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THE DEVELOPMENT OF THE ORGANIZATION OF INFANT CRYING: A DYNAMIC SYSTEMS APPROACH

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A description of some aspects of the development of infant crying was presented by adopting a dynamic systems perspective. Of particular interest were (1) The temporal organization of individual vocalizations and pauses within one cry bout, in relation to the length of respiration cycle, and (2) The integration of vocalization, and other motor skills of the infant to form a system of communication and control in the early months. Contrast between some features of crying vocalization observed immediately after birth and at later ages was made. It was suggested that the dynamic systems approach was useful in understanding the development of crying as action, the construction of which started at the kinematic level and the final movement or action was a combination of patterned voices, in coordination with movements of limbs and body. Implications of this perspective for understanding development in other domains was discussed.

Key words: action; coordinative structure; dyanamic systems theory; infant cry

Introduction

Infant cry has attracted the attention of the investigators for obvious reasons. Not only is crying a matter of practical concern for the parents and the care givers, it also suggests other possibilities to psychologists and the medical professionals. For example, it has entertained great hope in providing clinical clues for making diagnosis of diseases and dysfunctions of central nervous system of the infants (e. g. Karelitz and Fisichelli, 1962, Wasz-Hockert, Lind, Vuorenkoski, Partanen, and Valanne, 1968, Golub and Corwin, 1982). Some psychologists argue that some aspects of infant crying are indicative of some characteristics of infant temperament and the maternal sensitivity in infant mother relationship (Bell and Ainsworth, 1972, Bates, Bennett-Freeland and Lounsbury, 1979). Infant crying also appears to some investigators in language development as a natural starting point for the achievement unfolded a few months later (c.f. Stark, 1980).

In this paper, a different viewpoint from those mentioned above will be adopted. The approach is based on the dyanamic systems approach (Thelen, Kelso & Fogel, 1987). In adopting this view, the development of infant crying is to be examined from the point of view of the development of the control of movement. This perspective is derived from contempory theories of motor control to " view skill as a multidimensional, emergent

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phenomenon" (ibid, p. 40). In the description that follows, the development of infant crying is considered to begin at the kinematic level of making adjustment between vocalization and respiration, and to end where vocalization is voluntarily controlled by the infant to serve not only as a means of announcing that something has gone wrong, but also as a means of proximity seeking and making more specific demands. The kinematic level mentioned above is not an arbitrary starting point, for the infant is born with the ability to respire and to vocalize. That is, vocalization and respiration can be regarded as two initial, basic units of behavior for our purpose here. In this connection our present task is to try to give an account of how the integrated action of crying as will be observed at a later age begins to be constructed out of the few given "units." Of course, the description has to continue beyond the starting point to cover the process through which crying becomes goal-directed action.

One basic and fundamental notion underlying the dynamic systems approach is that of "*functional synergy*" or "*coordinative structure*" (Easton, 1972). As a solution to the so-called degree-of-freedom problem, this concept suggests that coordinated movement is constructed from a limited number of some sub-structures each of which is in charge of only a discrete part of the final motor sequence. Central to this concept are several points such as the primacy of function in defining the constraints on the units of actions, the special systems quality of coordinative structures in which order and regularity emerge from the unique relationships among the elements, but are not readily predicted by the elements themselves (ibid, p. 43). Also much emphasized is the recognition that movement outcome could not be predicted by muscle forces alone, but was the ensemble result of both muscular and nonmuscular forces, including the inertial and reactive forces from the moving body and forces associated with contact with the supporting surface and medium (ibid). A final point concerning the nature of cooperative systems that has profound developmental implications is the nonlinearity of their modes of change. A frequently used illustration is the gait patterns of horses (Tuller, Turvey, and Fitch, 1982). The issue here concerns with whether the discontinuous transition is accomplished by, for example, switching to a new motor program or a gait prescription that exists in the CNS, as some traditional formulations will have it. The dynamic systems approach argues that there is no preexisting plans for the different modes, nor is the transition realized by some kind of switching. However, the phenomenon is commonly found in nature, in physical, chemical and biological systems. The phenomenon of discontinuous phase shift at critical point in a continuous scalar is to be understood as the inherent geometry and its organization as a dynamical biological system (Thelen, Kelso, and Fogel, 1987).

In recent literature, such examples as from facial expression movements, spontaneous stereotypies, the development of reaching, the development of hand gestures are given to illustrate the concept of coordinative structures and the dyanamic systems approach (see Zivin, 1985; Thelen, Kelso, and Fogel, 1987).

In this paper, an outline of the development of infant crying behavior will be sketched by applying some of the ideas derived from these theories. As a preliminary attempt, only two main points will be addressed, namely (1) The coordination of vocalization and respiration, and (2) The integration of vocalization and other motor and

cognitive skills into crying as an action.

