NOTES ON A DYNAMIC SYSTEMS APPROACH TO THE STUDY OF DEVELOPMENT OF INTERACTION IN HOLDING AND BEING HELD

Shing-Jen Chen
Hokkaido University

Abstract

This paper presents an outline of a research program for studying the developmental process involved in holding and being held between mothers and their infants. A developmental frame is proposed to include two aspects of the developmental process. The aspect dealing with the evolution of mutual corporeal patterns will be analysed by using the concept of affordance as well as dynamic systems concepts such as attractor, behavioural coordination. Inter-corporeal relationship between the mother and her infant will be considered from a dynamic systems point of view. In the interaction during holding and being held, mother's body is an environment from which the infant picks up affordances (AF 1) and to which he tries to adapt, in search of comfort for the child, and/or for behavioural stability. Similarily, to the mother, the infant's body is also perceived as a part of the environment, from which she picks up affordances(AF 2), and to which she tries to accommodate, in search of comfort offered to infant. However, due to differences between the mother and her infant in the mental and physical abilities, AF 1 and AF 2 are expected to be different.

Key Words: Holding, inter-corporeal coordination, affordance, attractor, *daki*

Introduction

Holding is a care-giving behaviour often practised by caregivers of young infants. It is an effective means for soothing or comforting crying children. It can also be observed during feeding or when transporting the infants for some distance. In addition to serving as a care-giving behaviour, holding can also be observed as simply the caregivers' expression of affection as when the caregivers hold and caress their children. The most prominent feature of holding is its function in regulating the infant's negative emotions. The soothing effect of holding comes from the comfort of physical contact, as well as from the vestibular stimulation resulting from the change of body position and posture when infant is picked up. For normal infants, frequent and satisfactory holding is believed to contribute to the formation of secure attachment between the infant and the caregiver during early infancy.

What is called "holding", "carrying", "cradling" or "picking-up" in English, is called "*daki*" or "*dakko*" (derived from their verb form "*daku*") in Japanese. For the sake of simplicity, when referring to the fact of holding and being held, the Japanese word *daki* will be used instead of the English word holding, through out this paper.

Holding has been studied mainly from two points of view: That of the position of

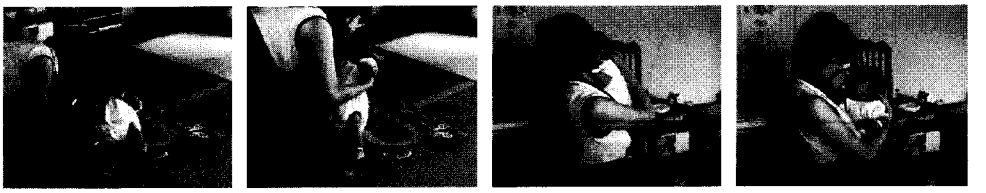
the infant in relation to the caregiver (i.e., the left or the right side of the caregiver's upper body), and that of its potential benefit to the physical growth and/or mental development of infants born prematurely.(see e.g., Sieratzki & Woll, 1996; Lucas, Turnbull & Kaplan-Solms, 1993) The former type of research attempts to answer the question "Why human mothers tend to hold their babies on their left hand side, near their hearts?" while the latter reflects the concerns of the nursing profession. Both lines of research focus on the phenomenon from the caregiver's point of view. In this sense, they are studies of holding cradling or carrying. In this paper however, *daki* (Holding and been held) will be considered from the point of view of inter-personal, corporeal interaction, paying special attention to both the microgenetic process as well as the long-term developmental process during the first year, and from both the caregiver and the infant's points of view.

