IMITATION, EMULATION
AND THE TRANSMISSION OF CULTURE

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**Imitation, Emulation and the Transmission of Culture**

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and hereby certify that, in their opinion, it is worthy of acceptance.

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Abstract

This study explored the tendency for children to prefer imitation over emulation in various goal-oriented learning situations where emulation might be a more efficient means to reach goals. Young children between the ages of a few months and six years are persistent imitators. Surprisingly, rather than out-growing this behavior as they age, children appear to become even more persistent imitators. The tendency to imitate other people’s actions is so prominent that researchers have labeled the behavior “overimitation.” This study was designed to test 4- and 5-year-old children’s ability to switch behavioral tactics between imitation and emulation when changing circumstances cause an emulative strategy to be more efficient than an imitative one. The research involved showing pre-school age children how to open a pair of small puzzle boxes. Demonstrations contained several pointless or irrelevant actions. When given a chance to open boxes, children performed not only necessary actions but also irrelevant actions copied from demonstrators. Even when urged to hurry in their attempts to open boxes, children did not abandon the irrelevant actions of demonstrators. Even offers of special prizes could not persuade this group of children to switch from imitation to emulation. Children’s insistence on using imitation despite the availability of another more efficient copying behavior has been linked with our species’ production of culture.
Introduction

For centuries, scholars and thinkers have sought explanation for the extraordinary productivity of human culture. Other species share behavioral adaptations and possess various traditions that may be thought of as expressions of culture, but human culture: our technological innovation, varied and particular languages, our ideals of morality and ethics, our rituals, traditions and complex forms of social organization express a capacity for cultural adaptation of such exceptional degree that comparisons to other species traditions seem hardly meaningful. But what accounts for our species incredible ability to create and disseminate culture; what singular gift separates us from our unknowing animal cousins? There are several possible explanations for our species’ success including our extraordinary intelligence, our elastic and expressive use of language, our inclination to live in cooperative coalitions. Could any of these traits serve as foundation for our lavishly sophisticated society? Each may be important in explaining human capacity for cultural adaptation. Certainly, some unique mental mechanisms are at work driving our extraordinary cultural departure from the limited traditions of other species. One such exception is a peculiar and as yet not fully understood human predisposition to imitate those around them.
In recent decades, researchers from varied fields, including primatology and cognitive neuroscience as well as developmental and evolutionary psychology, have focused on observational learning and, more specifically, on imitation as a primary process explaining transmission of human behavior adaptations. This is nothing new. Researchers in developmental psychology have studied children’s propensity to copy behavior since early in the 20th century (Baldwin, 1902; Meltzoff, 1988). These studies have isolated a number of different ways that children employ observational learning and copying behaviors.

Definition of Terms

Many recent researchers have explored distinctions between imitative and emulative behaviors (Tomasello et al. 1987; Nagell et al. 1993; Call and Tomasello 1994; Byrne & Russon, 1998; Myowa-Yamakoshi & Matsuzawa 2000; Hayes, 2001; Heyes & Rey, 2002; Call et al. 2005; Horner & Whiten, 2005). Unfortunately, precise definitions of terms given to various learning behaviors are difficult to isolate, but generally, copying behaviors may be divided into distinct categories; most simple among these is ‘mimicry’ that Bellagamba & Tomasello (1999) maintain is behavior observed in any person copied by another person with no underlying understanding of the first person’s goals or motives. At first glance, this type of copying behavior may seem pointless or even backward, but children may successfully use mimicry to perform goal-oriented actions without knowing in advance what the goal is.

This mindless copying contrasts to ‘emulation’ as described by many researchers working to explain learning behavior in humans and other great apes. According to
Tomasello (1996) and Horner & Whiten (2005) emulative behavior involves observers attempting to reproduce the obvious results of another person’s behavior without directly trying to reproduce their precise actions or understanding their underlying intentions. By this definition, emulation is a behavior that simply seeks to replicate the result of actions, or as Want & Harris (2002) describe it, emulation is action by an observer that: “might not produce a faithful copy of the actions seen, but might instead produce a causally efficacious version.” Byrne (2002) argues against these definitions, pointing out that emulation has been used in a variety of ways, including not only “goal emulation” which involves priming, but also “understanding cause-and-effect relationships and changes of state of objects” (Byrne, 2002). According to Byrne, behaviors other researchers term emulation are open to other cognitively complex interpretations.

Finding a precise definition of imitation is also difficult. Carpenter, Call & Tomasello (2002), Want & Harris (2001) and Nielson (2006) define imitation as a learning behavior in which children not only copy actions with great fidelity but also have some speculative understanding of the goal behind model actions. Heyes & Rey (2002) object to this definition, maintaining that imitation is a descriptive and not an explanatory term. These authors point out that researchers outside of primatology often use the term ‘imitation’ to describe any phenomena where an individual simply copies a person’s movements or actions. In other words, Heyes & Rey’s definition of ‘imitation’ would include behaviors such as mimicry and perhaps even emulation. For these authors, any obvious copying behavior is imitation; questions of how such replication is achieved are a separate issue that requires a different name (Heyes & Reys, 2002).
In this paper, we will use Horner & Whiten’s (2005) definition of emulation: actions that attempt to reproduce the result of behavior without necessarily reproducing exact performances with great fidelity. Thus emulative learning takes place when observers are interested in the ultimate result of a performance and not the performance itself. Emulators make casual connections between action and result but do not attempt to faithfully reproduce a model’s exact performance and cleverly exclude any obvious irrelevant actions. In short, emulation is an attempt to copy results, and only those behaviors which lead to results are reproduced.

