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ABSTRACT

Goals and challenges pertaining to infant sensory and perceptual development are discussed. It is suggested that the inability of researchers to think and talk wisely about "partial accomplishments" in development creates a barrier in developmental research. Conceptual schemes are needed to accommodate these partial accomplishments. Three major points are emphasized: (1) research needs to move beyond its dichotomous paradigms and categorical concepts to formulate a more graded and sensible picture of perceptual development in infancy; (2) researchers must rise above questions about discrimination and move toward examining the functional role of perception in action and cognition while trying to link the infant perception research with that of the rest of the human species; and (3) researchers need to pay more attention to the rising tide of biological and computational approaches to perception, which will require extensive effort in training of the new cadre of graduate students and postdoctorate researchers. Contains 26 references. (LB)

Setting a Path for the '90s: Some Goals and Challenges

Infant Sensory and Perceptual Development

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(Note: This paper was written for oral presentation and is circulated as such for the convenience of the reader. Some graphs and references may be missing)

This is really exciting. You don't know how long I have waited to be able to tell the rest of you what to do with yourselves for the next 10 years.

I want to start by telling you about a barrier that affects our research. The barrier is our inability to think and talk wisely about what I call "partial accomplishments" in development. We have been too categorical in conceptualizing infant skills. Let me use visual pattern organization to make the point. Generally, we attribute pattern organization to babies only after about two months or so of age. Such organization requires that babies appreciate the relations among elements that comprise a pattern. For example, in the pattern shown here (from a study by van Giffen & Haith), a viewer must appreciate the relations among the separate dashed segments to realize that the out-of-line segment is, in fact, out of line. At 3 months of age babies look more in the region of the odd segment than in other places, suggesting that they detect that something funny is going on, but 1 month olds do not. A lot of other data converges with the notion that babies acquire an ability to perceive pattern organization sometime between 1 and 3 months of age, and we chalk up this skill as one of the baby's early accomplishments. But a little thought, or a visit to the local art gallery, will convince almost anyone that this is not the end of the developmental story; even as adults, it may take time and education for us to perceive relations among elements of a complex display and to appreciate the full pattern. We have shown the subjective contour displays in the following slide to babies in several paradigms and find that babies respond differentially to the subjective-contour display at 7 months, but not at 5 months or less. The point is obvious: Babies pick up some patterns before others. However, we don't talk or think that way. The number of studies that have been done to answer yes/no to the visual pattern

question are legion; the number to answer the developmental question about how pattern perception develops is close to zero. The reason? We tend to think in a categorical form: Babies have pattern organization, or they don't. Too often, we take as our task finding the earliest age at which a skill can occur, not to understand how it unfolds, and our thinking has likewise been corrupted.

Slides from Van Giffin and Haith

and Bertenthal et al., about here

The problem is that we find a shred of evidence that a piece of a process is functional and then infer that the whole process is intact, at least implicitly. But, we only have evidence for what I call a "partial accomplishment," and we need conceptual schemes that will accommodate these partial accomplishments. This problem is certainly not unique to pattern perception. In our "heart of hearts," we do not believe that our statistical demonstrations of infant discriminations of such things as mother's and stranger's voices, or "ba" and "pa," or one color and another, or one number-set and another number-set, implies anything like the adult perception of the dimension at issue. Yet, we <u>talk</u> about our demonstrations as though this is so. This state of affairs produces serious problems for people to understand us when, for example, we claim that infants "have" size constancy by 4 months of age at the same time that research on older children demonstrates that size constancy improves up to 10 or 11 years of age (Day, 1987).

A similar kind of dichotomy exists in our thinking about brain functioning. Either the visual cortex is functional at birth, or it is not;

the prefrontal cortex is operative in early infancy, or it is not. Our metaphor for brain functioning is the light switch. At some age, it turns on. Seldom does one come across a discussion of how especially higher brain areas might function in a rudimentary form before they supposedly come online.

The problem is even more complex than our not appreciating the way stations to mature skill. In addition, we often fail to recognize that a baby might "have" a skill at one moment and not the next. Think back to when you were learning trignometry or calculus and those experiences you had of having it and then losing it. I suspect that if we could get inside the baby's head, we would find perceptual and perceptual/cognitive oscillations during periods of transition for such phenomena as size constancy, face and number discrimination, and voice discrimination, and that parallels probably exist for changing brain functions. Performance variance is probably not error, but rather, quite real.

