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RESURGIMIENTO DE LA RESPUESTA DE PICAR UNA TECLA EN POLLOS EMPLEANDO UN ESTÍMULO IMPRONTADO O COMIDA COMO REFORZADOR

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Abstract

Resurgence of newborns' operant responses that have been reinforced by phylogenetically important events has not yet been investigated. The present study investigated whether, in newly hatched chicks, resurgence of key-peck operant responses previously reinforced by delivery of either an imprinted stimulus or food as a reinforcer would recur under extinction. The possibility of intrusion into the resurgence of behavior related to the imprinted stimulus and food as phylogenetically important events was also explored. Ten chicks that were imprinted to a moving stimulus were divided into two groups, using either an imprinted stimulus or food as a reinforcer, respectively. First, their pecking a red key was shaped and maintained under a variable-interval schedule (Phase 1). After pecking rates stabilized, pecking a second, blue, key was reinforced using the same reinforcer as in Phase 1, while pecking the red key was extinguished (Phase 2). After the rates of pecking the red key were extinguished, pecking of either key was extinguished (Phase 3). Resurgence was measured as the number of pecks on the red key in the initial session of Phase 3. Most chicks in both groups

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showed resurgence of pecking the red key during the final extinction phase. However, the magnitude of resurgence was much stronger in the food group than the imprinted-stimulus group, and resurgence in both groups occurred at a relatively early stage of extinction. Furthermore, while resurgence of responses reinforced by the imprinted stimulus was accompanied by responses related to the imprinted stimulus, resurgence of responses reinforced by food was accompanied by those related to food. These results were discussed in terms of potential biological and behavioral constraints on resurgence, response chains, and related recurrence procedures.

Keywords: resurgence, chicks, imprinted stimulus, food, key-peck response

Resumen

El resurgimiento de respuestas operantes de neonatos que se han sido reforzadas con eventos filogenéticamente importantes no ha sido investigado. En el presente estudio se investigó si, en pollos recién nacidos, el resurgimiento de la respuesta operante de picar una tecla previamente reforzada por la entrega de un estímulo improntado o comida recurriría bajo extinción. La posibilidad de la intrusión en el resurgimiento de conducta relacionada con el estímulo improntado y la comida como eventos filogenéticamente importantes también se exploró. Diez pollos que fueron improntados a un estímulo que se movía fueron divididos en dos grupos, usando ya sea el estímulo improntado o comida como reforzador, respectivamente. Primero, se moldeó y se mantuvo el picoteo a una tecla roja usando un programa de intervalo variable (Fase 1). Después de que las tasas de picoteo se estabilizaron, el picoteo a una segunda tecla de color azul se reforzó usando el mismo reforzador que en la Fase 1, mientras que el picoteo a la tecla roja se extinguió (Fase 2). Después de que el picoteo a la tecla roja se extinguió, el picoteo a cualquiera de las dos teclas se extinguió (Fase 3). El resurgimiento se midió como el número de picotazos en la tecla roja en la sesión inicial de la Fase 3. La mayoría de los pollos en ambos grupos mostraron resurgimiento de la conducta de picar la tecla roja durante la fase final de extinción. Sin embargo, la magnitud del resurgimiento fue mucho mayor en el grupo de comida que en el grupo del estímulo improntado, y el resurgimiento en ambos grupos ocurrió en una etapa relativamente temprana de la extinción. Aún más, mientras que el resurgimiento de las respuestas reforzadas por el estímulo improntado estuvo acompañado por respuestas relacionadas con el estímulo improntado, el resurgimiento de las respuestas reforzadas por comida estuvo acompañado por respuestas relacionadas con comida. Estos resultados se discutieron en términos de potenciales limitaciones biológicas y conductuales en el resurgimiento, cadenas de respuestas, y procedimientos de recurrencia relacionados.

Palabras clave: resurgimiento, pollos, estímulo improntado, comida, respuesta de picoteo a una tecla

The present study investigated whether resurgence of key-peck operant responses in newly hatched chicks previously reinforced with the delivery of either an imprinted stimulus or food as a reinforcer would occur under response extinction. Additionally, the possibility was explored of intrusion into the resurgence of some responses related to the imprinted stimulus and food as phylogenetically important events.

Although the term "resurgence" is used in a wide range of contexts (e.g., Cleland, Guerin, Foster, & Temple, 2001), resurgence is defined as a phenomenon in which an operant response that has undergone extinction reoccurs when a second operant response that has replaced it itself undergoes extinction. Resurgence and related extinction-induced phenomena have been investigated for a long time (e.g., Leitenberg, Rawson, & Bath, 1970; Mulick, Leitenberg, & Rawson, 1976; Pacitti & Smith, 1977; Rawson, Leitenberg, Mulick, & Lefebvre, 1977). Epstein (1983, 1985) surveyed classical studies of this phenomenon and argued that the study of resurgence provides us with a behavior-analytic understanding of extinction-induced behavior sometimes attributed to Freud's concept of *regression* (see Doughty & Oken, 2008). Although researchers investigating resurgence have used a wide range of procedures, including punishment (Wilson, & Hayes, 1996) and increased response requirements (Mechner, Hyten, Field, & Madden, 1997), recently, this behavioral effect has been investigated using the following experimental paradigm.

