Imitation, Objects, Tools, and the Rudiments of Language in Human Ontogeny

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Abstract

Human beings are imitative generalists. We can immediately imitate a wide range of behaviors with great facility, whether they be vocal maneuvers, body postures, or actions on objects. The ontogeny of this skill has been an enduring question in developmental psychology. Classical theory holds that the ability to imitate facial gestures is a milestone that is passed at about one year. Before this time infants are thought to lack the perceptual-cognitive sophistication necessary to match a gesture they can see with one they cannot see themselves perform. A second developmental milestone is the capacity for deferred imitation, i.e. imitation of an absent model. This is said to emerge at about 18 months, in close synchrony with other higher-order activities such as object permanence and tool use, as part of a general cognitive shift from a purely sensory-motor level of functioning to one that allows language. Research suggests that the imitative capacity of young infants has been underestimated. Human infants are capable of imitating facial gestures at birth, with infants less than one day old manifesting this skill. Moreover recent experiments have established deferred imitation well before the predicted age of 18 months. Studies discussed here show that 9-month-olds can duplicate acts after a delay of 24 hours, and that 14-month-olds can retain and duplicate as many as five actions over a 1-week delay. These new findings re-raise questions about the relation between nonverbal cognitive development and language development: What aspects, if any, of these two domains are linked? A hypothesis is delineated that predicts certain very specific relations between particular cognitive and semantic achievements during the one-word stage, and data are reported supporting this hypothesis. Specifically, relations are reported between: (a) the development of object permanence and the use of words encoding disappearance, (b) means-ends understanding (as manifest in tool use) and words encoding success and failure, and (c) categorization behavior and the onset of the naming explosion. This research on human ontogeny suggests close and highly specific links between aspects of early language and thought.

In addition to language, one of the hallmarks of *Homo sapiens* is a proclivity for imitation, a trait that enables essentially no-trial learning. Humans depend upon and profit from imitation more than any other species. Many of the skills, behavior patterns, cultural rituals, and traditions exhibited by adults are acquired at least in part through imitation and not the maturation of genetically specified motor programs, trial and error, or independent invention.

While evolving in accordance with Darwinian principles, early hominids at some point also began to benefit from a more Lamarckian-type process in which information acquired by one generation was directly transmitted to the next. This must have been accomplished through imitative learning by the young and perhaps explicit teaching by the adult (BARNETT, 1973). Without some such capacity, the knowledge of how to manufacture stone tools or use fire would have been lost after each generation, endlessly dependent upon independent re-discovery.

Beck (1974) notes that baboons, but not chimpanzees, are probably isolated from their ancestors in just this way. Wild chimpanzees use tools such as levers, sponges, and probes during food-gathering; conversely the use of simple tools by wild baboons is rare. Why is this so? Beck proposes that the sensory, motor, and cognitive capacities for tool use are not the decisive factors. It also is not that environmental conditions are unfavorable for wild baboons, because both chimpanzees and olive baboons occupy the same space and often compete for the same resources in the Gombe National Park. Although both spend hours catching and eating termites, the chimpanzees greatly facilitate this by inserting sticks into the subterranean nests (van Lawick-Goonall, 1968, 1970). The baboons do not and are correspondingly less efficient in obtaining this valuable source of protein.

Beck suggests that one important key to the wild chimpanzees' tool-using superiority is their ability to learn from conspecifics who fortuitously discover tool use and the inability of baboons to profit in this way. Baboons are limited to independent reinventions, whereas chimpanzees can benefit from their cultural heritage. Thus he notes that «a researcher sampling a slice of time in the history of a wild chimpanzee population is quite likely to see tool behavior frequently, while a study of baboons will yield, at best, a few isolated instances» (Beck, 1974, p. 515). In conclusion Beck speculates that the advent of tool-using traditions in hominids may have been tied to the evolution of an aptitude for observational learning, for without it the inventive uses made of tools by single individuals would have died with them instead of being transmitted to others in the culture.

Recent evidence has provided interesting constraints on chimpanzees' ability for cultural transmission (Kitahara-Frisch & Norikoshi, 1982; Tomasello, Davis-Dasila, Camak & Bard, 1987). In the Tomasello et al. study chimpanzees were given the task of imitating another chimpanzee who had been trained to use a stick to obtain out of reach food. Although the older subjects consistently failed, the younger ones profited from the exposure to the model. Nonetheless the authors note that even this behavior may not have been full scale imitation. The animals may merely have become more interested in using the stick because they saw it picked up and handled by a conspecific, and this might have led them subsequently to the chánce discovery that it could be used to retrieve the food. This hypothesis could be tested experimentally by exposing subjects to an animal taught to handle the implement in a non-effective way (which should not lead to systematic tool use in the observer, if imitation is operating). This control was not conducted, therefore the authors' conservative conclusion was that true imitation of tool use by chimpanzees was not unequivocally demonstrated either by their experimental work or other more naturalistic observations which, of course, did not use such experimental manipulations.

The purpose of this essay is not to re-open the long-standing debate about whether non-human animals are capable of true imitation. (For recent reviews, see Galef, 1988; Zentall, 1988.) It is sufficient to note that such behavior is often difficult to demonstrate in animals once proper controls are instituted. This does not contradict the idea that animals are capable of some types of «social learning», that is, of modifying their behavior in a way that brings it into conformity with the behavior patterns of others. However, it is useful to subdivide this very general category of social learning into a hierarchy of abilities, including at least the

following: social facilitation, stimulus enhancement, and imitation (See Meltzoff, 1988a, and Galef, 1988 for a discussion of further subdivisions such as contagious behavior, co-action, and pseudoimitation).

Social facilitation can be defined as an increase in the production of the target behavior due to the presence of others, rather than the observation of the behavior itself (e. g., the sight of an active conspecific may lead to increased activity and thus to the emission of a particular act). Stimulus enhancement is the increased production of a target behavior resulting merely from directing of an animal's attention to a class of objects or part of the environment that is manipulated by the demonstrator (e.g., seeing an animal use an implement may increase the probability that it is handled, which in turn may elevate the chance likelihood of correct use). Finally, the term imitation should be reserved for the duplication of an act on the basis of perceiving this same action demonstrated (e. g., the observer systematically manipulates an object in two different ways depending upon the way the demonstrator does so). Imitation is most interesting from a theoretical and functional viewpoint when it is spontaneous duplication, that is when the observing animal has never been reinforced for copying this act in the past. (If the stimulus-response link has been forged by training it is often termed pseudoimitation or matched-dependent learning and not true imitation at all).