I suppose the problem is that we lack concrete metaphors or complete articulation of what development consists of in these domains. Consider a case for which we do have a good metaphor. We know that when we say a newborn can see, we do not imply adult-level visual acuity. We understand what development must be like, because we know what out-of-focus means and can think about "partial accomplishments" on the way to adult-scale performance[2]. And the result has been beautiful research on visual acuity and the development of spatial frequency. The slide shows estimates of visual acuity at different ages, based on visual preference paradigms, on Teller's forced-choice procedures, on evoked potential paradigms, and on OKN. One sees continuous development, not a step-function relation, converging on newborn acuity of around 20/500 and improvement by about six months to around 20/40.

It will be quite a while before we can formulate analogues and concepts that will permit us to think about partial accomplishments in other domains at comparable levels. But, until we do, I believe it is important for us to recognize and communicate that our experiments are not demonstrating full-blown competence in perceptual domains, only some sensitivity and only discriminatory sensitivity at that.

Slide from Dobson and Teller about here

I consider the attack on this barrier to constitute one of our challenges for the 90's. While I believe this is a general problem across all areas of infant development and a lot of areas across developmental psychology, it is especially acute within the area of infant sensory and perceptual development. We are too focused on demonstrating at what age babies have skills and when they happen -- skills such as smell, taste, touch, auditory perception of phonemes, and visual perception of color, pattern, form, and texture. These skills are exciting to hear about for the press, the lay public, and even ourselves. But now that we have convinced everyone of how wonderful the baby is, it is time to begin the hard work of figuring out what the baby's perceptual world is really like at different ages. To do so, we are going to need data and some analogues and concepts that will permit us to lay out Station points along the continuum of skill from partial to complete for each perceptual domain. You might summarize this argument by saying that we need to get development back into developmental psychology.

My second pony concerns the infants' functional use of perceptual skill. There are a couple of issues here that relate to our recognized tendency over

the decades of the 60's, 70's, and 80's to approach the study of perception with stripped-down stimuli -- for example, clicks, pops, tones, and phonemes, in audition, and lights and colorless, two-dimensional, static patterns in vision. Not only did we try to simplify our perceptual exhibits for the baby, but we treated perception as isolated from anything else; certainly, considerations of cognition and action played minor roles in our studies. Thus, we essentially have a catalogue of capabilities, based on impoverished stimuli, with very little sense of the functional value of these capabilities to the infant. I suspect that we find ourselves in this position because of our obsession with paradigms that focus on discrimination. These discrimination paradigms have appropriated our concepts, so that we think of the baby as a chooser and discriminator, not as a functional user.

Things are changing. It is clear to me that the whole field is moving toward the study of perception in more dynamic situations. The push has come from many directions. Eleanor Gibson and her students have compellingly argued that the world is a dynamic place (Gibson & Spelke, 1983). Investigators are now questioning the elementist assumptions that perceptual motion and change are simply added dimensions to color, intensity and form, which make the infant's perceptual task more difficult (Nelson & Horowitz, 1987). Much of the work in the dynamic tradition has exploited intersensory perception. Young infants are sensitive to the visual-sound correspondences of changing events and to the specific sound properties of visually colliding objects (Bahrick, 1988; Spelke, 1987) and even to the isomorphism between speech sounds and the lip movements that produce them (Kuhl & Meltzoff, 1989).

However, the interest in "dynamic perception" has been heavily weighted on the input side. The output side of the equation and the consequences that

perception has for action (and vice-versa) have been relatively ignored, an interesting irony given the extraordinary burden that theorists place on action for the infant's acquisition of knowledge about its world. Here, too, change is on the horizon. Much of the newer work is organized around the onset of self-produced locomotion (creeping and crawling) and its consequences for spatial perception and goal orientation (Benson, in press; Benson & Uzgiris, 1985; Campos, Svejda, Campos & Bertenthal, 1982) and the development of reaching and catching (von Hofsten, 1988). But we also need to think about the interactions between perception and action in other domains such as sucking, eye movement, reaching, sitting, standing, cruising and walking. As Herb Pick (1983) put it, "We perceive to act and we act to perceive." To take this proposition seriously, we will need to develop better tools for thinking about, recording and analyzing ongoing, dynamic behavior in real time. Recent advances in approaches to this problem bode well for the future, and the adaptation of biomechanical and kinematic procedures provides a quantitative and representational base that should provide comfort to the more experimentally inclined (Benson, 1990). Ultimately, we are not going to be able to talk about perceptual development meaningfully, until we can rise above questions about discrimination and characterize how the baby applies his or her perceptual skills in the real world.