In this paradigm, an operant response is first reinforced (Phase 1). Then, while that response undergoes extinction, a new response is reinforced (Phase 2). Finally, when the second response is then extinguished (Phase 3), with resurgence, the first response recovers, irrespective of its having been extinguished. For example, in Leitenberg et al. (1970), pressing one lever by rats was first reinforced by the delivery of food, then this operant response was extinguished while pressing a second lever was reinforced, and, finally, pressing both levers was extinguished. Pressing the first lever reoccurred in the final condition.

Resurgence is thought to be a reliable behavioral effect that occurs across a variety of animal species (including human beings), operant responses, and reinforcers (Lattal & St. Peter Pipkin, 2009). Further, resurgence is increasingly recognized as an important phenomenon for understanding various behavioral problems. For example, Epstein (1985) suggested resurgence as a special case of the concept of regression in psychoanalysis. It is also believed that the study of resurgence promotes the understanding of mechanisms underlying reoccurrence of problem behavior in applied and clinical settings (e.g., Lattal & St. Peter Pipkin, 2009; Winterbauer, Lucke, & Bouton, 2013).

Previous experimental studies have clarified many variables that contribute to resurgence. Naturally, these variables are related to the experimental procedures involved in each phase, and Lattal and St. Peter Pipkin (2009) summarized some the variables studied, including those related to amount of training in the first phase,

schedules of reinforcement for the first operant response (da Silva, Maxwell, & Lattal, 2008; cf. Winterbauer et al., 2013), rates of response in the first phase (da Silva et al., 2008; Winterbauer et al., 2013), and degree of extinguishing the response in the second phase (Cleland, Foster, & Temple, 2000; Leitenberg et al.,1970; Rawson et al., 1977; cf. Lattal & St. Peter Pipkin, 2009). Such variables related to the first phase are naturally important because resurgence is the recurrence of responses reinforced in the first phase.

Undoubtedly, the history of reinforcement in the first phase contributes to resurgence, as resurgence might be strongly affected by the reinforcing events. Most experimental studies of resurgence using animals have used a reinforcer such as food. Resurgent behavior in previous studies using food as a reinforcer might include behavior related to food. Generally speaking, it is possible that resurgent responses include those related to the type of reinforcers used to maintain the responding. These latter responses may be respondents and/or fixed-action patterns. Given this possibility, resurgence of previously reinforced responding during extinction of another second response may reflect not only reoccurrence of the previously established operant behavior but also intrusion of respondents and fixed-action patterns related to the reinforcers. Such a possibility is reminiscent of instinctive drift (Breland & Breland, 1961) and biological constraints on learning (cf. Hinde & Stevenson-Hinde, 1973).

Many studies using pigeons as subjects have reported resurgence of pigeons' key pecking as an operant response established by food. Although explaining pigeons' pecking as an operant is plausible (Brown & Jenkins, 1968), the possibility remains that pecking under extinction is respondent behavior. Jenkins and Moore (1973), for example, found that the topography of pigeons' autoshaped pecks is affected more by the unconditioned stimulus (US) than by operant contingencies. Autoshaped pecks produced by key light and food resemble eating pecks, whereas those produced by key light and water resemble drinking. This finding suggests that, for pigeons, the sight of grain is a US that elicits an unconditioned response peck at the food (cf. Epstein & Skinner, 1980).

If so, both operant and respondent responses may be involved in the resurgence of pigeons' key-peck responses, as in autoshaping. Further, pigeons' pecking of a key under extinction might include attack (Azrin, Hutchinson, & Hake, 1966) and topographic variability in responding (Antonitis, 1951; Morgan & Lee, 1996), induced by total extinction in the third phase. Furthermore, there might be the possibility of response-class hierarchies in resurgence (Lieving, Hagopian, Long, O'Connor, 2004; Shabani, Carr, & Petursdottir, 2009).

Given the above considerations, in resurgence related to a history of reinforcement, there is the possible involvement of other response classes, especially respondents and/or fixed-action patterns, related to reinforcers as phylogenetically important events.

To investigate this possibility, experiments examining the involvement of such re-sponse classes are invited. However, to our knowledge, little research is available on this issue.