Once these distinctions are made, it may be asserted that humans are the most gifted imitators among animals. Although many species are capable of social learning (Zentall & Galef, 1988), and some are proficient at imitating a delimited class of special behaviors (e.g., bird song, Marler & Tamura, 1964), humans have taken this one step further and become imitative generalists. Even a preschool child can readily copy a wide range of acts including actions on objects (as in tool use), raw motor movements (as in dance and athletics), or vocal maneuvers (as in speech duplications).

That humans' general imitative facility may be instrumental in the formation of «culture» has not escaped the notice of scholars from evolutionary biology (Lorenz, 1974; Morgan, 1932; Huxley, 1963), cultural anthropology (Washburn, 1961), and psychology (Bandura, 1986; Bruner, 1983; Piaget, 1962). Indeed, it has been argued that humans' imitative proficiency evolved hand in hand with our lengthy period of postnatal dependence and behavioral plasticity (Bruner, 1972; Dawkins, 1976) — imitation being a primary means by which the preverbal infant begins to acquire the skills, rules, and customs of the culture.

Given the potential functional significance of imitation, its ontogeny in the human child has been a topic of classic concern. Are the imitative skills of infants sufficiently developed to play the vital role often assigned to it by theorists? Are humans born with an aptitude for general imitation? Is the ability to imitate itself learned, the product of some period of prior tutoring by adults?

The most comprehensive developmental treatment of these issues is Piaget's (1962). In this essay two fundamental aspects of his thesis will be considered. The first is that imitative skills are highly constrained in early infancy; infants have little or no ability to imitate at birth and gradually develop through stages that expand their imitative faculty. The second is that progress in imitation plays a role in the emergence of what Piaget calls the «semiotic» or symbolic function, which occurs at about 18 to 24 months and constitutes a general shift from a purely sensory-motor to a representational mode of intelligence. According to the Piagetian thesis, the highest level of infant imitation, deferred imitation, provides practice in responding to events that are displaced in time and space. Deferred imitation is still a sensory-motor skill but it is a transitional behavior, an important stepping-stone to the emergence of language, which is a still more flexible and symbolic system for referring to events beyond the immediate perceptual field (Piaget, 1962; see also Hockett's, 1960

«design feature» of displacement). In short there are hypothesized links between an infant's imitative «stage» and the emergence of language.

The research discussed in this paper concerns both aspects of Piaget's theory. Contrary to the Piaget, recent studies suggest that human newborns can already imitate certain actions; a primitive capacity for imitation appears to be part of our biological endowment and does not depend upon an extended period of postnatal development. Moreover, the work shows that deferred imitation does not emerge in synchrony with the emergence of language, for it occurs in robust form much earlier in infancy than heretofore suspected, as early as 9 months of age. These findings force a revision in notions about the development of imitation and thereby re-raise the question of the possible links, if any, between early nonverbal cognitive development and the emergence of language. If imitation and Piagetian stages do not provide the connections, what does? In this context I will discuss work by Gopnik and myself in which very specific connections have been found between infants' developing notions of object permanence and means-ends understanding (e.g. using tools to achieve desired ends) and particular aspects of semantic development. Similarly we have documented a close coupling between changes in categorization behavior and the sudden «naming explosion» that occurs in the second year of life.

The Ontogenesis of Imitation: Piaget

Piaget's theory addresses the development of spontaneous imitation in infants. It is not concerned with specially trained matching responses (or «pseudoimitation», as Piaget 1962 calls it). It is clear that human beings, at some age at least, are capable of spontaneously imitating adult displays for which there is no previous reinforcement history, no physical molding of the body, and no coaxing in any way other than the brief presentation of the model. It was the ontogenesis of this capacity that was the focus of Piaget's work.

Piaget postulated six stages in infants' spontaneous imitation, and for the purposes of this paper they will be collapsed into three major developmental levels. Infants in the first eight months are restricted to the first level, which consists of the imitation of simple hand movements and vocalizations. For instance, the Piagetian 8-month-old would be expected to imitate a simple hand opening gesture or an /a/-like vocalization even if the infant had never been specifically trained to do so. Piaget's notion is that both of these types of imitation are similar in that they can be accomplished on the basis of an intramodal matching process. In principle, the infant could directly compare the adult's hand movements with those of his own visible hand, and thereby use vision as a guide in the matching process. Similarly, the infant could use audition as a way of monitoring both his own vocalizations and the model's. From Piaget's cognitive-developmental perspective, visually guided manual imitations are analogous to auditorially guided vocal imitations.

The fundamental claim made by PIAGET is that regardless of the difficulties involved in mastering manual and vocal imitation (for an extended discussion of such intricacies see Kuhl & Meltzoff, 1982, 1988; Lieberman, 1984), they pale in comparison to those involved in facial imitation, because in facial imitation an intramodal guidance process is completely ruled out. Consider the act of spontaneously imitating mouth opening and closing. Although infants can see the adult's mouth, they will never have seen their own. Conversely, although they have proprioceptive information from their own mouths, they will never have received any from the adult's. On what basis can infants possibly compare the stimulus and their response? How can untrained infants «link up» the gestures they see but do not feel, to acts of their own they feel but have never seen? Facial imitation depends not on an *intra*modal but on an *cross*-modal matching process. It is not helped either by an auditory-auditory or visual-visual pattern similarity between the adult and the infant. According to PIAGET, facial

imitation is beyond the perceptual-cognitive abilities of young infants. Facial imitation is the hallmark of ᴘɪᴀɢᴇᴛ's second level of imitation and is first passed at approximately 8 to 12 months of age.

Finally, the third level is attained at about 18 months. The cardinal development is deferred imitation — the ability to perceive a behavior at one point in time and then, without having responded in the presence of the demonstration, to delay the duplication for a significant period. The deferred imitation of facial gestures would be especially difficult because in such a case infants would need to match their own invisible responses to an event that is also currently invisible.

Deferred imitation directly implicates the infant's representational capacities, and indeed ᴘɪᴀɢᴇᴛ postulated that it emerged synchronously with other complex cognitive abilities such as high-level object permanence (the search for invisibly displaced objects), means-ends understanding, and symbolic play. All these synchronous developments constituted what ᴘɪᴀɢᴇᴛ termed «stage 6», the last purely sensory-motor stage of infancy before the emergence of language.

