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PEER ATTRACTION IN WHITE PEKING DUCKLINGS (Anas platyrhynchos).

by

Marta Darczewska

A Thesis

Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF ARTS

Department of Psychology
University of Manitoba
Winnipeg, Manitoba

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Peer Attraction in White Peking Ducklings (Anas Platyrhynchos)

BY

MARTA DARCZEWSKA

**A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University
of Manitoba in partial fulfillment of the requirements of the degree
of
MASTER OF ARTS**

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Abstract

Parent-offspring relationships have been studied much more than the relationships among siblings in precocial birds (those that are highly developed upon hatching). It is suggested that the attraction to siblings and unrelated peers in precocial birds is not of the same sort as the rapid attachment to a parental figure that has been called filial imprinting. The present experiments investigated the development of individual and species recognition and the significance of brood size in white Peking ducklings. The ducklings were reared singly or in pairs and they were tested under a simultaneous choice condition, across seven days of age, for a preference of (1) a peer (same-age duckling) versus an inanimate object (a pyramid), (2) a peer versus a different-species bird (a domestic chick) of the same age, (3) a single unfamiliar peer versus a conspecific brood of 10 ducklings, (4) a familiar peer versus an unfamiliar conspecific brood of 10, and (5) a familiar peer versus a brood of 10 chicks. The results were analyzed using a paired-samples t-test for each hypothesis stated and a trend analysis for age effects. The ducklings demonstrated a strong preference for (1) a peer over a pyramid, (2) a duckling over a chick, (3) a brood over a single peer, (4) a brood of ducklings over a familiar peer, with increasing attraction to the familiar peer over days, and (5) a familiar peer over a brood of chicks. These results indicate the importance of siblings and unrelated peers for white Peking ducklings. The significance of these results is discussed.

INTRODUCTION

The relationship between young precocial birds and their parents has been studied extensively (e.g. see the reviews by Hess, 1973, Hess & Petrovich, 1977, and Skutch, 1976). The relationship among siblings or peers has not received as much attention, although a strong sibling attraction has been observed in nature (Lorenz, 1970, p. 234-242). In this paper I will use the word "peers" to refer to conspecific birds that are not necessarily related and "siblings" to refer to birds that are biologically related.

It has been generally accepted that mallard ducklings (and other precocial birds) have to learn the visual characteristics of a parent early in their life and this rapid learning has traditionally been called imprinting. Although observations of such behaviour date back to antiquity (Pliny the Elder, quoted in Hess, 1973, p.67), Konrad Lorenz (1937) was the first to name this phenomenon and study it extensively. He also noticed the special attraction of peers to one another: "The parent bird does *not* form the nucleus of the flock - the offspring primarily congregate with one another and exhibit only secondary attachment to the parents." (Lorenz, 1970, p. 235). On the basis of his observations, he considered peer attraction to be different from imprinting. Other observations supported Lorenz's idea: "The chicks follow each other as they move along" (Collias, 1952, p. 146). "Communally reared chicks behave as if they were imprinted on one another" (Guiton, 1959, p. 32). During experiments investigating other variables, it has been observed that chicks (Sigman, Lovern & Schulman, 1978) and ducklings (Darczewska & Shapiro, 1997) try to establish close physical contact when

separated by a mesh barrier. While together, "No chick ever ventured more than about 20 cm. away from its companions" (Guiton, 1959, p. 31). Mallard ducklings are also responsive to one another's vocalizations (Gaioni & Platte, 1982).

One should take into account the naturalistic context of the behaviour studied in imprinting experiments. "The failure to do so can lead to erroneous conclusions" (Miller, 1994, p. 627). Under natural conditions, many young precocial birds stay in close contact to one another *and* follow their mother. For mallard ducklings, the two most powerful attractors seem to be a live vocalizing hen and a brood of ducklings (Storey, 1976). These stimuli are the ones normally encountered *simultaneously* by a hatchling. Gottlieb (1971) found that hen vocalizations are extremely attractive to a naive duckling and do not need to be learned. The strong attraction to peers, which is apparent in ducklings and which will be described in later sections, may be a similar case of birds responding to an attractive stimulus without previous learning.

Completely naive ducklings join other ducklings (Darczewska & Shapiro, 1997). They also prefer a live peer over a mirror or a piece of Plexiglas (Shapiro, 1980b), a brood over a conspecific hen (Donovan, 1984; Storey & Shapiro, 1979), and a hen accompanied by a brood over a hen alone (Bruce & Shapiro, 1977a; Darczewska & Shapiro, 1997). The ducklings are also attracted to older broods (Lindgren & Shapiro, 1980) and do not seem to differentiate between familiar and strange broods (Bruce & Shapiro, 1977b). Many investigators would assume only that "with continuous socialization chicks become sufficiently imprinted or conditioned to one another to be able to discriminate between a fellow chick and a strange box" (Guiton, 1959, p. 31). My

observations (Darczewska & Shapiro, 1997), however, indicate that ducklings should be perfectly capable of making such discriminations without any previous social experience.

