Title
The Role of Motion in Children's Categorization

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 20(0)

Authors
Mak, Benise S. K.
Vera, Alonso H.

Publication Date
1998

Peer reviewed

The Role of Motion in Children's Categorization

Benise S. K. Mak (h9313988@hkusua.hku.hk)
Department of Psychology, The University of Hong Kong
Pokfulam Road, Hong Kong

Alonso H. Vera (vera@hkucc.hku.hk)
Department of Psychology, The University of Hong Kong
Pokfulam Road, Hong Kong

Abstract

Perceptual cues clearly play a fundamental role in early categorization. Perceptual properties, however, are typically understood to be *static* shape cues. Some studies have suggested that dynamic perceptual cues, such as motion, may also be important in categorization. This study was an attempt to explore the role that motion plays in children's categorization of biological kinds as well as in more abstract concepts, such as geometric figures. Confronted with a choice between movement and shape, 4-year-old children were found to base their inductions about category membership primarily on motion cues, regardless of whether the objects were animals or geometric figures. This pattern of responses is also present in 7-year-olds for animals but not for geometric figures. Older children may begin to appreciate that motion is unique to animals and are therefore less likely to use motion cues to categorize geometric figures. The results support the view that children are initially guided by motion in categorization. Only as they grow older do they begin to constrain their inferences with respect to different motion cues. The present findings suggest that motion plays an overriding role that is central in the process of concept acquisition and in the mechanisms by which concepts are later structured.

Introduction

Children are often characterized as perceptually bound. Many studies (e.g., Bruner, Olver, & Greenfield, 1967; Inhelder & Piaget, 1964; Roberts, 1988; Roberts & Horowitz, 1986; Rosch, Mervis, Gay, Johnson, & Boyes-Braem, 1976) have supported the view that perceptual cues are the basis of children's categorization. Young children tend to classify objects sharing similar superficial perceptual properties, such as shape or color, together. Although recent studies by Gelman and her colleagues (Gelman & Coley, 1990; Gelman & Markman, 1986; Gelman & Markman, 1987) found that children as young as two years of age are able to go beyond perceptual appearance and use category labels to make inductive inferences about natural kinds, they nevertheless agreed that 'perceptual cues are still the primary means of discovering category membership for unlabeled objects' (Gelman & Coley, 1990, p. 803).

The importance of perceptual similarity in understanding early categorization has been widely recognized (e.g., Brown, 1989; Medin & Ortony, 1989; Smith, 1989), and its significance in children's categorization has also been well documented in the literature. Perceptual cues, however, are typically understood to be the static, visually available characteristics of objects, although most would agree that, in principle, features can be more widely construed, including properties, such as motion and functionality (e.g., Murphy & Medin, 1985; Rosch et al., 1976; Schunn & Vera, 1995). However, most past studies on children's categorization put stress on superficial appearance (e.g., shape or color), and these types of features appear to be insufficient to account for the cognitive phenomenon of perceptual similarity. Motion may also be one of the major perceptual cues involved in information pick-up by children.

The Importance of Motion in Early Perception

There has been a great deal of research on the importance of motion in early perception. *Studies on infant motion sensitivity* suggest that babies are readily able to extract motion information to make inferences about the outside world (Banks & Salapatek, 1983; Gibson & Gibson, 1991). They indicate that infant perception not only uses but depends on information provided by motion (see Gibson, 1987). Early in infancy, visual acuity for static displays is low (Banks & Salapatek, 1983), but motion information is readily detected and attended to and also used for specifying the nature and properties of objects (Freedland & Dannemiller, 1987; Haith & Campos, 1977). Studies have shown that infants are able to use accretion-deletion motion (which is produced by a background region filled with dots moving either to the right or to the left and a foreground region moving at the same speed in the opposite direction) to detect the form of an object (Kaufmann-Hayoz, Kaufmann, & Stucki, 1986), use common motion to see an object as unitary and separate from its background (Kellman & Spelke, 1983), and use motion vectors in point-light displays for detection of coherent structures (Bertenthal, Proffitt, Kramer, & Spetner, 1987).