Suffice it here to underscore the logic driving ᴘɪᴀɢᴇᴛ's theory of imitative development. His cognitive-developmental hypothesis is that infants gradually become able to imitate events that are farther and farther removed from the immediate sensory field. First they imitate those involving intramodal comparisons (manual and vocal acts), next those involving cross-modal comparisons (facial acts), and finally those implicating some sort of stored representation of the modeled act (deferred imitation).

Innate Imitation

In 1977 we reported there was an innate capacity to imitate certain facial gestures (Meltzoff & Moore, 1977). Rather than this behavior emerging at about one year, we found evidence that it existed in rudimentary form at birth. Examples of this precocious facial imitation are given in Figure 1, which shows imitation by infants less than and 21 days old.

The studies were designed to be sensitive to the fact that the target response might be elicited for non-imitative reasons (e.g. social facilitation, as discussed earlier). In order to isolate imitative responses a «cross target» design was used. We tested whether infants were more likely to respond with a given facial pattern after that pattern was modeled than after a variety of other control conditions in which the same experimenter, at the same distance, moved his face in a highly similar manner. If such a differential response obtains the conclusion of imitation is warranted. (See Meltzoff & Moore, 1977, 1983a for a methodological review).

Following this logic we conducted two studies. In the first, 12 to 17-day-old infants were each shown four gestures in a repeated-measures design. The four gestures were lip protrusion, mouth opening, tongue protrusion, and sequential finger movement. The infants' facial behaviors were videotaped for subsequent analysis. The videotapes were scored by judges who remained uninformed as to the stimulus conditions. The results showed that infants differentially imitated all four gestures. These findings were particularly informative because the four gestures revealed something about both the generality and the specificity of the phenomenon. Regarding the former, it was theoretically possible that the oral region was uniquely privileged for neonatal imitation, given its biological connection with speech and eating functions. That infants also imitated one manual act suggests that neonatal imitation is a more general than purely oral-facial in nature. Regarding specificity, the gestures were chosen to allow two converging tests. In particular we tested whether all oral «protrusions» were treated the same by the infant; the answer was no, for infants differentiate lip from

tongue protrusion. Conversely we tested whether different actions with the same body part were confused; this answer was also negative, for the infants differentially imitated two actions with the same part of their bodies (lip protrusion versus mouth opening). Evidently infants can use one body part to duplicate two different actions (lip protrusion vs. mouth opening) and also can use two different body parts to perform similar actions (tongue vs. lip protrusion). Thus the imitative visual-motor mappings are surprisingly specific for infants in the first month of life.

In this first study infants were allowed to respond while the display was present. Investigated next was the question of whether early imitation might be tightly constrained from a temporal viewpoint, such that infants were somehow «entrained» by the adult's actions but could not imitate if the visual motor loop were severed and infants forced to delay their productions. To investigate this a new group of 16 to 21-day-old infants was tested. The stimuli were the mouth-opening and tongue-protrusion gestures presented in a repeated measures design. The stimulus and response were temporally split by providing infants with a pacifier to suck on during the visual displays. For example, each infant was shown the mouth-opening display while he or she was sucking on a pacifier. The experimenter then stopped presenting the gesture, assumed a passive-face pose, and only then removed the pacifier. The response period was 2.5 minutes, during which the adult maintained a passive facial pose. The pacifier was then reinserted and the experimenter presented the tongue protrusion in an identical fashion. (Order was counterbalanced across Ss.)

It is noteworthy that the infants actively sucked on the pacifier during the stimulus-presentation periods. The infants did not gape and let the pacifier fall out during the mouth-opening presentations; nor did they push it out with their tongues in the tongue-protrusion trials. In short, the sucking reflex took precedence and insured that infants engaged in competing motor activity during the display (Meltzoff & Moore, 1977, 1983a).

Even using this design, the findings supported the hypothesis of imitation. The results showed significantly more infant tongue protrusions in response to that adult display than in a baseline condition ($p < .005$) or to the adult mouth-opening display ($p < .005$). Conversely, there were significantly more infant mouth openings to that display than in a baseline ($p < .05$) or in response to the tongue-protrusion gesture ($p < .05$).

How can these neonatal behaviors be explained? The most obvious account would be that infants had learned to imitate in the first two to three weeks of postnatal life. Recent findings have revealed that the *en face* exchanges which occur in the first few weeks are more elaborate and «communicative» in nature than previously expected (Brazelton & Tronick, 1980; Trevarthen, 1985). A devout learning theorist might claim that differential imitation was shaped during these mother-infant cycles. A talent for imitation would not be biologically prepared, but the result of parental tutoring.

Maternal shaping may be sufficient to produce the obtained results, but is it necessary? If it is then newborn infants should fail on this task. Meltzoff and Moore (1983b) investigated this question by testing 40 newborns in a hospital nursery. All the infants in the sample were younger than 72 hours old, and the mean age was 32 hours. The youngest subject was just 42 *minutes* old at the time of the test. The mouth opening and tongue protrusion gestures served as stimuli in a repeated measures design, and the data were scored blind from videotape.

The results demonstrate the existence of early imitation. Infants produced significantly more tongue protrusions during that display than to mouth opening ($p < .001$), and conversely produced more mouth openings to the mouth display than to tongue protrusion ($p < .05$). The

strength of the effect is evident even at the level of individual subjects. Sixteen of the 40 subjects switched their behavior so as to match *both* displays in the same session, first matching one display and then the other, thus fully tracking or shadowing the adult's oral behavior with their own. In contrast only 1 of the 40 infants systematically «anti-imitated,» switching his behavior to be in precise opposition to the adult display. On the basis of chance alone these two patterns, both of which entail systematic switching, are equiprobable; thus the data support the hypothesis of imitation. We can conclude that extended postnatal learning is not a necessary condition for imitation in humans. Some primitive capacity to copy actions of adults seems to be a part of our initial biological endowment.

Object-Related Imitation Tested Immediately and After a Delay

Earlier it was asserted that infants are imitative generalists — that they copy actions on objects as well as basic body movements. Research in our laboratory has been directed to assessing object-related imitation in older infants. The dual aims of this research were to test for the immediate imitation of object use, and also to investigate the emergence of deferred imitation. Deferred imitation of object use is especially critical from a functional viewpoint, because infants will often not be able to act on an object or tool in close temporal proximity to the adult's demonstration. While two objects, one for the adult and one for the baby, are common in laboratory tests, the vicissitudes of the real world often demand that the child merely observe at T_1 and then recall the appropriate behavior at T_2 when given access to the object. The capacity for def erred imitation is postulated by Piaget to emerge at approximately 18 months.