According to Kelso, the foundational concepts of self-organization in physical, chemical and biochemical systems are not only relevant to cognitive and behavioural function. And it has been shown that the same coordination dynamic also applies to the functional coordination among anatomically different parts, ranging from intentional movements of two or more fingers and limbs, coupling among the joints of a single, multijointed limb, perception-action coupling between visual and auditory stimuli and motor responses, postural sway, to visually-mediated coordination between two people (Kelso, 2003, p. 51). At this preliminary stage, with almost all the ideas still in the realm of speculation and/or inference, yet to be put into practice, this paper will attempt to sketch out an outline of a research program on *daki*. Many of the ideas to be described here come from following and applying the suggestions of Kelso's theory of coordination dynamics of self-organizing systems (Kelso, 1995, 2000, 2003).

Emotion Regulation through Holding

Every parent knows that one of the most effective measures for soothing a crying baby is to pick up and hold the baby. Holding, however, is seldom simply holding the baby and doing nothing. Usually, actions such as patting, stroking the baby's back, or swaying are often accompanied by the care-giver's vocalizations and other behaviours. These behaviours of the caregiver and the infant's vocalizations, facial expressions and movements of the body naturally arising are often observed during an episode of *daki*, as can be seen in the following sequence (Figure 1). Holding consists not only the caregiver's act of supporting the baby's body; it includes the caregiver's manipulating and maneuvering her own body, as well as her vocalizations in an attempt to accommodate the perceived baby's psychological need. In this sense, the caregiver holds the baby not only with her body and behaviours, but also with her words and expressions.

The soothing effect of the caregiver's holding on the infant can be shown more clearly by observing changes in several of the infant's behavioural as well as physiological indices such as grimaces, negative vocalizations, body movements, heart rate, respiration, and muscle tones of limbs. Figure 2 is a conceptual representation of what may be observed in the changes in infant behaviours, with the upper waves summarizing higher frequency, larger variations and amplitudes before holding, and the lower sine waves indicating much reduced frequency, variations and amplitudes of the infant's behavioural



a b c d

e f g h

Figure 1: Interaction and Emotion Regulation during Holding and Being Held
a: M(other) calling baby' name, in rising tone. I(nfant) slightly fussing. M: What's up?
b: M: What's up? Yoisho! Yoisho! (M picking baby up).
c: What' wrong? Are you all right? Better now?
d: M: You like that, eh? (M supporting baby's head).
e: M:Well, you're slipping down. (M adjusting her own torsor axis).
f: That's better. ???(M talking to baby in a rising questioning tone). (M vocalizing with baby's body movements)
g: (M calling baby's name). You like that? Baby vocalizing as if answering.
h: M: What's the matter? (M calling baby's name). M:What's the matter?

and physiological indices.

Using a dynamic systems concept, *daki* , or the interaction of holding and being held, can be considered as an attractor for caregiver-infant interactive behaviours during the first year or so. During this period, the caregiver and the infant keep coming back to this attractor state for some time, until the infant's weight, his self-regulatory capacities, etc. has increased so much that they evolve into repulsive forces that the dyad is expelled from this attractor state at some point. For the dyad, a number of other attractors in addition to *daki*, such as face-to-face play or teasing without body contact (Reddy, 1991, Nakano & Kanaya, 1993) can coexist. As the infant grows and as the dyad increases its experience, some attractors lose their stability. Applying concept authored by Tsuda (Tsuda, 2001), Valsiner describes the attractors of weaker instabilities as attractor ruins, and characterizes the behaviour of the system as chaotic itinerancy. The system of the dyad's *daki* can be conceptualized as to visit these attractor ruins from time to time (Valsiner, 2005). As observed sometimes in the later part of the first year, the dyad can be observed to engage themselves in activities with shadows of *daki*, play and teasing. Sometimes, the form of *daki* "vanishes from the field of observation and becomes temporarily unclassifiable" (Valsiner, 2005). According to Valsiner, this feature of developmental phenomena reflects the notion of itinerant attractor (Valsiner, 2005).

