A Sequential Analysis of Early Development of Behaviors in Chicks.

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Developmental studies of behavior have examined changes in temporal patterning of behavior as well as each appearance of new behavioral pattern (2). Of the various temporal aspects of behaviors mentioned by FAGEN et al (3), the present study deals with behavioral sequences. The sequence of behaviors occurring in a social setting involves two aspects: intra- and inter-subject behavioral sequences, which are not totally separate processes but partly dependent on each other. However, only one of these processes has been analysed thus far (4, 6, 9). In this connection VAN DEN BERCKEN and COOLS (13) developed a new sequential model which considered both aspects of sequences simultaneously. Using this model the present study attempted to describe sequential patterning of behaviors and their developmental changes in socially reared chicks.

Method

Subjects and their rearing conditions:

The subjects were 20 white leghorn chicks. Eggs were obtained from a commercial supplier and incubated in a forced draft incubator (Showa Electric Incubator P-01) maintained at 37.5°C. Chicks were hatched in groups and reared in pairs. The home cage, in which two chicks were housed, was a wooden box (25×38×38cm). One of its longer walls was transparent and the floor of the box was covered with sand, which was presumed to promote natural behaviors. Home cages were separated from each other. A brooder containing six such cages was heated constantly at 33°C and illuminated by a 100w fluorescent lamp for a period of about 12 h daily. Food and water were always available in each home cage.

Procedure:

In this study, the 0-day of age refers to the day of hatching. But in case of

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hatching at night, the 0-day of age was arbitrarily defined as the first day when the chick was found to be hatched. The observation time of the day was held as close as possible to the time of hatching in order to maintain the homogeneity of subjects.

Before observation each home cage was gently transferred by the experimenter from the brooder to the observational room, where the cage was heated approximately at 33°C and illuminated by a 100w fluorescent lamp. Each pair was observed 30 min a day after 10 min adaptation at 1-, 3-, 5-, and 7-day of age. A video system (VTR, SL-J9; video color camera, DXC-17; Sony, Co.Ltd.) was used for recording all observations.

Analysis:

Table 1 shows the behavior categories. The intra- and inter-subject sequences

Table 1. The behavioral categories.

(1) Approach(Ap)	:one chick rushes or runs to the other (excluding incidental and slow approach).
(2) Bill to Bill(BB)	:one chick moves its bill toward the other's, holding this position for a while without bill contact.
(3) Bill Open(BO)	:the chick opens its bill for a short while.
(4) Bill Clean(BC)	:the bill is scraped against the cage in a side-to-side motion.
(5) Body Shake(BS)	:the chick shivers in a fixed manner.
(6) Distress Call(DC)	:the chick peeps.
(7) Does Nothing(DN)	:the chick does nothing in spite of behavioral changes of the partner.
(8) Drink water(Dr)	
(9) Eat(E)	
(10) Head Shake(HS)	:the chick rapidly shakes its head horizontally several times in a fixed manner.
(11) Head Scratch(HSc)	:the chick scratches its head with its foot.
(12) Peck(P)	:the chick pecks at the cage (excluding food and water).
(13) Peck at Bill(PB)	:one chick pecks at the other's bill.
(14) Peck at Eye(PE)	:one chick pecks at the other's eye.
(15) Peck at Foot(PF)	:one chick pecks at the other's foot.
(16) Peck at Head(PH)	:one chick pecks at the parts of the head of the other chick, excluding (13) and (14).
(17) Peck at the other body parts(PO)	:one chick pecks at the other's body parts, excluding (13), (14), (15) and (16).
(18) Preen(Pr)	

(19)	Push(Pu)	:one chick pushes the other.
(20)	Scratch(Sc)	:the chick scratches the floor with its feet in a fixed manner.
(21)	Sleep(Sl)	:the chick is inactive with eyes closed for at least several seconds.
(22)	Self Peck(SP)	:the chick pecks at its own body parts.
(23)	Body Stretch(Str)	:the chick stands on one leg and stretches its body and neck together with the wing and leg of the opposite side.
(24)	Wing Flap(WF)	
(25)	Wing Up(WU)	:the chick raises up both of its wings, holding this position for a while.
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of these behaviors in a pair setting were recorded by a modified sequence sampling method (8). Behavioral repetition was recorded only in the case where one chick retained the same behavioral pattern in spite of behavioral changes of the partner.

Based on these records, two analyses were carried out: informational analysis and chi-square statistical analysis.

An informational analysis was performed by the same method as that of VAN DEN BERCKEN and COOLS (13). In the present study two measures, normalized partial auto-covariability and normalized partial cross-covariability, were calculated. For brevity, auto-constraint and cross-constraint are used below. These two measures show the extent to which the variability of ongoing behavior (Res) is constrained by its own previous behavior (Pre) and the other's previous behavior (Sig), respectively.