An initial study of these issues involved infants from two ages, 24 and 14 months old (Meltzoff, 1985a). The delay period used in the test was 24 hours. The test object was a specially constructed dumbbell-shaped object, and the modeled action was to hold the endpoints and pull apart the two halves of the toy.

Infants from both ages (14-month-old = 120 *S*s; 24-month-old = 60 *S*s) were randomly assigned to either the immediate or delay imitation groups. Within these subdivisions infants were further assigned to either the imitation or control conditions. In the immediate imitation condition the experimenter demonstrated the target action three times in a 20-sec period and then presented the *S* with the object for a 20-sec response period. In the baseline control the experimenter presented the object with no prior modeling. However, following my earlier comments regarding the animal literature, it could be argued that infants are simply more motivated to manipulate the object in the imitation condition than in baseline because their attention was drawn to the toy by the adult. This in turn could lead to an increase in the fortuitous production of the target. An adult-manipulation control was therefore included in which the same experimenter used the same toy as in the imitation condition to demonstrate a different, non-target behavior. Specifically, the experimenter picked up the toy by the ends and moved it in a circle; the diameter of the circle was the same as the linear extent of the pull-apart' motion, and the action was also performed three times in the 20-sec demonstration period.

The infants' behavior in the response periods was videotaped and subsequently scored by observers who were uninformed about the subjects' test condition. The results revealed significant overall imitation (Figures 2, 3). The 24-month-olds demonstrated imitation in both the immediate ($p<.01$) and deferred ($p<.05$) conditions. The 14-month-olds also performed immediate imitation ($p < .001$), but what was unpredicted by theory was their significant imitation after the 24 hour delay ($p < .01$).

The findings demonstrate that infants younger than the Piagetian 18-month-old watershed can delay their imitation, but how much younger and what are the boundary conditions? Meltzoff (1988b), pursued this, assessing both immediate and deferred imitation, using 120 9-month-old infants. Three different object related actions served as stimuli. Infants were shown *all three* actions on the first day (without handling the toys), and then were given the 24-hour delay. The infants thus needed to store and reproduce not only one, but up to three different behaviors across the 24-hour delay.

The target behaviors chosen were ones of no special import to the species; thus the adult displays could not be thought of as simply priming innately specified motor programs. A brief description of the three objects and actions will suffice. The first object was a small black box with a recessed button mounted on its top surface. The action demonstrated was to reach out and poke the button, which electronically activated a beeper inside the box. The second object was an L-shaped wooden construction, consisting of a vertical segment hinged to a baseplate. The action demonstrated was to fold the vertical piece flat. The third object was a small plastic egg filled with a few metallic items. The action demonstrated was to reach out and vigorously shake the egg.

Three control groups were used to assess the likelihood of non-imitative production of these targets. In the baseline condition, the modeling period was omitted and infants were simply presented with the series of three 20-sec response periods with the toys. This assessed the probability that infants this age will produce the targets «on their own». In the adult-touching condition the adult reached out and touched each object three times during the 20-sec modeling periods. This controlled for the possibility that infants in the imitation condition may have been more likely to explore the objects because they saw the adult reach out and handle them, and that this fortuitously led to the production of the target. The third control was designed to mimic specific features of the target display, still without presenting the target behavior itself. Infants in the imitation condition were exposed to the fact that the objects had certain «affordances» (Gibson, 1979), that they beeped or rattled. Might this prompt greater exploration of the objects and thus fortuitous (non-imitative) production of the target behavior? An adult-manipulation control assessed this by causing the objects to produce their effects in the absence of the appropriate manipulation. For example, the adult reached out and touched the black box while surreptitiously activating the beeper by a switch on the back of the object. Similarly the rattling sound was produced by spinning the egg in place on the table, and the flap on the L-object was shown to be a moveable unit in relation to the base without specifically demonstrating the folding motion.

The results provide evidence for both immediate and deferred imitation. A condition (4) × delay (2) ANOVA showed a main effect for condition [$F (3, 112) = 10.39$, $p < .001$]. A follow-up Neuman-Keuls test showed that infants produced more target behaviors in the imitation condition than in each of the controls (all p's $< .05$) and that the response in the controls did not differ. There was no main effect for delay, and no Condition × Delay interaction, indicating that the imitation effect was not dampened due to the 24-hour delay. At the level of individual subjects, the most striking examples of intentional imitation derive from those subjects who duplicated all three of the behaviors they were shown. In the imitation condition about 20% of the infants retained and accurately imitated all three of the displays. None of the 72 control infants did so, documenting that this is an otherwise improbable behavioral sequence on the basis of chance manipulations alone.

Imitation of a Novel Act by Infants

In order to document imitation it is not necessary that a target behavior occur at a zero baseline rate. Adults might legitimately be said to «irnitate» nose touching or producing an

isolated /i/ vowel if prompted to do so, even though these behaviors have some non zero baseline probability, and, of course, are not completely novel actions. Nonetheless the imitation of a completely novel act is a very powerful demonstration of imitative proficiency. Imitation serves the function of providing «no trial» learning in our species precisely because it allows the direct pick-up of novel behaviors from the observation of others. The ability to delay the imitation of novel acts would be of great adaptive significance.

A recent experiment in our laboratory was designed with the dual goals of testing infants' capacity for imitating a novel act and also their ability to keep in mind a wide variety of actions over an extremely long delay. A total of 36 14-month-olds were seen. The delay period chosen was one week. Six different acts were shown to the infants in their initial visit. They were: (a) the three acts described above in the three-object study, (b) the pull-toy from the previously described study, (c) shaking an object from a short string, and (d) a completely novel act,one in which the adult bent foward from the waist and with his forehead pressed a small plastic panel mounted on the table. The design of the experiment was essentially the same as that just described; that is, the performance of an imitation group was compared both to baseline and adult manipulation controls.