Another important form of motion perception is that directed to the movement of animate objects. *Studies on infant sensitivity to human motion* indicate that by three months of age, babies show more interest in and dishabituate more to point-light displays that specify biological motion of humans than to either static displays or random arrays of moving points (Bertenthal, Proffitt, & Cutting, 1984; Fox & McDaniel, 1982). They are also perceptually able to differentiate the motion of people from similar but biologically incorrect motion (Bertenthal, 1993).

Apart from the findings on human infants, movement information has also been shown to be important for young vervets (a species of small gray African monkeys) to develop accurate alarm calls (Seyfarth & Cheney, 1986; Seyfarth, Cheney, & Marler, 1980). *Studies on the vocalization of infant vervets* found that baby monkeys often make false alarms, giving leopard alarms to various mammals, snake alarms to various snake-like objects, and eagle alarms to various birds and even to leaves falling from trees. Only as they get older do the alarm calls become more specific to those species that prey on them (Seyfarth et al., 1980). An analysis of the development of alarm calls indicates that errors made by infant vervets are not so much associated with physical similarity but rather with motion (Seyfarth & Cheney, 1986). This may suggest that infant vervets begin with a motion-oriented categorization, for which objects in motion are initially classified in terms of behavior or actions (see Allen, 1996).

The Importance of Motion in Children's Categorization

From these studies on human infants and young vervets, it is evident that objects in motion are discriminated very early in life and that motion perception is an active, information-seeking process which is adaptive in nature (Gibson & Gibson, 1991). Human infants, like young vervets, may begin life with a motion-oriented categorization mechanism, and their sensitivity to motion may still remain important as conceptual development proceeds into childhood.

In Piaget's (1929) studies, children at three to five years of age were often found to be 'animistic' (i.e., attributed life to non-living things), and motion was one source of their confusion. Children tended to judge objects, such as clouds, moon, bikes, and watches, as alive because they were seen to move. Later studies (e.g., Carey, 1985) also show that young children do sometimes have difficulty in drawing the line between living and non-living things, although the confusions were found to be less pervasive than Piaget believed (see Flavell, Miller, & Miller, 1993).

The Present Study

These converging lines of evidence suggest that similarity and dissimilarity of motion may well be one of the major perceptual cues children rely on in categorization. In this study, movement was pitted against appearance. We expected that children would be more likely to use movement than shape to categorize objects.

A developmental change in the categorization of animals/geometric figures was also expected in 4- and 7-year-old children. A study by Gelman (1988) has shown that 4- and 7-year-old children are different in their conceptualization of natural kinds and artifacts. Older children were found to be able to understand that natural kinds share more common internal parts than do artifacts. They tended to draw more inferences within natural kinds than within artifacts, while younger children, who seemed to be less capable of making a natural kinds/artifacts distinction, drew inferences equally often for both.

Based on Gelman's findings, we expected that the 4- and the 7-year-olds would not be very different in their inductions about animals but would be different for geometric figures. Younger children, without a clear natural kinds/artifacts distinction, may not be able to see movement as unique to animals. Therefore, they would be equally likely to use movement cues to make inferences about animals and geometric figures, whereas older children use movement cues more for animals than for geometric figures.

Method

Participants

Three hundred and twenty children from 4 kindergartens and 2 primary schools in Hong Kong participated: 160 4-year-old children (80 girls and 80 boys), ranging in age from 4;0 to 4;11 with a mean age of 4;6, and 160 7-year-old children (80 girls and 80 boys), ranging in age from 7;0 to 7;11 with a mean age of 7;6.

Design

We used an inductive methodology, similar to that utilized by Gelman & Markman (1986), because of two methodological issues raised with respect to earlier studies on categorization (Wellman & Gelman, 1988). The issues involve the experimental design and stimuli used. Firstly, some past studies used a free-sorting method, simply asking subjects to group objects that go together. This procedure however fails to capture the reasons behind the sorting behavior and hence, the inductive nature of concepts. Secondly, many used arbitrary or invented concepts (e.g., blue circles). These concepts, unlike natural kinds, are not able to provide a rich source for inductive inference, so that findings cannot be generalized to more natural concepts.

To address these concerns, we adopted an inductive methodology. Instead of asking participants to sort arbitrary objects, we required children to make inferences about animals as well as geometric figures based on information given. For example, we showed children three stimuli at a time. Then, they were taught new properties about two of the stimuli and were required to infer which properties applied to the third one.