I see an urgent need to unite theory, concepts and methods that have been used with older children and adults with those that are used in infancy. It is remarkable how large the gap is between the papers that are written in the field on infants and those that are written on post infancy, almost as though infants were another species. (Skip: Exceptions to this tendency do exist in the domain of basic sensory processes and in a few papers on

information-processing analyses [e.g., Olson & Sherman, 1983]). Part of the problem has been the vastly differing methodologies that have been applied and, again, the preoccupation of infant researchers with relatively static discrimination measures. A trend that may help is the extension of perceptual studies more toward the interface between perception, action and cognition. One example is the work in which dynamic perceptual settings and eye movements are used to study future-oriented behavioral processes, such as how young infants form expectations about future events (Haith, Hazan & Goodman, 1988; Smith, Arehart, Haaf & de Saint Victor, 1989). A second example is von Hofsten's elegant research which nicely marries questions about visual perception, reaching and expectations (von Hofsten, 1980, 1988; von Hofsten & Ronnqvist, 1988). Cognitive theories depend extensively on notions of expectations. When we think of perception as important for organizing a dynamic flow of information, rather than as a system that responds to a stimulus, and when we realize that both ongoing mental and physical activity depend on forecasting aspects of that flow, it seems clear that we are going to have to move toward a concept of infant perception that fits more closely with notions of the perception-cognition interface that have been developed for adults.

An obvious direction for future research is the relation between perception and brain development. Some progress has been enjoyed in this domain in the sphere of evoked potentials, but I believe the future will belong to the new generation of imaging techniques, for example the MRI for studying structural development of the brain and PET scanning (Chugani & Phelps, 1986) for understanding specific areas of brain involvement for various functional tasks.

Relatedly, I expect concepts that have been developed in more neurophysiological approaches to perception with animals to find increased currency among developmental psychologists. Already, researchers have found insights in the work of such people as Hubel and Wiesel and Goldman-Rakic (Banks & Salapatek, 1983; Diamond & Goldman-Rakic, 1986; Haith, 1980; Karmel & Maisel, 1975). Greenough, Black and Wallace's notions (1987) of experience-expectant and experience-dependant synaptogenesis in the brain provide an example of concepts that have promise for accommodating a variety of known effects of early experience on perception.

We face a real problem, however, in producing the generation of psychologists who will mine the potential by combining the new wave of biotechnology with developmental theory and knowledge of perceptual processes. There is, at best, a very small cadre of senior researchers who possess the requisite combination of talents to train this new generation. Whether hybrids can be generated through students who work among mentors who have components of the mix is a real question. Regardless, the creation of the needed generation of scientists will require a long period of time, unless some new training models are created as well as federal encouragement through new funds.

Related to these neurophysiological orientations is a rising interest in computational perception, including the ground breaking work of Johannson (1973) and the current wave of interest in neural modeling and parallel-distributed processing models of perception (and of several other processes). Connectionist models also have potential for helping us to formulate a new metaphor for both partial accomplishments and perceptual oscillations. I can only take a neutral stand on whether this movement will significantly impact

our field. But, researchers should familiarize themselves with these approaches; neural modelers have paid too little attention to development, and developmentalists have been paying too little attention to neural modelers.

Let me summarize the major issues that I have highlighted as important challenges for the 90's. First, we need to move beyond our dichotomous paradigms and categorical concepts to formulate a more graded and sensible picture of perceptual development in infancy. Second, we must rise above questions about discrimination and move toward examining the functional role of perception in action and cognition while trying to link up the infant perception work with that of the rest on the human species. Third, we need to pay more attention to the rising tide in biological and computational approaches to perception which will require an extraordinary effort in training of the new cadre of graduate students and postdocs.

Now that I have charted your paths for the next 10 years, a caveat. If my own grant applications are any guide, I can't even predict my research directions in three-year bites. Still, maybe I can do better in telling others what to do. We'll see.