As for methodology, we can use a reinforcer for the original response that is dif-ferent from that used for the second (alternative) response (see Wintenbauer et al., 2013). Further, we can establish as the original response one not phylogenetically related to food and then investigate resurgence of that response. For example, Lieving and Lattal (2003) investigated resurgence of pigeons' pecking responses after extin-guishing a treadle press as the alternative response. If they had transposed the two responses and investigated resurgence of the treadle press, they could compare re-surgence of the two responses and investigate the possibility noted above. As pigeons' treadle pressing seems to be unrelated to food in their natural habitat, if resurgence of the pecking response included food-related behavior, even if resurgence of the treadle press were to occur, the resurgence might be lower in magnitude relative to that of pecking responses.

As another method for investigation of the involvement of responses related to phylogenetically important reinforcers in resurgence, we selected subjects that were susceptible to operant reinforcement but had a minimum history of such reinforce-ment prior to the experiments. We therefore used newborn subjects, since it is well known that newborns show various respondent-like behavior patterns to phylogeneti-cally important stimuli, but their history of operant reinforcement is short. Subjects with a short operant history of food reinforcement would not be likely to show resur-gence of the operant due to their respondent behavior to food. Contrary to this, if newborn subjects showed resurgence of an operant response irrespective of their short history of food reinforcement, we could say the resurgent behavior might be mostly operant behavior derived from the history of food reinforcement.

As a third method to investigate the involvement of behavior related to phyloge-netically important reinforcers, we used species-specific reinforcers such as releasers for fixed-action patterns. When we used such species-specific stimuli as operant re-inforcers, we could identify the intrusion of species-specific behavior into the resurgence.

Considering the above three methods, we used newly hatched chicks to study resurgence because they have been shown to be susceptibile to operant reinforce-ment (cf. Skinner, 1966), and we used food and an imprinted stimulus as a species-specific reinforcer (Bateson & Reese, 1968; Hoffman, Searle, Toffey, & Kozma, 1966; Peterson, 1960) to compare the resurgence of responses reinforced by each type of reinforcer. Using chicks, the present study investigated whether resurgence of previ-ously reinforced operant responses would occur under their extinction, using either delivery of food or an imprinted stimulus as a reinforcer. Possible intrusion into the

resurgence of responses related to food and the imprinted stimulus as phylogeneti-cally important events also was explored.

Method

Subjects

The subjects were 31 White-Leghorn chicks hatched in a dark incubator. After hatching, they were transferred to individual cages as noted below. Water and food were always available before the chicks received resurgence sessions. Throughout the resurgence sessions, the chicks were deprived of food based on a deprivation method described below. Each cage was illuminated by an 18–W white fluorescent during approximately half a day throughout the experiment, and chicks had unlimited access to food, water, and their respective stimulus.

On the third day, they received the imprinting test. After the test, chicks imprinted to each stimulus were divided into imprinted-stimulus and food-reinforcer (hereafter *food*) groups, and they received the respective experimental procedure for resurgence. There were five chicks in each group. Each chick in the food group only was deprived of food by providing daily an amount of equivalent to 10% of its weight.

Apparatus

Immediately after hatching, each chick was transferred from the incubator to a rearing cage (29.5 cm by 19 cm by 17 cm) that contained either a red cylinder (5.5 cm in diameter x 9.5 cm high) or a yellow ball (6.5 cm in diameter). An 18–W white fluorescent lamp remained on in the cage during the first 12 hours of each chick's life. Either a runway box (18 cm by 120 cm by 45 cm) without a ceiling or a two-key op-erant chamber for chicks (15.5 cm by 20 cm by 28.5 cm) was used for the imprinting training in which each chick was exposed to the moving red cylinder or yellow ball, either emitting metronome tones. These stimuli to be imprinted were continuously moving back and forth in the runway box with the metronome tones pulsing notes. The speed of the movement was approximately 35 cm/s. The metronome tones were emitted via an 8 Ω speaker placed on a rail over the runway box. The pulse rate was 3 notes/s. Two 12-W lamps were mounted on the top of a side wall of the box. The distance between the central part of the side wall and each lamp was 45 cm. When either stimulus was exposed to the chicks, these lamps turned on.

During both the imprinting sessions and the experimental sessions for resurgence, the operant chamber and the runway box with either imprinted stimulus were used. The chamber was placed next to the left-side wall of the runway. The left-side wall of

the runway box was removed from the box, and the right-side wall of the operant chamber was removed so that each chick in the operant chamber could see the moving stimulus as a reinforcer in the runway box. In each session for resurgence, either food or the imprinting stimulus was used as a reinforcer for the chicks' key-peck responses. Reinforcement during the operant sessions was 4-s visual access to the moving imprinted stimulus in the runway box through the right-side wall of the operant chamber or 4-s access to a solenoid-operated food hopper that was raised into an aperture centered on the base of the front panel that was lit only during reinforcement. The right-side window of the operant chamber consisted of a wire-mesh screen. When the runway box was dark (lamps turned off), the chick in the operant chamber could not see the stationary imprinted stimulus in the runway box. When the imprinted stimulus was exposed to each chick as a reinforcer, the stimulus moved back and forth under the illumination of two lamps above the runway box. Under this condition, the chick could see the moving imprinted stimulus through the wire mesh of the right-side window of the operant chamber during the reinforcement.