In this study, the independent variables were two categories of object (animals and geometric figures), three shape/movement conditions (Conflict, No-conflict and Static), and two age groups (4- and 7-year-old children), and the dependent measures were children's responses on the inductive tasks: whether they based their judgments on movement or shape.

Table 1
Category items and properties used

Category	Target Displays (object - movement)	Target Properties Used	Test Displays (object - movement)
Animals:			
Set 1	Horse - Walk	Good vision	Donkey - Walk/Jump
	Antelope - Jump	Poor vision	
Set 2	Owl - Hop	Good hearing	Sparrow - Hop/Walk
	Quail - Walk	Poor hearing	
Geometric Figures:			
Set 1	Square - Travel across	Good at recording visual images	Rectangle - Travel across/Bounce
	Triangle - Bounce	Poor at recording visual images	
Set 2	Diamond - Bounce	Good at recording sound	Ellipse - Bounce /Travel across
	Circle - Travel across	Poor at recording sound	

Stimuli

There were 4 sets of stimuli, each of which consisted of 3 series of animations. Details are presented in Table 1.

Two of the four animation sets were animals and two were geometric figures. For each set, there were two target displays and a test display. The shape and motion similarities between the target and test stimuli could either coincide or be in conflict with each other. For example, a walking horse and a jumping antelope which looked and moved differently from one another were used as the target displays and a walking or a jumping donkey as the test display. The donkey's shape was similar to that of the horse but different from that of the antelope, but it either walked like a horse (the No-conflict Condition: shape and movement coincided) or jumped like an antelope (the Conflict Condition: shape and movement were in conflict).

To avoid creating any biased responses towards either shape or movement, the properties used to elicit children's inductions (e.g., good vs. poor vision) were selected to be unrelated to the shape and the movement of the objects.

With respect to the object movement, we were not sure whether children would show more interest in particular patterns of movement. If this were the case, and if the motion patterns of the animals and the geometric figures were very different from one another, we would not be able to make a conclusive comparison between animals and geometric figures. Therefore, the choice of geometric figures was primarily based on the animals. They were matched not only on the patterns of motion (e.g., a jumping antelope vs. a bouncing triangle) but also on the properties used (e.g., an animal with good vision vs. a device with a good function in recording visual images). This inevitably made the shape and the properties used for the geometric figures become rather arbitrary.

To make sure children were able to detect the shape of the objects, the movement of the animals in the animations was slightly slower than the corresponding real motion, but the speed for all the stimuli were the same. All the stimuli were drawn in the same brown color with black outline. The drawings used for the biological kind animations are shown in Figure 1.

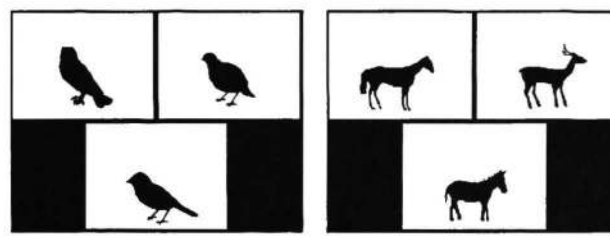

Figure 1. Stimuli used in the biological kind conditions.

Procedure

Each child was tested individually and was shown either two animal sets or two geometric figure sets but not both in corresponding conditions, with a presentation order of the two sets counterbalanced across subjects.

Property Control

Before conducting the experiment, we ran a control study to test if children would be biased toward certain types of properties. Children were shown the test object (e.g., the donkey) by itself, without motion, and were asked which of the two target properties applied (e.g., good vision or poor vision). Children were expected to have no bias (i.e., perform at about chance level) with respect to the properties used since they were selected to be unrelated to shape or movement.

Conflict Condition

In this condition, the shape and movement between the target and test stimuli were in conflict. The two target stimuli looked and moved differently from one another (e.g., a walking horse and a jumping antelope), while the test object (e.g., a jumping donkey) looked like one of the target objects (the horse) but moved like the other (the antelope).