We will define imitation as behavior that not only reproduces a model’s actions with a great deal of fidelity, but also requires some inferred understanding of the purpose of those actions, or at least understand or assume some causal connection between the model’s actions and the apparent results (Carpenter, Call & Tomasello, 2002). It is important to keep in mind that a subject’s speculative knowledge of a model’s motivation does not need to be correct. Imitation is goal-oriented, but the goals of imitators may involve complex mental calculations that are difficult to distinguish.

Lastly, we will define ‘overimitation’ as an observer persistently and precisely reproducing the unnecessary actions of a model, even in circumstances where their slavish reproduction of a model’s actions appears utterly illogical.

Purpose of Study

Recent experimental work by Horner & Whiten (2005) examined preferences for either emulation or imitation as learning behaviors within populations of human children and chimpanzees. Not surprisingly, human children aged four and five adopted different
learning behaviors than chimpanzees of a similar age. While chimpanzees demonstrated admirable flexibility by switching between simple imitative and complex emulative behaviors as researchers introduced new causal information, human children demonstrated an surprising propensity to imitate regardless of the availability of additional causal information. For Horner and Whiten, this suggests that in certain limited ways chimpanzees are better, more efficient learners than human children. The implication is clear: five-year-old children lag behind their chimpanzee cousins in learning efficiency. While similar aged chimpanzees astound us with their imitative/emulative switching, the preferred learning style of five-year-old human children is blindly imitative.

In a follow-up study with both three and five-year-old children, younger three-year-old children chose more efficient emulative approaches to learning much as chimpanzees do, but five-year-old children employed less efficient imitative approaches (McGuigan et al., 2007). For researchers outside of developmental psychology, these studies revealed five-year-old children as surprisingly thorough imitators. This second study offered an even more unsettling revelation: five-year-old children not only reproduce irrelevant actions that chimpanzees ignore, but children become more dedicated imitators as they grow older. This study is an attempt to explore this peculiar phenomenon, to gain greater insight into somewhat surprising workings of our species’ extraordinary mind.

**Importance of This Study**

Emulation and imitation are undoubtedly important behaviors in terms of transmitting information, both social and technical, between individual humans as well as
chimpanzees (Bekkering & Wohlschlager, 2000: Byrne 2002; Horowitz 2003; Whiten 2005: Horner & Whiten 2005). But why is it that these closely-related species employ these behaviors so differently? How is it that chimpanzees and three-year-old children exhibit behavioral flexibility and problem-solving creativity that five-year-old children apparently lack? If, however unlikely it seems, human children increasingly turn to less efficient learning behaviors as they grow older, some adaptive benefit must be derived from such behavior.

Recent research exploring boundaries between children’s imitative or overimitative behaviors have approached this problem from almost every possible perspective. Still, little research has focused on using direct verbal cues and rewards to induce young children to ignore irrelevant actions. In this paper, we offer a new study intended to provide insights into children’s tendency to imitate by offering children just such an inducement. We began this work with a simple hypothesis that on some level, five-year-old children understand the difference between relevant and irrelevant actions at least as well as chimpanzees. That some explanation, be it social conformity, inference assumptions, magical thinking or just plain indifference is available to explain how, in terms of task-oriented behavior, five-year-old children are consistently outperformed by chimpanzees.

Of even greater importance are the connections between imitation and cultural transmission. Some form of imitation is critical to human cultural productivity, and the nature of this relationship is briefly explored. How can it be that a behavior as limited as imitation is so overwhelmingly important to transmission of information from one person to another that children use this behavior even in cases where emulation would clearly be
more task effective? Others have long maintained that imitation has a central role in human behavioral adaptation. This paper will argue an expansive and profound view that while imitation is not the primary mechanism for creating innovations, excessive imitation of irrelevant actions or overimitation may be the key to understanding the vast scale and scope of human cultural production.

**Review Of Literature**

This overview of relevant research was undertaken to explore and better appreciate current issues among those studying imitation and emulation in human children and other primates. Accordingly, only articles reporting primary research in this area were considered for inclusion. In recent decades, researchers have increasingly focused on clarifying distinctions between emulation and imitation when comparing learning behaviors exhibited by humans with those of other primates. Exploring behavior similarities and differences with the intention of better understanding how humans are different, much literature has focused on relationships between these learning behaviors and the transmission of culture between generations of human and non-human primates.

The research presented here is in no way exhaustive; in just the last two decades, researchers have published dozens of articles directly related to this topic. Examples presented here are intended to broadly explore recent work within time and space limits afforded to this project. This review was conducted with an eye towards presenting a brief but representative sample of current efforts to study imitation and emulation in small children as these studies relate to children’s sometimes startling preference for
imitative behavior in instances where emulative behavior might seem a more efficient way to learn. This review includes studies exploring suggestions that a preference for imitation is a social adaptation; and includes a short section exploring imitation as a developmental process. In addition, there is a section on how imitation and emulation behaviors may affect the transfer of human culture.

**Imitation and Intention**

Meltzoff (1995) investigated children’s propensity to duplicate what adult models actually intended to do in contrast to what models actually did. In a study where children witnessed an adult attempting but failing to perform specific target actions, Meltzoff showed that children as young as eighteen months could infer an adult model’s goals by observing his or her actions even if these actions did not accomplish an obvious goal such as pouring small beads into a cylinder. In fact, children observing failed goal-oriented actions, succeeded in reproducing the goal as often as children witnessing a successful demonstration. According to Meltzoff, by age eighteen months, children already place other people within a psychological framework that includes both goals and intentions. Meltzoff further supported this thesis with experiments involving a mechanical device that performed actions identical to those of human models. In this second test, children observing a mechanical device attempting but failing to perform a target action did not successfully infer the purpose of failed actions.

