DE GRUYTER OPEN

GESTALT THEORY, DOI 10.2478/gth-2018-0016
© 2018 (ISSN 2519-5808); Vol. 40, No.2, 189–206

Original Contributions - Originalbeiträge

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Hier bin Ich: Wo bist Du?

The Affiliative Imprinting Phenomenon in the Modern Study of Animal Cognition

Introduction

In a world in which animals were seen as little robots or machines, only capable of being shaped by punishments and reinforcements as per the strictest behaviorist perspective, Lorenz's experiments on imprinting (alongside those performed by other contemporary famous ethologists) represented a true revolution.

First described by Douglas Alexander Spalding in 1873, and then studied extensively by Konrad Zacharias Lorenz (1935), the imprinting phenomenon is a form of attachment to the mother or, when absent, to the first conspicuous object seen after birth. The following behavior displayed by the hatchlings of precocial bird species is a typical affiliative response genetically determined, by means of which we recognize imprinting. While the response is innate and hence preprogrammed and identically present in all individuals, the features of the stimuli toward which the young direct their attention are not identical and can differ depending on what is available in the environment. Imprinting is a learning mechanism that guarantees that the animal memorizes the mother's features and uses them in the future by the sole fact of being exposed to them. Such a mechanism is present not only in precocial species but also in other animals, with the difference that the attachment response shows variations depending on the species: altricial chicks flap wings, mammals seek physical contact, and newborns of humans smile. Furthermore, imprinting is not only visual but can also involve all other sensory modalities and their different combinations. For instance, some birds are subjected to acoustic imprinting before hatching (Gottlieb, 1979; Heaton, 1972) and human newborns recognize their mother's voice at birth (DeCasper & Fifer, 1980) or remember the songs she used to intonate during the last period of pregnancy (Partanen, Kujala, Tervaniemi, & Huotilainen, 2013). One interesting aspect of imprinting is that it is a form of exposure learning in which no reward strengthens the association between a stimulus and any response: the exposure by itself facilitates further learning and discrimination (for reviews, refer to Bolhuis, de Vos, & Kruijt, 1990; Bolhuis, 1991). As such, the process of imprinting is still studied extensively, especially in the fields of recognition memory and exposure learning (for reviews, refer to Horn, 2004; McCabe, 2013).

The Imprinting Phenomenon

In Lorenz's formulation, imprinting was a special kind of learning that precocial nidifugous birds show during a very brief critical period after hatching. It was also described as irreversible and devoted to the learning of the features of the species. The following studies, conducted in the laboratory, have tempered his position, showing that the time window in which a memory of the relevant object can be formed extends to a slightly longer period, that imprinting is a form of perceptual learning devoted to learning the characteristics of a single individual, not the species, and in part is reversible, because the animal can bond with a second artificial object, different from the first, although it will never forget the features of the first one encountered within the same time window (Bateson, 1990). In natural environments, the stimulus that the chicks are first exposed to is the real mother, but it may happen, as happened to Lorenz's greylag geese (*Anser anser*), that the chicks show filial imprinting toward a different object, say a surrogate, which in Lorenz's case were his boots. This is nicely described by Lorenz in his book entitled "Hier bin ich: wo bist du? Ethologie der graugans" (Here I am: Where are you? The behavior of the greylag goose), in which he depicts the behavior of the young goose Martina. In the evocative title, he summarizes Martina's call and behavioral display looking for his figure (and his boots), namely, her imprinting on Lorenz or on the parts available to her sight. Such flexibility in imprinting gives special power to scientists interested in this form of learning because they can easily transfer the testing to an artificial environment, i.e., the laboratory. This is what several researchers did during the past century to understand the neurobiology of the phenomenon, especially at the University of Cambridge (refer, for instance, to Bateson, Horn, & Rose, 1973; Horn, Bradley, & McCabe, 1985). Working in the laboratory, and using stuffed hens or artificial shapes, it is possible to exert accurate control over chicks' sensory experiences. Hence, immediately after hatching, naïve chicks can be exposed in a controlled environment to a certain stimulus for a time interval ranging from 1–2 hours to 7 days (imprinting phase); next, the chicks, with no further visual experience, are allowed to choose between two alternatives placed at the opposite ends of a runway either by walking freely and associating for longer period with the one they appreciate the most, or by operating a running wheel with a higher number of revolutions toward the one they prefer. Chicks' uneven motor activity to the two alternatives shows us whether, for instance, they perceptually organize the visual scene by means of rules that are functionally comparable to those that we, as humans, use. With this strategy, Mario Zanforlin (1981) showed that chicks are sensitive to illusory contours and, some years later, Lucia Regolin and Giorgio Vallortigara (1995) proved that they also show amodal completion. After watching a triangle partially occluded by a horizontal rectangle, the chick

