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# 14 Work Group on Perceptual Development

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## INTRODUCTION

The study of perceptual development focuses on the foundations of perception and traces the changes that perception undergoes with growth and learning. Thus from a developmental perspective on event perception, one seeks to discover the origins in infancy of the ability to perceive events, ways in which this ability changes during childhood, and the aspects of this ability that persist throughout development. Although the study of event perception is a relatively new field, a significant amount of developmental research has already been undertaken. In our discussion, we considered some of this research, in order to find out what has been learned and to identify directions for further investigation (see Gibson & Spelke, 1983, for further discussion).

Events are changes in the layout of the substantial surfaces of the environment, such as displacements and deformations. They have a beginning and an end, and are nested within other events (however, see Mace, this volume). Events are specified by information in ambient arrays, and usually this information is available to more than one perceptual system. Some events have consequences for an organism and provide certain possibilities for its action. In J. J.

Gibson's (1979, Ch. 8) terminology, they have *affordances* for behavior. For example, some musical events afford the possibility of synchronous rhythmic movement for humans. In addition, events can reveal the affordances of objects and places: the affordances of some objects may remain ambiguous until an observer encounters those objects within an event.

The above characterization of events leads to several questions concerning the development of event perception. When does the perception of events and their affordances begin, and how does it develop? Specifically, is the perception of events primary in development, or is it achieved on the basis of ontogenetically prior perceptions of static surface layouts? Is multimodal perception of events an early achievement or is it dependent on extensive learning of correlations between modality-specific sensations? Are some of the affordances of events and of objects immediately perceived and acted upon by infants, or are meanings attached to events over the course of development through an associative or constructive process? The expanding literature on event perception suggests that infants begin life with the ability to perceive events multimodally and to act on some of their affordances. Studies of event perception in childhood suggest that these abilities are refined and that perception becomes differentiated as the child actively explores the environment.

## EVENT PERCEPTION IN INFANCY

Despite the emphasis on infants' perception of unchanging two–dimensional patterns that has characterized most work on perception in infancy, it has long been evident that infants are attentive to events. For example, Wertheimer's (1961) early observation that his newborn daughter turned her eyes to look in the direction of an event that produced a sound suggested that exploration of events by the auditory and visual perceptual systems is coordinated at the beginning of life. Recent studies support this suggestion (e.g., Muir & Field, 1979) and indicate that coordinated visual and haptic exploration occur as well (e.g., von Hofsten, 1982).

Given that many events are specified by information available to more than one perceptual system, and that infants explore events with different perceptual systems in a coordinated fashion, the question arises as to whether infants perceive unitary events when there is information available multimodally. In a series of studies, Spelke (1976, 1979) has investigated 4-month-old infants' detection of optical and acoustical information specifying the temporal structure of events. The method developed by Spelke is to present infants with two movies side by side with the sound track corresponding to one of the movies centered between the two screens. A concealed observer records the direction of the infant's gaze, and preferential looking to the sound-specified movie is taken as evidence for bimodal perception of the unity of the event. Using this method, Spelke has found that infants perceive an audible and visible event as unitary based on certain characteristics of the event's tempo. For example, she found that infants who saw movies of two unfamiliar toy stuffed animals moving up and down, each arbitrarily paired with different percussive sounds, looked for the sound-synchronized object, even when the sound was not simultaneous with the object's impact on the ground. Thus fairly abstract properties of events, such as their tempo, can be perceived bimodally in infancy.



In further studies using this method, Bahrick (1980) investigated infants' intermodal perception of the substance of objects. She hypothesized that infants would perceive a single meaningful event (i.e., show preferential looking to the sound-specified event) only if both the acoustical and optical information specified an object of the same substance. She showed 4-month-old infants two films, one of two wooden blocks hitting each other and one of two wet sponges hitting each other. The blocks had a sound track of "clacking" noises and the sponges had a sound track of "squishes." She found preferential looking for the sound-synchronized film only when the optical and acoustical information for the object's substance specified the same kind of thing. Apparently the infants could perceive the substance of the objects both through the motions and the sounds, and they perceived a unified event only when the two sources of information were consistent.