Other attempts to evaluate an observer’s interpretation of the relevance of a model’s actions is to study what children learn when models make mistakes. One such study conducted by Carpenter, Akhtar & Tomasello, (1998) explored connections
between children’s fidelity in reproduction and their ability to discriminate between goal-oriented actions and other actions. These researchers had eighteen-month-old children observe adults perform a series of two-step actions punctuated with verbal exclamations to indicate either an intentional or accidental action. Models exclaimed “There!” to reflect an intentional action and “Woops!” to indicate an accidental action. After viewing these demonstrations, children given an opportunity to replicate the adult’s actions imitated intentional actions at nearly twice the rate of accidental actions.

Along similar lines, Carpenter, Call & Tomasello, (2005) studied responses of twelve- to eighteen-month-old children participating in an imitation game involving adult models manipulating a toy mouse. As children watched, models manually moved the mouse across the floor in a hopping manner before placing it either inside a small toy house or laying it back on the floor. When allowed to interact with the mouse, children who witnessed models placing the mouse inside the house did not reproduce the hopping action. Instead, they simply placed the mouse inside the house. Apparently, they inferred that the model’s purpose was to place the mouse inside the house. However, when children who witnessed the model placing the mouse on the floor were allowed to interact with the toy mouse, they did reproduce the hopping action. This second group of children who did not witness a model placing the mouse inside the house apparently inferred that the hopping action was the goal and reproduced only that action. Children imitate behavior, but according to this study, they also interpret a model’s goals, copying only actions thought to be part of the goal.

Want & Harris (2001) hypothesized that an observer witnessing both actions that lead to a desired outcome and actions that do not might be in a better position to perform
relevant actions than an observer witnessing only single actions that lead to a positive result. In two tests, young children were shown either correct procedures or both correct and incorrect procedures for removing a toy from inside a tube. Three-year-old children shown both correct and incorrect procedures were more successful at retrieving a toy than three-year-old children shown only correct procedures. This strongly suggests that observing the outcome of incorrect actions was some benefit to children when performing correct actions. If children are making distinctions between causal and non-causal actions, then witnessing accidental or mistaken actions may improve children’s odds of reproducing relevant actions by providing children both information about what to do but also information about what not to do.

Information from non causal actions was not available in cases where children only observed demonstrations of actions that lead directly to goals. This strongly suggests that children do make distinctions between causal and non-causal actions, because if they did not, witnessing accidental or mistaken actions would make it less likely that children would choose only causal actions. In this case, children might copy both causal and non-causal actions or only non-causal actions, leading to less efficient learning or learning incorrect behaviors.

Horner & Whiten (2005) explored the tendency of young chimpanzees and preschool age children to use either imitation or emulation when attempting to open either of a pair of puzzle boxes with a stick or long piece of wood. These tasks were complicated by variations in the availability of causal information. Adult human demonstrators used stick tools to open puzzle boxes and retrieve rewards. Both chimpanzees born in the wild and three- and four-year-old children viewed these demonstrations. Like similar studies,
these demonstrations consisted not only of causally relevant actions, but also involved causally irrelevant actions. Although the inner workings of these boxes were identical, the surfaces differed. One was clear, allowing subjects to see the workings inside the box, while the surface of the other box was opaque, obscuring the inner workings. Thus, subjects interacting with the opaque box had no causal information about the effect manipulating wooden tools had inside the box. Therefore, when interacting with the opaque box, subjects could not distinguish the relevant or irrelevant actions of the demonstrator. Conversely, when subjects worked with the clear box, they had access to causal information, making it possible to determine which of the demonstrators’ actions were essential to retrieving rewards.

Chimpanzees presented with an opaque box reproduced both relevant and irrelevant actions alike, so the entire demonstration was copied with great fidelity. However, when presented with the clear box, chimpanzees ignored the irrelevant actions of demonstrators and opened the box using only clearly relevant actions. However, children presented with either clear or opaque box copied both relevant and irrelevant actions. According to Horner & Whiten, this result suggests that in some ways chimpanzees were superior to human children in their ability to switch from one strategy to another when learning a task.

**Imitation: A Social Skill?**

Following Horner & Whiten, a study by Lyons, Young & Keil (2007) found comparable results working with preschool aged children performing similar tasks. Additional results from this study suggested that children’s tendency to reproduce
irrelevant actions while pursuing goal-oriented tasks did not depend on the presence of the researcher when children performed tasks, nor did it depend on children believing they were required to perform actions in a prescribed way. As part of this test, children were left alone outside the presence of the demonstrator to retrieve a reward. In some cases, they were encouraged to identify irrelevant actions performed by demonstrators and even asked to check to make certain a reward was in place for the next child. Nevertheless, these children displayed a strong tendency to reproduce the irrelevant actions as initially performed by adults. In light of evidence that children’s tendency to overimitate persists even after they believe the experiment has ended, these authors argue that overimitation is mediated by casual beliefs that have been distorted by viewing adults’ irrelevant actions.