Next, intra- and inter-subject behavioral sequences were separately broken down into dyads and two transition matrices (Pre-Res, Sig-Res) were produced. A chi-square statistical analysis (4) was performed on both matrices. Two manipulations were specific to the method used in the present analysis. One was that the less frequent behaviors (occurring less than 70 times) were excluded from analysis because of the possibility that only a few exceptional subjects might have influenced the results. The other was that only the positive association of dyads was considered, because this study was mainly interested in co- or serial occurrence tendencies among behaviors rather than mutually inhibitive ones.

Results

Table 2 shows the number of behaviors sampled for each day of observation.

According to the criterion set by FAGEN and YOUNG (3) the sample size can be considered large enough for statistical analysis.

Table 2. The number of behaviors sampled in each day of observation.

Day of age	1	3	5	7
The number of behaviors sampled	4278	4518	5628	5509

Figure 1 shows the values of auto- and cross-constraints over seven days after hatching, indicating that the values of cross-constraint were high at 1- and 3-day of age and decreased thereafter, and the auto-constraint increased greatly between 1- and 3-day of age.

Fig. 1. The auto-constraint(●—) and cross-constraint(○—).

Figure 2 shows the system diagrams of intra- and inter-subject behavioral sequences (for brevity, Pre-Res system and Sig-Res system are used below) at 1-, 3-, 5-, and 7-day of age on the basis of the chi-square statistical analysis. The arrows between the circles represent significant ($p < .05$) positive associations between two behaviors. This figure indicates two characteristics underlying Pre-Res and Sig-Res systems.

First, the most striking characteristic of peer-interaction in newly hatched chicks was the behavioral synchrony, which was shown as a looped arrow in the Sig-Res systems. This implies that chicks match their behaviors to each other. Since 1-day of age this phenomenon was observed through various behaviors, such as PB, P, E, SI, Pu, Pr, DC, and Sc.

Second, social pecks were classified into three types: PE-PF, PB, and PO, on

Fig. 2. The intra-subject behavioral sequence system (A) and inter-subject behavioral sequence system (B) in each day of observation, based on the chi-square statistical analysis. The circles represent kinds of behaviors. The arrows between the circles represent significant ($p < .05$) 2-act transitions.

the basis of the temporal context of their occurrences and their developmental changes. PE and PF frequently occurred immediately after hatching and contingently with P, decreasing rapidly thereafter. PB occurred also contingently with P but did not decrease over seven days after hatching. PO occurred in temporal contiguity with Pr, Pu, and/or Sl. This occurrence was quite different from other social pecks which had a close relationship with P.

Discussion

The present study described quantitatively the temporal structure (especially serial occurrence tendency) of behaviors in chicks and its developmental changes over seven days after hatching.

An informational analysis showed the high values of cross-constraint at 1-day of age. Thereafter, the cross-constraint decreased and the auto-constraint increased. This result suggests that during the early period of peer-interaction chicks are socially sensitive and their ongoing behaviors are more determined by the other's behaviors rather than by their own previous behaviors, and that this relation reverses over time.

Social pecks could be classified into three types, PE-PF, PB, and PO, which occurred in different contexts and took different developmental courses from each other. Thus social pecks should not be counted as a single category (1, 5, 7). Further studies are necessary to specify the function of each type of social pecks.

The behavioral synchrony, shown as a looped arrow in the Sig-Res system (Fig. 2), showed marked characteristics of peer-interaction. This was observed through various behaviors shortly after hatching. But only the synchrony of eating was investigated so far (10, 11, 12). This referred to social facilitation, in which a satiated chick continued to eat at the sight of feeding chicks, and which was assumed to have an adaptive value in that it made them grow faster. It is not likely that the same mechanism which produces social facilitation underlies all the behaviors synchronized between chicks. For example, PB or Pu is not assumed to promote chicks to grow. Gallus chicks in their natural habitat live under as high a pressure of predation as other species of ground-nesting birds. So chicks are hatched precociously and their mother abandons the nest a few days after hatching. Under these circumstances, it may possibly be more adaptive for chicks to synchronize behaviorally to each other than otherwise, for the possibility for them to be detected by a potential predator may be reduced when they all rest or travel

rapidly at the same time rather than when each chick behaves in an individual manner. VINCE (14) reported the synchronization of hatching in quail, the origin of which could be experimentally traced back to auditory communication among embryos. The present study did not control for prenatal and auditory experiences, so further studies focusing on this aspect are necessary to deal with the origin and mechanism of the behavioral synchrony.

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