Coordination of Vocalization and Respiration

Among the various aspects of infant crying, the observation to be made here is that the first qalitative change in the vocalization of the very young infant appears in the infant's capacity to coordinate vocalization with respiratory movements. Observations of the temporal organization of the birth cry vocalization suggest that it is characterized by (1) irregularity of vocalization duration, (2) segmentation of vocalization within one respiratory cycle, (3) relatively short bout duration in which the number of rhythmic vacalization is small. These features are especially obvious at the few beginning vocalizations of each bout. In addition, unlike crying vocalization observed a few hours or days later, birth cry vocalization tends to occur not at the beginning, but the end or the middle of a respiratory cycle. This is reflected in the frequent occurrence of extremely long vocalization, the lack of " audible respiration " and the prevalence of inspiratory vocalization. A further observation to be mentioned in this connecton concerns with the way the amount of time for vocalization and for inspiration is distributed within one respiratory cycle. As the first vocalization of birth cry tends to be very long, sometimes stretching over 7 or 8 seconds, the infant often tends to overtax its inspiratory capacity so that little or no time is left for inspiration neccessary for the next vocalization. This situation seems to be attributable to three factors: (1) The first is the fact that infant immediately after birth is not so skillful even at this vital task of respiration as it may soon becomes a few hours or days later. (2)The second is the fact that immediately after birth, vocalization tends to be triggered by startles, convulsion-like movements of the limbs or body (causing loss of balance) or by small irregularities of the respiratory movements. As these proprioceptive stimuli do not seem to be predictable nor is the newborn good at expecting and coping with them, the first vocalization tends to be executed without enough preparation. (3) Thirdly, the fact that once the first vocalzation begins, its temporal dimensions are fixed, as if a spring is set in motion. The extra force has to be dealt with (" absorbed ") by subsequent respiratory and vocalization cycles.

A few hours or days later, the beginning vocalization of the infan's cry tends to be preceeded by audible respiration or by obvious air-drawing movement and the vocalization ended with enough time for the next inspiratory movement. As a result, vocalization duration tends to become less variable and no extremely long vocalization under normal circumstances. After the first few days, when extremely long vocalization does occurrs (as a result of acute pain stimulation), it is always preceded by strong expulsion of air.

Based on these observations, perhaps the birth cry can conveniently be termed *"passive crying mode "* to distinguish it from the *" active crying mode "* later on.

Since the vital capacity of the infant is more or less invariant (as a result of the constraint imposed by the anatomy of human infant) and the task of vocalization is a set task (in the sense that once the newborn infant is activated to made vocalization of a certain intensity and length, it has to continue to cry for some time), the infant is faced with a taxing task of having to fulfill the demands from both vocalization and respiration with limited resources.

The change from " passive crying mode " to " active crying mode " is brought

forth by the improvement in the way respiration is managed and in the coordination between vocalization and respiration. As these changes occur whithin a few hours or days, it seems reasonable to assume that practice, rather than maturation, is the main factor.

Integration at multilevels

The next issue to be discussed concerns with what is called one of the cardinal rules of development, namely that the spontaneous behavior of the infant contains the bits and pieces of adult voluntary action (Trevarthan, 1982, Thelen, 1985, p. 227).

Observations of birth cry behavior show that although some movements of the body or limbs, including hand to face or mouth movement, were observable preceeding the utterance of sounds, no particularly obvious pattern or state change seem to be associated with voclaization. However, on the second or third day, if not earlier, hand to mouth movement and head movement are frequently observed before and after vacalization, together with kicking or stretching which was also present at birth. It is not the appearance itself, but the apperance in a certain order, in relation to vocalization that is to be considered evidence of integration. Now, the infant would begin its crying by short adjustment of the respiration which becomes audible when reaching a certain rate, followed by several vocalizations which are irregular. The crying will either dimish or continue to build up by slightly shorter and regular series of vocalizations. At the end of this phase, vocalizations of longer duration (500 to 800 msec) appear, as if to set a model for later more sustained rhythmic vocalizations. At the end of a cry bout, the infant either becomes drowsy or falls into sleep or begins to move its limbs toward the face or mouth area (even when feeding time is yet to come). Failing to be satified, the infant begins again the sequence as described so far.

At two weeks, if not earlier, one addition which begins to be observable is the exploratory vocalizations. These are single inflected vocalization usually uttered after several phonated respirations and glottal plosives and before the escalated rhythmic full blown cry vocalizations. Another change of behavior at this time is a more complex structure of crying behavior sequence, consisting of repeition of short series of glottal plosives, phonated respirations and exploratory vocalizations, increasing in intensity and in the bout length each time, with short pauses during which infant's searching behavior (turning from side to side or orienting toward sounds) and listening were observable. The appearance of short pauses, searching behavior, listening and the increase in responsiveness toward sounds in the environment before the infant reaches a sustained rhythmic vocalization phase are supported by the infant's development in various domains such as its cognitive ability (in perceiving and discrimination), its ability for state regulation, and for holding the goal and working toward its attainment. The integration seems to suggest the completion of a more economic (therefore, effective) system for communication and control.

Conclusion

Both the progress from the passive crying mode to the active crying mode and the gradual integration of different elements at different levels illustrate the notion of coordina-

tive structure as proposed by the dynamic systems approach. To be granted, the above is too sketchy an illustration. The main purpose of this paper is to suggest that as are true with the cases of the development of stereotypies, reaching, manual gestures and facial expression, our understanding of infant crying can also benefit from the motor action theories.

In this model no mention was made about the role of the environment in facilitating or shaping the later outcome. The description attempted above focused only on the intra-organic aspects of the development. But what is the role of the environment in facilitating or eliciting new forms of coordinative structures? If the infant-mother dyad or the infant-mother-sibling triad, etc. can be conceived as developing systems, further insights can be gained by applying the dynamic systems approach. Indeed, this seems to be the message in Thelen, Kelso, and Fogel (1987).

Needless to say, further research will be necessary to substantiate the view proposed here. It is hoped that not only this will be accomplished in the near future but also that the approach will contribute to the understanding of development in other domains too.

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