A similar study by Nielson, Simcock & Jenkins (2008) examined connections between levels of social availability and children’s tendency to learn through imitation. In this study, two-year-old children witnessed an adult model open one of several boxes using a special tool; however, using the tool was an irrelevant action since boxes could be easily opened without a tool. While some children witnessed a live demonstration, other children witnessed a video of the same model performing the exact same demonstration. These results suggest that children observing a live demonstrator copied the model’s exact actions even though some of these actions were irrelevant to opening the box. However, children witnessing a video demonstration were much less likely to reproduce the exact actions of the model. According to the authors, children’s inclination to copy irrelevant as well as relevant actions is strongly affected by their interpretations of their social relationship to the model.
To further explore connections between social availability and imitation, Nielson & Blank (2011) conducted a follow-up study of preschool aged children observing pairs of adult demonstrators extract a small toy from inside a box. Each demonstrator acted separately, one retrieving a toy after performing both causally relevant and irrelevant actions, the other performing only causally relevant actions. After both demonstrations, one demonstrator left the room. Next, the remaining demonstrator handed the apparatus to the child. When left with demonstrators who performed irrelevant actions, children reproduced irrelevant actions even though the actions of the absent demonstrator underscored how needless these actions were. Not surprisingly, children left alone with demonstrators who performed only relevant actions were less likely to reproduce irrelevant actions. “Unlike other animals,” write the authors, “human children will copy all of an adult’s goal-directed actions, including ones that are clearly unnecessary for achieving the demonstrated goal.” However, they are much more likely to imitate these actions if the demonstrator is present. Nielson and Blank suggest that when children imitate irrelevant acts, they are displaying a specialized skill helpful for humans who have evolved while participating in cultural groups.

**Development of Imitative Behavior**

McGuigan, Whiten, Flynn & Horner (2007) used similar experiments to investigate the possibility that imitation is influenced by the physical presence of the demonstrator and also whether children’s predisposition to overimitate diminishes as they age. Following earlier work, after a demonstration involving both relevant and irrelevant actions, children three and five years old were presented with either a clear or opaque
puzzle box, but in this case some children witnessed a live demonstration and others viewed a video demonstration. As in earlier studies, despite the presence of causal information in live demonstrations, children copied both relevant and irrelevant actions performed by demonstrators. However, children witnessing video demonstrations of models performing identical actions responded differently based on age. While, five-year-old children continued to faithfully imitate both relevant and irrelevant actions, three-year-old children omitted irrelevant actions. This surprising result suggests that as young children age they become more likely to repeat a model’s irrelevant actions, even in circumstances when the demonstrator is not present. To the authors, this result suggests that children’s tendency to overimitate is an important adaptive strategy, even if it sometimes results in inefficient goal-directed behaviors.

Nielson & Tomaselli (2010) explored the tendency of different aged children to either imitate or emulate when learning new tasks. In this study, children between two and thirteen years old interacted with a puzzle box similar in design to boxes used by Horner & Whiten (2005). Nielson divided these children into groups who witnessed demonstrations and groups who did not. Results show that older children witnessing demonstrations were more likely to use imitative learning behavior, copying both relevant and irrelevant actions, than younger children who copied only relevant actions. Nielson & Tomaselli join other researchers in suggesting that children’s tendency to overimitate is somehow adaptive. For children of a species dependant on a wide variety of tools, children confronted with a substantial assortment of objects they must learn to purposely manipulate, overimitation, although inefficient in certain isolated tasks, may be a useful adaptation.
The developmental features of imitation were further examined by Horowitz, (2003) who tested the propensity of 37 human adults (18 to 21 years old) to imitate demonstrators while retrieving a chocolate Hershey’s candy from inside a clear Plexiglas box. Extracting candy from this box involved removing a pair of plastic rods attached to both the front panel and lid of the box and manipulating a lock attached to the box’s front cover. While previous studies (Horner and Whiten, 2005; McGuigan, et al., 2007; Nielson & Tomaselli, 2010) strongly indicated progressive increases in imitation from chimpanzees to young children to older children, this study suggests that this trend does not extend to adult humans. Adults witnessing demonstrators perform specific procedures for opening the box did not consistently imitate a demonstrator’s actions. According to Horowitz, the imitation rate of adult subjects was somewhat higher than chimpanzees but lower than even young children. An unexpected result particularly in light of exit interview data showing that two thirds of Horowitz’s subjects stated: “that they were in fact imitating the experimenter.” Horowitz suggests a possible explanation for adults diminished imitation is the result of human subjects ability to quickly determine steps needed to open the box combined with the obvious appeal of using a more efficient method to open this box.

A Chain Link to Culture

A study by Flynn & Whiten, (2008) investigated children’s propensity to reproduce a series of complex hierarchically ordered actions. Flynn & Whiten tested 117 children either three or five years old by letting them observe video of demonstrators using one of four intricate nine-step processes to open boxes of artificial fruit. Put
simply, these nine-step processes involved removing a number of skewers from rows of hollows on either side of boxes containing artificial fruit. The skewers were removed after insertion of tools either taped or twisted into other hollows in the sides of the same boxes. Once all skewers were removed, boxes could be opened and the plastic fruit extracted. Removing skewers in the correct order was recorded as a hierarchical process and either tapping or twisting tools into place was coded as a detail action. Results suggest that while children imitate both hierarchical and detail actions, children were more likely to faithfully reproduce hierarchical actions than detailed actions. Additionally, this study indicates that children replicating one level of imitation was a poor predictor for reproduction at other levels. These children, rather than blindly mimicking the actions of models, demonstrated some awareness of underlying task structures. This implies that children are motivated to imitate complex tasks for reasons other than social pressure. While children possess a general tendency to imitate demonstrator actions, they are more likely to copy action that appears relevant to the task at hand.

**Methodology**

Data for this study was gathered from a pre-school located on the campus of the University of Missouri in Columbia, Missouri. Participants were recruited from a classroom of approximately 25 children four and five years of age. These were typical, healthy pre-school children whose mean age was 55.4 months (boys mean age = 56.4 months; girls mean age = 54.5 months). Data collection took place between October 11,
2011 and November 1, 2011. All trials were conducted in the afternoon between 3:00 p.m. and 5:00 p.m.