The tendency to stay close to broodmates may even be stronger than the tendency to follow the mother. Lorenz (1970, p. 235) believed that peer attraction is different from filial imprinting, and observed that "the offspring (of greylag geese, Anser anser) primarily congregate with one another and exhibit only secondary attachment to the parents" (p. 235). Lorenz also claimed that in Anatids (the dabbling ducks) the sibling companion plays a much more important role than in gallinaceous (chicken-like) or other precocial birds. In nature, the mother duck occasionally leaves her young for a short time, during which they do not try to follow or find her (field observation on canvasback, Aythya valisineria, Collias & Collias, 1956). "The brood shows a strong tendency to keep together, whether or not a parent is present" (pertaining to redhead ducklings, Aythya americana, Collias & Collias, 1956, p. 391). Indeed, it may be the hen who follows the brood (Shapiro, 1980a).

PEER RELATIONS IN VARIOUS KINDS OF BIRDS

Many authors recognize that companions exert a strong influence on the behaviour of social animals, among them birds (Lorenz, 1970; Skutch, 1976). This influence may be so strong that a lack of social contact may cause a state of deprivation and motivate an animal to seek the company of others, usually conspecifics. Early social deprivation may have profound and negative influence on the development in many species, especially social mammals like rats and monkeys (Harlow, 1958; Zajonc, 1969).

Sibling interactions, however, vary widely across bird species. For example, songbirds usually do not fight in the nest, but many birds of prey do, and in some birds like pelicans it is a rule that the older sibling kills the younger one (Skutch, 1976).

1. PEER RELATIONS IN PRECOCIAL VS. ALTRICIAL BIRDS

Birds can be divided into groups according to the degree of development reached upon hatching (see the reviews by Shapiro, 1980a, and Skutch, 1976). Development level determines most of the young bird's early behaviours, including its social responses. The development ranges from the least advanced altricial birds to the most advanced precocial birds, with a range of different combinations in between. Precocial species hatch in a relatively advanced stage of development, are able to feed and locomote soon after hatching, and can thermoregulate, at least to some degree, while altricial birds hatch much less developed and are completely helpless without parental care and provision of food and warmth (Immelman & Beer, 1989).

Precocial and altricial hatchlings exhibit physical and behavioural differences. The brain and muscles of a precocial bird are larger at hatching than in comparable altricial species (Skutch, 1976). The latter still have some parts of their nervous system unmyelinated, and thus not fully functioning, while in precocial birds the myelinization is finished days before hatching (Collias, 1952).

Precocial birds have a special problem: they have to react appropriately to many different stimuli very soon after hatching, and they do not have as much time as altricial birds to learn about their environment (ten Cate, 1994). Precocial birds are usually

nidifugous (leaving the nest soon after hatching; Immelman & Beer, 1989), and they require varying degrees of parental care, depending on the species, weather, environment etc. Ducklings are considered the hardiest of all precocial birds (Skutch, 1976), which means that they could be the most self-sufficient. Indeed, the black-headed duck of South America is as independent as the superprecocial Megapodes which require no parental care at all (Shapiro, 1980a).

Since the altricial birds stay in the nest for several weeks and initially express a very limited set of behaviours, it is very difficult to investigate their attachment to siblings. On the other hand, the young of precocial birds exhibit mutual attachment and are synchronized in their activities (Guiton, 1959; Sowls, 1982), which is very important for the survival of the brood. They react together to the hen's warning calls; they also sleep, eat, preen etc. at the same time. The larger the brood, the more attractive it is to a single bird. This phenomenon has been observed in chicks (Guiton, 1959) and ducklings (Bruce & Shapiro, 1977b; Kirvan & Shapiro, 1972; Rogan & Shapiro, 1974).

2. THE CRECHE AS A FORM OF PEER ATTRACTION

Creches are unrelated broods grouped together. Some species always form creches, while others do so only as a response to specific environmental conditions. For example, penguin chicks always congregate when they are old enough to survive without parental brooding as a method of heat conservation and defence from predators while their parents are foraging (Williams, 1995).

In ducks, the duration of parental care depends in part on the mother's needs rather than that of the young (Skutch, 1976). The factors that determine the length of parental care are the hen's physical condition and her nutritional needs after a period of incubation, as well as the beginning of her moult. Usually the brood stays together after separating from the hen, which suggests that the attachment to peers may be stronger than the attachment to the mother.