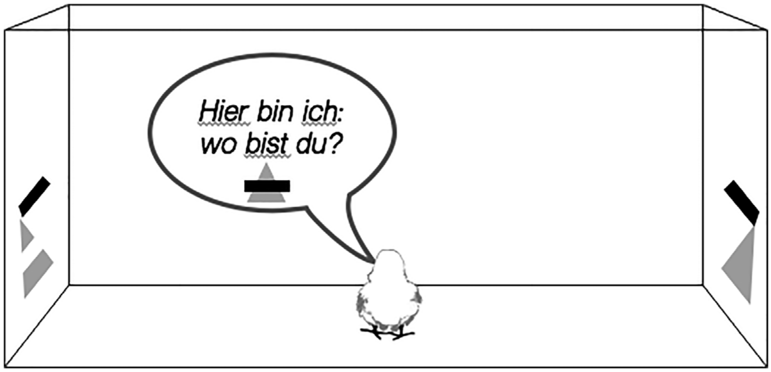

Fig. 1. The chick is first exposed to a triangle partially occluded by a horizontal rectangle (as depicted inside the call-out); after this imprinting phase, the chick is placed in the middle of the runway and left free to choose between an amputated triangle perceptually identical to the occluded one with a dislocated rectangle, as seen during the imprinting phase (depicted on the left end) or an entire triangle with a dislocated rectangle (depicted on the right end). In the call-out, the chick expresses its memory of the imprinting object it is looking for, talking as Martina, the goose in Lorenz's book (drawing by Cinzia Chiandetti).

can choose either an entire triangle with a dislocated rectangle or an amputated triangle perceptually identical to the occluded one with a dislocated rectangle, as seen during the imprinting phase (Figure 1). The majority of the chicks tested in this condition prefer to walk closer to the entire triangle with the rectangle placed apart, indicating that they complete in a whole triangle the shape seen during the imprinting phase.

Amodal completion has its biological relevance in a common problem to survival: objects (conspecifics, preys, and predators) can be partly occluded and only fragments may be visible from behind vegetation or when illumination is scanty. However, they need to be represented as complete entities so that the adequate motor response can be programmed (attacking a prey, escaping a predator, or following the siblings). Conditioning paradigms have been used to test such ability in other species; with imprinting, there is the unique advantage of exploiting a chick's strong motivation in a low situation of stress or deprivation to investigate its perceptual organization.

Agent Detectors

As described in the previous section, chicks "imprint" or attend to animated objects seen shortly after birth. Much effort has been devoted to understanding the visual mechanisms ruling the social attachment and recognition that are based on non-learned preferences for face-like stimuli (Johnson, 2005; Rosa-Salva, Regolin, &

Vallortigara, 2010), sensitivity to biological motion (Vallortigara, Regolin, & Marconato, 2005), animacy cues (Mascalzoni, Regolin, & Vallortigara, 2010), and self-propulsion (Rosa-Salva, Grassi, Lorenzi, Regolin, & Vallortigara, 2016). Thus, at the beginning, conspecifics are not even discernible from heterospecifics (Johnson & Horn, 1988); at the very onset of a chick's life, a detection mechanism, named CONSPEC, orients chicks' attention toward face-like configurations defined by a triangular arrangement of dark blobs. Thereafter, a second mechanism, labeled CONLERN, allows learning the features of specific individuals (Johnson, 1992; Johnson, Bolhuis, & Horn, 1992). Similarly to what was initially predicted by this CONSPEC–CONLERN model, evidence has been found that a first raw schema of faces or biological motion acts as a template attracting also the human newborn's attention to social stimuli and, on to this template, learning the distinctive features of specific social partners is possible (Rosa-Salva et al., 2010; Rosa-Salva, Farroni, Regolin, Vallortigara, & Johnson, 2011; Rosa-Salva, Regolin, & Vallortigara, 2012). Thereafter, individual recognition (Vallortigara & Andrew, 1994) provides an adaptive advantage in a species in which a strict dominance hierarchy applies to food access by means of the pecking order. Chicks also show transitive inference (Daisley, Vallortigara, & Regolin, 2010) in order to avoid a direct encounter with an individual they have never directly fought with if it is of a higher rank.