The results show that infants produce significantly more of the target behaviors in the imitation ($M = 3.42$) versus control groups ($M = 1.46$) ($p < .05$). What is most striking, however, is the aptitude these young infants exhibited for duplicating the completely novel action. Fully 66% of the infants in the imitation condition produced this behavior as compared to none in the controls (p< .0001). We can assert with some confidence: (a) infants have probably not seen an adult bend forward and touch a panel with his forehead before, (b) they themselves have probably never done so, (c) they have no reinforcement history with this particular behavior, and (d) this manner of acting on the panel is unlikely to arise through individual discovery during the test. Note also that infants perform this feat even though the test involved a one-week delay, and that most infants kept in mind not only this new act but several other actions from the week before. (The modal response was imitation of three of the maximum of six behaviors.) Imitation of a series of behaviors, including a completely novel act, was thus firmly established over a delay interval of one week.

On Linking Infant Sensory-Motor Development and Language Development

Considered so far have been data concerning only one aspect of PIAGET's theory, that of imitative development. However the theory not only describes particular infant skills such as imitation, but provides hypotheses about the transition from a preverbal to a linguistic mode of intelligence in the child. The Piagetian thesis is that there is an ancestor-descendant relation between the progress in sensory-motor development and the emergence of language; achieving the «stage 6» level of cognition is a prerequisite for the emergence of the first use of productive language (Piaget, 1952, 1962). His hypothesis about the growth of language from earlier sensory-motor intelligence has attracted the attention of linguists, comparative psychologists, and evolutionary theorists. This aspect of his theory was a prime focus in the recent PIAGET-CHOMSKY debate (PIATTELLI-PALMERINI, 1980). In a provocative proposal, Parker & Gibson (1979) have articulated a view of how the Piagetian ontogenetic stages might provide a model for the evolution of intelligence and language in early hominids. This modern day attempt to link ontogenetic and phylogenetic change relies on the Piagetian stage developmental theory.

Given the unexpected results on infant imitation, it seems natural to reexamine recent tests of PIAGET'S broader proposals about the relation between early cognition and the emergence of

language. If deferred imitation occurs in early infancy and is not part of the putative across-the-board shift to «stage 6» cognition at 18 months, this raises questions about whether any other cognitive milestones are in fact related to language, and if so, the nature of that relation.

It is fair to say that the current empirical work has not been overly supportive of the Piagetian notion of «stage 6» intelligence as a cognitive precursor to the development of language. It has been difficult to demonstrate any strong relations between Piagetian cognitive «stages» and general measures of early language, and there have been two types of reactions to these findings (or lack thereof). (For a more complete discussion of the debate in infant development, see Gopnik & Meltzoff, 1986, 1988). On the one hand, some have emphasized that seeking close links between early cognition and language is a doomed venture, for human language is a special, modularized, and innately structured system that is neither constructed from nor develops out of preverbal problem/solving activity. CHOMSKY and his followers remain wholly unsurprised (if not pleased) by developmentalists' failures to find significant interrelations between early thought and language (Chomsky, 1968, 1980; PIATTELLI-PALMERINI, 1980). On the other hand, some developmentalists explain the negative findings by suggesting that language in the child is more firmly rooted in social than cogmtlve development — mother-infant exchange games, communicative gesturing, and the like being prime aspects to consider (Lock, 1980).

GOPNIK and I have recently proposed a different account, which we called the «specificity hypothesis» (Gopnik & Meltzoff, 1986). We noted that most attempts to find relations between early cognitive and linguistic development, following PIAGET, have sought general «stage-like» relations. We hypothesized that the sought-after relations between cognition and language might still exist, but be more *specific* in nature. Many such specific links are possible, but our focus has been on connections between early cognitive and semantic development. Based on GOPNIK's earlier work (Gopnik, 1982, 1984) we tested whether infants develop certain types of meanings at about the same time as they solve specific related cognitive problems.

GOPNIK's work has revealed an interesting class of words that systematically emerge in the one-word period, between 15- and 21-months (Gopnik, 1981, 1982). These are non nominal expressions, sometimes called relational words, such as «gone» (when an object has disappeared), «there» (when the child succeeds in *his* plans, such as building a block tower), and «uh-oh» (when the child's plans fail and the tower is bumped and falls). GOPNIK hypothesized, and her early work supported, the idea that the use of disappearance words such as «gone» might be intrinsically tied to the developing object concept which so preoccupies children of the same approximate age (Gopnik, 1984). Recently we have extended and elaborated this work.

In one study we tested 19 children longitudinally in approximately three-week intervals from about 14 months to 2 years of age (Gopnik & Meltzoff, 1986). Two types of cognitive tasks and two types of semantic developments were tested. The semantic achievements were the first occurrence of disappearance words (e.g. «gone») and words marking success/failure in carrying out a plan (e.g. «there», or «uh-oh»). The children's use of language was monitored through a combination of maternal questionnaires and laboratory assessments.

The two cognitive achievements were: (a) solving complex object permanence tasks and (b) exhibiting insight to solve means-ends tasks, such as using a stick to obtain an out of reach object. A standard infant test battery (Uzgiris & Hunt, 1975) was administered on each visit to assess these cognitive achievements. Infants were scored as having acquired object permanence when they could solve an «invisible displacement» hiding task. In such a task

the infant must deduce the location of an invisible object. The problem is posed by having an experimenter visibly hide a desired object in his or her hand; the closed hand is then moved on a trajectory under a sequence of three screens, and unbeknownst to the infant, the object is deposited under the third screen. Infants who have not yet reached the highest level of object permanence will typically look in the hand (which is where they saw the object disappear) and then give up searching when the object is not where it was last seen hidden. Infants who have developed an understanding of object permanence search in the hand, then systematically under the first, second, and third screens, fully confident that the object continues to exist and must be somewhere along the path traveled by the hand; i. e. although the object is not in the place it was last seen (surprisingly), it nevertheless continues to exist, and therefore must be somewhere the hand has traveled. The tests of means-ends understanding included tests of tool-use such as using a stick to obtain an out-of-reach toy. A success was scored only if the child exhibited insight on these tasks, that is, immediately used the stick to obtain the object without a prior period of trial and error.

The «specificity hypothesis» under test predicted that the development of object permanence would be closely coupled with the acqumtion of disappearance words. Similarly the insightful use of a tool to reach a goal was predicted to be linked to the acquisition of success/failure words, which also tap on a linguistic level the relation between one's goals and the current state of affairs (Gopnik, 1982). The hypothesis predicts very specific cognition-language links. It postulates that the cross relations will not hold, e.g., object permanence ability will not be linked to the acquisition of success/failure words, and means-ends will not be linked to disappearance words.