The vertical positions of two keys (each 2 cm in diameter) were changed as the chicks grew. The keys were spaced 5 cm from center to center in a horizontal plane and trans-illuminated by colored LEDs. Further, during the experimental sessions, a black spot (.5 cm in diameter) was attached to the center of each key to promote the chicks' pecking responses. The operant chamber was illuminated by a 24V DC lamp (houselight) mounted on the chamber ceiling. This houselight and the key lights were illuminated at all times except during reinforcement. Both the runway box and the operant chamber were housed in a sound attenuating chamber into which white noise was pumped. The chicks' behavior in the box and the operant chamber were monitored via a video camera. An Apple IIe microcomputer system located in an adjacent room controlled the presentation and withdrawal of each stimulus and recorded the chicks' responses.

Procedure

After the first 12 hours of life, the lamp in each rearing cage was turned off. An hour later, each chick was placed in either the dark runway box or the dark operant chamber and then exposed to either the moving red cylinder or the moving yellow ball with tones and with the two 12-W lamps on. The stimulus exposed to each chick was the same as that exposed to each chick in its cage. This imprinting training session lasted for 30 min. The training session began with the illumination of the two lamps on the runway box and terminated with turning off the lamps. The training session was conducted three times within three days after the chicks hatched. Throughout each session, the stimulus-emitting metronome tones moved continuously in the run-

way box. Fourteen chicks were trained in the operant chamber during the imprinting training and thus had not experienced following the stimulus. The remaining seventeen chicks were trained in the runway box and thus experienced following the moving imprinted stimulus and had contact with it. The reason why two kinds of apparatus were used for the imprinting training was to compare the effects of experiences of following and contacting the stimulus on imprinting. After each imprinting training session, each chick was returned to its cage.

On the third day after hatching, each chick was tested for imprinting in the runway box with the right-side solid wall. Each chick was simultaneously exposed to both the red cylinder and the yellow ball placed at the opposite sides of the runway box under the illumination of the two lamps. Both stimuli were stationary and silent. Two test sessions of 10 min each were conducted. Positions of the two stimuli were reversed throughout the sessions. In these test sessions, the time each chick spent in the area within 15 cm from each of the stimuli was measured.

Ten chicks that chose only the stimulus to which they had been exposed first and that stayed near the stimulus for more than 785 s throughout the two test sessions were selected as the imprinted subjects for the subsequent resurgence sessions. This strict criterion was based on our previous studies (Kubota & Moriyama, 2007; Hasegawa & Moriyama, 2011). The 10 chicks imprinted to the stimuli were equally divided into two groups: the imprinted-stimulus and the food reinforcement groups. The imprinted-stimulus group consisted of two chicks imprinted to the red cylinder and three chicks imprinted to the yellow ball. One of the two chicks imprinted to the red cylinder was trained in the runway box and the other chick was trained in the operant chamber. Two of the three chicks imprinted to the yellow ball were trained in the operant chamber and the remaining one in the runway box. The food group consisted of three chicks imprinted to the red cylinder and two chicks imprinted to the yellow ball. Two of the three chicks imprinted to the red cylinder were trained in the runway box and the remaining one in the operant chamber. One of the two chicks imprinted to the yellow ball was trained in the runway box and the other chick was trained in the operant chamber. From the results of the imprinting test, there were no significant differences in the strength of imprinting neither between two imprinted stimuli nor between two training apparatus.

On Day 5 post-hatching, the chicks' key-peck responses for either the imprinted stimulus or food were shaped individually in the two-key operant chamber by the method of differential reinforcement of successive approximations (shaping). The reinforcer for the imprinted-stimulus group was the imprinting stimulus and that for the food group was food. Only the left key was used, and it was transilluminated red. The right key was covered by black tape.

After shaping, a few continuous reinforcement sessions were conducted. A fixed-ratio (FR) 3 schedule then was implemented for pecking the red left key. The FR 3 schedule remained in effect until response rates were stable as assessed by visual inspection. For different chicks, this required between 2 and 5 sessions. Each session continued until 30 reinforcers were delivered.