Walker (1982) has shown that 5- and 7-month-old infants can perceive the unity of a movie of a person speaking expressively (happy or sad) and its appropriate sound track, also by using the preferential looking paradigm (see also Dodd, 1979; Spelke & Cortelyou, 1981). In investigating the information used in perceiving this event, Walker found that it was not merely a simple timing relation, because the appropriate preferential looking occurred when the movie and its sound track were out of synchrony; nor was it simply the level of activity because the preferential looking was not found when the movies were presented upside down. Walker suggests that it is the mutual affordance that links the two presentations as one event. Finally, Born, Spelke, and Prather (1982) have found that newborn infants, as well as 4-month-olds, detect the intermodal relation when they view a person speaking and a musical performance, and hear a sound that is specific to one of them. Although further work needs to be done to discover what information is being used by the infants, all of these studies, and many others, demonstrate intermodal perception of events by very young infants. Intermodal perception of events is not dependent on extensive learning about the correspondences between modalities; rather, it appears to be a fundamental perceptual ability by which infants explore and obtain knowledge about the world.

Studies of the perception of the affordances of events have revealed that quite young infants perceive some of their affordances and act upon them appropriately. In studies of visually guided reaching, von Hofsten (von Hofsten, 1979, 1980; von Hc1979) has shown that infants will reach for moving objectcuracy, and begin to do so at least as early as they reach fo Infants adapt their reaching to the object's motion, reachon that the object will occupy when their arm is fully extenddapt their reaching to the speed of the object, even the first object moving at a given speed, limiting their reaching atterhey can, in fact, catch (von Hofsten, 1979, 1980). These t infants accurately perceive when a moving object affordslating and that they coordinate their actions to realize those ;

Objects mways afford catching, but objects moving in other ways aord collision. Investigations of reactions to approaching ( have revealed that infants as young as two weeks will blive an approaching obstacle. Later on, infants also withdraw object (Yonas & Granrud, 1981; cf. Ball & Tronick, 1971 & Moore, 1971). However, when 3-month-old infants perture, a surface that approaches an observer rapidly but ath safely, they show no defensive reactions (Carroll & Givents involving the approach of objects that afford either or safe passage are discriminated and acted upon approprinment, within the limits of the available action systems.

Another im be seen is that of oneself moving through the environment. motes, information for its own path of movement is givenm of optical flow (Lee, 1980). Studies by Lee and Aronson worth (1981) indicate that infants and toddlers use optical ineir postures and control their movements; that is, they bothl the event of their own swaying. In these studies, childvith optical information specifying their own forward or balobal optical flow with foci of expansion and contraction atns of a "swinging room," whose walls and ceiling moveand forward. The children compensated for their apparenting in the opposite direction, or at least by attempting to ly toddlers this often meant a complete loss of balance, indion optical information in responding to this event, even vc and proprioceptive sources of information specified stab

Events alsc of objects and this is a topic that holds great promise for ro static displays, events can reveal the boundaries of an objportant properties such as its elasticity, mass, and animacy ohansson, von Hofsten, & Jansson, 1980). Research by K79, 1981) has shown that 4-month-old infants



perceive the unity of an object whose center is occluded when the object undergoes a translatory motion but not when it is stationary. Using an habituation-dishabituation paradigm, they found that infants habituated to a stationary rod, when the center of the rod was occluded from their view, showed moderate and equal dishabituation to both an unoccluded broken rod and an unoccluded complete rod. However, those infants to whom the rod was presented translating behind the occluder during the habituation phase behaved like a control group who saw an unoccluded complete rod during habituation, showing dishabituation to an unoccluded broken rod and showing little interest in an unoccluded complete rod. Thus the motion of an object provided information about the boundaries of an object in the region where it was hidden.

Studies by Gibson and her students (Gibson, Owsley, & Johnston, 1978; Gibson, Owsley, Walker, & Megaw-Nyce, 1979; Walker, Owsley, Megaw-Nyce, Gibson, & Bahrick, 1980) indicate that infants can perceive the rigidity or elasticity of an object through deformation events. In one study, they habituated 3½-month-old infants to a foam rubber object undergoing three rigid transformations and then compared looking times to a novel rigid transformation with looking times to a novel nonrigid transformation. They found that infants viewing the former transformation continued to demonstrate signs of habituation, but infants who saw the nonrigid transformation became dishabituated. Parallel experiments with deforming, elastic transformations yielded similar results. These findings indicate that infants can detect several different types of optical transformations that specify the substance of an object. Combinations of properties such as elasticity constitute the affordances of objects, and recent evidence indicates that these may be perceived and acted upon by young infants (Gibson & Walker, 1982).