The results showed that children attained all four of these cognitive and semantic achievements at about 18 months, with no significant differences in the mean age of attaining these four milestones. Across the sample of 19 children the mean age (in months) of reaching these attainments were as follows: object permanence, 17.90; means-ends, 18.52; disappearance words, 18.37; success/failure words, 18.34. At first glance this appears compatible with Piaget's assertion that there is a unified shift in mental organization at 18 months, «stage 6». However, further analyses of the results also showed that there was wide individual variation in the age of attaining these milestones, the range for each extending from approximately 15 to 24 months.

The data show that an individual child might reach one cognitive milestone as much as three months earlier than the other cognitive milestone; and a different child might manifest as large a gap in the opposite direction. Thus across the sample, the mean age of achieving these milestones centered on 18 months, as predicted by Piaget's model, but any individual might be relatively accelerated in one set of skills and relatively delayed in another. These gaps are not predicted by Piaget's «stage» model. The specificity hypothesis made clear predictions about which particular achievements should be closely coupled with which within development.

There were two statistical approaches for assessing these specific developmental links. First, for each child we calculated the temporal gap between his acquisition of one type of behavior and the other. The results are shown in Table 1. As shown, there is a small gap, only 13.53 days on average, between an individual child solving the complex means-ends problems and his or her first use of success/failure words. Similarly there is a short gap, 27.95 days, between solving complex object-permanence problems and using disappearance words. The other gaps are considerably larger, and these differences in the gap scores reach statistical significance. The data support the notion that particular semantic acquisitions occur concurrently with the particular cognitive achievements and not others.

The second statistical assessment of the results yielded the same picture. Correlation statistics were used to test the relation between the age of acquiring these cognitive and semantic skills (Table 2). As shown, the relations predicted by the GOPNIK-MELTZOFF hypothesis exhibited high correlations. It is also of interest that the predicted cognition-language links are actually stronger than are the relations between the two cognitive tasks or between the two linguistic achievements (Tables 1,2). Apparently, it is *not* the case that children who are accelerated on one cognitive skill are accelerated in the other cognitive domain. If a child is accelerated in object permanence he or she is likely to use disappearance words but not necessarily to be accelerated on solving means-ends tasks or using success/failure words. The same holds true for the link between means-ends understanding and success/failure words. To rephrase this: On the basis of a child's object-permanence skills one is better able to predict aspects of language (the child will be using disappearance words) than to predict other aspects of cognition (such as whether he or she will be using tools in means-ends tasks). Conversely, on the basis of the insightful use of tools one is better able to predict aspects of language (the child will be using success/failure words) than to predict his object-permanence skills.

The next experiment explored relations between children's categorization behavior and their tendency to use names (Gopnik & Meltzoff, 1987). Developmental studies suggest that there are important changes in children's tendency to sort objects into groups between one and two years of age (Ricciuti, 1965; Sugarman, 1983; Starkey, 1981). We hypothesized that there might be a relation between this cognitive change and the onset of the «naming explosion» — the first sharp increase in children's naming vocabulary that typically occurs at about 1.5 years of age.

Twelve children were tested longitudinally in triweekly sessions from about 15 to 20 months of age. Mothers filled out a child language questionnaire before each session. The criterion for the naming explosion was the first session in which more than ten new names were acquired. Three cognitive tests were administered in each test session: object permanence, means-ends understanding, and categorization. The first two of these were assessed in the way previously described. The categorization test consisted of presenting an array of eight objects to the child. Four objects were of one type and four of another (e.g. four rectangular boxes versus four spheres). The question was whether the child would spontaneously sort the array of objects into the two categories.

The results showed that the children developed through three levels of categorization behavior. At an early age ($M = 16.04$ months) they exhibited some sensitivity to the categories by grouping objects from one class together but without dealing with the second class (e.g., they would put one type of object in a pile but not touch the other kind). At a slightly older age infants developed to the point of systematically manipulating all eight objects, first touching four of one type, then four of the other ($M = 16.39$ months). Finally, the highest-level development was to form two-category spatial groupings (M = 17.24 months). At this level the children would spatially displace all eight objects in the array, spontaneously sorting all the objects of one type into one pile and all of the other in a second pile. (Hereafter level-3 behavior is referred to as «solving» the categorization problem.) Of the 12 subjects, only one violated this developmental ordering, producing level 2 categorization earlier than level 1 ($p < .05$).

The results showed that individual children solved the object-permanence, means-ends, and categorization problems at a wide variety of ages (range = 15-21 months), and there was no significant correlation between the age of achieving any of these cognitive abilities. The mean for solving these three cognitive problems hovered around 17-18 months, which replicated and extended our previous work.

The age of achieving the naming explosion also had wide individual variation, ranging from 15.5 to 21.5 months with a mean of about 18 months. However, the results showed that there was a close coupling between an individual child solving the categorization problem and the onset of his naming explosion. Whether that child's naming explosion was early or late, it tended to occur in close conjunction with his solving the nonverbal categorization problem. In particular, there was a strong positive correlation (r=.78, $p < .01$) between the development of these two behaviors, and the mean temporal gap between these two was only 33.17 days. There was no significant correlation between solving means-ends problems and the onset of the naming explosion (r=−.02), indicating that the onset of the naming explosion is not simply correlated with a broad set of 1.5-year-old cognitive milestones. Moreover, the gap between means-ends and the naming explosion was significantly longer than that between categorization and naming (p<.05). As might be expected, the relation between the development of object permanence and the naming explosion lay between these endpoints; a relation might here be expected because object permanence tasks tap children's concepts about objects (Gopnik & Meltzoff, 1987).

In sum, the study provides further support for the «specificity hypothesis» by showing a close developmental relation between categorization behavior and the naming explosion. An individual child may be accelerated or relatively slow at solving the categorization problem. Within the restricted range of normal children studied here this did not predict whether the child would be early or late at solving other cognitive problems (object permanence or means-ends tasks). However, whenever that individual child solved the categorization problem, this was tightly coupled with the onset of this child's naming explosion. We interpret these results to indicate that when children become fascinated with the prospect of dividing the world of objects into «natural kinds», they begin to do this with fervor both in word and in actions. Not only do they begin spontaneously to group like objects in piles, they begin to seek out (pointing to an object and asking «da?») and reproduce new object names at an explosive rate. This is quite a clear relation between a nonverbal cognitive achievement and language development.