After response rates were stable, both keys now were transilluminated by colored LEDs. The left key was red, as before, and the right key was blue. The schedule was changed from FR to a concurrent variable-interval (VI) 3-s Extinction (EXT) schedule, and the resurgence portion of the experiment began. When the resurgence experiment started, the chicks were between 11 and 13 days old. The VI 3-s schedule was implemented for pecking the red left key, with interreinforcer intervals from 1 s to 5 s. The intervals were relatively short because chicks' key-peck response rates to an imprinted stimulus were extremely low in our previous studies (Hasegawa & Moriyama, 2011; Kubota & Moriyama, 2007; Moriyama, 1981, 2008; Moriyama & Kubota, 2007), and therefore the chicks' actual relatively long interresponse time (IRT) did not correspond to the VI interreinforcer intervals. Extinction was implemented to the pecking to the blue right key. A 2-s changeover delay (COD) was in effect to control rapid switching between the two keys.

There were three phases in the resurgence portion of the experiment, each lasting for several sessions. In the first phase, chicks' pecking responses to the red left key were reinforced by the presentation of either their imprinting stimulus or food. After 4-6 sessions in the first phase, the second phase began. However, as some chicks in the food group pecked only the left key, two sessions in which only the blue light was on were conducted before the second phase. Thus, in these sessions, only pecks to the blue right key were reinforced.

In the second phase, although the two colored keys were simultaneously presented to each chick, only pecks on the blue–right key were reinforced by the presentation of the same reinforcer and under the same schedule as in Phase 1. The second phase was designed to continue until the response rate to the red left key was 0 across three consecutive sessions. However, seven chicks did not attain this stability criterion. For these seven chicks, therefore, the second phase continued until response rates to the red left key were relatively low across three consecutive sessions.

After the above criteria were attained, the final phase was conducted in which the chicks' pecking responses to both keys were extinguished. That is, all reinforcement was withheld. Four extinction sessions lasting 30 min each were conducted. Resurgence was measured as the number of pecks on the red key in the initial extinction session.

In the resurgence sessions, a few chicks in the imprinted-stimulus group could not obtain 30 reinforcers due to their low rates of key pecking. In such cases, the relevant sessions terminated in 30 min after the final response of each session. Throughout the

resurgence sessions, each session occurred 7 days a week at approximately the same time each day.

Results

As previously noted, resurgence was defined as the number of pecks to the red key in the first extinction session of Phase 3. However, we used the key-peck response rates to both keys (number of pecks per min) to investigate resurgence. The reason why the rate of pecking was used as an index for investigating resurgence was that the duration of each session was different across the three phases.

Further, we calculated the rate of resurgence (ROR) as an index showing strength of resurgence using the following equation (cf. Obata & Moriyama, 2014).

$$ROR = \frac{m_1 + 1}{m_2 + 1} - 1$$

where m_1 denotes the rate of each chick's pecking response to the red key in the initial session of the third phase and m_2 denotes the rate of the chick's pecking response to the red key in the last session of the second phase. If resurgence did not occur in the initial session of the third phase, the ROR was zero or a negative value because the rate of the last session of the second phase was equal to or larger than that in the initial session of the third phase. In contrast, if resurgence occurred in the initial session of the third phase, the ROR was a positive value. Further, the stronger the level of resurgence is, the larger the ROR positive value is. We subjected this index to an ANOVA to test for differences in the magnitude of resurgence between groups.

Figure 1 shows each chick's rate of key pecking to both keys in each session across the three phases and their RORs. The RORs are shown in the parenthesis below each chick's number. Further, the figure shows the difference in resurgence comparing the two reinforcers. The left column shows the rates of the 5 chicks in the imprinted-stimulus group, and the right column shows those of the 5 chicks in the food group. Note that the vertical scales for the imprinted-stimulus group are smaller than those for the food group.

Overall, the rates of pecking in the food group to both keys were higher than those in the imprinted-stimulus group in all sessions. In the first phase, while the chicks in the food group rarely pecked the alternative blue key, those in the imprinted-stimulus group pecked that key frequently. In the last three sessions of the second phase, all chicks except for Chick #2 differentially pecked both keys, with more frequent pecking of the blue key. For the food group, Chicks #9, #20, and #29's key-peck responses to the red key were completely extinguished in the last three consecutive sessions in