Chickens produce a series of well-known and stereotyped vocalizations that are used in different contexts, but they neither sing nor can personalize the calls (Collias & Joos, 1952). We know also that chicks hatch with a predisposed raw model of maternal calls. Specific height, frequency, and intensity of a hen's call may be preferable to others (Kent, 1993). In trying to dissect complex sounds and identify musical universals subtending agents' vocalizations and supporting the identification of the presence of agents, together with Giorgio Vallortigara, we focused on consonant sounds.

Chicks hatched in small isolated compartments within incubators that were completely isolated from external sounds; hence we controlled for their auditory experiences, too. Each chick had its own imprinting object at hatching and, a few hours later, it was placed in the middle of a runway. At the opposite ends of the runway, there were two identical replicas of the imprinting object seen at hatching, one playing the consonant version of a melody and the other the dissonant version of the same melody at the same time (Figure 2), with the assumption that if there was a preference for a certain kind of sound, the chick would have preferentially approached the area where it could better hear the favorite version of the melody. We found that chicks spent significantly more time closer to the replica that was playing consonant sounds (Chiandetti & Vallortigara, 2011a).

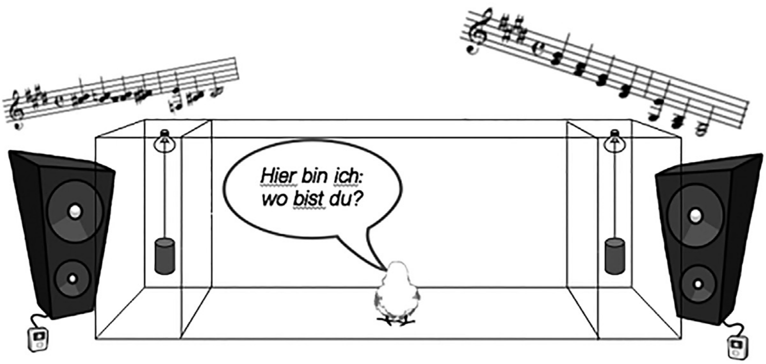

Fig. 2. The chick hatched with a red imprinting object and when still acoustically naïve, is placed in the middle of the runway and left free to choose between two replicas of the object playing simultaneously a different version of the same melody: dissonant (leftward) and consonant (rightward). The chick calls the mother/conspecific it is looking for, talking as Martina, the goose in Lorenz's book (drawing by Cinzia Chiandetti).

In this study, we used melodies played with piano timbre taken from a previous experiment carried out on human infants. In the attempt to make the stimuli more naturalistic and to replicate the first findings, we have recently exploited an ecological situation: broody hens keep clucking while walking around to stimulate chicks' following behavior. We simulated such condition in the laboratory by placing each chick in a running wheel with its imprinting object 50 cm apart. We then manipulated an adult hen's vocalization so as to administer in a sequence a consonant and a dissonant clucking presented within the hen's rhythmical species-specific pattern. The assumption was that chicks would operate the running wheel more to join the object when it was "calling" with consonant intervals than with the dissonant ones, and again chicks showed a preference for the consonant version of the clucks (Baiocchi & Chiandetti, 2016).

An analysis of animals' vocalizations reveals that harmonic structures are common and hence naturally present among agents (Schwartz, Howe, & Purves, 2003). Therefore, consonant sounds may well represent a crucial discriminative factor to decide whether the object is a living creature and to establish affiliative interactions. In this sense, consonances seem a pervasive and phylogenetically ancient building block that could well represent the innate precursor of more complex musical abilities in other species (Chiandetti, 2016; Bowling & Purves, 2015).