Summary and Conclusions

Imitation can be a powerful mechanism for the intergenerational transmission of culture. It is a direct and efficient means for the young to pick up the acquired skills and behavior patterns of the adults in their group. It is less costly for the young than trial-and-error learning, quicker than individual re-invention, and it enables greater adaptability to changing environmental demands than innately fixed behavior patterns. It is altogether fitting that *Homo sapiens*, a broad-niched species with a prolonged period of initial dependency, is the most imitative animal in the phylogenetic scale — the consummate imitative generalist. Although other primates exhibit imitative skills (Chevalier-Skolnikoff, 1977; Gardner & Gardner, 1969; Kellogg & Kellogg, 1933), they pale in comparison to the preschooler and even the preverbal child. Although still other taxa demonstrate impressive imitation within a restricted band of behaviors, passerine birds for example (Marler & Tamura, 1964), they are narrowly tuned specialists. In contrast the human infant, an imitative generalist, is capable of a wide range of feats — duplicating vocal maneuvers, body postures, actions on objects, and/or completely arbitrary and novel acts (e.g. touching a panel with one's forehead). Elsewhere I suggested the label *Homo imitans* for human infants (Meltzoff, 1988a).

That young human have this proclivity has not been lost to primitive societies, as documented in numerous anthropological accounts. In several languages the word for «teach» is the same as the word for «show» (Reichard, 1938). The Tallensi natives in Africa believed that a child's imitativeness was a good measure of his or her cleverness, rapid

learning of a new skill being explained by *u mar nini pam*, «he has remarkable eyes» (Fortes, 1938).

Although there is broad consensus about the utility of imitation and its apparent universality across cultures, developmentalists are still actively debating the ontogeny of imitation (Meltzoff, 1985b). Piaget (1962) offered an account of the evolution of imitation in infancy. Two principal themes were the following. First, imitation develops in an age-linked series of «stages» that are determined by the child's perceptual-cognitive growth. Before 8 months the child's imitation is constrained to the realm of manual and vocal matching, between 8 and 18 months facial imitation develops, and by about 18 months deferred imitation emerges. A second theme is the idea that the shift to deferred imitation at about 18 months is intrinsically tied to a broad set of cognitive changes in other domains, so-called «stage 6». PIAGET thought it no accident that deferred imitation, object permanence, and insightful tool use all emerged at about 18 months, and he postulated that they prepared the infant for language.

A series of studies has now been completed concerning the ontogenesis of facial imitation and deferred imitation. The data call for a revision in theory. Evidently facial imitation does not emerge at the end of the first year. Instead, human newborns have some primitive capacity to duplicate certain conspecific facial actions; it is an innate skill. These early imitations lie at the boundary between biology and culture, for they embody an innate mechanism for cultural transmission.

Piaget's second milestone, deferred imitation, occurs in robust form far earlier than the predicted 18-month-old, «stage 6» level of development. The research shows that infants as young as 9 months old can defer imitation of three different object-related actions over a 24-hour delay. Another experiment showed that 14-month-old infants can succeed on an imitation test in which six object-related actions are presented and then a one-week delay intervenes before infants are allowed to respond. This latter study documented both that infants can keep in mind several perceived actions over a surprisingly long window; and also that they can imitate a completely novel act. One of the displays was specially designed to be an arbitrary and unusual act, probably never witnessed or executed before in the infant's life. It was simply an act performed in the rather bizarre «culture» of the University of Washington psychology laboratory. Nonetheless when infants returned one week later they demonstrated a capacity and willingness to perform this culturally transmitted ritual of bending forward and touching one's forehead against a plastic panel.

These findings on deferred imitation suggest that imitation in early infancy is well enough developed to be of use in everyday life. Infants in their homes will probably not have access to an identical object at the moment the display is presented. Older siblings, of whom imitation may be especially important, are notoriously poor at such sharing; and adults often adopt a successive «watch what I do, then it's your turn» pedagogical style. Then too there will be many cases in which mere observation, but no action, is allowed before the circumstances quickly change and the opportunity for immediate imitation evaporates. The new research suggests that these social realities are not enough to check imitation. Infants are capable of perceptually encoding the relevant information and delaying their «read out» of it in action until an appropriate situation presents itself.

Recall also that in the def erred imitation studies the stimulus presentation periods were only 20 sec in duration. Thus a long, repetitive exposure is not a necessary condition for subsequent imitation. Moreover, the infants were not allowed even to manipulate the object; they were simply shown multiple acts and then given a delay of up to seven days before being given access to the toy. It is difficult to describe the astonishment and self-

consciousness one feels upon realizing that a infant has watched your brief acts so carefully that he or she will repeat them after delays as long as one week. In sum, all the data suggest that imitation may be an important mechanism in social learning during the first two years of life.

The findings of robust deferred imitation in young infants do raise something of a puzzle, however. A standard assumption among developmentalists is that there is a general change in the level of cognitive functioning at around 18 months that can be characterized as a shift from a purely sensory-motor to a more symbolic/representational level of functioning (Flavel, 1985). The precise way of characterizing this change and the list of new behaviors it allows varies somewhat from author to author; but there has been some consensus that the insightful use of tools, object permanence, and deferred imitation are among the list of criterial behaviors. In the most influential and comprehensive theory, PIAGET's, the shift was described in terms of a «stage 6» cognitive-developmental change in which there was a necessary and tight coupling among all these domains. These achievements set the stage for language.

The new research indicates that deferred imitation must be plucked from this list. Moreover, it may be noted that the predicted links between «stage 6» intelligence and language have always been difficult to document in developmental studies, independent of imitation. It thus appears that the early onset of deferred imitation is not so much an isolated exception to theory as a symptom that something may be awry in the assumed «stage 6»-language link.