In sum, the evidence from many different studies leads us to conclude that infants perceive events from the beginning of life and that these events inform them about possibilities for action, aspects of their own movement, and the properties of objects. Further research is needed to specify the information infants use in perceiving events, especially in intermodal perception, and research is also needed to investigate perception of the various properties of events through all of the perceptual systems.

## TRENDS IN THE DEVELOPMENT OF EVENT PERCEPTION

Event perception undergoes clear and striking changes with learning and development. Some of these changes are revealed through observations of the child's changing patterns of exploration of events. Others are revealed through investigations of the child's changing ability to detect the information for events. In the course of development, exploration becomes more systematic, and perception becomes more differentiated and economical. Most important, the child comes to discover progressively higher order structure and meaning in events.

From the beginning of life infants have a small but effective repertoire of investigatory activities such as moving their eyes and heads, listening, and mouthing; and they can use these activities to discover properties of the environment. The development of infants' visual exploration skills recently has been a subject of much study. It has been found that when a display suddenly appears as far as 30° in the periphery, even one-month-old infants will localize it accurately (Aslin & Salapatek, 1975). It has also been shown that infants are especially apt to look at a target in their peripheral field of view if it moves (Tronick, 1972), but they do so by making a series of inefficient saccadic movements. With age, both the accuracy of the localization and the efficiency of the scanning improves. The improvement is gradual; children continue to localize and to track targets less efficiently than adults throughout the preschool years (Kowler & Martins, 1982).

The increase in the efficiency of eye movements is paralleled by the increase in the efficiency of reaches to moving objects found by von Hofsten (1979). Younger infants (18 wks.) make a series of jerky movements to reach a target while older infants (36 wks.) make a fairly smooth reach. Reaching continues to undergo developmental change throughout the first year (see, for example, Piaget, 1952; Bresson, Maury, Pieraut le Bonniec, & de Schonen, 1977), and the perceptual guidance of manual skill continues to develop through childhood.

All of the experiments mentioned indicate that infants explore events from the beginning of life in systematic, though limited ways. The infant's capacity for exploring events is especially clear in experimental studies in which actions in the infant's repertoire control the presentation of environmental events. One of the earliest developing exploratory actions is mouthing. Infants explore by mouthing nearly from birth (see Piaget, 1952), and it is likely that they can detect object properties such as texture and substance by mouthing long before they detect them by manipulation. For example, infants detect correspondences between the sight and touch of a rigid or flexible object by one month of age, provided that the object is placed in the mouth (Gibson & Walker, 1982). This is the case even when the optical information for the object's substance is available solely through motion. Because manual exploration does not become skillful before 10 or 12 months, infants do not detect the same intermodal relation when they hold an object in the hand until many months later (Gibson & Walker, 1982).

A large number of experiments indicate that infants as young as one month will engage in active sucking when that sucking provides information about events. For example, infants will suck to bring a motion picture film (a representation of an event) into focus (Kalnins & Bruner, 1973). Similar results have been found with speech or articulatory events (e.g., Eimas, Siqueland, Jusczyk, & Vigorito, 1971). Thus active sucking appears to be an early developing activity by which infants can explore events. Older infants are less apt to suck to produce visible or audible events, presumably because other exploratory systems become available that are more effective.



These studies all indicate that exploratory activities change and develop, as do other patterns of activity. As children come to explore with increasing accuracy and efficiency, they will be able to detect more and more of the relevant properties and affordances of events. We consider a few examples.