Aware of Walking on Eggshells

The Gestalt school of psychology labeled as "naïve physics" the untrained common intuitions of the observed physical phenomena (Bozzi, 1990) that we simply cannot elude in our everyday reasoning when we interact successfully with a world made of objects. Many of these notions are oversimplifications that nevertheless predict the exact outcome of physical events, although they are sometimes based on a misunderstanding of the underlying proper physical principles. Quite surprisingly, when the naïve beliefs lead to erroneous predictions of the final effect, we discover that those beliefs are also resilient to experience, which may not be sufficient to provide correct knowledge of the phenomena (e.g., Caramazza, McCloskey, & Green, 1981; Hetch & Proffitt, 1995). This makes it apparent that some significant effort is necessary to understand the exact formal mechanisms of nature: there is a real battle in our heads between common implicit beliefs and formal acquired rules. The presence of such beliefs in childhood would also explain why it is difficult for infants to understand scientific subjects. Wolfgang Köhler described the difficulty of chimpanzees (*Pan troglodytes*) in stacking boxes in a pile (1921), a difficulty common to human infants and familiar to those of us who have played with young children. However, by devising specific situations in which the animals only see a physically possible or, vice versa, an implausible event, without the need for the animals to act on the objects, their eye gaze and fixation times reveal their intuitions: they stare significantly longer at those impossible events that are violating simple intuitive principles of how objects interact (Cacchione & Krist, 2004; Call, 2007). And with the same ploy, it has been proved that infants as young as 2.5 months attribute specific physical properties to objects by reasoning in terms of naïve physics (Aguiar & Baillargeon, 1999; Baillargeon, 2004). Infants and chimpanzees are not alone in showing an understanding of the folk physics: dogs (Pattison, Miller, Rayburn-Reeves, & Zentall, 2011) as well as rooks (Bird & Emery, 2010), for instance, master comparable tasks.

One might then wonder what proportion of these abilities depends on specific experiences with objects and their resultant behaviors. Domestic chicks comprise an optimal animal model to address this issue. Indeed, their high motility soon after hatching and the spontaneous response to follow and rejoin the imprinting object as soon as it is displaced is the perfect combination of ingredients to investigate whether they reason in terms of intuitive physics and whether such skill is independent of experience.

After living with an artificial companion with specific physical features (tall, short, stout, or thin, as visible in Figure 3), each chick was shown it disappearing behind one or the other of two identical opaque barriers (Figure 4, leftmost panel). Soon the chick explored the barrier circumvented by the object, rejoining with it, simply keeping track of the place where the object had gone before. In the crucial situation, the chick was only shown the object moving toward the barriers and then its sight was prevented by an opaque partition. With the chick restrained in

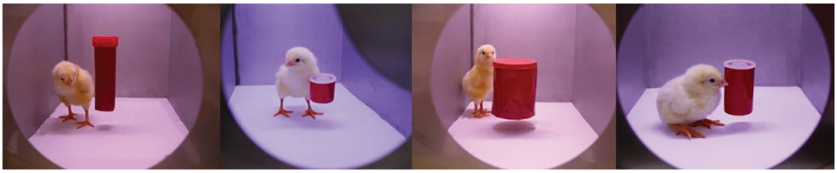

Fig. 3. Each chick lives with a different red artificial companion: tall, short, stout, or thin (pictures taken by Cinzia Chiandetti).