GOPNIK and I recently suggested that there may not be a unified and global «stage 6» shift that is related to «language». We suggested that it may be more fruitful to look for a series of very specific cognition-language links, and in particular have begun to examine couplings between specific cognitive developments and specific semantic achievements. The results provide support for this «specificity hypothesis». The data show a close coupling between the development of object permanence and the use of disappearance words; similarly there is another coupling between means-ends understanding (e.g., as measured by the insightful use of tools) and the use of success/failure words. A further relation seems to hold between the development of categorization behavior and the onset of the «naming explosion». These results suggest that there are specific connections between early cognitive and semantic developments. It appears that children in the second year begin to talk about the conceptual problems that so fascinate them in this age period (Gopnik & Meltzoff, 1985, 1987). The discovery that objects are permanent, that they continue to exist somewhere even when out of perceptual contact, is a momentous one for the child and moreover one in which some children seem deeply immersed. Children at this age will often sit for long periods systematically covering and uncovering an object, smiling and laughing at the reappearances they themselves cause. They will also entreat an adult to play peekaboo. They seem captured by the disappearance-reappearance transformation and the concept of «permanence» that explains the event. Another child at the same age may be more engaged in means-ends understanding and the use of tools. A third child of the same age may be a rampant categorizer, piling all the spoons in one place and cups in another. Virtually all children will solve all three concerns within the 15- to 24- month window, it is just that some seem to focus on one problem before the other.

What seems to be true more generally is that children in this age period begin to use language as part and parcel of working on their cognitive concerns (Gopnik & Meltzoff, 1988). The fact that one child is working on understanding disappearance-reappearance transformations may also focus his or her attention on the language the adults use in conjunction with these object transformations. Whether or not the recognition that a variety of disappearance transformations are labeled with the same word can feed back and boost

the cognitive understanding of a child who is already on the verge of developing the concept is a topic we have only begun to study (Gopnik & Meltzoff, 1984, 1988). If so, there will be evidence for a bidirectional interaction between early thought and language, each capable of bootstrapping on the other.

It is surely true that language can be used to encode abstractions and hypotheticals that are beyond the reach of action imitation. The power, productivity, and uniqueness of language need not be extolled here. However it would also seem that imitation serves as a natural supplement, for it is often difficult to describe linguistically the movement patterns needed in skill acquisition — how to build a proper hand tool, tie a knot, or start a fire.

Evolution has prepared the human young to be attuned to both the words and deeds of the adults in their culture. They are biologically predisposed to take advantage of their cultural heritage.

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Figure 1.
Two- to three-week-old infants imitating facial gestures presented by an adult experimenter.
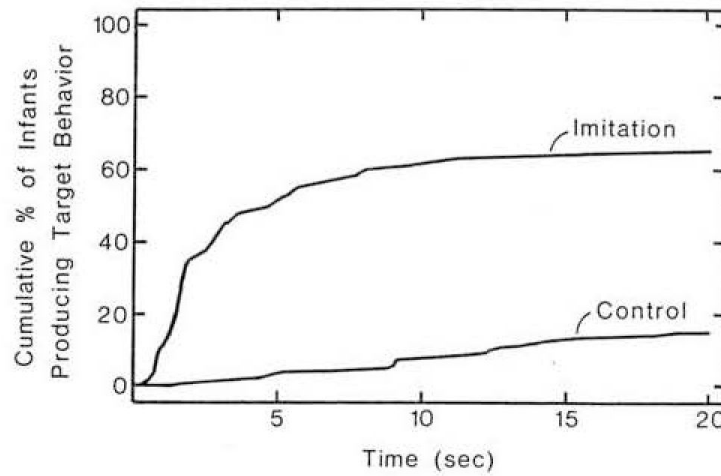(From: A.N. MELTZOFF & M.K. MOORE, *Science*, 1977, 198: 75-78).

Figure 2.
Cumulative percentage of infants in the imitation and control conditions producing the target acts as a function of time. Sixty-five per cent of the infants in the imitation condition produced the target as opposed to; 17% in the controls ($p < .0001$). The data are collapsed across age and delay because neither of these factors interacted with the main effect of imitation.
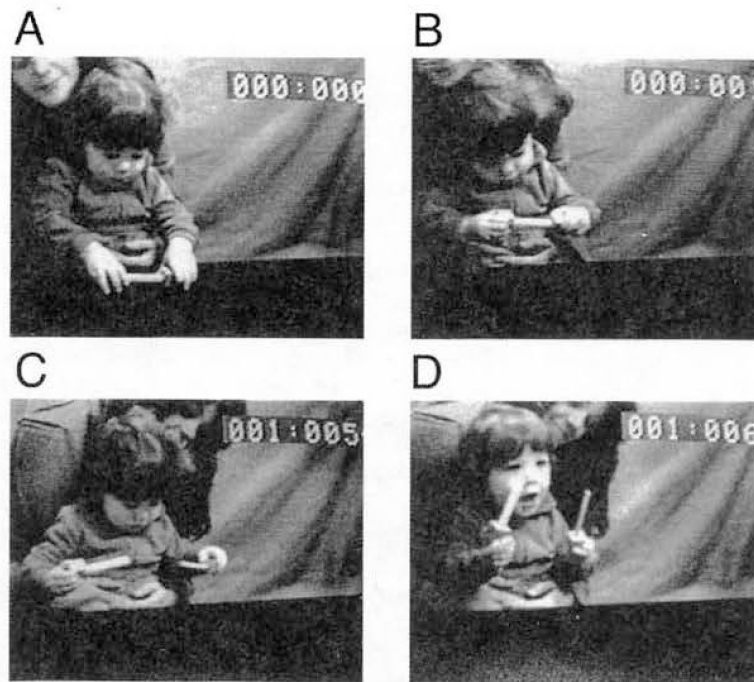
Figure 3.
This 14-month-old child saw the adult pull apart the toy 24 hours earlier. After duplicating the act, infants will often look up, smile, and offer the toy to the adult. Time from first touching the object is shown in the upper right of each frame.

TABLE 1

Mean Gap Between the First Solution of Object-Permanence and Means-Ends Tasks and the First Use of Disappearance and Success/Failure Words.

Achievements [a]	Mean Gap [b] (days)
Object-permanence and disappearance words	27.95
Object-permanence and success/failure words	55 .68
Means-ends and disappearance words	64.63
Means-ends and success/failure words	13.53
Object-permanence and means-ends	59.84
Disappearance words and success/failure words	58.68

[a] See text for operational definitions of these developmental achievements.

[b] The gap is the absolute value of the interval between one achievement and the other.

TABLE 2

Correlations Between the Age of Solution of Object-Permanence and Means-Ends Tasks and the Acquisition of Disappearance and Success/Failure Words.

	Disappearance Words	Means-Ends	Success/Failure Words
Object-permanence	.70 **	.37	.46 *
Disappearance words		.23	.26
Means-ends			.95 **

*
$p < 0.05$.

**
$p < 0.001$.