After obtaining consent from participants’ parents, children were tested in a small room immediately across the hall from their classroom. Inside this room, children sat at a small table directly left of the demonstrator. Two coders stationed on either side of the room observed and recorded children’s actions in real time.

A total of 18 children were initially tested, but data collected from two subjects were excluded from this analysis. One child was excluded due to a refusal to participate in trials unless another child was present in the testing room during trials. Tests of this subject outside parameters set for the study were performed because it was considered less disruptive of the classroom than declining to test this subject. In addition, the superfluous test was deemed no threat to the study. Data gathered from this subject suggested a child with an extraordinary knowledge of the test, likely gleaned from children tested previously, perhaps the child who accompanied the subject during the test. Data from a second child was excluded due to behavior contrary to the study’s purpose, including excessive restlessness during trials and a natural but inconvenient curiosity about boxes used during the trials. This child repeatedly attempted to peek inside the doors of boxes.

**Apparatus**

Following Horner & Whiten (2005), the apparatus used were two structurally identical polycarbonate boxes approximately 20cm square (Fig. 1). One box was transparent and allowed children to see everything inside except the contents of a small
opaque tube inside the box. A second box was opaque and completely obscured the boxes’ inner workings. Situated on the top surface of each box was a small 3cm × 3cm hole (Fig. 2); on either side of this hole, brackets held a 12cm long bolt-defense that blocked access to the hole, but could be moved left or right to uncover the hole. The front surface of each box contained a second hole approximately 2cm × 2cm connected to a short (approximately 10cm long) downward sloping opaque tube inside each box. These front-facing holes were covered by small door-defenses that slid to either side allowing access to the opaque tubes (Fig. 1).

![Fig. 1 Illustration of clear and opaque boxes with bolt and door defense in place. Note: Wooden tool has Velcro attached to one end.](image-url)
Before each trial, a small Velcro-backed animal sticker (usually a frog) was placed at the bottom of the opaque tube (fig. 2). To retrieve this sticker, it was necessary to first slide the door open; then, by inserting a 40cm long wooden rod into the tube, the sticker could be removed. Like the animal stickers, the wooden rod had Velcro backing attached to one end (Fig. 1).

Neither sliding the top bolt defense left or right nor poking tools inside the top hole had an effect on the accessibility of prizes held within the opaque tubes. Due to barriers just above the inner tube of each box, it was not possible to reach a sticker or even the tube containing stickers by inserting the rod into the top hole. Tool insertions in the top hole resulted in contact with the barrier only.

Thus, action performed both by demonstrators and children can be divided into relevant and irrelevant actions. All actions directed at the top of boxes were irrelevant, and actions directed at the bottom of boxes were relevant.

**Procedure**

During trials demonstrators used a wooden rod to perform all actions including irrelevant actions, i.e. sliding bolt-defenses above the top hole and inserting the rod inside the top hole; and relevant actions, i.e. sliding open doors at the front of boxes and inserting the tool inside the tube to remove stickers.

It was possible for children to use their hands to open either the sliding bolt-defenses or sliding doors, but reaching inside the hole at either the top or front of each box could only be performed with the wooden rod.
There were two conditions in this experiment: In condition ‘opaque’, children interacted with the opaque box, and in condition ‘clear’, children interacted with the clear box. In addition children were divided into two groups: ‘Group A’ children interacted with the opaque box in the first set of trials and the clear box in the second set of trials. With ‘Group B’, the order was reversed; children interacted with the clear box in the first set of trials and the opaque box in the second set of trials.

While interacting with the opaque box, children lacked causal information: they could not use visual clues to identify how it worked. However, causal information was available when children interacted with the clear box since the inside of the box could be plainly seen. Even a cursory examination of the clear box could reveal that the top bolt and hole were irrelevant to the workings of the box.

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**Fig. 2** Illustration showing clear and opaque boxes with bolt and door defenses removed. In both boxes, the tube containing the prize is opaque, and the prize cannot be seen with door defense in place.
Specific steps of the demonstration:

1. Demonstrators tapped at one side of the sliding bolt above the top hole.
2. Using the rod, the bolt is pushed from the opposite side. The bolt slides in the direction of the tapping uncovering the top hole.
3. The rod is inserted into the top hole and tapped against the inner barrier of the box three times.
4. Using the rod, the door covering the front hole is slid in the opposite direction of the upper bolt revealing the front hole and sticker containing tube.
5. The rod is inserted into the tube and the sticker removed.

To control for left/right bias, demonstrators alternated procedures so that half of these children witnessed demonstrations commencing with right-side bolt tapping while the other half witnessed left-side bolt tapping. After each trial, a second researcher reloaded boxes with a new sticker outside the view of the children.

Following Whiten (1998) and Horner & Whiten (2005), each subject viewed three demonstrations before the first trial and one additional demonstration before each subsequent trial for each of the first three trials. A second set of trials followed the same pattern. These six trials were a close approximation of research performed by Horner and Whiten (2005). However, in this study, a seventh trial was added in an attempt to induce children to skip irrelevant actions.

During the first six trials, demonstrators did not instruct children in any way. Children were simply told: “It’s your turn” before interacting with boxes. Before the seventh trial, children were told that they would receive a special prize if they retrieved the sticker “very quickly.”

Each child’s actions were recorded on a coding sheet. Actions were coded for:

- Hitting bolt with tool
• Hitting bolt with hand
• Pushing bolt
• Dragging bolt
• Tool insertion in the irrelevant hole (irrelevant action)
• Hit barrier (times recorded)
• Sliding door (left or right)
• Insert tool in relevant hole (relevant action)

After the final trial, demonstrators left the room, and each child was interviewed by a second researcher. These interviews consisted of several short questions meant to prompt children into revealing any understanding of how the box worked beyond what the child exhibited during trials.