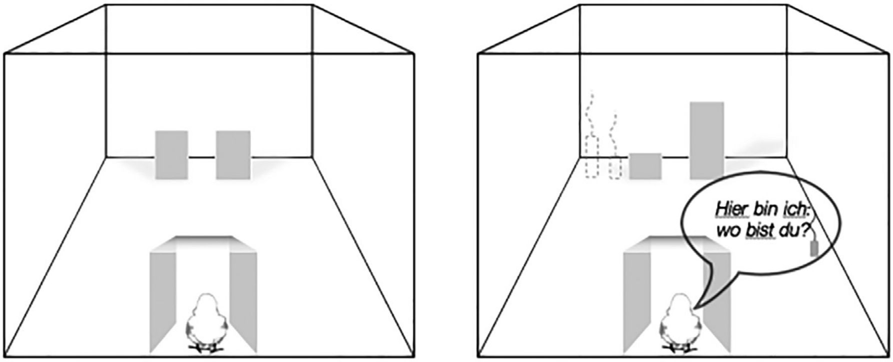

Fig. 4. The chick is shown its imprinting object moving and hiding behind one or the other of two identical barriers (leftmost); then, its view is prevented by an opaque partition while the experimenter changes the size of the barriers (rightmost, in this example height is manipulated: the short object (depicted with dotted line) can be concealed by both panels, whereas the tall object (depicted with continuous line) can be concealed by the higher barrier only). Finally, the chick is released for the choice. In the call-out, the chick expresses its memory of the imprinting object it is looking for, talking as Martina, the goose in Lorenz's book (drawing by Cinzia Chiandetti).

this condition, the experimenter manipulated the physical aspect of the barriers, for instance, by making one taller and one shorter, so that one barrier, but not the other, had the proper relative size to conceal the tall imprinting object behind it and both could instead hide the short one (Figure 4, rightmost panel). As soon as the chicks were released and left free to make a choice, most of them explored the barrier with the appropriate size to act as an occluder, avoiding any visit to the other one that was inadequate to conceal the object behind it.

The same procedure was applied to other dimensions, including the slant of the barrier of a degree compatible with the presence of the object beneath it; the results were of the same kind: only the adequate barrier was approached by the chick to check whether the object was hidden beneath it.

In a further experiment, we also reduced the possibility that chicks learned some physical features by living in direct contact with the object: we prevented chicks from touching or pecking at objects in order to eliminate any experience of its solidity by rearing them in small compartments with the object only visible from a transparent window (Figure 5). Even in this case, the chicks chose the appropriate occluder, likely showing that a certain basic intuitive reasoning on folk physics is possible from birth and without previous interactions with objects: chicks infer correctly the object's physical properties when the possibility to have learnt them from experience is extremely reduced (Chiandetti & Vallortigara, 2011b).

All intuitions, such as support, cohesion, connectedness, occlusion, continuity, boundedness, solidity, and so forth, are at the basis of further learning. Evidence in support of this claim comes from recent studies on infants in which researchers' attention was focused on what happens after violation of one of these concepts. In this experiment, 11-month-old infants detected either the violation of solidity when a toy car magically penetrated a solid wall or the violation of support when the toy car was magically floating: as in the studies described before, looking times for such implausible events were significantly higher with respect to the control condition in which the same toy car was not violating any physical law. The violations proved to be special conditions for learning further properties of the objects, which, researchers showed, are better associated with the violating toy than to the control toy that produced no violation. Most convincingly, when the infants were left free to play with the toy, they tested the violated principle by producing systematically the most appropriate action to verify the object's behavior: the infants banged the toy against the table to verify solidity and dropped it on the ground to verify support (Stahl & Feigenson, 2015). The innate building blocks of physical reasoning, acting as an expectancy framework, promoted

Fig. 5. A chick reared in a small compartment with the object, which is only visible from a transparent window; pecking and touching are prevented by this restraining condition (picture taken by Cinzia Chiandetti).

information-seeking and hypothesis-testing behaviors when violated, thus offering unique opportunities to learn: very young infants weigh new evidence against prior beliefs.

Geometers in the Poultry Yard

Animals get their bearing in a rectangular room by relying on distances, lengths, and angles among surfaces, all "geometric" information used in combination with left–right directional sense.