There are some differences in the family dynamics of dabbling and diving ducks (this division is based on feeding style; certain physical and behavioural characteristics are also connected to it). Creching is much more frequent among the diving ducks (Skutch, 1976); it has been reported as common in 14 species and occasional in several species more (mainly in tribes Aythyini and Mergini; Eadie, Kehoe & Nudds, 1988). For example, the adults and young of the common eider (Somateria m. mollissima) feed on different prey found in different places, so it would be beneficial for them to stay apart. Therefore, the young eiders often form mixed broods under the care of one or more females (Munro & Bedard, 1982). Creching is less common among dabbling ducks in which both young and adults can efficiently obtain food in the same area, but they too form motherless creches or joint families on occasion.

Eider broods usually mix shortly after leaving the nest, while on their way to the nearest body of water, especially when topography and local conditions facilitate it. Often this mixing is caused by predator attacks, but creches also form in the absence of predators. Munro and Bedard (1982) suggest that in eiders it is the hens who congregate and regroup their broods to deal with the predators. One broody hen may also displace

other females, which then form a group of "associates". The eider ducklings usually congregate around the most "stimulating" hen, which is the one that is most protective, as defined by vocalizations and brooding posture, predator defence, and aggression towards strange hens. Thus, the leadership of a broody hen seems to elicit congregating in eider ducklings (Munro & Bedard, 1982). On the other hand, the same researchers also observed stable groups of ducklings with no accompanying adults. They, as well as other observers (unpublished works cited in Munro & Bedard, 1982), did not observe cases of imprinting or attachment of the brood to one particular female. Gorman and Milne (1972) observed that "there was no evidence that females (of common eider) attempted to maintain the individuality of, or remain with, their own broods or the creches with which they were temporarily associated" (p. 22). "It appears, then, that the creche system was 'manned' by a constant turnover of breeding females who arrived with their young, stayed for a few days, and then abandoned their young and left the creche system" (ibid., p. 23). Such evidence suggests that attachment to siblings may last longer than attachment to the mother.

Gorman and Milne (1972) suggest that creche behaviour helps the young eiders to conserve heat during resting and reduce predation due to group vigilance and a dilution effect (each member of a group has less chance of being caught as the group grows). However, creching is observed only in some populations of common eider, which suggests that it is an adaptation to specific environmental conditions. Alison (1982) states that the young gathering into large groups, whether under the care of their mothers or not, is an effective predator defense behaviour.

Brood mixing has also been observed in four species of geese (Eadie, Kehoe & Nudds, 1988). Nastase and Sherry (1997) observed in Canada geese (Branta canadensis) that goslings from mixed broods had a higher chance of long-term survival than goslings from natural families with no adopted young, but the mechanism of brood mixing is not yet understood. The family bonds in geese generally last longer than in ducks, and the family stays together until the next spring.

Unlike geese, young ducks do not associate with their families after reaching adulthood; the family dissolves and they may migrate in different flocks (Martinson & Hawkins, 1982). Still, the evidence that the young stay together longer than they stay with their mother suggests that peer attachment may be stronger than the attachment to the mother.

3. INDIVIDUAL RECOGNITION AMONG SIBLINGS

Peer attachment may include mutual individual recognition, but it is also possible that young birds are motivated to join any group of conspecifics, familiar or not. The data on individual recognition among young precocial birds are inconsistent. Eider ducklings were observed to tolerate strange broods of similar age, at least initially. As they grow older, they may start displaying aggression towards other broods (Munro & Bedard, 1982). This evidence is different from the observation that mallard ducklings reject strange ducklings after they get to know their own siblings, which takes up to three days according to Raitasuo (1964). Lorenz (1970) also stated that "the young exhibit mutual individual recognition earlier than the mother recognizes her young

individually" (p. 236), and he observed eight-day old ducklings attacking a strange brood, while the hen stayed indifferent. Munro and Bedard (1982) suggested experiments be done to see how early ducklings can recognize one another.

Observations made on Canada geese (Branta canadensis) and bar-headed geese (Anser indicus) indicated that goslings were more distressed, as measured by frequency of distress vocalizations and jumping, when separated from their foster parent, both in single and social conditions (Lamprecht, 1977). The bar-headed goslings did not show distress when separated from a sibling, but the young Canada geese did (increased jumping). However, both appeared to be aware of the sibling's absence or presence, uttering more contact calls when the sibling was present and less when it was absent. On the basis of contact call measurements Lamprecht suggested that the goslings are indeed attached to siblings, but they maintain close physical contact to one another only as a means to maintain contact with parents. "Although the presence of a sibling can sooth an isolated gosling, a sibling cannot fully replace the parent... When a gosling has lost its parents, it increases the chances of finding them by running towards the sibling, because the parents are very likely to be in their vicinity" (Lamprecht, 1977, p. 422). However, Lorenz (1970) observed distress behaviour in greylag goslings in the presence of their foster parent and absence of several foster siblings. The above observations suggest that goslings may be attached to their siblings.