Children were shown a set of three stimuli at a time. They were first taught new properties about two target stimuli and were required to infer which properties applied to the test stimuli. To take the 'horse' set as an example, the experimenter first pointed to the walking horse and said, "This animal has good vision. It can see things clearly at a great distance." She then pointed to the jumping antelope and said, "This animal has poor vision. It can only see things clearly at a short distance." The children were asked to repeat the properties they learned until they could recall them correctly. Then, the experimenter went on and pointed to the jumping donkey and asked, "See this animal? Does it have good vision, like this animal (referring to the horse); can it see things clearly at a great distance? Or, does it have poor vision, like this animal (referring to the antelope); can it only see things clearly at a short distance?" The experimenter did not label the objects, simply saying 'this animal ...' (for animal sets) or 'this thing ...' (for geometric figure sets).

This condition was designed to test if children's judgment would be more influenced by movement or by shape. We predicted that younger children would base their inductions more on movement than on shape for both animals and geometric figures, while older children would base their inductions more on movement for animals but not for geometric figures.

No-Conflict Condition

The procedure was identical to that in the Conflict Condition, but in this condition, the shape and movement between the target and the test stimuli coincided. The test object was shown to not only look like one of the training objects but also move like that object. In this case, for example, the donkey appeared to be walking which both looked and moved like the horse.

This condition was designed to examine if children were ready to base their inductions on the coincidence of shape with the movement.

Static Condition

The same procedure applied, but children were presented with three motionless objects. The purpose of this condition was to make certain that the children would draw inferences based on shape alone (e.g., categorize the donkey and the horse together if no movement cues were present).

Results

Children scored a 1 for each item with an answer based on shape and 0 for each with an answer based on movement. These scores were summed within subjects, and the score for each subject ranged from 0 to 2. For each condition, a one-sample t-test was conducted to examine if children performed significantly above or below 50% chance level. The results are summarized in Table 2.

Property Control

Data in this condition indicate that children of both age groups showed no significant preference for any particular type of answer. The children, in the absence of additional information to guide their answer, performed at about chance level in saying an object possessed any given property. Thus, we can assume that children's inferences were based on the shape/movement information provided in the other conditions.

Conflict Condition

Movement and shape were contrasted in this condition. In making judgments about animals, both younger (70% of the time) and older (75% of the time) children relied significantly more on motion than on shape. However, in drawing inferences about geometric figures, older children, as predicted, were less likely to use movement (45% of the time, which is not significantly below chance level), while younger children used movement significantly more (77.5% of the time). The 7-year-olds appear to realize the uniqueness of motion in categorizing animals and consequently saw the movement of geometric figures as comparatively irrelevant in drawing inferences about them. But this animals/geometric figures distinction was not found in the 4-year-olds. Figure 2 summarizes these results.

Table 2
Percentage of responses based on shape similarity

	Conflict Condition		No-Conflict Condition		Static Condition		Property Control
Animal							
Age 4	30.0%	+	87.5%	***	75.0%	**	52.5%
Age 7	25.0%	++	85.0%	***	80.0%	***	50.0%
Geometric Figure							
Age 4	32.5%	+	87.5%	***	80.0%	***	52.5%
Age 7	55.0%		87.5%	***	85.0%	***	60.0%

* above chance, $p<.05$, 1-tailed
** above chance, $p<.005$, 1-tailed
*** above chance, $p<.0005$, 1-tailed
+ below chance, $p<.05$, 1-tailed
++ below chance, $p<.005$, 1-tailed

Property Control: Percentage of 'good' property responses (e.g., good vision)

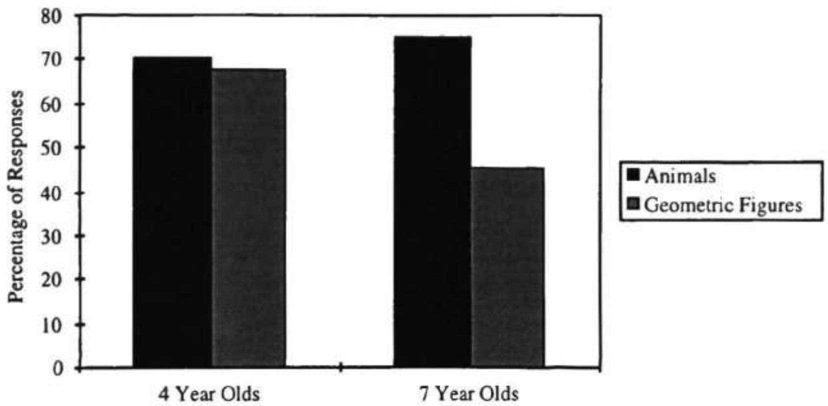

Figure 2. Percentage of responses based on motion in the condition where motion and shape are pitted *against* one another (Conflict Condition).

