2. Imprinting and Attachment[1]

Imprinting provides a striking example of the way in which a particular experience has a specific effect only when the animal is at a certain stage of behavioural development. Indeed, the regulation of imprinting predisposes many species of bird to learn the characteristics of their parent at what would appear to be the biologically appropriate time in their life cycles. It is a good example of how behaviour gives the appearance of being well designed to serve the needs of the young birds.

A Mallard Duck hen calls vigorously as she leads her ducklings who have already formed an attachment to her. Photo by Crystal Marie Lopez (2010), Flickr, https://www.flickr.com/photos/labellavida/4697991484, CC BY-ND 2.0.

Even though birds like domestic chicks and mallard ducklings, the species most commonly used in studies of imprinting, respond to a wide range of objects before they have formed an attachment, they

1 Much of this chapter is based on an updated version of Bateson, P. (1973), Internal influences on early learning in birds. In: R.A. Hinde and J. Stevenson Hinde (eds.), *Constraints on Learning: Limitations and Predispositions*. London: Academic Press, pp. 101–116, with thanks to the Master and Fellows of St John's College, Cambridge.

https://doi.org/10.11647/OBP.0097.02

respond much more strongly to some than to others. This selective responsiveness is a major constraint on what is readily learnt in the imprinting situation. The characteristics of the stimuli that are most effective in eliciting social behaviour in naïve birds vary from species to species. In general stimuli that resemble most appropriate biological objects are preferred by naïve chicks and ducklings more strongly than those that don't.[2]

One feature of imprinting is its apparent restriction to a brief period early in life. At one time it was supposed that a window opened on the external world and then closed again. While the window was open the young animal was affected by certain types of experience and at other times it was not. This interpretation did not follow from the evidence. While maturational changes, occurring independently of specific experience, have been implicated in its onset,[3] the sensitive period is brought to an end by a specific type of experience. Birds become familiar with their immediate environment, whether this be their mother, other chicks, or even the walls of their isolation cage, and come to discriminate between such stimuli and other things that are novel to them. When they can tell the difference, they avoid the strange object and subsequently

2 Day-old domestic chicks trained with a flashing, rotating light or with a rotating stuffed jungle fowl, the ancestral species of domestic fowl, and then given a choice between them did not differ in their preferences. The stuffed jungle fowl became more attractive than the box by the second day after hatching. The shift towards a stronger fowl bias was also apparent in birds that had been imprinted with either a fowl or a box. Features of the jungle fowl that make it especially attractive as the predisposition emerges are located around the head. They are not specific to jungle fowl since the heads of a stuffed duck and small predator were equally attractive. Under laboratory conditions, the necessary feature detectors for head and neck evidently take longer to develop than do the ones driven by flashing lights and movement. Johnson, M.H. & Horn, G. (1988), Development of filial preferences in dark-reared chicks. *Anim. Behav.* 36.3, 675–683, https://doi.org/10.1016/S0003-3472(88)80150-7. Vallortigara, G., Regolin, L. & Marconnato, F. (2005) in Visually inexperienced chicks exhibit spontaneous preference for biological motion patterns (*PloS Biol.* https://doi.org/10.1371/journal.pbio.0030208), found that animation sequences of point-light-displays in which a few light points are placed on the joints of a digitalized image of a moving hen were more attractive to naïve chicks than the same points of light upside down. The spatial relational properties of the imprinting object have proved to be important (Martinho, A. III & Kacelnik, A. (2016), Ducklings imprint on the relational concept of 'same or different'. *Science* 353.6296, 286–288, https://doi.org/10.1126/science.aaf4247).

3 Experience before hatching is important. When the unhatched chick starts to vocalise, its calls facilitate the preference for the maternal call after hatching (Gottlieb, G. (1988), Development of species identification in ducklings: XV. Individual auditory recognition. *Devel. Psychbiol*. 21.6, 509–522, https://doi.org/10.1002/dev.420210602).

show no evidence of having developed a preference for it. The end of the sensitive period does not mark the point at which learning is complete; it merely marks the point at which the young bird is able to discriminate between stimuli that it has already experienced and other objects.[4]

Imprinting is an example of tightly constrained learning. Paradoxically, its general interest lies in its particularity. The predispositions to respond to particular features and give particular responses to the stimulus are central in the case of imprinting. Processes that change as a result of experience are dependent on features that have developed before imprinting has taken place. In other examples of learning that have different functions and are involved in different motivational systems the inter-dependence is less obvious, but present nonetheless. The differences in the ways in which animals learn can be explained in terms of variation in the perceptual and motivational mechanisms used in the various contexts in which learning occurs. In general, the properties of the whole animal allow for the evolution of differences in function.