the second phase, whereas the remaining two chicks' responses were not. For the imprinted-stimulus group, all chicks emitted a few responses to the red key in the last three sessions in the second phase.
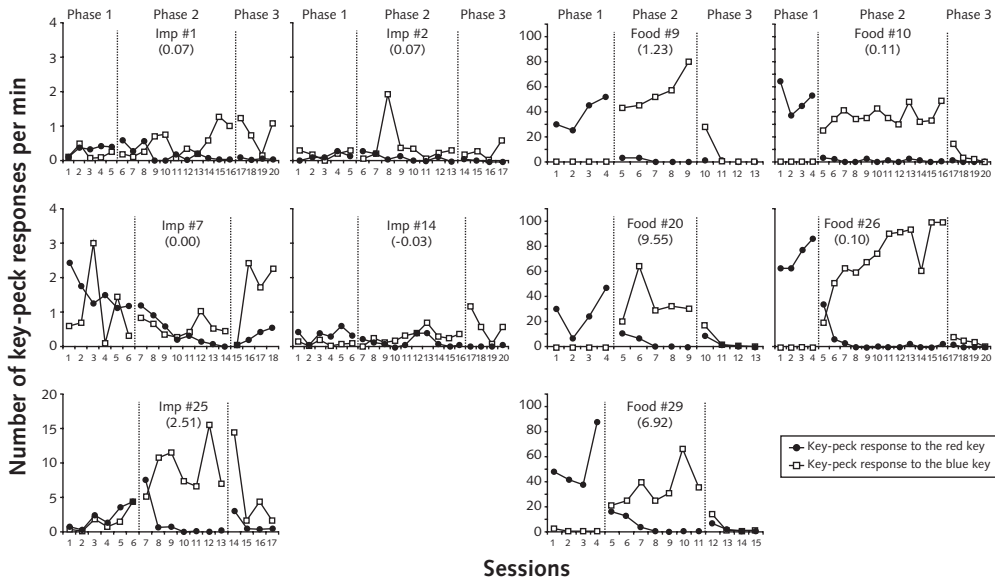

Figure 1. The rates of each chick's pecking of the red and blue keys for the imprinted-stimulus (lmp) and the food (Food) groups in each session throughout three phases. In the initial phase, only pecks to the red key were reinforced by either reinforcer. In the second phase, while pecks to the blue key were reinforced by the same reinforcer as in Phase 1, those to the red key were extinguished. In the final phase, the responses to both keys were totally extinguished. The numerical value given in parenthesis below each chick number denotes rate of resurgence (ROR).

In the third phase, for the imprinted-stimulus group, three chicks (#1, #2, and #14) pecked both keys in the first session at the same level as that in the last session of the second phase. Chick #25's rates of pecking both keys increased in the first session of Phase 3. Chick #7's rates of pecking both keys decreased and then increased over the Phase 3 sessions.

For all chicks in the food group, rates of pecking the blue key decreased in the first session of Phase 3, whereas rates of pecking the red key increased. Their rates of pecking both keys decreased over the Phase 3 sessions.

Therefore, in the first session of the third phase, although Chicks #1 and #2 showed slight increases in the rates of pecking to the red key, all chicks except for #7 and #14

showed resurgence of the pecking response to the red key initially reinforced by either the imprinted stimulus or food.

Resurgence in the food group was greater than that in the imprinted-stimulus group in terms of both ROR and the number of chicks with high RORs. The mean ROR for the food group was 3.58 (SD = 4.37), whereas that for the imprinted-stimulus group was .52 (SD = 1.11); the difference was not statistically significant (F(1, 8) = 2.243, p = .173).

For the food group, the RORs of Chicks #9, #20, and #29 were higher than those of the other two chicks in that same group. The former three chicks' key-peck responses to the red key were completely extinguished in the last three consecutive sessions in the second phase, whereas the latter two chicks' responses were not.

For the imprinted-stimulus group, three chicks (#1, #2, and #25) that had been trained in the operant chamber during the imprinting training (and thus had not experienced following the stimulus) showed weak resurgence. The remaining chicks (#7 and #14), which had been trained in the runway box and thus had experienced following the moving imprinted stimulus and had contact with it, did not show resurgence. Differences in the ROR between the chicks (#2, #14, and #25) imprinted to the yellow ball and those (#1 and #7) imprinted to the red cylinder were not systematic.

Next, we investigated the types of responses that occurred during the first session in Phase 3. First, we observed the chicks' behavior via video recording. Then, we identified four kinds of responses to be observed: those related to the red key (REDK), those related to the blue key (BLUEK), those related to the feeder (FOOD), and those related to the imprinted stimulus (IMP). The REDK class consisted of each chick's facing, approaching, and pecking the red key and the front panel near the red key. The BLUEK class consisted of each chick's facing, approaching, and pecking the blue key and the front panel near the blue key. The FOOD class included each chick's approaching the feeder and looking into its aperture. The IMP class included each chick's approaching the wire mesh window through which the chicks could see the moving imprinted stimulus and rubbing against it.

Two of the authors independently observed each chick's behaviors during the session by interval recording via video recorder. The four kinds of responses noted above were observed. The interval was 1 min in duration. As the first extinction session was 30 min in duration, the number of intervals was 30 for each chick. The observers recorded only whether each response class occurred or did not occur during each interval. The inter-observer agreement (IOA) for each response class for each chick was calculated by dividing the number of agreements between the two observers by the total number of intervals and converting the result to a percentage. The mean IOA (%) across four response classes for each chick was as follows: for the imprinted-stimulus group,

82.1 (#1), 82.4 (#2), 95.1 (#7), 71.7 (#14), 79.2 (#25) and for the food group, 74.2 (#9), 74.7 (#10), 75.4 (#20), 68.1 (#26), and 79.6(#29). The mean IOA for the imprinted-stimulus group was 82.8 (*SD* = 8.45), and that for the food group was 74.4 (*SD* = 4.12).