No-Conflict Condition

When shape and movement led to the same conclusion, children were able to draw inferences accordingly about 87% of the time (which is significantly above chance level). Children were ready to make judgments based on the coincidence of shape with movement.

Static Condition

Figures indicate that, in the absence of movement cues, children were ready to make inferences based on shape (80% of the time, which is significantly above chance level) as it became the only cue they could rely on.

A 4-way ANOVA was also performed, including condition (Conflict, No-conflict, and Static), age, category type (animals and geometric figures), and sex. There was a main effect of condition, $F(2,216) = 52.33$, $p < .005$. On average, children made judgments based on shape for 36% of the time in the Conflict Condition, which was significant lower than that in the No-Conflict Condition (87%) and the Static Condition (80%). No other significant main effects or interactions were found.

Discussion

The results clearly support our main hypothesis: Children are particularly sensitive to motion, and especially so with respect to the categorization of animals. Confronted with a choice between shape and movement, 4-year-old children tended to override shape and used movement cues to draw inferences. This is also true for the 7-year-olds when they made inferences about animals but not when they dealt with geometric figures. The 7-year-olds may begin to appreciate that movement is unique to animals. Similarity in movement becomes a good basis to infer properties about animals, but not in categorizing geometric figures.

This developmental change in young children would seem to be consistent with the development of alarm calls in young vervets. The baby monkeys often make false alarms. They cannot distinguish among predators (e.g., eagle), non-predators (e.g., ordinary birds), and falling leaves which move rapidly from the sky. Only as they get older do the alarm calls become more specific to the real predators. Likewise, as figures in the Conflict Condition indicate, the younger children drew inferences primarily based on movement regardless of whether the objects were animals or geometric figures, whereas the older children were able to use motion cues significantly more often to categorize animals than for geometric figures. With development, both children and young vervets are able to pick up the differences behind the characteristic movements of animals and non-animals and make responses accordingly.

The study presented here shows that motion plays a primary and supervenient role in early categorization. Motion becomes less important in the categorization of non-biological kinds only when children begin to realize the differences behind animate and non-animate movement. However, motion does not become completely irrelevant. As the data show, in drawing inferences about geometric figures when shape and movement were in conflict, the older children's judgments were still guided by movement about 45% of the time.

Although this study stresses the importance of perceptual similarity in early categorization, we do not wish to suggest that young children are purely perceptually driven. Evidence has shown that children as young as two years of age are able to override perceptual similarity and use their knowledge, beliefs, or 'theories', as Murphy & Medin (1985) put it, about the world to make judgments. Perceptual similarity, even including motion, is probably not sufficient to account for the development of children's category structure. Nevertheless, an understanding of the structure and development of the basic perceptual relations in children is important (Smith, 1989), and motion, we believe, plays a central role in the process of concept acquisition as well as in the mechanisms by which concepts are later structured.

References

Allen, C. (1996). Actions and objects: unequal partners in the evolution of communication. In G. W. Cottrell (Ed.), *Proceedings of the Eighteenth Annual Conference of the Cognitive Science Society*. Mahwah, New Jersey: Lawrence Erlbaum.

Banks, M. S., & Salapatek, P. S. (1983). Infant visual perception. In M. M. Haith & J. J. Campos (Eds.), *Handbook of Child Psychology*. New York: John Wiley & Sons.

Bertenthal, B. I. (1993). Infants' perception of biomechanical motions: Intrinsic image and knowledge-based constraints. In C. Granrud (Ed.), *Visual Perception and Cognition in Infancy: Carnegie Mellong Symposia on Cognition*. Hillsdale, NJ: Lawrence Earlbaum.

Bertenthal, B. I., Proffitt, D. R., & Cutting, J. E. (1984). Infant sensitivity to figural coherence in biomechanical motions. *Journal of Experimental Child Psychology*, 37, 213-230.