Attachment in humans

Analogies between imprinting in birds and the development of attachments in humans have been drawn, particularly by the great psychiatrist John Bowlby.[5] The day-old baby is affected by her auditory experience before birth and she prefers the sound of her mother's voice to that of other women. She has a clear predisposition to respond to face-like images and rapidly develops a preference for the details of her mother's face. She makes much effort to maintain contact with her mother and is upset when the behavioural exchange with the mother is disrupted.[6]

4 Bateson, P. (1979), How do sensitive periods arise and what are they for? *Anim. Behav.* 27.2, 470–486, https://doi.org/10.1016/0003-3472(79)90184-2. For a more recent review of sensitive periods in the development of brain and behaviour see Knudsen, E.I. (2004), Sensitive Periods in the Development of the Brain and Behavior. *J. Cogn. Neurosci*. 16.8, 1412–1425, https://doi.org/10.1162/0898929042304796

5 Bowlby, J. (1969), *Attachment and Loss*. Vol. 1: *Attachment*. London: Hogarth Press. Bowlby was concerned to provide an empirical basis to the field of psychoanalysis.

6 The elegant work of Murray, L., & Trevarthen, C. (1986), The infant's role in mother-infant communications. *J. Child Language* 13.1, 15–29, https://doi.org/10.1017/s0305000900000271 showed that a two month old baby would respond normally to the face of her mother on a TV screen but was upset when a time delay was inserted between her behaviour and that of her mother.

The human mother and her child have formed a strong attachment to each other. Photo by Bob Whitehead (2006), Flickr, https://www.flickr.com/photos/kryten/125710155, CC BY 2.0.

The dynamics of her social relationships as she develops is the subject of much research. In this respect the work on imprinting in birds and the development of social attachments in children have diverged. The work on imprinting in birds has been focused on those species that are feathered and active in early life, with particular attention paid to the detailed mechanisms involved. The work on attachment processes in humans has focused on the ramifying consequences of the child's experiences on her subsequent behaviour.[7] As so often happens, the bodies of knowledge have separated and attempts to bring them together have often been at a superficial level. Nevertheless, the general conceptual questions have value inside the various silos of knowledge.

Imprinting in the wild

The conditions under which imprinting is studied in the laboratory are necessarily impoverished and artificial. The results can give a seriously misleading view of what happens in the wild. Chicks and ducklings spend most of the daylight hours on the first day after hatching being brooded by their mothers. The little birds hardly seemed to pay her any attention. Their activity around the hen does increase substantially on the second day after hatching, or even later if the ambient temperature is low.

Although the development of new preferences is initially prevented by escape from novelty or by the low level of social responsiveness to

7 Holmes, J. (2010), *Exploring in Security: Towards an Attachment-informed Psychoanalytic Psychotherapy*. London: Routledge, https://doi.org/10.4324/9780203856321

unfamiliar things, enforced contact may wear down these behavioural constraints to the point where the bird does develop a new preference. This flexibility could be of some functional importance in colonial nesting species such as gulls. In the absence of parents, for which the young bird forms its strongest preference, the bird may still be able to survive by responding socially to other adults and inducing them to feed it.

Even in the laboratory, when a recently hatched mallard duckling or domestic chick, which has been sitting quietly in a dark incubator, is removed and alley at room temperature, it soon begins to move about. Before long it starts emitting shrill peeps, often referred to as 'distress' calling, and it shuffles about in disorientated fashion with its neck extended. If a conspicuous visual stimulus is now presented to the bird, it orientates towards the stimulus and its distress calling stops. In many ways, its behaviour resembles that of a bird that has become separated from its mother, vigorously searching for her.

Such an observation suggests that even before they have been imprinted, the bird will behave in a way that increases the likelihood of their making visual contact with their parent or a surrogate.[8] The animal plays an active part in determining the kinds of things that it will learn and will continue to do so even after the imprinting process is under way. The bird cannot predict what the back view of its mother is like from knowledge of her front view. If a bird that has formed an attachment to an individual can respond selectively to that individual regardless of its orientation, then the bird must have been exposed to all those views of the parent that it can subsequently identify. It has built up a composite picture of its parent's characteristics. In the normal course of events, the mother will probably present many different aspects of herself during the attachment process while the young are learning her characteristics. Assurance would be made doubly certain if, after learning a certain