**Results**

This section first describes and explains the testing process, summarizes various statistical analysis used to evaluate research questions and hypotheses established in the previous chapters, and outlines limitations of the process. Next, results comparing rates of fidelity in reproduction are examined for both irrelevant and relevant actions across conditions. Reproduction of actions, both irrelevant and relevant, with each apparatus is calculated and described. Lastly, multivariate analyses of each condition are explained and summarized.
These analyses were performed using the IBM’s SPSS Statistics, Version 20 and Microsoft Excel, Version 14 (Office 2010). Following Horner and Whiten (2005), the proportion of irrelevant actions under different conditions was determined by dividing the number of tool insertions into the top hole (irrelevant opening) by the total number of tool insertions in both relevant and irrelevant openings. This measure is thought to be simple to identify and quantify.

All subject actions were recorded by pairs of coders who observed trials from opposite sides of the room where trials were conducted. Interobserver reliability was high for both the number of irrelevant tool insertions (ITT): Cronbach’s α = 0.96) and the number of relevant tool insertions (ITF): Cronbach’s α = 0.98). Prior to main analysis, variables were examined with SPSS for missing values, accuracy of data entry and outliers. There were no missing values. Identified outliers were checked against original observer records, and no corrections were needed.

Since this research focused on methods or strategies children used in an attempt to extract rewards from inside boxes, children’s success rate at retrieving stickers was not analyzed. All 16 remaining subjects were successful in extracting Velcro backed stickers from the tube compartment inside each box; however, in several instances, the thick Velcro-stickers became lodged inside tubes making removal more difficult. As a result, some children made repeated insertions of the stick tool in the lower compartment of a given box. In such instances, only the first tool insertion into the lower compartment was counted as a relevant action.

Again following Horner and Whiten (2005), medians are reported here as a measure of central tendencies, but in this study. All statistics are two-tailed tests, and all
reported statistics are non-parametric. Mann-Whitney $U$ tests were used for analysis of unmatched samples comparing subjects from different conditions or experimental groups. The Wilcoxon Test for matched pairs was used to evaluate subjects under different experimental conditions. Freidman’s Related Samples Test was used to examine variance between three conditions.

Since our 16 subjects only ranged in ages from 50 months to 61 months, no analysis of variation by age was attempted. Children’s performance was analyzed by gender, but no significant influenced was indicated: $Z = -0.541$, $n_1=8$, $n_2=8$, $P = 0.645$.

**Data Analysis**

Using the Mann Whitney $U$ Test, we found no significant difference in the proportion of irrelevant actions (ITT) performed by subjects in group A, who interacted with the opaque box first, and group B, who first interacted with the Clear Box first: $Z = -0.463$, $n_1=8$, $n_2=8$, $P = .643$; median (group A) = .5000; median (group B) = .5000. Thus the overall ratio of irrelevant actions to relevant actions was unaffected by subjects’ ability to see the workings of puzzle boxes in the first set of trials as opposed to the second set of trials.
Fig. 3: The mean percentage of tool insertions into the top (irrelevant hole) by children in each of three conditions: opaque, clear and fast box.

Analysis using the Wilcoxon Signed Ranks Test showed that subjects who interacted with the Opaque Box first did perform a significantly greater number of irrelevant actions when interacting with the clear box than with the opaque box, $Z = -2.410$, $n_1=8$, $n_2=8$, $P = .016$; mean: opaque box = .4271, clear box = .5139. Children in group A who interacted with the opaque box first performed more irrelevant actions when interacting with the clear box than they performed with the opaque box.

Subjects who interacted with the clear box first, however, did not perform a significantly greater number of irrelevant actions when interacting with the clear box than with the opaque box ($Z = -1.633$, $n_1=8$, $n_2=8$, $P = .102$; mean: opaque box = .4681,
Clear Box .5208; median: opaque box = .5000, clear box .5000). In group B, analysis did not reveal a significant difference in subjects’ irrelevant actions with either clear or opaque box.

In addition, using The Mann Whitney Test, subjects in group A who interacted with the opaque box first performed fewer irrelevant actions when interacting with the opaque box than subjects in group B who interacted with the clear box first performed when interacting with the clear box (Z = -2.904, n₁=8, n₂=8, P = .004; mean: opaque box = .4271, Clear Box .5208; median: opaque box = .4444, clear box .5000).

On the other hand, subjects in group A interacting with the clear box did not perform significantly different than subjects in group B interacting with the opaque box (Z = -1.934, n₁=8, n₂=8, P = .053; mean: Opaque Box = .5139, Clear Box .4618; median opaque box = .5000, clear box .5000).

Further comparison using Friedman’s Related Sample Tests of subjects in Group A (starting with the opaque box) showed significant difference in irrelevant actions across the three conditions: (X² = 8.00, n=8, P =.018). Pairwise comparisons showed no significant differences between the opaque and the fast box (Mean Ranks: Opaque box = 1.29, Fast Box = 2.14, P = .109). Similarly, there was no significant difference in irrelevant actions between performance with the clear box and fast box (Mean Ranks: Clear Box = 2.37; Fast Box = 2.14, P = .423). The only significant difference was between the Opaque Box and the Clear Box (Mean Ranks: Opaque box = 1.29, Clear Box = 2.37, n₁=8, n₂=8, P = .016). Thus, with condition A, there was no significant difference in irrelevant actions between either the clear or opaque box and the fast box.
Similar analysis of subjects in group B (interacting with the clear box first) shows no significant difference across the three conditions ($X^2 = 6.00, n=8, P = 0.50$). Again, Pairwise comparisons showed no significant difference in irrelevant actions between the Opaque and Fast box (Mean Ranks: Opaque box = 1.62, Fast Box = 2.19, $n_1=8, n_2=8, P = .261$). Similarly, there was no significant difference in irrelevant actions with the Clear and Fast Box (Mean Ranks: Clear Box = 2.19; Fast Box = 2.19, $n_1=8, n_2=8, P = 1.000$). Neither was there a significant difference between the Opaque Box and the Clear Box (Opaque box = 1.62, Clear Box = 2.19, $n_1=8, n_2=8, P = .261$).