Imagine being inside a rectangular room; a red object is placed in the corner in front of you: it has a long wall on your right and a short wall on your left. If you turn 180°, you will face another corner that is located on the opposite side of the room along the same diagonal and has an identical arrangement of the walls: it has again a long wall on your right and a short wall on your left. When provided with no other information within the room, you cannot distinguish between the correct corner and its rotational equivalent. However, by recognizing the metric arrangement (long–short and left–right) of the walls at the two corners, preference for these corners is expected to be well above chance, since the other two corners have the opposite combination of the geometric information. Such symmetry of the environment along the diagonals is used by almost all animal species that have been tested thus far in the same room, from ants to fish, from monkeys to pigeons (Cheng, 1986; Cheng & Newcombe, 2005). Is the processing of the metric information something that we can all deal with because it is predisposed in our brains?

Chicks' performance within the rectangular room is comparable to that of all other animal species; moreover, they provide researchers with the possibility to investigate whether the ability to deal with the Euclidean geometry of the environment depends on specific experiences, i.e. whether navigation in different rooms may affect their performance or, rather, whether this is an inborn ability. To address this question, precocial domestic chicks were maintained since hatching in either rectangular or circular rearing cages, with the understanding that a rectangular cage was providing the animal the experience of joint surfaces, right angles, and differently elongated walls, hence a geometrically rich environment; conversely, circular cages were limiting such experience to the minimum, a geometrically poor environment. After living for 3 days in such cages, different groups of chicks were tested in the same rectangular room you imagined at the beginning of the paragraph; in each corner, there was a food jar but only one had a hole to access the food so that visual and olfactory cues were balanced but chicks had to use the geometry of the room to learn navigating toward the correct corner subtended by a specific arrangement of wall length and left–right directional sense. Chicks of both groups, rectangular and circular reared, resorted in a comparable fashion to the geometry of the room when reorienting to the target food jar (Chiandetti & Vallortigara, 2008, 2010).

Of course, exposure to geometry – as provided by the shape of the training room – was unavoidable during the acquisition of the task itself, and before sensitivity to geometry was tested. Hence, with a new method, which combines chicks' spontaneous responses to rejoin the imprinting object as soon as it is displaced and a working memory version of the testing paradigm, it has been possible to eliminate all previous experience in a geometrically structured environment and to evaluate immediate responses to geometry. Baby chicks, only 1 day old, were hatched in darkness and exposed to the imprinting object directly in the rectangular room for testing. They first could observe the object moving in a particular corner; then, they were disoriented under an opaque cylinder, while the experimenter placed four identical replicas of the imprinting object at the four corners (Figure 6). When chicks were released for a reorientation choice, they showed a spontaneous recovery of their bearings by using the lengths of the surfaces combined with their left–right directional sense and rejoined the imprinting object located in the correct corner or its rotational equivalent (Chiandetti, Spelke, & Vallortigara, 2015). With no experience of navigating in a geometrically structured environment such as the rearing cage or the testing room itself, chicks proved to be able to spontaneously use the metric of the environment to relocate a target object.

Animals thus seem born endowed with the specific spatial knowledge to appreciate and use the geometry of outer flat surfaces (see, for instance, Spelke, Lee, & Izard, 2010). In ecological terms, geometric features are detectable in

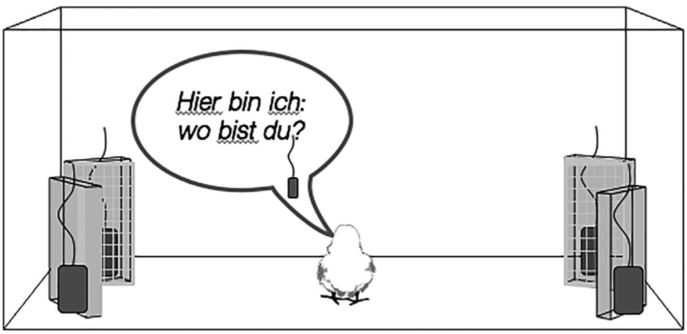

Fig. 6. A chick, before the choice for the correct corner or its rotational equivalent, with the four replicas making the corners indistinguishable if no geometric information is used to reorient. In the call-out, the chick expresses its memory of the imprinting object it is looking for, talking as Martina, the goose in Lorenz's book (drawing by Cinzia Chiandetti).

the visual appearance of a heterogeneous distribution of discrete objects, such as the trees of a forest seen from a distance; hence, adaptive pressures have prepared organisms to cope with a geometric environment and sculpted the mechanisms to encode and use it in their brains. Indeed, the hippocampal formation, which seems central to orientation and navigation in birds, has been characterized with a number of different classes of cells in rodents (review in Stensola & Moser, 2016), which seem related to the specific ability of navigating with a metric map, as if an abstract spatial structure is constructed inside the brain and imposed on the environment by the brain with no regard for the sensory features of the environment. Although the same classes of cells have not been recorded in the avian brain, the involvement of the hippocampal formation in orientation by spatial geometry and encoding of the geometric shape of the environment has been recently found in chicks (Mayer et al., 2016, 2017).