8 If stimuli that are highly effective in the imprinting situation do bring such searching behaviour to an end, they might be expected to reward the young bird. Naïve domestic chicks and wild mallard ducklings taken from a dark incubator quickly learn to operate a pedal that turns on a flashing rotating light. Age, and prior experience, affect the ability of domestic chicks to learn the pedal-pressing task in the same way as they affect the imprinting process (Bateson, P. & Reese, E.P. (1969), The reinforcing properties of conspicuous stimuli in the imprinting situation. *Anim. Behav*. 17, 692–699, https://doi.org/10.1016/s0003-3472(69)80014-x).

amount about her, the young actively worked to present themselves with a different view.[9] The active element in the young bird's behaviour makes the attachment process much more flexible and adaptive than it would have been if the bird had simply locked on to the first thing it saw and attempted to maintain contact with that and nothing else.

The incisive, single-shot image conjured up by the term 'imprinting' does not adequately represent what happens. Clearly, acquisition of the complex pattern recognition involved in detecting a particular parent or surrogate from many different angles and distances takes some time. Imprinting with two objects presented in rapid alternation can have a retarding effect on rewarded discrimination learning.[10] It is as though the stimuli are classified together and come to share the same identity. This could be an integral part of the imprinting situation where the young animal has to build up a composite picture of its parent as it obtains the opportunity to view the parent at various angles.

The advantages of doing this are not restricted to the attachment process. Classification together of physically different stimuli may well be necessary for some of the more complex examples of 'concept formation', even though abstraction of common features of different stimuli and generalisation from familiar to novel stimuli are also likely to be involved. The process may also play a larger part in human perception than personal experience suggests — introspection being a poor guide to the distinctions ignored in existing classifications.

Individual recognition

Filial imprinting and sexual imprinting have certain things in common even though sexual imprinting takes place later in development than filial imprinting.[11] Both filial and sexual imprinting have evolved to enable birds to recognise their close kin, but the necessity for kin recognition is different in young and adult. The young bird needs to

9 Jackson, P.S. & Bateson, P. Imprinting and exploration of slight novelty in chicks. *Nature*, 251.5476, 609–610, https://doi.org/10.1038/251609a0

10 Bateson, P. In Heyes, C. & Huber, L. (eds.), *The Evolution of Cognition*. Cambridge, MA: MIT Press, 2000. pp. 85–102.

11 Vidal, J.-M. (1980), The relations between filial and sexual imprinting in the domestic fowl: Effects of age and social experience. *Anim. Behav.*, 28.3, 880–891, https://doi.org/10.1016/s0003-3472(80)80148-5

discriminate between the parent that cares for it and other members of its species because parents discriminate between their own offspring and other young of the same species, and may attack young that are not their own. Adult behaviour of this kind is well known in many mammals and birds. In most cases the parent that cares exclusively for its own young will be more likely to rear them to independence than a parent that accepts and cares for any young that come up to it. The suggestion is, then, that filial imprinting is required for individual recognition of parents and is a secondary consequence of the evolutionary pressures on parents to discriminate between their own and other young. In each generation individuals may differ in the stage of development when their filial responsiveness to parent-like objects first increases. Those that do it too early obtain inappropriate or insufficient information about their parents. They might, for instance, have inadequate opportunities to explore all facets of their parent and so fail to recognise it quickly enough later on when quick recognition is important. Those that do it too late respond in a friendly way to hostile members of their own species and consequently suffer attacks. In these different ways the optimal timing for the increase in intrinsic responsiveness could have evolved. It would be critically affected by how rapidly the parents learn to discriminate between their own young and other young.

The evolutionary pressures that give rise to sexual imprinting are likely to have been quite different. Sexual imprinting enables an animal to learn the characteristics of its close kin and subsequently choose a mate that appears slightly different (but not too different) from its parents and siblings (see Chapter 7).

Conclusions

Imprinting is an example of tightly constrained learning. The predispositions to respond to particular features and give particular responses to the stimulus are central to understanding what happens. The robust processes of development make possible the plastic changes in behaviour that follow. Processes that change as a result of experience are dependent on features that have developed before imprinting has taken place. In other examples of learning that have different functions and are involved in different motivational systems the interdependence

is less obvious, but present nonetheless. The differences in the ways in which animals learn can be explained in terms of variation in the perceptual and motivational mechanisms used in the various contexts in which learning occurs. In general, the properties of the whole animal allow for the evolution of differences in function. Imprinting is a good example of how bringing together all the factors known to affect it provides a systems approach to development. It also has the appearance of being well designed for the needs of the animal.