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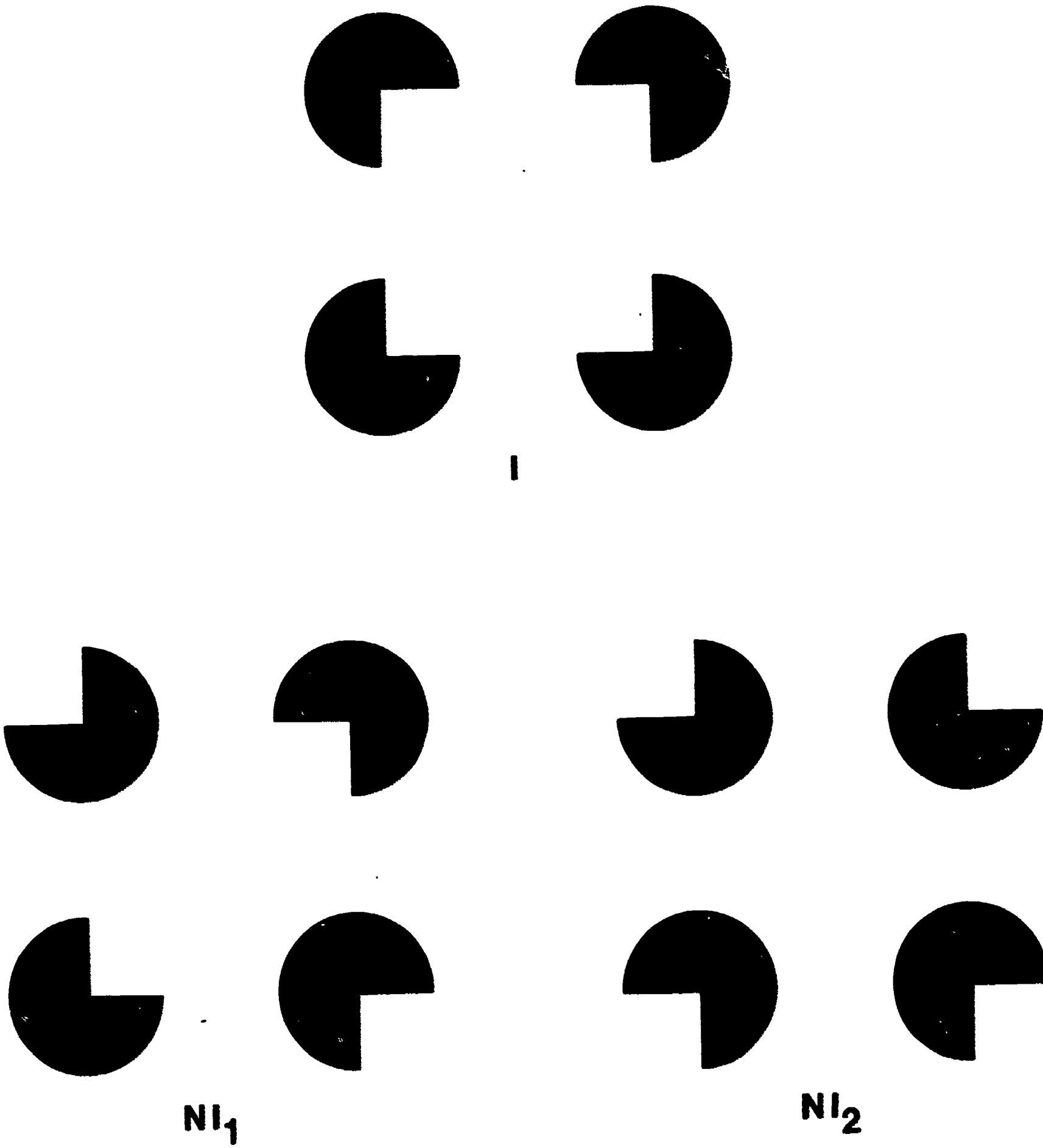

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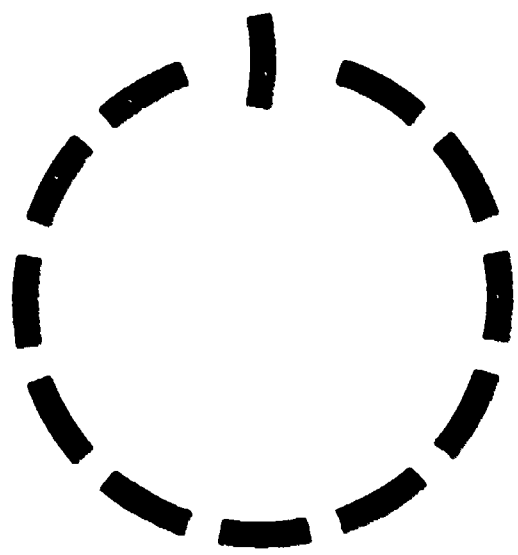

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