Extraordinary Precocious Learners, too?

Imagine you are frightened by a sudden loud noise (e.g., the window bangs because of the strong wind). You react with a startle and, if you are too lazy to fix the window to prevent the loud noise in the near future, it can happen again, but after few repetitions, you soon start decreasing your startle response. Now, imagine you move in another room and another window bangs: you will probably react with a startle again, despite the fact that you had already an experience of this specific noise in the previous room. Following this simple logic, you have just realized that the phenomenon of habituation, i.e., the decrease of a response whenever an irrelevant nonnoxious stimulus is filtered out, is context dependent. Hence, although usually referred to as a textbook example of nonassociative learning, the fact that the noise is associated with a certain context makes it an associative form of learning (Wagner, 1978).

Recently, together with my colleague Massimo Turatto, we pondered over whether baby chicks are already capable of such a sophisticated associative learning process that takes into account complex environmental information. To investigate this, we exposed chicks for the first 3 days of their life to an imprinting object and then we administered them two series of five identical auditory stimuli on 2 consecutive days. Crucially, all animals were exposed to the auditory stimulation in different contextual settings on their third day of life and then tested in the same context, i.e., the running wheel, on their fourth day of life. Chicks spontaneously operated the running wheel in order to rejoin the object placed a few centimeters apart, and we recorded the stops of the wheel-running behavior triggered by the acoustic stimulus as a measure of habituation with the assumption that they would stop the running wheel behavior at the first presentation of the sound and then decrease the number of stops due to the fact that it was recognized as nonnoxious (i.e., habituation occurred). The results showed that in very young animals of this avian species, habituation changes in a context-dependent manner, meaning that chicks at early stages of development can use complex contextual information to adapt their behavior (Chiandetti & Turatto, 2017). A role of context was also previously described in a familiarization condition, in which chicks learnt the texture of their pen within the first 3 days of life and recognized it when later presented on a model, i.e., the neophobic reaction in front of a new object was reduced by previous experience with the same texture (Bateson, 1964a).

In a subsequent work, we studied the ontogenetic development of such a learning mechanism by looking at the performance in the running wheel of chicks 1 or 2 days younger (i.e., when 1 day or 2 days old). We found that habituation was already present 1 day after hatching and also that, on the second day of stimulation, the amount of learning was significantly attenuated in chicks of 3–4 days of age as compared to the younger animals, thus showing that 24–48 hours of maturation are sufficient to reduce the level of neural plasticity underlying habituation. This rapid attenuation of plasticity could partly explain the benefits of precocious learning, since it is well known that to acquire full proficiency in some activities, practice should start at an early age during childhood. In avian species, this massive learning capacity is restricted to a narrow time window soon after birth, showing that younger individuals may learn more than their 1-day-older companions (Chiandetti, Dissegna, & Turatto, 2018). Bateson (1964b) found that while chicks approached a novel object on the first day after hatching, on the following 4 days, the majority progressively increased the avoidance of the same object. A distinction between avoidance and startle should be made at this point: although both can be included in a range of phobic responses, avoidance produces withdrawal and startle produces freezing, which are probably recruiting different neuronal circuits. Moreover, differently from previous results, we did not find a phobic response that increases with age, because the first observed reaction to the acoustic stimulus is lower when chicks are 3 days old as compared to when they are 1 day old. Rather, we observed a higher level of alertness in older chicks. There are undoubtable advantages with a more cautious attitude shown by older individuals; however, it could be relevant to study whether the high level of plasticity of the early stages can be reopened and to understand how it interacts with learning at later stages. Recently, Japanese colleagues found that, in chicks, sensitive periods can be reopened by thyroid hormone T3 (Yamaguchi et al., 2012), a result that, combined with our behavioral observations, paves new exciting ways to interdisciplinary investigations.