In the course of development, children appear to distinguish ever more finely among events. A good, but little studied, example concerns the perception of moving objects. In baseball, skilled batters differentiate with awesome precision among pitches thrown at different speeds, with differing paths and amounts of spin, and skilled fielders are similarly adept at perceiving the trajectories of balls hit into the air. All of us come to achieve some skill in detecting differences in the patterns of motion of a ball. The development of such abilities should prove a fascinating area of study. Ball playing skill is just one illustration of the pervasive tendency of perceptual development toward greater differentiation: an increase in the specificity of discrimination of information (Gibson, 1969, Chs. 6, 20). Furthermore, since events typically are embedded in other events in superordinate and subordinate relations, there are many levels for potential differentiation.

Children also come to perceive events more efficiently. The perception of speech provides an example. Recent evidence seems to indicate that infants discriminate more potential phonemic differences than they will as adults. Experience with a language eventually leads to discrimination of only those sounds that create meaning differences in the language; differentiation within the total potential set improves resultant efficiency (see Jusczyk, 1981, for a review).

Another trend in perceptual development is for children to become increasingly able to detect the higher-order structure in events. An example of perceiving the higher-order structure of an event is perceiving a theme and variations in a musical piece. This is an ability that develops across the life span and is just beginning to be studied from the viewpoint of a developmental perspective on event perception (Pick, 1979). In perceiving music, as in perceiving speech and other events, children become progressively more sensitive to higher-order relationships that unify a complex sequence of changes over time (Gibson & Spelke, 1983).

Finally, children learn more about the affordances of events and they become increasingly able to produce events that reveal the affordances of objects (Gibson, 1982). For example, toddlers and older preschool children are especially apt to play with objects in ways that reveal their affordances. They bang blocks on tables, squeeze clay into multiple shapes, tear and crumble paper, and so forth (Piaget, 1952, 1954, provides many revealing examples). They also discover the special functions of more complex, jointed objects, such as levers, through active exploration and manipulation (e.g., Koslowski & Bruner, 1972). These ctivities hold special promise for studying how affordances come to be per-eived.

## CONCLUSIONS

esearch on event perception in infancy has established that humans begin to xplore and perceive events at the beginning of life, and that this capacity rovides a foundation for many other aspects of perceptual development. This esearch indicates, moreover, that event perception becomes increasingly differ-ntiated and efficient with development, and that children become increasingly ensitive to the higher-order structure and the affordances of events. As percep-ion develops, it continues to be tied to the child's actions.

We have pointed to areas where more developmental research is needed. In losing, we wish to give one of these areas special emphasis. During infancy and hildhood, humans discover more and more of the affordances of the world. Affordances appear to be discovered primarily through events, as children act on bjects to transform them and detect the information provided by these transfor-nations. Perception is directed to the affordances of events, objects, and places hroughout life, and is adaptive only in so far as the perceiver comes to have seful knowledge of these affordances. Studies of the growth of knowledge bout affordances in infancy and childhood should shed light on this central spect of perception. To date, few studies of the development of the perception f affordances have been conducted. Nevertheless, they provide one illustration f the special contribution to the understanding of event perception that a devel-pmental perspective can give. Specifically, a developmental perspective pro-ides a clearer view of skill acquisition and perceptual learning than do experi-nents with adults, precisely because it focuses on the young organism as a impler, less skilled actor-perceiver. Thus developmental findings can offer rich nsights into the acquisition of various types of special expertise by children and dults, and can help to resolve major theoretical controversies about the founda-tions of perceiving, acting, and knowing.

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# 15 Work Group on Perception and Action


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The work group on perception and action was concerned with those eve Gibson called "encounters," that is, events that involve an organism's tual-motor activity. Like inanimate events such as rotation or breaking, ( ters may be described in terms of structural and transformational invarian temporal period over which the event transpires (see Warren & Sha volume). However, the work group was concerned less with how acti specified to an onlooker than with how actions are appropriately selec detection of affordances) and tailored to local conditions (the perceptual of activity) by the participant. As Lee put it, the problem is one of disc perceptual information *about* and *for* the act.

The group focussed on the problem of how an action system might lated by perceptual information specific to the dynamic requirements o We found ourselves returning again and again in this discussion to thre questions. First, what perceptual information is necessary to guide ar Second, what in the basic design of the motor system allows perceptual tion to guide it? And third, how does the action system adapt to change tions, and what is the role of perception in guiding adaptation? Here w discuss each of these issues.