During brief post-trial interviews conducted by a separate researcher after demonstrators left the room, children were asked if they knew of any way to open boxes faster than they had demonstrated during previous trials. The majority of children responded in the negative, and although several children claimed that they knew of a faster method, after being offered another opportunity to open the box, these children still imitated both relevant and irrelevant actions although they performed these actions very quickly.

**Discussion**

This section commences with a discussion of results reported in the previous section, explores how these results compare with prior work and how they extend our understanding of imitation as related to culture. Next, there is be a brief evaluation of the current state of research in imitation and emulation, and some suggestions about the future direction of research in this area.
Overall, we found no significant difference in the proportion of irrelevant to total actions performed by children who first interacted either with the opaque or the clear box. Similar to previous studies, children in this study across conditions and groups generally reproduced a model’s actions with a high degree of fidelity. This supports and confirms the results obtained by Horner and Whiten (2005) and Nielson and Tomaselli (2010).

In addition, children’s tendency to reproduce irrelevant actions did not diminish with increased access to causal information. Children who witnessed demonstrators opening the opaque box first performed no fewer irrelevant actions when interacting with the clear box than children who interacted with the clear box first performed when interacting with the opaque box. Even though causality was easily available to children when interacting with the clear box, there was no significant decrease in children’s fidelity in reproducing the demonstrator’s irrelevant actions. Neither did children witnessing demonstrations with the opaque box first perform fewer irrelevant actions with the clear box than children witnessing demonstrators of the clear box first performed when interacting with the opaque box. As with previous research (Horner & Whiten 2005) (Nielsen & Tomaselli 2010) participating children were unaffected by researchers’ introduction of causal information about the workings inside puzzle boxes. Regardless of the availability of causal information, children consistently preferred to use imitative behavior rather than emulative behavior when retrieving rewards from inside puzzle boxes.

These results confirm that children four or five years old prefer imitation to emulation after observing the actions of adult models performing a task oriented action (Horner & Whiten, 2005; McGuigan, et al. 2007; Lyons et al. 2007). Similarly, the test
supports the notion that once children have imitated and adopted a model’s irrelevant actions as part of a procedure for performing a task, they are unwilling or unable to switch to a different or more efficient procedure (Horner & Whiten, 2005; Nielsen & Tomaselli, 2010). The children’s behavior suggested no appreciation of the effect their actions had on the puzzle box and no understanding of which actions were relevant or irrelevant to retrieving the prize.

Similarly, results show no significant drop in the ratio of relevant to irrelevant actions when children are encouraged to perform a task quickly. If subjects performed significantly fewer irrelevant actions when interacting with the seventh (fast box), they would be switching from imitative to emulative behavior, which would strongly indicate that children understood the workings of the box, even if they consistently reproduced irrelevant actions in previous trials. However, while children’s actions became noticeably faster and somewhat haphazard when offered special rewards, the proportion of irrelevant actions did not diminish when compared to other conditions. Despite obvious verbal prodding and offers of a “special prize”, demonstrators could not persuade children to abandon their imitation of irrelevant actions.

**A Successful Strategy**

In certain circumstances, imitation may be a more successful strategy than emulation (Bekkering & Wohlschlager, 2000; Heyes, 1993). For example, when critical causal relationships are apparent to an observer, emulation may be more effective due to the inherent flexibility of the behavior and potential for generalization. On the other hand, imitation may be more useful when causal relationships cannot be perceived or are
difficult to discern (Horner & Whiten 2005). But why do human children forgo obvious advantages of emulative behavior when causal factors can be discerned?

One might suspect that the ability to emulate or to switch from imitation to emulation develops slowly in human children. Perhaps five-year-old children simply have not yet developed this ability? But current evidence suggests the opposite is true. Human children between three and five years old become more prone to imitate (McGuigan, et al., 2007; Nielson, & Tomaselli, 2010). As children grow older, they are increasingly likely to disregard obvious shortcuts, often pursuing ceremonial, unnecessary and irrelevant steps in a goal-oriented situation.

At first glance, this seems to strikingly illogical. However, much research indicates that children infer the intentions of adult models, often copying irrelevant actions when they perceive that a model’s actions are intentional regardless of apparent irrelevance (Carpenter, Call & Tomasello, 2005). Children as young as 18 months are known to infer adult intentions even when adults do not successfully complete the action or achieve an obvious intended result (Meltzoff, 1995) (Want & Harris, 2001).

This raises questions of why children imitate intentional actions instead of relevant actions. It is often suggested that such mindless imitation is social, that children purposely imitating and conforming to behavior norms is a potentially valuable skill in species living in highly social coalitions, but research with chimpanzees, who also live in coalitions and are also highly social, strongly contradicts this view (Horner & Whiten, 2005; Horner et al., 2006). Moreover, studies suggest that children’s tendency to reproduce irrelevant actions is not dependent on the presence of adult models (Lyons, Young, & Keil, 2007). Results of this study imply that children using imitative behavior
in goal-oriented activities do not understand which actions are irrelevant. While observing these children attempt fast box trials, it was apparent that they did not understand that some of their actions were not necessary. Post-trial interviews with children confirmed this. When children were asked if they could think of a faster or better way to open these boxes, they could not. Despite various forms of verbal encouragement, not one of the 16 children tested could demonstrate a method for opening either box that differed from the one they had first witnessed.