However, as pointed out by Valsiner, the "use of attractor notion only opens the door half-way for developmental and dialogical analyses of the developing systems." (Valsiner, 2005). The challenge of introducing the concept of attractor to the phenome-

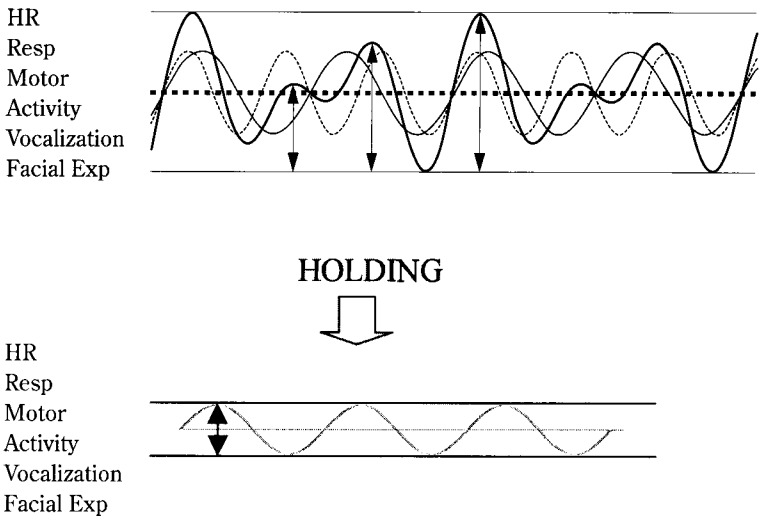


Figure 2: Reduction in frequency, variability and amplitude through effective holding

non under examination is to see if it enables us to trace how the dynamic system itself is constructed and changed over a period of time. To this end, it is suggested that a combination of the concept of affordance, with that of coordination dynamics, may be feasible. Before addressing the issue of mutual affordance pick-up of the dyad, a description of the global changes in the infant's action system concerning holding and being held will be in order. The following descriptions are based on observations selected from a longitudinal database, made roughly fortnightly, of Japanese infants and their caregivers at home, from six weeks after birth to ten months. The infants were all healthy first-borns.

Changes of Holding Patterns Attributable to Development of the Infant's Body

There are several distinctive changes in patterns formed during the first several months, due to physical development of the infant such as the infant's ability to regulate his/her own posture, the development of the arms and legs, the development of grasping. During the first two months, the relative small size of the infant's body, the infant's inability to hold his/her neck straight, and head, up, the lack of clasping or gripping power of the arms hands and legs, make it necessary for the caregiver to contain the infant's entire body into the cradle formed by her arms and upper frontal torso. In order to keep the infant's body as close as possible to hers to maintain stability, the caregiver finds it sometimes necessary to bent her upper body as seen in c and e in Figure 1. When performing face-to-face interaction as when viewing and/or talking to the infant, the infant's neck or head has to be supported by the caregiver's hand or palm (see c, d, g, h in Figure 1). In general, the caregiver uses her arms and hands as well as the structure of the infant's body to form some kind of net or hook, and to maximize the surface of contact to keep the infant from falling. Often the two bodies are en face to each other. However, it is the caregiver who makes most of the efforts in keeping or

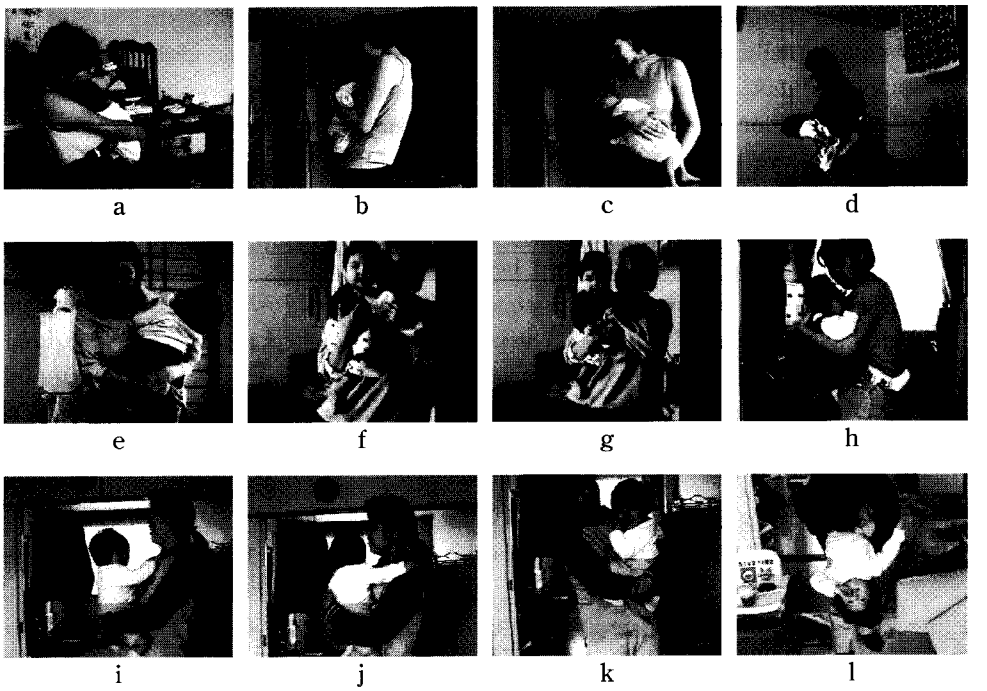


Figure 3: Changes in Holding Patterns Attributable to Infant Physical Development
a to d: Caregiver makes most of the efforts, maximizing surface contact.
e to g: Using forearms to form a strapping belt around infant's thigh and/or buttock.
h to k: Infant's hands and legs clipping caregiver's cloths and/or body.
l: Excitement to be obtained by moving the system to the brink of instability.

maintaining the form.

Around four months after birth, infants begin to be able to maintain their heads up right. With increase in stiffness of the torso, caregiver usually uses one of her forearms to keep the lower part of the infant's body (thigh and buttock) close to her abdomen and/or waist, while the other hand can do stroking or patting as needed. Infants at this state of development are able to turn their bodies sideways, and are given more freedom to do so, while being held (see Figure 3, e, f, g).

As the infants become mobile around six to seven months, both the arms and the legs of the infants are more effective in grasping the caregiver's clothes or part of her body such as her arms or shoulders. The infants are often seen with their legs placed around the caregiver's waist, and their hands on the caregiver's upper arms or shoulders (Figure 3. h). Infants begin to play a more active role in holding on to the caregivers.

At ten months, the infants can maintain upright position while being held, using the contact between their arms or hands and the caregiver's body or clothes as anchorage point (Figure 3. i, j, k). The infant's lower body is secured to the caregiver's abdomen or waist by the latter's hands, while the infant is allowed to turn from side to side or around, relatively freely. The bodies of the dyad when held are so securely fasten to each other that they sometimes enjoy a play in which the infant is repeatedly plunged upside down for the excitement (Figure 3. l). *Daki* is transformed into play, and

its original form is unrecognizable.

Developmentally, the coordination patterns formed by the caregiver and the infant in an instance of *daki* change from a state in which the newborn is almost without any contribution except for letting him/herself to be held, through a stage when infants begin to play a more active role of capturing the caregiver's body or clothes, to the final stage when the caregiver and the infant construct a flexible regime, allowing the infant maximal freedom. We also note that the early holding, with the caregiver's body and words aiming at maximal stability, is replaced by a form of holding, with minimal anchorage point between the two bodies and a consensual attempt to throw the system into a maximal, but maintainable, instability which generates excitement for both. *Daki* or holding and being held can thus be conceived as constituting the building block of interactive behaviours of each dyad, with its unique trajectories which are also their attachment relationshionship.

Development of Holding Skill Learning: Mutual Affordance Pick-up

The inter-body encounter involved in holding and being held constitutes a learning situation for both the caregiver and the infant. This is particularly true for new mother and her first infant, and when we consider the large number of *daki* episodes likely to be experienced by a normally developing dyad within the first year or so. Observed as an individual learner, the first such body encounter presents a subset of tasks to be solved, or learned, for both the mother and her infant.

Before the actual body contact between the caregiver and the infant, usually, a signal of some kind, such as the fussing or crying sound of the infant, is uttered and perceived. After the caregiver judges that holding is required, the caregiver approaches and picks up the infant. The caregiver's actual manner of holding as applied to the infant's body (the pattern results) is the result of a number of factors, both of the caregiver and of the infant. From the mother's point of view, these can include such factors as the affordances picked up from the infant's body at that particular moment, the intention of the caregiver (whether to soothe (emotion regulation), to change, to bathe (transportation), or to feed, or any combination of them), and the caregiver's preconceived image of the kind of holding required or expected (i.e., memories and/or images obtained by putting herself in the infant's shoes, so to speak), to mention only the most prominent ones. From the point of view of the infant, on the other hand, the immediate pattern may result from the infant's weight, the stiffness of the body, or the current normal posture assumed (e.g., with arms stretched flexibly or flexed near the infant's shoulders), etc.

Following the formation of the first *daki* pattern, mutual adjustment may begin immediately, as when, for example, the ways of holding is perceived to be not comfortable, or not acceptable, by the infant, and if the infant manages to express his disagreement or complaint, by negative emotional expression and/or the wriggling of his body. Episode shown in Figue 1 illustrates the mutual adjustment process of one Japanese caregiver and her seven-week-old infant. This kind of episodes with extended mutual adjustment can be observed often, especially during the early months of the dyad's life together. This suggests that the caregiver and the infant are exploring the characteristics of each other's actions.

In developmental psychology applications of the concept of affordance, emphasis has been on perception of the physical environment or objects (Thelen & Smith, 1994). Little attention is assigned to kinesthetic and/or haptic perception of the other's body as an immediate environment. This state of affair is not restricted to the study of the development of perception in infant. Barnard, Brazelton & Hertenstein et al have called our attention to the importance of touch in the development of children (Barnard & Brazelton, 1990; Hertenstein & Campos, 2001). It is from considerations such as these that the present research program proposes to investigate the mutual affordance picking up of the caregiver and the infant through holding and being held.

Another complaint put to the direct perception approach by development theoriests is that while "it says much about the availability of environmental structures and their "pick up" through dynamic perceptual processes, it says little about the structures of the mind that are necessary to support direction perception". (e.g., Bremner, 1997, 1998). It is hoped that the approach, which will be outlined below, will provide us with an entry point for reconstructing the "structures of the mind that are necessary" to support direction perception of affordances of each other's body as an environment.

Dynamic Patterns of Holding and Being Held

The patterns of holding and being held observed at home in our subjects during the first year will be summarized from three points of view:

a. Relative positions of the two bodies (surface/point of contact)

b. Relative angle of the two body fronts, and point of support

c. The relative angle of the two torso axes

In order to describe the developmental changes of the patterns formed, the caregiver's body, especially her upper body, will be divided horizontally into three zones: (1) upper (above the shoulders), (2) middle (between chest and shoulders), and (3) lower (abdomen and waist) zones. The caregivers are observed to assume two postures: standing and sitting, with sitting observed more often during the early months, probably reflecting the fact that the caregivers may feel more stable when holding a very young baby.

The developmental changes of the patterns formed by the caregiver and the infant during the first year or so can be summarized as follows:

1. Due to the relative small size and light weight of the infant's bodies during the first months, point of contact between the caregiver and the infant tends to fall on the upper and middle zones, rather than the lower zone. The surface of contact tends to occupy the infant's entire frontal surface, or either side of the body, reflecting the lack of stiffness in the infant's neck. The caregiver's one arm or palm (more often of the left) tends to place across the infant's upper part (neck, shoulders), while the other arm (more often the right one) supports the lower part of the infant's body, along the infant's head-buttocks axis. *Dakigae* (adjusting of holding position/style) occurs frequently, often accompanied with caregiver's searching vocalizations aiming to find out how the infant feels or to confirm the result of the *dakigae* maneuver. The caregiver decides the style of holding and the timing of *dakigae*. Due to the perception of the infant's body as lacking stiffness, the caregiver sometimes bends backward or forward while holding, allowing

maximal contact to increase stability (Figure 1, e; Figure 3, a, b). Occasionally, during *dakigae* the infant's head is let to rest on one lower arm or on one palm of the caregiver, allowing the latter to have a look. During this early period, the stability of the two bodies is strengthened by the caregiver's placing one hand or arm under the infant's head/neck.

2. With the increase of weight and size, and the infant's ability to hold his/her head upright, the point of contact between the caregiver and the infant moves towards the caregiver's lower zone. The infant's extended and freed limbs begin to hitch onto the caregiver's palms, arms shoulders, or hips. The surface of contact is reduced to the infant's waist and the inner sides of the upper thighs. The belt formed by the lower arms of the caregiver provides both stability for the structure formed by the two bodies as well as freedom for the infant's upper body and limbs. Generally, the two bodies are en face to each other, with one of the caregiver's hands supporting the lower part of the infant's back. Change of holding position and/or the point of contact are gradual, with the infant playing a greater role in the patterns formed. Infant's posture is maintained upright most of the time while being held.

3. With the infant's hands now able to grasp the caregiver's body and/or clothes, resulting in the stability of the holding greatly increased, the point of contact is reduced to the infant's hips-thighs and the caregiver's waist areas. The caregiver's closed arms around the infant's lower body serves as a fastening strap or belt on infant. The infant's hand(s) are free to point, or to grasp an object. As the structure maintains high stability, the infant is able to adjust his/her own posture/position vis-à-vis the caregiver, The upper bodies of the caregiver and the infant form a V-shape, without the supporting hand of the caregiver. *Dakigae* hardly occurs. The forming and the breaking of *daki* result from more obvious bidding by the infant.

Relative Angles of the Two Bodies as Control Parameter

The last notion to be attempted in these notes is that of control parameter. The purpose of this exercise is to identify the dimension on which all the pattern changes observable in all daki events during the development period in question occurs. Two relative angles will be discussed here. One is the relative angles form by the arms of both the caregiver and the infant during daki (RA1)s. It will be observed that due to the relative small size and light weight, and the lack of stiffness of the infant's body during the first months, the caregiver's two arms tend to maintain a angle smaller than 90 degree most of the time. It is seldom that while holding an infant before 3 or 4 months the caregiver extend her arms so that they form angles larger than 90 degree. The angles formed by the infant during this period seem to include a larger variety; ranging from the small angles most young infants exhibit spontaneously (Figure 1, c), to a relatively larger angle as when their arms are allowed to dangle as in Figure 1, g. In either cases, while the angles formed by the very young infant can be large or small, the tone of his arm muscles is normally very low, especially when compared to that of the caregiver while holding the infant.

As the infant becomes more able to maintain his head/neck up right (increase in body stiffness in general), his arms are observed to increase their muscle tones as well

as their angles during *daki*, so that their arms are more involved in the formation of the *daki* coordination patterns. The angles formed by infant's arms at this stage tend to vary in coordination with the behaviour of the caregiver's, as a *daki* unfolds.

A second relative angle to be proposed is that formed by the axes of the participants' upper torsi (RA2). It is suggested that during *daki*, a certain range of relative positions will be maintained by the two bodies in order to obtain and to offer the stability necessary for fulfilling the minimal requirement of *daki*.

It would be the tasks of future research to identify the coordination dynamics of the inter-corporeal interactions of *daki* by analysing the developmental changes of RA1 and RA2 of individual dyads, and extracting the common regularity.

Concluding Remarks

These notes were the result of an attempt to critique the research of holding during infancy by Saijo and Negayama (2001) and Saijo (2002). Saijo's reseach was the first to attempt to study holding from a dyanamic systems approach. As can be clear by comparing the present view points sketched out in these notes and Saijo's papers, the present formulation is a very different one in the sense that (1) I focused on the *daki* that involves emotional regulation as the caregiver's perceived task, (2) I used concepts such as attractor and affordance in an attempt to look into the effects of learning on the patterns formed, (3) I placed more emphasis on the process of the infant's gradual participating in the formation of the coordinative patterns, as a result of the dynamics of infant's capability in regulating his own posture, the changes in his body size and weight, (4) I intended to use daki as an exercise to learn more about pattern formation in the development of inter-corporeal interaction and its coordination dynamics as proposed and demonstrated by Kelso.

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References

Barnard, K. E. & Brazelton, T. B. (1990). Touch: The Foundation of Experience. Madison: Internation Universities Press.

Bremner, G. (1997). From perception to cognition. In G. Bremner, A. Slater & G. Butterworth (Eds.), *Infant Development.* Hove, East Sussex: Psychological Press. Pp. 55-74.

———(1998). From perception to action. In F. Simon & G. Butterworth (Eds.), *The Development of Sensory, Motor and Cognitive Capacities in Early Infancy.* Hove, East Sussex: Psychological Press. Pp. 239-255.

Hertenstein, W. J. and Campos, J. J. (2001). Emotion regulation via maternal touch. *Infancy*, 2(4), 549-566.

Kelso, J. A. S. (2000) Principles of dynamic pattern formation and change for a science of human behaviour. In Lars R. Bergman, Robert B. Cairn, Lars-Goran Nilsson, and Lars Nystedt (Eds.), *Developmental Science and the Holistic Approach.* Hillsdale, New Jersey: Lawrence Erlbaum Associates. Pp. 63-83.

Kelso, J. A. S. (2003). Cognitive coordination dynamics. In Wolfgan Tschacher & Jean-Pierre Dauwalder (Eds.), *The Dynamical Systems Approach to Cognition: Concepts and Empirical Paradigms Based on Self-Organization, Embodiment, and Coordinative Dynamics.* Singapore: World Scientific. Pp. 45-67.

Nakano, S. & Kanaya, Y. (1993). The effects of mothers' teasing: Do Japanese in Fauts. read their mothers' play intention in teasing? *Early Development and Parenting,* 2(1) 7-17.

Reddy, V.(1991) Playing with others' expectalions: teasing and mucking about in the first year. In A. Whiten (Ed.), *Natural theories of mind.* Pp.143-58. Oxford: Basil Blackwell.

Lucas, M.D., Turnbull, O.H., & Kaplan-Solms, K.L. (1993). Laterality of cradling in relation to perception and expression of facial affect. *The Journal of Genetic Psychology,* 154(3), 347-352.

Saijo, T. (2002). The transition from mother's horizontal to vertical holding of infants: Application of a dynamic systems approach. *The Japanese Journal of Developmental Psychology,* 13, 97-108. (In Japanese)

Saijo, T. & Negayama, K. (2001). A study on the development of styles of holding infants and their infants: Active participation according to their positions. *The Journal of Child Health,* 60(1), 82-90. (In Japanese)

Schöner, G., Zanone, P. G. & Kelso, J. A. S. (1992). Learning as change of coordination dynamics: Theory and experiment. *Journal of Motor Behavior,* 24, 29-48.

Sieratzki, J.S. & Woll, B. (1996). Why do mothers cradle babies on their left? *The Lancet,* 347, 1746-1748.

Thelen, E. & Smith, L. B. (1994). *A dynamic systems approach to the development of cognition and action.* Cambridge, Ma.: MIT Press.

Tsuda, I. (2001). Toward an interpretation of dynamic neural activity in terms of chaotic dynamic systems. Behavioral and Brain Sciences, 24, 793-847.

Valsiner, J. (2005). The concept of attractor: How dynamic systems theory deals with future. *Annual Report, Research and Clinical Center for Child Development, Graduate School of Education, Hokkaido University,* No. 27, 13-25.