Conclusions

In this brief tracking shot of biological predispositions, I have shown that imprinting is still instrumental in the study of aspects of chicks' cognition that are relevant to human cognition. Imprinting applies successfully to the investigation of perception, agent recognition, physical reasoning, and spatial reorientation (reviews in Vallortigara & Chiandetti, 2017), but also of numerical cognition (review in Vallortigara, 2017) and other forms of abstract learning (see, e.g., Santolin, Rosa-Salva, Vallortigara, & Regolin, 2016). Addressing of issues such as whether basic mechanisms in core domains of cognition are inborn is only possible in suitable animal models. The key strategy in the reviewed studies and that resides in Lorenz's legacy is that of taking advantage of chicks' filial attachment to artificial objects from boots to triangles, from boxes to cylinders, which – alongside their rapid motor development – gives the unique opportunity of limiting the experiences of the outer world in order to perform a systematic investigation of what natural selection has engraved within the brain. Mounting evidence is supporting the core knowledge hypothesis (Spelke & Kinzler, 2007; Carey, 2009), which postulates that core problems and their cognitive solutions are largely shared between species, independent from culture and formal training, inborn and at the basis of further learning. Comparative studies that parallel results on early cognition in human newborns and chicks are particularly informative (Vallortigara, 2012). Knowing what our brain systems are endowed with and what should serve as functioning building blocks of cognition in order to cope with the basic common problems in core domains for survival helps the development of adequate teaching programs, early diagnosis of neurodevelopmental disorders (Piazza et al., 2010; Di Giorgio et al., 2016; Gori, Molteni, & Facoetti, 2016), and, hopefully, precocious interventions.

Summary

Since its first description, the imprinting phenomenon has been deeply investigated, and researchers can nowadays provide profound knowledge of its functioning. Here, I present how this peculiar form of early exposure learning can be used as a strategy to study animal cognition. Starting from imprinting as a social trigger for the domestic chick (*Gallus gallus*) and combining it with the unique possibility of accurate control of sensory experiences in this animal model, I present evidence that in artificial environments, imprinting serves as a rigorous test of the core domains of cognition. Whether basic cognitive concepts are already present at birth or whether they need extensive experience to develop are questions that can be addressed in precocial birds and still, following the tradition of the seminal works made by Lorenz, can inform on human cognitive processing.

Keywords: Filial Imprinting, Attachment, Domestic Chick, Core Knowledge, Innate.

Hier bin Ich: Wo bist du?

Das Phänomen der Nachfolgeprägung in der modernen Wahrnehmungsforschung von Tieren

Zusammenfassung
Seit der ersten Beschreibung wurde das Phänomen der Prägung umfassend untersucht, sodass die Forschung heute über ein profundes Wissen zu ihrer Funktionsweise verfügt. In diesem Beitrag wird dargelegt, wie die spezifische Form des Lernens, die durch frühzeitiges Aussetzen entsteht, strategisch zur Erforschung der tierischen Wahrnehmung benützt werden kann. Prägung als sozialer Auslöser für das Zucht-Küken *(Gallus gallus),* kombiniert mit der einzigartigen Möglichkeit umfassender Kontrolle der sensorischen Erfahrungen des Tieres führen zum Nachweis, dass in einer künstlichen Umgebung Prägung als rigorose Überprüfung für die Kerngebiete der Wahrnehmung dienen kann. Ob kognitive Grundbegriffe schon bei der Geburt vorhanden sind oder zu ihrer Entwicklung umfassender Erfahrungen bedürfen sind Fragen, die an nestflüchtende Vögel gerichtet werden können und immer noch, der Tradition der bahnbrechenden Werke von Lorenz folgend, über menschliche kognitive Verarbeitungsprozesse Auskunft geben können.
Schlüsselwörter: Nachfolgeprägung, Bindung, Zucht-Kücken, Kern-Kognition, Angeboren.

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