Bertenthal, B. I., Proffitt, D. R., Kramer, S. J., & Spetner, N. B. (1987). Infants' encoding of kinetic displays varying in relative coherence. *Developmental Psychology*, 23(2), 171-178.

Brown, A. L. (1989). Analogical learning and transfer: What develops? In S. Vosniadou & A. Ortony (Eds.) *Similarity and Analogical Reasoning*. New York: Cambridge University Press.

Bruner, J. S., Olver, R. R., & Greenfield, P. M. (1967). *Studies in cognitive growth*. New York: John Wiley & Sons.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Flavell, J. H., Miller, P. H., & Miller, S. A. (1993). *Cognitive development*. Englewood Cliffs, New Jersey: Prentice-Hall.

Freedland, R. L., & Dannemiller, J. L. (1987). Detection of stimulus motion in 5-month-old infants. *Journal of Experimental Psychology: Human Perception and Performance*, 13(4), 566-576.

Fox, R., & McDaniel, C. (1982). The perception of biological motion by human infants. *Science*, 218, 486-487.

Gelman, S. A. (1988). The development of induction with natural kind and artifact categories. *Cognitive Psychology*, 20, 65-95.

Gelman, S. A., & Coley, J. D. (1990). The importance of knowing a dodo is a bird: categories and inferences in 2-year-old children. *Developmental Psychology*, 26 (5), 796-804.

Gelman, S. A., & Markman, E. M. (1986). Categories and induction in young children. *Cognition*, 23, 183-209.

Gelman, S. A., & Markman, E. M. (1987). Young children's inductions from natural kinds: the role of categories and appearances. *Child Development*, 58, 1532-1541.

Gibson, E. J. (1987). Introductory essay: what does infant perception tell us about theories of perception. *Journal of Experimental Psychology*, 13(4), 515-523.

Gibson, E. J., & Gibson, J. J. (1991). The senses as information-seeking systems. In E. J. Gibson (Ed.), *An Odyssey in Learning and Perception* (pp. 503-510). London: MIT Press.

Haith, M. M., & Campos, J. J. (1977). Human infancy. *Annual Review of Psychology*, 28, 251-293.

Inhelder, B., & Piaget, J. (1964). *The early growth of logic in the child*. London: Routledge & Kegan Paul.

Kaufmann-Hayoz, R., Kaufmann, F., & Stucki, M. (1986). Kinetic contours in infants' visual perception. *Child Development*, 57, 292-299.

Kellman, P. J., & Spelke, E. S. (1983). Perception of partly occluded objects in infancy. *Cognitive Psychology*, 15, 483-524.

Medin, D., & Ortony, A. (1989). Psychological essentialism. In S. Vosniadou & A. Ortony (Eds.) *Similarity and Analogical Reasoning* (pp. 179-195). New York: Cambridge University Press.

Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. *Psychological Review*, 92, 289-316.

Piaget, J. (1929). *The child's conception of the world*. London: Routledge and Kegan Paul.

Roberts, K. (1988). Retrieval of a basic-level category in prelinguistic infants. *Developmental Psychology*, 24(1), 21-27.

Roberts, K., & Horowitz, F. D. (1986). Basic level categorization in seven- and nine-month-old infants. *Journal of Child Language*, 13, 191-208.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, 8, 382-439.

Seyfarth, R. M., Cheney, D. L., & Marler, P. M. (1980). Monkey responses to three different alarm calls: evidence of predator classification and semantic communication. *Science*, 210, 801-803.

Seyfarth, R. M., & Cheney, D. L. (1986). Vocal development in vervet monkeys. Animal Behavior, 34, 1640-1658.

Schunn, C. D., & Vera, A. H. (1995). Causality and the categorization of objects and events. *Thinking and Reasoning*, 1(3), 237-284.

Smith, L. B. (1989). From global similarities to kinds of similarities: the construction of dimensions in development. In S. Vosniadou & A. Ortony (Eds.) *Similarity and Analogical Reasoning* (pp. 146-178). New York: Cambridge University Press.

Wellman, H. M., & Gelman, S. A. (1988). Children's understanding of the nonobvious. In R. J. Sternberg (Ed.), *Advances in the Psychology of Human Intelligence* (pp. 99-135). New Jersey: Lawrence Erlbaum.