**A Conduit for Culture**

To explain this confusing and seemingly illogical human preference for imitation over obviously more efficient and ostensibly more effective behaviors, some researchers have examined how children use imitative behavior to reproduce complex, hierarchically ordered tasks (Flynn & Whiten, 2008). Results of this work indicate that children are more likely to faithfully reproduce hierarchical actions than detailed actions which are not hierarchical. This information may be critical not only for understanding why human children, more than chimpanzees and other animals, are persistent imitators unable to switch between imitation and emulation, but also why our species is by far the most culturally productive species on earth.

Emulation and imitation may seem to be equally practical adaptations in terms of facilitating goal-oriented actions. Despite their similar levels of practicality, the distinction between these two behaviors may have staggering implications for an ever-evolving human culture. The tendency of children, though somewhat curious, to consistently reproduce relatively precise copies of other people’s behavior and their oblivious repetition of futile and superfluous actions may be key to their ability to
accumulate and preserve cumulative culture (Tomasello, 1999). Emulation, despite obvious advantages and efficiencies, may lack the precision to act as a reliable conduit for transmitting complex behaviors and technologies key to the development of an abundantly diverse human culture (Shea, 2009; Tomasello, 1999; Tennie et al., 2006 & 2009).

To better understand how imitation outshines emulation in generating complex culture, imagine a child witnessing an adult constructing an arrow. Making a useful arrow requires many steps: finding a suitable piece of wood, stripping this wood of bark, finding and shaping a suitable stone for the point, etc. If any of these steps are skipped or performed in a haphazard way, the finished arrow is likely to be useless. It seems evident that for acquiring skills like making arrows, skills human ancestors required to survive, imitation would be a much more effective behavior than emulation. In terms of transmitting culture, emulation is likely a poor shortcut; it may be well used to perform simple stand-alone tasks but is poorly suited for learning how to build a hut meant to keep rain out.

Imitation, on the other hand, allows transmission of nearly exact behaviors from one generation to the next (Tomasello, 1999; Boyd & Richerson, 2005; Horner et al., 2006). Since a high rate of fidelity is necessary, if a successful behavior is to be transferred across generations, the obvious flaw of imitation becomes a strength. Because blind imitation or overimitation copies the exact actions of the model, behaviors zealously imitated, unlike actions weakly emulated, are likely to be preserved. Over time, an accumulation of innovations builds; once rudimentary performances and technologies become complex; systematic, hierarchal structures multiply; our
multifarious tools orbit the earth. Our accumulation, modification and transmission of complex culture defines us, and the key to this process may be our ability to ignore logical behavior. It is possible that we owe all we are to a behavioral oddity that, on the surface at least, seems dim-witted.

**Costs of Imitation**

The problem with overimitation as a means of vertically transmitting culture is that the high rate of fidelity, the same feature that makes overimitation successful as a conduit for cumulative culture, may also lead to replication of many errors, and these too may accumulate over time. Children may be capable of imitating behaviors with a high degree of fidelity, but over generations, irrelevant or even silly behaviors might creep into the imitated performance. Could this help explain highly ritualized and often silly behaviors observed in every culture?

Could our tendency to blindly imitate other people’s actions extend to irrational ideals and fanatical behavior? In due course, can an accumulation of simple, irrational ideas become complex, systematic and irrational hierarchal structures? Our ability to place satellites into space may be a wonderful thing, but what of jihad? Indeed, the same behavioral oddity that has so favored our species may share blame for much human suffering. This may seem paradoxical, but this notion of irony is merely illusion. After all, irrational belief systems and notions of jihad are culture too.

This is not to suggest that irrational belief systems owe their origin to imitation. Even imitators as thoroughgoing as humans require some original action before they can replicate it. However, it does seem likely that the same tendency to thoughtlessly
replicate the behaviors of others, the same oblivious conformity that produces and preserves so much culture, might play a leading role in the almost unlimited human capacity for irrational and appalling behavior. At any point during this research, children might have realized that many actions they were imitating were pointless, but they either did not see this or, having realized these actions were pointless, decided to do them anyway. Having begun to imitate, children seem to disregard information that contradicts behaviors they are imitating. People who hold irrational beliefs seem to share this acute lack of insight, as if their cognitive processes are simply set in the off position.

**Conclusion and Questions**

Research into observational learning behavior seems to follow a pattern of fitful starts and relative slumbers. Recent work by primatologists has helped reawaken interest among behavioral sciences, making the present an exciting time for those interested in a better understanding of human behavior including cultural transfer. Nevertheless, much work remains to be done; an exact accounting of our species’ tendency towards profligate imitation is yet to be made.

While connections between transfers of human culture and overimitation seem well established, questions remain. For example, how does a system of cultural transmission built on overimitation thrive in absence of any apparent scheme to limit errors in replication? What is the exact relationship between imitation and human belief systems? Is our tendency to imitate so strong that it overcomes rational thinking?

On a more practical note, in evolutionary terms, one might expect that successful traits would be shared with group members, but outsider traits might be ignored or
resisted. It would be interesting to see if children would be less likely to imitate models who are outside their cultural group. Would children copy the unsuccessful actions of in-group adults while ignoring the successful behavior of out-group models? In our heterogeneous, multicultural society, the implications of such results would be staggering. These problems are exacting, but despite obvious obstacles, further research into these questions promise a reward worth the effort.
References:


