cultures have rites-of-passage like this in which the young person is officially acknowledged as a member of the community. But, to my knowledge, no culture does this at 12 months of age. Now I know this is pushing an argument to the breaking point but sometimes a little exaggeration goes a long way. And, of course, researchers in the nativist camp aren't suggesting that infants have the capacity of a seven year old. That being said, Heyes has shown us that a lack of caution in labeling the infant's capacities has led to a blurring of the distinction between child and adult mental abilities. As the rite of confirmation above illustrates, the world of adult mental states is a domain of narration. It is a lexically bracketed world of descriptors denoting mental state changes. Those descriptors - thoughts, and beliefs, desires, and intentions are nouns, which is fine. But to be alive in the world is not to be a noun, if it resembles anything lexical it is a verb. These nouns and verbs have proven to be very useful common currencies in complex social orders where the ability to predict the behavior of others exceeds the capacity of shared body language. As such they acquire their utility by virtue of their function within a narrative, a story, a sentence. An infant however is not a narrative being. So at the very least the use of terms like belief and false-belief should probably be reduced or dropped altogether. But what do we replace them with? Well, let us turn to Heyes, 2018, *Cognitive Gadgets*, Chapter 7, page 164, line 29: "action vocabulary."

## Action vocabulary

If the mental state terms that the typical child is using by age seven refer to the same behaviors that the child is capable of at age 1 then what develops? Who knows, maybe it really is turtles all the way down? But I'm guessing it's more like a wing on a fly on a frog on a bump on a log in a hole in the bottom of the sea. Heyes uses the term submentalization to refer to the behaviors of the infant that resemble, but are not the same as, those of the fully paid-up mindreading adult. From a model-theoretic point of view submentalization is part of a Jamesian dual-process system but, in this case, it is not a 2-system model. The reason for this caveat is that most all of the players agree that there are two different systems running the show; one that is fast, automatic, parallel, and operates on information obtained from genetically inherited mechanisms. And the other that is slow, effortful, serial and operates on information from both the fast and parallel one as well as the results generated by its own activity. The difference between what Heyes proposes and the others is that the fast, automatic, and parallel processes of the others is considered to be genetically specialized for mindreading, and the equivalent processes in Heyes's model are genetically given general-purpose cognitive mechanisms. These submentalizing mechanisms include associative learning, involuntary attention orienting, spatial coding of response locations, object-centered coding of stimulus locations, retroactive interference, cued retrieval, and distraction. (Heyes, 2018. p.163). Add one more thing; an enhanced tolerance for the young on the part of adult humans and this mix of propensities bequeaths a library of mental-state precursors, the "action vocabulary" mentioned above.

How does this work? The human infant, taking full advantage of its species-specific statistics-gathering abilities, begins to make note of the invariant features of both the movement patterns of near-by human shapes and also the regularities in the utterances of those shapes. Said another way, a moving mass becomes an "arm," a dynamic extension of this "arm" becomes an intention to acquire, and the whole thing becomes associated with the adult utterance "get." Movements like this cease to be surprising to the infant because associative learning has made them predictable by a number of precursors; head movement, eye movement, or vocalization, for example. Thus, in Heyes's words, "The resulting action vocabulary provides an initial set of referents for mental state terms and for instructions about how mental states relate to behavior."(Heyes, 2018. p.165).

From her "intuition pump" of mindreading being like print reading, to her detailed analysis of recent experiments on implicit mindreading, Heyes has made a convincing case that mindreading is a culturally inherited cognitive gadget. Like print reading it has a weak dependence on genetics and a strong dependence on teaching. And like print reading, "mindreading mechanisms represent representational relations—between mental states, behavior, and events in the world—and allow the mindreader to regulate and interpret a virtually limitless range of mental contents." (Heyes, 2018, p. 168). To borrow, and to paraphrase, a line from the opening of this section, that's some cognitive gadget!

## Coda

I opened this review with a meditation on Tom Paxton's song *The Marvelous Toy*. A peculiarly nondescript gadget that thrilled, charmed, and perplexed the little boy who received it from his father and who, in turn, passed it on to his own little boy - equally thrilled, charmed and perplexed. I analogized this toy to Heyes's *Cognitive Gadgets*; neither is required for life, both are handed-down by other people, and one is marvelous and the other is wondrous. Although, in truth, both are both.

In my opinion Heyes has given us the opportunity to appreciate the subjective, the social, and the historical wonders of being human without being mystified by it. We've been here before. It took a while, but in time we said good-bye to life as a vital force and earth as the center of everything. It may now be time to bid farewell to homunculi and to genetically determined human behaviors. Farewells are difficult and they are best made when we understand why. Enter *Cognitive Gadgets 2018*. General purpose learning mechanisms, marginal propensities for the human infant to orient toward the features of human caregivers, the inclination of those caregivers to tolerate the presence of the young, the ability to form associations between actions and outcomes within and across modalities; none of these are for doing mathematics, reading, or writing book reviews. But in a nurturant social environment they unite to form an infant that is exquisitely primed to treat caregivers as a source of joy and learning.

## Come pretend with me

In this review I emphasized rhythmic entrainment between infant and caregiver. Many years ago I solidly formed the opinion that this phasic behavior was the means by which that all important Time-on-Task was established between learner and exemplar. Also over the course of those years, and with equally solid conviction, I arrived at the opinion that no mechanism designed for rhythm was going to be found in the brain. This was a kind of "Houston we have a problem" moment for me. Well, long story short, Cecilia Heyes played *Mission Control* to my *Apollo 13*. I discovered that even something as prototypically human as dancing together is a gadget! Well, maybe proto-gadget is a better term. But it is just as dependent upon general-purpose cross-modal associative-learning mechanism as those larger gadgets (See chapter 3 of the book). But that's not what I wanted to talk about. I want to talk about pretense. Although there is one more thing; it's the Miracle on 34th-week.

About halfway through infancy, human children begin to share objects with their caregivers. Michael Tomasello once called it "the nine month miracle" (Tomasello, 1993, pp. 174). At this stage infants "look where adults are looking (joint visual attention), they look to see how adults are feeling toward a novel person or object (social referencing), and they do what adults are doing with a novel object (imitation learning)." These, along with other new behaviors, such as giving things, pointing, and teasing, mark a significant change in the social life of the infant. Colwyn Trevarthan terms it secondary intersubjectivity (Trevarthan & Hubley 1978), and Daniel Stern, the domain of intersubjective relatedness (Stern, 1985, pp. 125). After about nine

months the infant is not just aware of an object, but also that another person is attending to that object. Activities like giving, pointing, and social referencing show an early sensitivity to the psychological relations between other people and objects; giving indicates a sensitivity to the adult's desire; social referencing to the adult's emotions; and pointing to the adult's state of attention (Wellman, 1993). This is often discussed under the auspices of shared focal attention, a term meant to capture the ability to engage in sustained, often cooperative, intentional behaviors toward objects or events in the world. At some point along the way the infant will notice that the object the adult is sharing intentions towards is the infant herself. This is, I believe, a transcendental moment in the life of the child. Although, as noted earlier in this review a secular transcendence, it is a form of reflexive awareness that we have no reason to believe is available to any other creature. And I think we have reason to believe that this capacity owes a debt to the 9 months of rhythmically mediated shared intimacy. This brings us, now, to pretense.

The new world that the toddler enters at around fifteen months is the world of the "non-actual". Pretend play, fantasy play, and acting as-if, are some of the terms that have been used to reference this new behavior of the child. Watson and Fischer observed that over half of fourteen-month-olds could pretend to lay their heads down on a pillow to sleep. Later, by eighteen months, children are capable of more complex play such as putting a doll down on a pillow for it to sleep, or substituting something else, such a block of wood for the doll and lying it down on the pillow (Watson, & Fischer, 1980). And significantly, Deleau cites studies indicating that the earliest manifestations of pretend play are examples of social scripts that can only have arisen out of shared understandings concerning role relationships, episodic structures and conventionalized attitudes toward objects and events (Deleau, 1993). Without pretending to have proven anything, I suggest that pretense is indebted to the Miracle on 34th week. That is, 9 months of "dancing" together, 9 months of engaging, predicting, confirming, disconfirming, and doing than over and over again produces an internal model of the "other," something like a "script," that in the teen months can "run on its own," so to speak, without anyone else actually being present. Pretense. Which means, yes, pretense is a kind of gadget.

The story continues. As the child acquires language pretense finds new opportunities in symbolic play. And as the symbolic child acquires conventional social categories symbolic play becomes lexical invention, and lexical invention morphs into metaphor which morphs into the ability to imagine oneself and other people in terms of invisible things like beliefs, desires, thoughts, and memories. This is the very stuff of mindreading, one of Heyes's more prominent gadgets.

This metaphorical self has nearly infinite dimensions as one might expect of a construct born of pretend play and constrained only by the practical needs of the culture. There is a discernable transition in our stone, clay, papyrus, velum, paper trail; from a lexicon denoting the experiential self in immediate rather concrete terms to the more metaphorically embellished one we are familiar with. A few examples of this malleability from classical studies are Bruno Snell's *The Discovery of the Mind* (1953), E. R. Dodds' *The Greeks and the Irrational* (1951), and *The Origins of European Thought: About the Body, the Mind, the Soul, the World, Time and Fate*, by

Richard Onians (1951). In commenting on Mycenaean era words for “seeing,” for example, Snell points out that “the verbs of the early period, it appears, take their cue from the palpable aspects, the external qualifications, of the act of seeing, while later on it is the essential function itself, the operation common to every glance, which determines the content of the verb” (Snell, 1953, p. 4). Like Snell, Onians also finds, in the oldest Homeric texts, a lack of abstract mental terms. Thinking, he says, is described as “speaking” and is located in the heart, or midriff (Onians, 1951, p. 23). And the term *noos*, which later came to be associated with intellectual thought, did not have such a clear mental demarcation in the Iliad. And Dodds, surveying the fragmented lexicon of expressions in the Iliad for what are later called thoughts, perception, and volition, concludes that “Homeric man has no unified concept of what we call ‘soul’ or ‘personality’” (Dodds, 1951, p. 15).

The psychologist Julian Jaynes independently noted the same pattern. Words in the Bronze Age Iliad, for example, that by Classical times meant mental things, denoted direct physical experience. The term *psyche*, which is typically translated as soul or mind, in most instances referred to life substances such as breath or blood. And the later Greek word *nous* denoting the conscious mind came from the more ancient term *noein*, to see. (Jaynes, 1976, p. 69 - 70). More recently the anthropologist Brian McVeigh notes how, in English, intangible mental events are given structure primarily with visual metaphors. We say that we “see” solutions to a problem, for example. And smart people are called “bright” while not so smart people are called “dull.” (McVeigh, 2016, p. 23).

The psychologist Angeline Lillard, in her 1998 paper *Ethnopsychologies: Cultural Variations in Theories of Mind*, called our attention to the striking variation in the concept of mind around the world. The Chewong of Peninsular Malaysia seem to have only 5 mental process terms: want, want very much, know, forget, and remember. There is no word for think. In a similar vein The Illongot, in the Philippines, have a term, *Rinawa*, which is the closest thing to the Western concept of mind. However, it is identified with the heart and does not separate thought, feeling, inner life, and social context. And she notes that for Samoans. minds are considered unknowable and thus not relevant. Further, intention is not important in assigning blame; only the actual effect of one’s action is considered. As enlightening as time travelling and globe trotting may be one of the most informative places to explore might be the sandbox where kids say the darndest things.

A four year old child is talking to the teacher at naptime and says: “I want to lie down but my body has to go to the bathroom.” (Swensen. 2009, p. 8). I once heard a toddler deny throwing something by saying “my hand did it.” Are these metaphors? Probably not. Proto, or quasi metaphors perhaps. Early metaphors tend to be noun to noun. Ellen Winner, in her book *The Point of Words: Children's Understanding of Metaphor and Irony* says, for example, that when a child calls a ladder a “scissors,” he is not suggesting that the ladder be seen in a new way. Rather, “The child was simply using the ladder to stand for an imaginary scissors.” (Winner, 1988, p. 98). What might be called “true metaphor” is still some years away. For example James Geary in his book. *I is an Other*, reports a study of metaphor comprehension in a cohort of five to

nine year old children. The children were asked to act out, using a doll, the story of a girl named Sally who was on her way home. There were two versions of the story. A literal one saying, "Sally was a girl running to her home," and a metaphorical one saying, "Sally was a bird flying to her nest." Children in the five-to-six year-old range tended to move the doll through the air in the case when Sally was described as a bird, apparently taking the sentence literally. But the eight-to-nine-year-olds, tended to move her quickly across the ground, taking the phrase metaphorically.

All of this variability, throughout time, around the globe, and during childhood is the result of one thing, pretense. No pretense, no persona. At least not the fragile, agile kind needed for Cultural Evolutionary Psychology. These two features, fragility and agility, come for free with being metaphorical, nothing has to be added. The flexibility of the metaphorical self is due to the fact that it must be taught here and now by people who are already functioning in a particular ecology. So they shape the young person's executive skills along with the narratives that explains those skills. That is, the story of what I am and how I fit in. Thus, if the social system changes the narrative can keep-up so to speak, it is not constrained by genetic lag times. The fragile part is simply an unavoidable conjugant of flexibility. That is, it must be taught, thus, it is not guaranteed by a genetic stipend. There are other details about how these factors promote sustainability over time at the population level which Heyes discusses in Chapter 5.

The Marvelous Gadget.

Heyes has pulled together scientific orphans that have been wandering around in plain sight for years just waiting to be adopted. She has added to these the results of her own work and enriched the mix with informed suggestions about how it all goes together. And I think it does the job it has to do at the level in which the questions are asked. Well understood cognitive capacities functioning within a known developmental landscape produces a primate that possess extraordinary learning capabilities. Including a well understood means of learning about it's own learning capacities.

But, here's the thing. If we understand it, as I assume we do after reading Cognitive Gadgets, then why is it not just one more understood thing? Why is it peculiar? Why is it wondrous or even marvelous as I have been saying? And the answer is that when we take our own observations as objects of observation we change the object that we are taking as an object of observation. (My apologies for the indigestion there) We're always just one step behind ... so to speak. As metaphorical beings we are not just agile and fragile at the population level and over cultural evolutionary time scales, we are fragile and agile as individuals moment by moment. This keeps us "light on our feet" as Heyes says in the section on Human Nature. It also keeps us wondering; who am I, where did I come from, where am I going, how long have I got? And this is about as far as you can get - all due respect to Evolutionary Psychology - from being a Stone Age Mind housed in modern skull.

So there you have it, a god-like mind trapped in a boney skull. Non-optionally trying to figure out what it is and always coming up short. And always trying again. And so we produce

art and cathedrals, and songs, and, yes, prayers. We also produce anguish, and confusions, and yes, therapists! Nobody said this life would be easy. And who would want that anyway? - well, sometimes in the middle of the night. And, sometimes, in the middle of whatever it may be that is taxing us, we might consider one of Heyes's closing messages: that, if her theory is correct, "we need not fear that our minds will be stretched too far by living conditions that depart ever farther from those of hunter-gatherer societies. On the cognitive gadgets view, rather than taxing an outdated mind, new technologies—social media, robotics, virtual reality—merely provide the stimulus for further cultural evolution of the human mind." So I think Yogi Berra got it right, even the future ain't what it used to be. But then, neither are we.

The human mind; it goes zip when it moves, bop when it stops, and whirrrs when it is still. We'll never know just what it is, and I guess we never will. Peculiar, uh?

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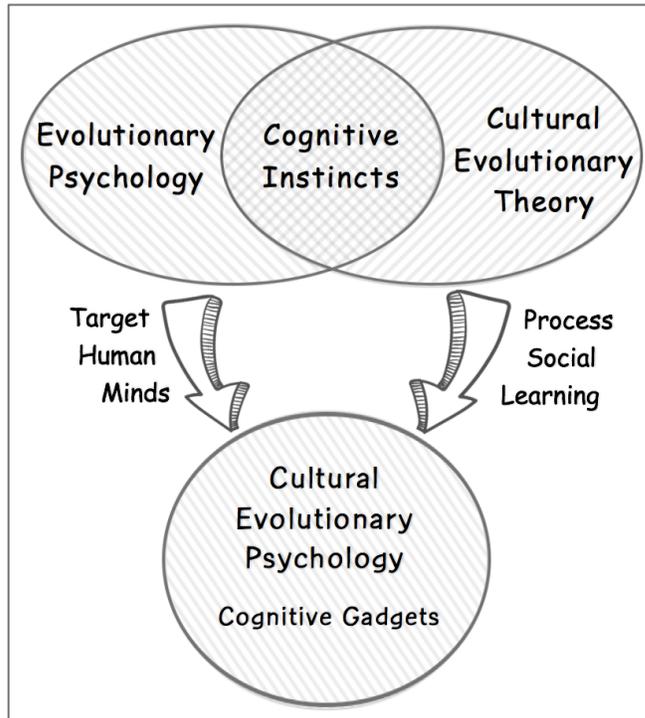


Figure 1. The arrows in the figure depict the features of the two preceding theories that are preserved in Heyes's Cultural Evolutionary Psychology.

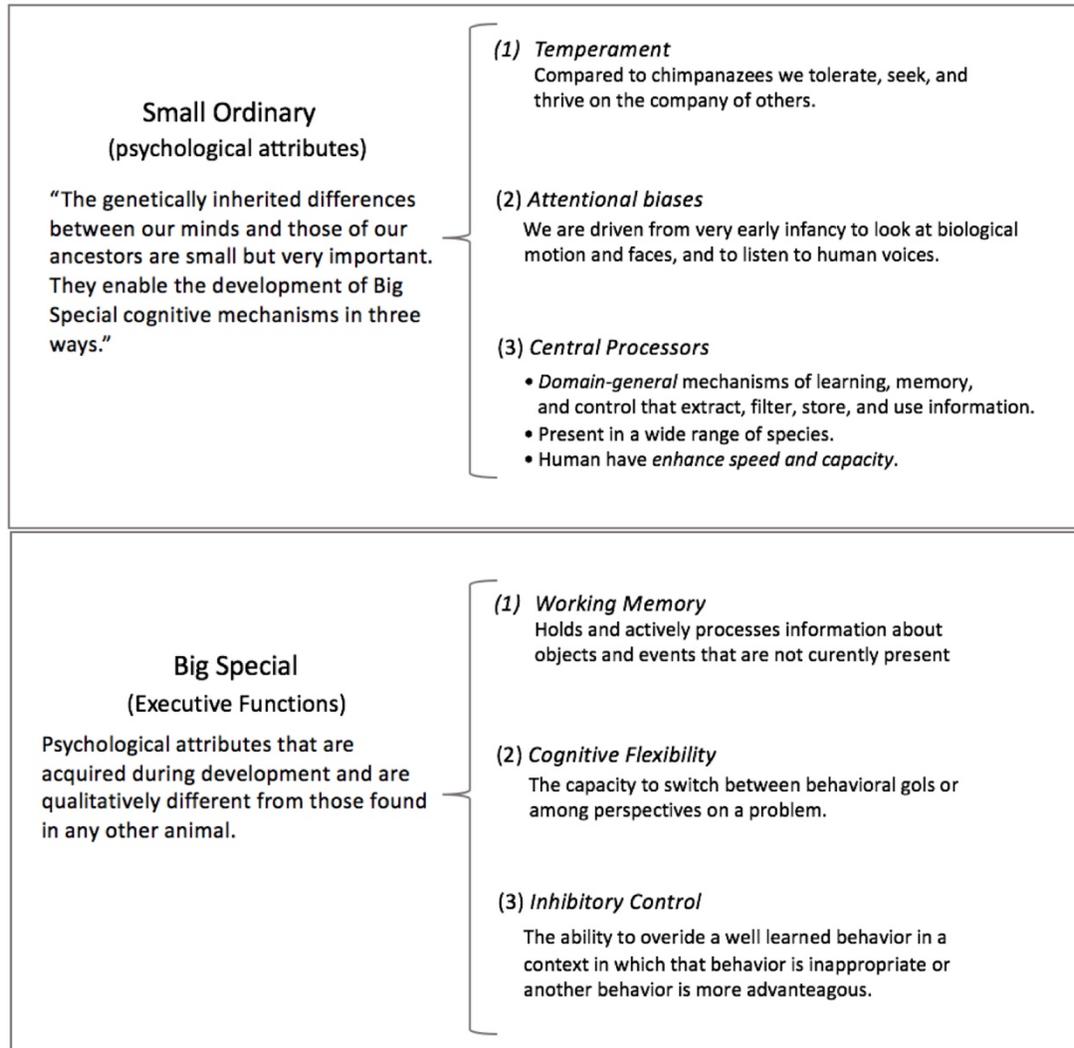
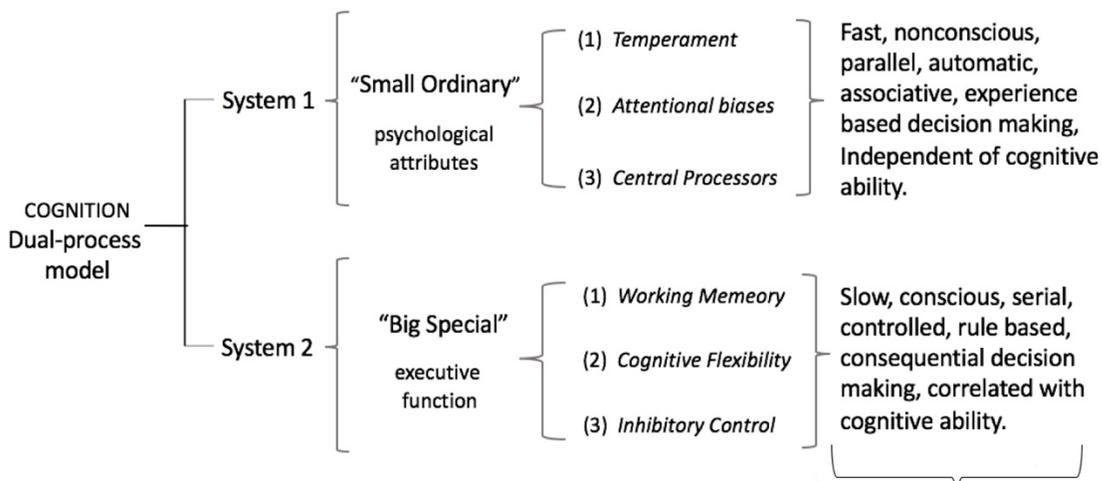


Figure 2. Features of "Small Ordinary" and "Big Special" elements



*Mindreading*  
Mill



Figure 3. Dual processing model illustrating the "Big Special" System 2 location of a mindreading mill. Other mills, Imitation, Language, et., would be similarly located.

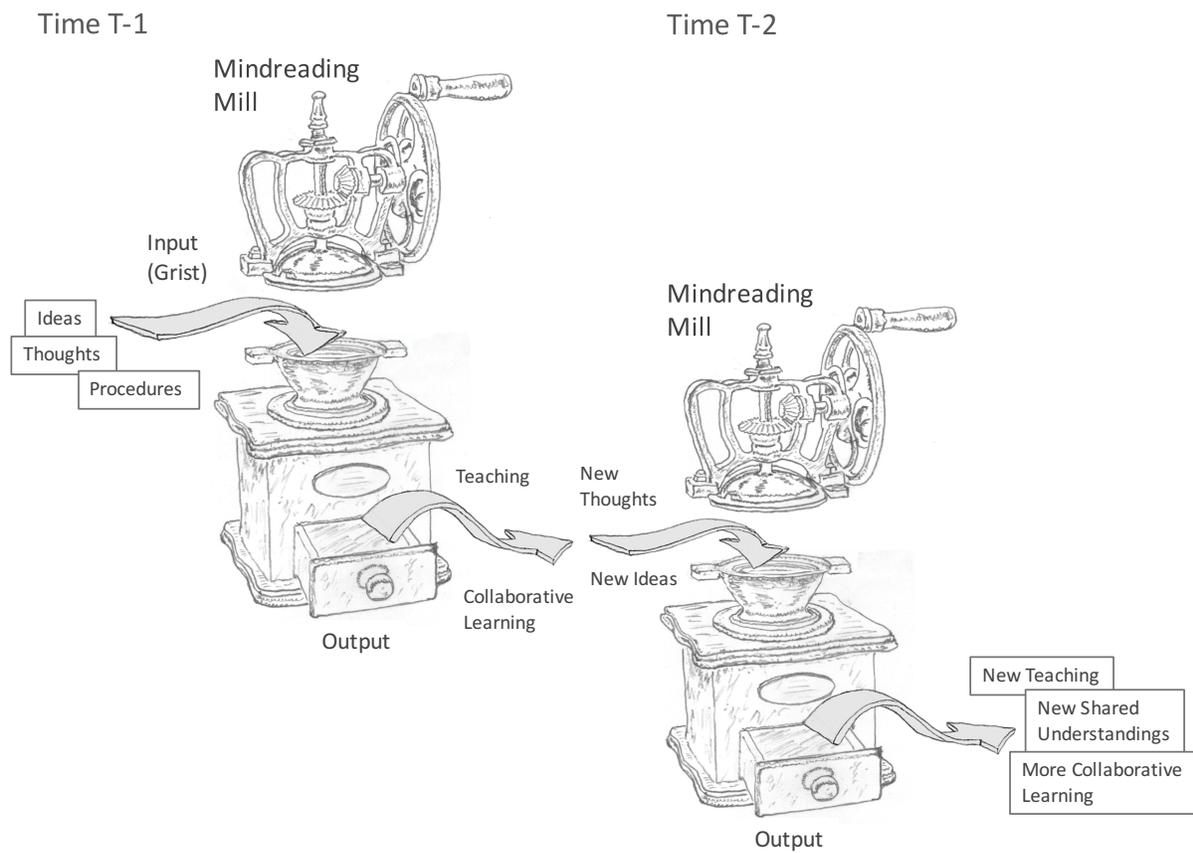


Figure 4. Cultural evolution of grist via the operation of two Mindreading Mills.

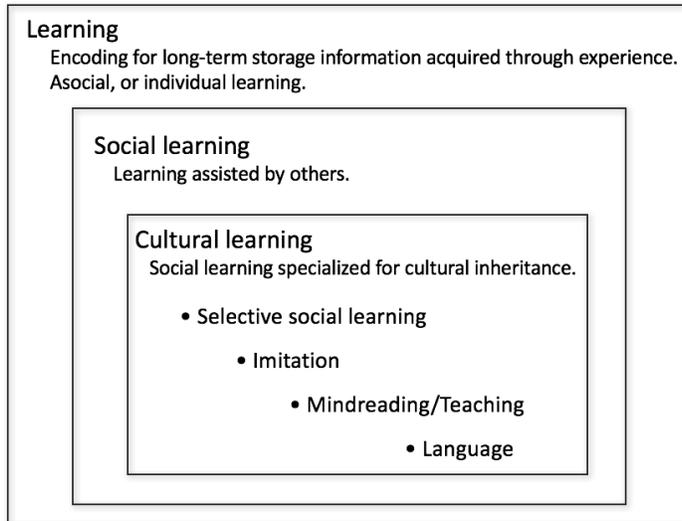


Figure 5. A framework for exploring the relationship between learning, social learning, and cultural learning, that facilitates a dialog between cognitive science and cultural evolutionary theory.

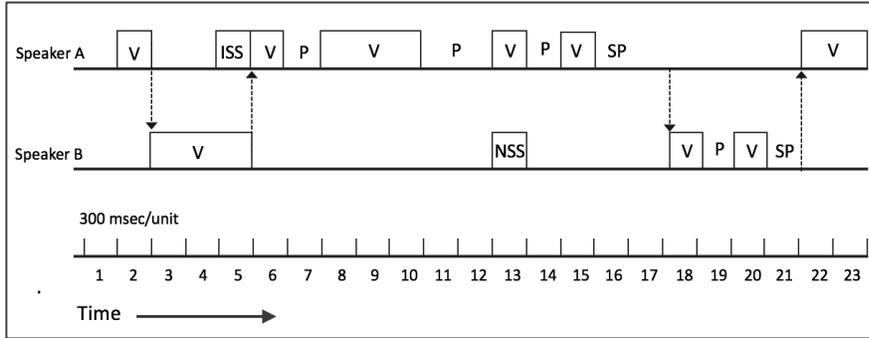


Figure 6. A phase diagram of an adult conversation. The time axis represents successive 300-msec units. V = Vocalization. P = Pause. SP = Switching pause ISS = Interruptive simultaneous speech. NSS = Non-interruptive simultaneous speech. The arrows that point down denote the end of speaker A's turn; those that point up denote the end of Speaker B's turn.

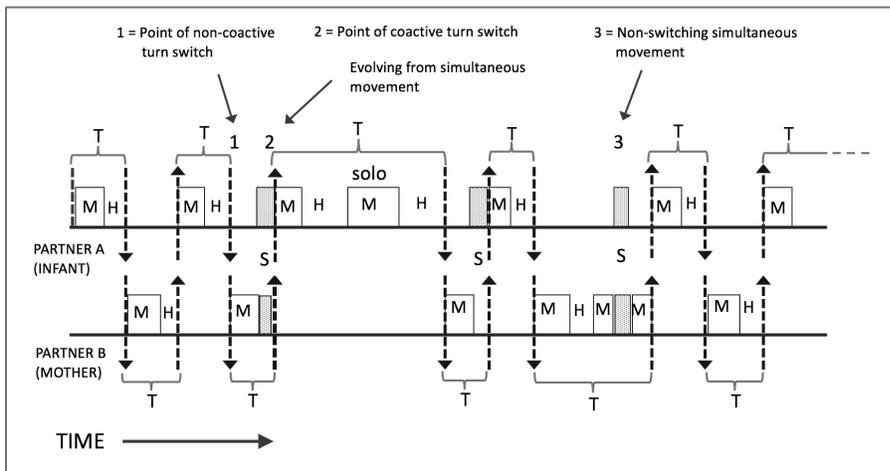


Figure 7 Diagrammatic representation of the temporal patterns of a mother and her infant. T = Turn, M = Non-coactive Movement, H = Hold, S = Simultaneous Movement, Solo = The partner who has the turn acts more than once

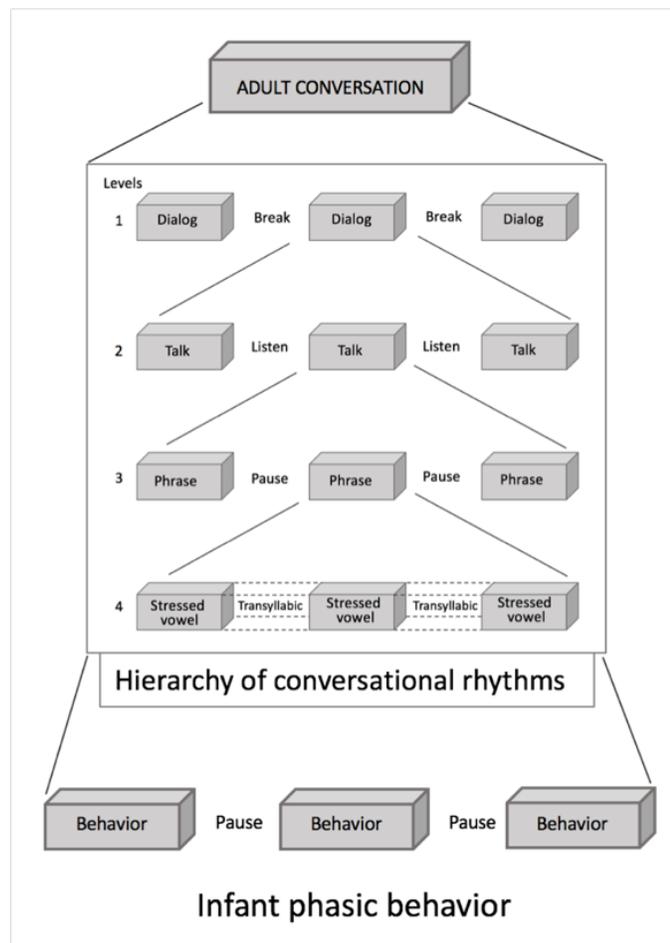


Figure 8. Hierarchy of conversational rhythms. Sandwiched between adult conversation patterns and infant proto-conversation are four levels of interpersonal phasic behaviors.

- Level 1 represents recurrent dialogs between adult conversants.
- Level 2 indicates the "turn taking" of a single individual.
- Level 3 shows the phrase-pause-phrase of an individual.
- Level 4 represents the stresses, or accented, syllables within a phrase.

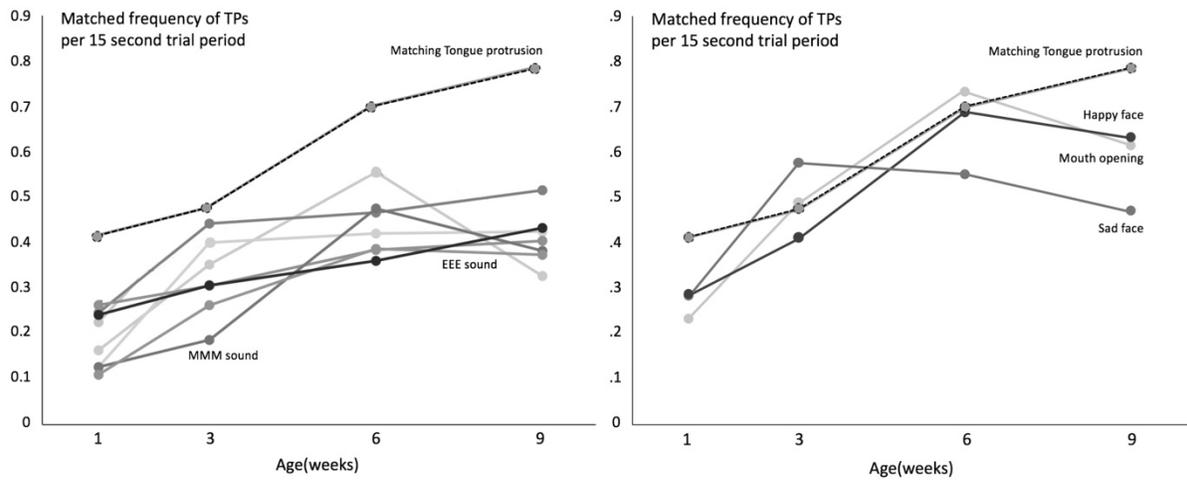


Figure 9. The data in these panels are the same as that shown in figure 3 of Oostenbroek 2016. They have been selectively separated in order to illustrate the relationship of matching tongue protrusion (the dotted line in both graphs) to unique classes of modeled gestures. In particular, three active facial gestures in the right-hand panel compared to all the other control gestures shown on the left. The gestures in the left-hand panel are, from top to bottom, Tongue protrusion, Finger protrusion, Click sound, Box opening, Grasping, MMM sound, EEE sound, and Tube protrusion. In the right-hand panel they are, from to bottom, Tongue protrusion, Happy face, Mouth opening, and Sad face.

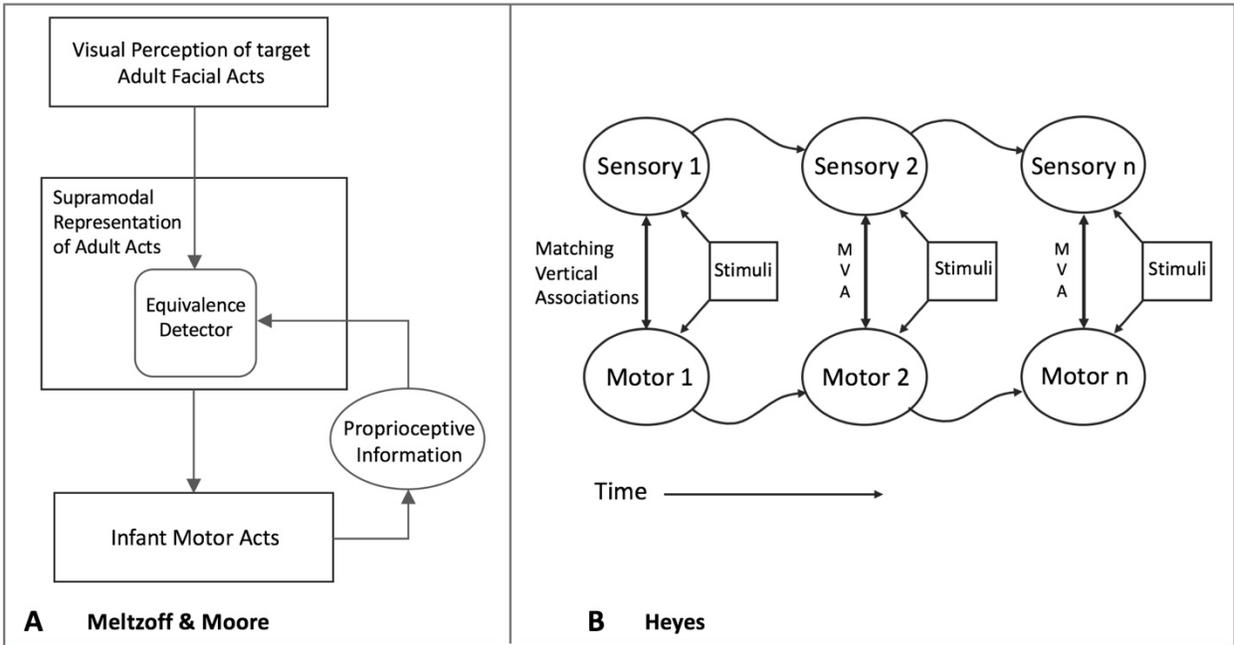


Figure 10. A, Meltzoff and Moore's conceptual schematic of the Active Intermodal Mapping hypothesis (AIM). Adapted from figure 1 of Meltzoff and Moore, 1997).

Figure 10 B, Heyes's Associative Sequence Learning (ASL) model of imitation.

(Adapted from Ray and Heyes, 2011, figure 1). In addition to the matching vertical associations there are other sources of "stimuli." Heyes suggests words as example stimuli. But they could also be proprioceptors that can assist in correlating the seen but unfelt with the felt but unseen.

Heyes:

"For example, retroactive interference – disruption of memory for event X because it is followed by event Y (Pearce, 2008) – is a robust phenomenon found in a broad range of nonhuman species (including monkeys (Fuster & Bauer, 1974) and pigeons (Grant, 1988)), and in human adults (Yoon, Curtis & D'Esposito, 2006) and infants (Diamond, 1985; Marcovitch & Zelazo, 2003)."

"In infants, retroactive interference contributes to the A-not-B error; in experimental paradigms similar to those used to test for FB attribution in infants, a distracting event, occurring after the infant has seen an object hidden at location B, disrupts memory for this event and thereby encourages her to search at location A (Diamond, 1990; Longo & Bertenthal, 2006)."

"Resistance to retroactive interference – maintenance of an active representation of X in spite of distraction by Y – depends on prefrontal cortex, and is therefore likely to be particularly weak in infancy (Miller, Erickson & Desimone, 1996; Olesen, Macoveanu, Tegner & Klingberg, 2007)."

p. 648, False belief in infancy: a fresh look.

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Table 1.