Figure 2 shows the probability of each response class for each chick over blocks of the first session of Phase 3. Each block consisted of five intervals. The probability of each response class was calculated by dividing the number of intervals during which the response class occurred by the total number of intervals in a block (i.e., 5). We could not observe the behavior of Chick #10 of the food group during Blocks 4, 5, and 6 because of a malfunction of the houselight in the operant chamber.
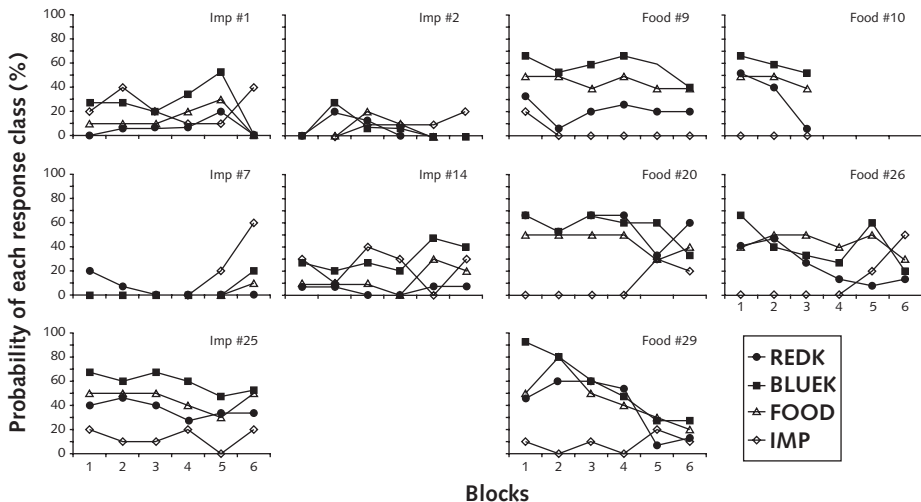

Figure 2. Probabilities of four response classes for each chick over blocks of the initial session of Phase 3. The classes were labeled REDK, BLUEK, FOOD, and IMP, which represent, respectively, responses related to the red key, those related to the blue key, those related to the feeder, and those related to the imprinted stimulus. Each block consisted of 5 intervals. Each interval was 1 min in duration.

Figure 2 shows that all chicks of both groups, except for Chick #7, frequently ex-hibited the BLUEK response class during the first three blocks, and after that, the prob-abilities decreased for the food group, whereas there was no consistent trend among the chicks of the imprinted-stimulus group. For the food group, the probability of the REDK response class was relatively high in the initial two and/or four blocks and was low in the last block. For the imprinted-stimulus group, the probability of REDK was

low over all blocks, except for Chick #25. All chicks in the food group exhibited a high probability of the FOOD response class and low probability of the IMP response class, whereas all chicks in the imprinted-stimulus group, except for Chick #25, showed the opposite tendency. The probability of the IMP response class was increased for all chicks in the last block. For the imprinted-stimulus group, there were no systematic differences in each response class between the chicks (#1, #2, and #25) that had been trained in the operant chamber during the imprinting training and those (#7 and #14) trained in the runway box. Further, there were no systematic differences in each response class between the chicks (#1 and #7) imprinted to the red cylinder and those (#2, #14, and #25) imprinted to the yellow ball.

As shown in Figures 1 and 2, chicks with relatively high ROR showed a similar pattern of probabilities for the four response classes. However, the chicks in the imprinted-stimulus group emitted more IMP-class responses than the food group, whereas those of the food group demonstrated more FOOD-class responses than the imprinted-stimulus group. For the imprinted-stimulus group, there were no systematic differences in each response class between the chicks (#1, #2, and #25) which showed resurgence and those (#7 and #14) which did not resurgence.

Discussion

Newly hatched white leghorn chicks showed resurgence of key-peck operant responses previously reinforced by either an imprinted stimulus or food when these responses were extinguished. Further, resurgence of the responses reinforced by food was much stronger than those reinforced by the imprinted stimulus, and the resurgence of both responses occurred during a relatively early stage of the extinction. Moreover, resurgence of the first responses reinforced by the imprinted stimulus was accompanied by responses related to the stimulus, whereas resurgence of those responses reinforced by food was accompanied by those related to food.

Low rates of key-peck responses when reinforced by the imprinted stimulus might explain the weak resurgence in this group of chicks. Low rates of key-peck operant responses when reinforced by an imprinted stimulus have been reported in our previous studies (Hasegawa & Moriyama, 2011; Kubota & Moriyama, 2007; Moriyama, 1981, 2008; Moriyama & Kubota, 2007). Thus, we can support da Silva et al. (2008), who suggested that the initial response rate might affect subsequent resurgence. Further, the RORs of the three chicks that showed complete extinction of the first responses in phase 2 were relatively high. Thus, an inverse relation between degree of extinction of the first response and its subsequent resurgence was partially suggested (cf. Leitenberg et al., 1970; Rawson et al., 1977).

Considering the above, we conclude that resurgence is a reliable behavioral effect due to an operant reinforcement history that occurs across a variety of animal species and various reinforcers (Lattal & St. Peter Pipkin, 2009).

Although the difference between the RORs of the two groups was not statistically significant, the magnitude of resurgence was extremely weak in the responses reinforced by the imprinted stimulus. The results of the ANOVA might be due to the small number of chicks in both groups and the large variability in the ROR for the food group. Thus, there may be a biological constraint on the occurrence of resurgence. Further, the finding that resurgence of the first responses was accompanied by responses related to the reinforcers may also reflect the constraint. The reason why the key-peck response rate was extremely low when reinforced by the imprinted stimulus may be due to the occurrence of competing responses directed toward the stimulus. We observed that the imprinted chicks often stayed near the right-side wire mesh window and rubbed against the wire mesh for a while even if the imprinted stimulus was withdrawn. In fact, some chicks bruised their beaks. This response tendency made their interresponse intervals longer. Owing to this, the rate of pecking might have been low. The tendency is suggested to be a species-specific reaction. If so, the low tendency of resurgence for the imprinted-stimulus group might be due to this biological constraint.

On the other hand, all chicks in the food group showed responses related to food. If these responses interfered with resurgence as in the imprinted-stimulus group, the magnitude of resurgence in the food group should have been weak, as it was in the imprinted-stimulus group. However, the magnitude of resurgence among chicks in the food group was relatively strong. Considering this, regarding food reinforcers, we cannot conclude an intrusion into resurgence of responses related to phylogenetically important reinforcers.

We thus must consider possibilities other than biological factors to explain the difference in the resurgence of key-peck responses when reinforced by either imprinted stimulus or food. The difference might be due to a difference of positional relation between the red key and the location where each reinforcer was presented. The distance between the key and the feeder was shorter (approximately 12 cm) than that between the key and the right side wall (approximately 15 cm). Furthermore, the feeder was on the same front panel as the key, whereas the place for viewing the imprinted stimulus was not. To examine this possibility, the imprinted stimulus should be presented on the same panel as the key.

For the imprinted-stimulus group, the chicks showing resurgence were those that had received the imprinting training in the operant chamber. On the other hand, the chicks that did not show resurgence were those that had received the training in the

runway box. From this result, the difference in settings between the imprinting train-ing and the resurgence experimental session might lead to the difference of resurgence. For the food group, such difference in the settings might not be irrelevant to resurgence of responses reinforced by food because the reinforcer was food. This issue needs further examination.

We also should investigate the possibility of a response chain consisting of peck-ing the red key as an initial link and pecking the blue key as a second link. Although a COD was programmed in each resurgence session, a response chain still might be generated. The occurrence of key-peck responses to the blue key was synchronized with that of key-peck responses to the red key in the initial session of Phase 3. Further, the chicks showing clear differential occurrence of pecking both keys in the second phase showed relatively high RORs. These results suggest the possibility of a response chain in resurgence. However, each link is usually extinguished backwards under extinction. If so, the initial link was the last to be extinguished. Resurgence in the ini-tial session of Phase 3 might reflect such a gradual extinction process of the chain. However, as our results indicate the recurrence of the initial response in an early stage of the extinction, the explanation of resurgence as resulting from a response chain might not be plausible, even if it is possible.

Finally, we should investigate the occurrence of resurgence as a function of re-sponse variability in extinction because there were four response classes in the pres-ent study in the initial session of Phase 3 (cf. Epstein, 1983; Cleland et al., 2001). To do this, we should have observed the four response classes in the last sessions of the first and second phases and compared them with those in the first session of Phase 3; without such observations, we cannot know whether the pattern for each response class is typical at the point of resurgence.

Considering the above possibilities, we believe it is important to first investigate environmental variables contributing to resurgence before investigating the intrusion of responses related to phylogenetically important reinforcers.

In conclusion, the present experiment provides new data on resurgence using newly hatched chicks and an imprinted stimulus as a species-specific reinforcer. These chicks showed resurgence of key-peck operant responses previously reinforced by either an imprinted stimulus or food under their extinction. Further, the magnitude of resurgence was much stronger in responses reinforced by food than those reinforced by an imprinted stimulus, and resurgence of responses reinforced by each reinforcer occurs in a relatively early stage of extinction. Finally, while resurgence of the first responses reinforced by an imprinted stimulus is accompanied by responses related to the imprinted stimulus, resurgence of those responses reinforced by food is accom-panied by those related to food.

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