4. EFFECTS OF SOCIAL EXPERIENCE VERSUS ISOLATION ON PEER RELATIONSHIPS

Social experience with siblings seems to be an important component of developing normal behaviour patterns. Many imprinting studies ignored this fact and the standard procedure was to isolate the birds and test them singly (reviews by Hess, 1973 and Hess & Petrovich, 1977). Collias (1952) found that domestic chicks are not very attracted to one another until they had a chance to experience mutual physical contact. Social experience allows chicks to develop more precise preferences. When reared alone, they will join any group of peers, irrespective of their colour (Rajecki & Lake, 1972; Salzen & Cornell, 1968). These authors actually tested a self-imprinting hypothesis, and concluded that seeing oneself did not help chicks to distinguish between like and unlike peers. Isolated chicks were much slower in responding and often made no choice or chose the empty goal over one containing a live chick (Salzen & Cornell, 1958). These conclusions are related to my own observations of visually naive (without previous visual experience with any living thing), isolated ducklings (Darczewska, 1995; Darczewska & Shapiro, 1997) which often chose an empty quadrant over the quadrants containing adult conspecifics. However, under the same conditions naive ducklings did attempt to join their peers.

Chicks also react differently to peers that were reared socially or in isolation, with an apparent preference for the former (Sigman, Lovern & Schulman, 1978), which suggests that previous social experience influences the subsequent behaviour of a young bird, as well as the peers' reaction to it. "Young hatchlings denied the opportunity for

direct social experience with siblings consistently display auditory and visual preferences different from those shown by hatchlings allowed ongoing experience with their broodmates during the period immediately following hatching" (Lickliter, Dyer & McBride, 1993, p. 185).

Among domestic chicks, the dominance order and the aggression connected with it does not develop until the young are several weeks old. Guhl (1956) suggested 10 weeks as the time needed for aggression to develop, and stated that downy chicks were rarely aggressive to the point of fighting. Others, for example Smith (1957), observed fights and signs of dominance order in chicks 10 days old, but the aggression occurred only between members of different breeds. Collias (1952) considered this aggression to be "play fighting" which did not result in the establishment of a dominance order until maturity. At the same time, chicks were much more attracted to another chick than to any artificial stimulus. Chicks tested in pairs influenced each other, and an inexperienced chick copied its more experienced companion. Smith (1957) also found that in flocks of mixed breeds the chicks tolerated one another, but there was no integration between them.

Generally, in a natural setting a group of precocial hatchlings follows its mother. However, laboratory studies on ducklings and chicks resulted in inconsistent results about approach and following behaviour, which is usually indicative of filial imprinting (a rapid development of attachment to the mother, described in greater detail in the next section).

An approach response to a maternal call is stronger in isolated ducklings than in communally reared ones (Shapiro, 1980b). Guiton (1959) found that "the following response to a strange object is lost at an earlier age in socially reared chicks than it is in isolated ones" (p. 26), and that the interest of a chick in artificial objects may also reappear when isolation follows a period of socialization. This result suggested that the process of attachment was not irreversible; it also pointed to the importance of socialization, with live peers preferred over other stimuli.

Guiton (1959) suggested that chicks might have learned to follow one another, and this following was later generalized to other objects. However, such explanation does not quite fit imprinting theory, which does not allow for such a broad generalization of preferences, but which does allow for imprinting to occur without overt following (Baer & Gray, 1960). In the Guiton experiments (1959) the best following was obtained in the group of chicks which first socialized, then were isolated. "It would seem that previous social experience is necessary if the response is to persist" (p. 29). The isolated chicks avoided a novel object most, although some of them eventually followed it, whereas social chicks never followed, but they were also less afraid of the model (Guiton, 1959). Chicks deprived of social contact and reared in isolation for the first 30 hours of life benefit less from social facilitation later on, as they are less inclined to join and/or copy the model. On the other hand, chicks reared in isolation for seven days or longer respond to an artificial hen more than social chicks (Turner, 1964).

Gaioni and his coworkers (Gaioni, Hoffman, Klein & DePaulo, 1977) further investigated sibling interactions. They noted that the dyadic (parent-young) interaction is

not the whole story of attachment development, but that siblings or peers have an important influence on one another's behaviour. Their experiments demonstrated that ducklings of the domestic strain of mallard reared in groups emitted distress vocalization when some members of the group were removed. Furthermore, the addition of other ducklings did not cause distress vocalization, while the exposure to a novel imprinting stimulus did (Gaioni, DePaulo & Hoffman, 1980). It seems that other ducklings are not just novel stimuli to their peers but are recognized for what they are. It is necessary then to investigate what stimuli mediate this recognition.

5. PEER RELATIONSHIPS IN INTRA-SPECIFIC FAMILIES

There is evidence that peer attraction is strong, at least early in a bird's development, even if the peers are not of the same species. In nature, intra-specific brood mixing is rare for waterfowl, unless it is a case of brood parasitism and the eggs are mixed before hatching (Eadie, Kehoe & Nudds, 1988). Under experimental conditions Collias and Collias (1956) observed "more or less coherent" (p. 393) broods consisting of mallards and redheads, and mallard ducklings with a ring-necked hen (Aythya collaris). However, when a mixed flock of mallard and pintail (Anas acuta) ducklings were three weeks old, they separated themselves according to species, with mallards being more aggressive and dominant (Collias & Collias, 1956). These observations suggest that age may influence the tolerance for other young birds. Cushing and Ramsay (1949) conducted a unique experiment in which they created families of mixed species, including different breeds of chicken, ducks, pheasants, and turkeys. Each family was

strongly established after a few days. Although the families could see and hear one another and were mixed during experiments, there was no regrouping according to species or breed. This lack of preference for conspecifics suggested that there was no genetic component to the birds' preference for social companions. The young followed their assigned mother and the hens aggressively prevented strange young from joining them. However, in the case where two mallard hens were friendly towards each other, their broods of wild and domestic ducklings mixed well. The authors also performed some adoption experiments and in most cases the young were actively rejected by the hen. There is no mention of mutual aggression among the young, although Lorenz (1970) reported aggression in similar situations. The above evidence suggests that, at least early in precocial birds' development, peer attraction is strong and may be undisturbed by dominance hierarchy or inter-specific aggression, and that it is the hen which keeps her brood away from other families. It would be interesting to see whether naive ducklings and chicks are motivated to join broods of different species.

IMPRINTING

The evidence concerning peers is scarce and confusing in imprinting literature. The term "imprinting" itself has many definitions. I will therefore summarize the main points and the evidence related to peer attraction.

Lorenz (1937) defined imprinting as a process different from associative learning, confined to a definite short period in life, irreversible, and possible to establish before any overt expressions of this process are apparent. Since his initial observations, imprinting

has been extensively studied and its definition broadly discussed. Later approach defines imprinting as "a type of process in which there is an extremely rapid attachment, during a specific critical period, of an innate behavior pattern to specific objects which thereafter become important elicitors of that behavior pattern" (Hess, 1973, p. 65). This idea has also been applied to phenomena other than filial attachment, such as parental attachment in ungulates or the establishment of a preference for a specific food or habitat (Immelman & Beer, 1989). One example is chemosensory imprinting in green sea turtles (Grassman & Owens, 1986). More recently, imprinting was considered to be "a form of gradual learning that entails an addictive process mediated by the release of endorphins" (Hoffmann, 1996, p.1).

When reviewing imprinting literature it becomes obvious that the methods used for rearing, handling, and testing the birds are extremely variable, thus the results are difficult to compare, a fact noticed by other investigators (e.g. Moriyama, 1987). Comparable results are often contradictory (Graves, 1973); also, there are many different species and strains studied.

Absence of identifiable reinforcers in imprinting led to a creation of a special category: template learning (or programmed learning) (ten Cate, 1994). Some stimuli are more attractive than others, and are learned more easily. Ten Cate (1994) suggested that when analysing the learning process one should first analyze the organism's perceptual sensitivity to various stimuli, and then the influence these stimuli have on the learning process. Most researchers of animal behaviour (e.g. Marler, 1993) no longer support the distinction between learned and innate behaviour. The development of any behaviour is

extremely complex and expresses an interplay between innate predispositions and environmental influences. Social interactions are particularly important here, as was shown in the case of such behaviours as song learning in sparrows (Gould & Marler, 1991; Marler, 1993) and filial imprinting in ducklings (Lickliter & Gottlieb, 1988). Prior experience of a young organism may influence its ability to imprint. Graves and Siegel (1968) found that both complex visual stimulation and social experience decreased the approach response towards artificial stimuli, but tactile stimulation (handling) had no effect if done in the dark. "These data indicate that chicks maintained in isolation had a significantly lower threshold for the approach response than chicks maintained in groups" (Graves & Siegel, 1968, p. 21). In the same study, age was not a significant factor until chicks were 23 hours old, whereupon they took longer to respond to and approach the stimuli if they were handled.

Following behaviour in young precocial birds, as defined by Barrows (1995), is innate. During filial imprinting the birds do not learn to follow, but rather they learn the characteristics of the object which should be followed. The young birds, especially if hatched in an incubator, are initially not at all attracted to an immobile and voiceless, even if alive, hen. This has been observed in chickens (Collias, 1952) and mallard ducklings (Darczewska, 1995). However, in the same situation mallard ducklings are attracted to their peers (Darczewska & Shapiro, 1997).

Responding to a maternal call used to be considered auditory imprinting. However, Gottlieb (1971) demonstrated that ducklings responded to maternal calls before hatching and without any previous experience. It may be that peers are also a very

attractive stimulus which facilitates the formation of social relationships. It may be that the ducklings do not need to learn to keep in a group and to seek their peers when lost.

"PEER IMPRINTING"

Lickliter and Gottlieb (1986) used the term "peer imprinting" to describe the special attraction of ducklings to other ducklings. The same idea was tested earlier by Guiton (1958), who suggested that chicks reared communally may imprint on one another. He suggested that imprinting established a sort of link between a young bird and the moving object which was then followed; the following of other objects was inhibited. His experiments demonstrated that the sensitive period for imprinting was prolonged to three days by isolation, while chicks reared communally did not follow a model. A sequence of rearing communally, then isolating the chicks resulted in the reappearance of the following response to a stuffed model. Guiton explained it not as a reversibility of imprinting, but as the effect of isolation (or social deprivation), which was found in many cases to "lower the stimulus threshold with a consequent loss of specificity" (Guiton, 1958, p. 13). Guiton also reported that isolated chicks appeared overall more "nervous" (p. 14). This conclusion agrees with my own observations: during experiments isolated ducklings ran around emitting distress vocalizations, while a small group of three in the same situation was calm (Darczewska & Shapiro, 1997).

Moriyama (1987) also investigated sibling effects on imprinting. He was one of the few who stressed the fact that in nature young precocial birds are exposed simultaneously to mother and siblings. Such an exposure has usually been disregarded in

experimental designs whose object has been to study normal parent-young interactions. However, Moriyama also believed in the existence of sibling imprinting. In his study, chicks followed an imprinting model better when alone than when paired. However, the paired ones improved more than the singles when tested once more separately. Moriyama (1987) suggested that the paired chicks imprinted as well as, or better than, the isolates, but the presence of a sibling interfered with the expression of imprinting (as measured by overt following) during testing. He called it covert imprinting. This conclusion explained the former contradictory results of other studies and at the same time was not opposed to filial imprinting in the natural setting.

Gottlieb and his associates did a series of experiments dealing with peer attraction in white Peking ducklings, Anas p. platyrhynchos (Johnston & Gottlieb, 1985; Lickliter & Gottlieb, 1985; Lickliter & Gottlieb, 1986a; Lickliter & Gottlieb, 1986b; Lickliter & Gottlieb, 1988; Dyer, Lickliter & Gottlieb, 1989; Dyer & Gottlieb, 1990). In these studies, stuffed hens emitting maternal calls and stuffed ducklings were used as models in simultaneous-choice tests. The “familiar hen” in these experiments referred to a mobile, vocal model to which subjects were exposed once for 30 minutes at about 24 hours after hatching. The ducklings were tested at 48 and 72 hours of age post-hatch. It was found that:

1. Early (up to 48 hours of age post-hatch) socialization of the subjects (living in the same compartment with a group of same-age ducklings) enhanced preference for a familiar mallard hen over unfamiliar models of hens, but later socialization disrupted this preference (Johnston & Gottlieb, 1985).

2. Socialization with siblings enhanced preference for a familiar mallard hen over unfamiliar models, but only if the ducklings were in full mutual contact. The visual contact with one or more siblings or housing with only one sibling did not enhance this preference (Lickliter & Gottlieb, 1985). The authors concluded that normal social experience was of extreme importance in the development of visual filial imprinting.
3. Singly-reared ducklings preferred a familiar mallard hen over unfamiliar stuffed ducklings, but they changed their preference to the ducklings if they were reared with live peers (Lickliter & Gottlieb, 1986a). The authors suggested that preference for the mother under natural conditions might be maintained only if the ducklings had continuing social interactions with her, and that "the strength or permanence of maternal attachments reported in the vast imprinting literature is, at least in part, an artifact produced by the isolation rearing conditions typically employed in studies of imprinting" (p. 276).
4. The familiar mallard model was preferred over four unfamiliar stuffed ducklings if subjects were reared in isolation and trained alone; if trained in a group, they preferred the stuffed ducklings (Lickliter & Gottlieb, 1986b). The suggestion, still not verified experimentally, was as follows: "It is the ducklings who keep track of one another, thereby ensuring brood cohesion, and it is the hen who then keeps track of the brood" (Lickliter & Gottlieb, 1986b, p. 565). This conclusion agrees with similar suggestions expressed earlier by Shapiro (1980a).
5. Ducklings reared with seven same-age chicks (Gallus domesticus) or muscovies (Cairina moschata) did not prefer a familiar mallard over an unfamiliar redhead model.

They had strong preferences for the mallard only when reared with conspecific peers (semi-wild mallards in this case) (Lickliter & Gottlieb, 1987). The authors also reported that the ducklings were interacting with their live peers and were in behavioural synchrony with their conspecifics 100% of the time. This percentage was lower for other species used: 73% of behavioural synchrony with chicks and 88% with muscovies. Although this difference was not statistically significant, it still suggested more social contacts among conspecifics.

6. Ducklings avoided the familiar mallard as well as the unfamiliar redhead model if they were raised with seven same-aged siblings and a vocalizing stuffed mallard. They also preferred stuffed ducklings over the mallard when they were raised with stuffed ducklings (Dyer, Lickliter & Gottlieb, 1989). The authors concluded that exposure to live siblings was not essential to develop an attachment to them. "Under simulated nesting conditions with hen and brood present, ducklings did not become imprinted to the visual characteristics of their hen...It is striking that 'passive' social rearing does not engender maternal imprinting, but does induce peer imprinting." (Dyer, Lickliter & Gottlieb, 1989, p. 473). The authors recognized that even stuffed ducklings presented a more attractive stimulus to a live duckling than did the stuffed hen. Their results suggested that "mallard ducklings do not become visually imprinted to their hen until after departure from the nest, that the visual component of maternal imprinting likely involves active following subsequent to nest departure, and that early in postnatal development siblings are more visually attractive than is the hen" (Dyer, Lickliter & Gottlieb, 1989, p. 463).

7. Social experience with peers improved ducklings' distinction of auditory cues as well as visual ones, and allowed them to make the correct choice of a mallard call over a pintail call (Dyer & Gottlieb, 1990).

The studies summarized above demonstrate that social experience with siblings has a definite influence on the behaviour of a duckling. This contact is also actively sought for, as the following section will demonstrate.

STIMULI ATTRACTIVE TO A NAIVE DUCKLING

An investigation of preferences in white Peking ducklings (Storey, 1976) has shown that a live duck paired with a maternal call constituted the most attractive stimulus to a single naive duckling, as long as there were no peers around. Once other ducklings were introduced, the preference changed, with most subjects preferring the peers over any other stimulus. Although this preference was not stable and statistically significant over all age groups, it did demonstrate once more the attractiveness of peers.

Previous research (Darczewska, 1995; Darczewska & Shapiro, 1997) has looked at the possible cues present in the adult mallard hen that may attract a duckling. Neither the plumage colour nor the presence of the blue wing patch seemed to be important. In fact, naive ducklings were not attracted to the adults of their species at all. The ducklings showed distress (running around and vocalizing loudly) when alone or with a strange hen, but were quiet when in the company of other ducklings, familiar or not. The ducklings were also extremely motivated to join their peers. These observations agree with others (Gaioni, Hoffman, Klein & DePaulo, 1977; Gaioni, DePaulo, & Hoffman,

1980), who reported fear reaction to a novel imprinting stimulus and distress calling upon removal of the duckling's companions. Naive ducklings join other ducklings (Darczewska & Shapiro, 1997; Donovan, 1984) and older broods (Lindgren & Shapiro, 1980), which is not supposed to happen if such behaviour was indeed peer imprinting. They also show no preference for a familiar over a strange brood (Bruce & Shapiro, 1977b), although they are apparently able to recognize their siblings (Lorenz, 1935). Naive ducklings also prefer a live peer to inanimate objects (mirror and Plexiglas; Shapiro, 1980c), so the presence of peers generally must be very important to them. It remains to be demonstrated whether species, number, and familiarity mediate the attraction to peers.

Therefore, the goal of this study was to investigate stimuli that accounted for peer attraction in white Peking ducklings, without invoking the concept of imprinting. I evaluated the importance of familiarity (social versus isolated rearing conditions), species, age, and brood size.

I used live peers as models, unlike other similar experiments (described in the previous section) in which ducklings were given a choice of stuffed models. I also tested the birds up to seven days of age post-hatch, which exceeded the testing periods of other experimenters (Sherrod, 1974, being a rare exception, testing her subjects after six weeks) and went beyond the optimal imprintability period (Hess, 1973).

GENERAL METHOD

Subjects

The subjects were white Peking ducklings Anas platyrhynchos (a domesticated form of the wild mallard). In each experiment 56 birds were tested. Each duckling was observed only once for 15 minutes.

Egg Source. White Peking eggs were obtained from a private farm (Graeme Hyndman, Rapid City, Manitoba, R0K-1W0) in seven batches between July 3 and October 23, 1998. The eggs were incubated in a Petersime incubator (Model 1, Petersime Incubator Company, Gettysburg, Ohio, USA); they were cooled daily at room temperature for 15 minutes, sprayed with lukewarm water, and candled once a week to detect and discard infertile eggs and dead embryos. On day 24 they were transferred to a Petersime hatcher (Model H-145). All birds were hatched in darkness. Hatching was defined as the complete separation of the bird from the eggshell without any help from the experimenter. During hatching, the ducklings were checked every two hours, so the time of hatching was determined with an accuracy of two hours. After each check, the experimenter sprayed lukewarm water into the incubator to compensate for the moisture lost while the incubator doors were open.

Rearing Conditions. The subjects were reared in two conditions: isolated and social, depending on an experiment. The isolated ducklings for Experiments 1,2 and 3 had no visual contact with any other living object until testing. While in the hatcher they were separated from other eggs by cardboard divisions to exclude tactile contact during and immediately after hatching. This method was employed before by Moriyama (1987).

They were subsequently transferred in the dark to individual brood units. The social ducklings for Experiments 4 and 5 were allowed to contact one another during hatching and they were housed in pairs in the brood units. They were paired up depending on their hatching time, so that their age was as similar as possible. One bird from each pair, randomly selected, acted as a subject and the other as a model during testing.

The hatched birds were randomly assigned to brood units and individually transferred there in a covered wooden transport box. Graves and Siegel (1968) found that the handling of chicks had little effect on later attachment behaviour, as long as it was done in darkness; the tactile stimulation inhibited an approach response only when it was paired with a visual stimulus (seeing the experimenter). Therefore, all handling in this study was done in the dark. Until testing, the birds were housed in visual but not auditory isolation from other subjects, with ad libitum access to food and water and in a 16:8 hr light/dark cycle, which approximated the natural conditions of early summer and allowed for several sessions of testing during the day.

For a detailed description of the facilities see Shapiro (1970), and Shapiro & Lundy (1974). The only difference in the present experiments was the lack of the brood heating system because the entire room could now be heated to a temperature proper for the birds' developmental stage (starting at about 32 C and lowering the temperature daily to about 28 C on the seventh day).

Age Groups. The subjects were assigned to seven age groups (from one to seven days of age) with eight birds in each age group. Their age was measured in hours since hatching and the testing occurred within two hours of their hatching age. The seven-day

age period is arbitrary, but it was chosen because it roughly corresponded to the first phase of plumage development in ducklings (Shapiro, 1977). It was also an attempt to study sibling attraction for more than the two days commonly used in imprinting studies. Shapiro (1977) suggested that attachment development is a continuous phenomenon which does not end after the 25-hour critical period traditionally defined for imprinting (Hess, 1973). Also, Sherrod (1974) found that social experience during the juvenile period might be more important in determining the lifelong companion preferences than the experience during the first day of life.

Randomization. The assignment of subjects to age groups was random with two restrictions. The first restriction on randomization pertained to group size, since each age group had to contain equal number of subjects (eight per group). The second restriction pertained to the time of hatching. Because the ducklings were tested at 24-hour intervals since the time of hatching and their age was measured in hours, they had to be tested at a closest possible time to their hour of hatching (allowing a two-hour margin both ways for practical reasons). In this arrangement, a bird that hatched at 4 am would have to be tested also at 4 am. The hatching process for each group lasted at least 48 hours with birds hatching throughout day and night. The same schedule was not followed for testing because of a concern for the live models, which would have had to remain in the testing chamber for prolonged periods at different times of day and night. Another reason for avoiding testing in the middle of the night was the fact that birds are diurnal creatures, and their normal behaviour at night is sleep. Disturbing that would probably introduce an undesirable bias to the results. On the other hand, scattering the testing sessions

throughout the entire day helped to randomize the possible effect of a diurnal rhythm of activity versus inactivity. Therefore, most of the ducklings that hatched between 1 am and 5 am were either assigned to be models or spare subjects.

Models

Live Models. Live models (Peking ducklings and chickens, Gallus gallus domesticus) were used because of the suggestions that inanimate models may not be appropriate (Hess, 1973, Shapiro & Agnew, 1975; Shapiro & Garretson, 1978). The duck eggs came from the same source as subjects. Fertile chicken eggs of the White Cornish meat strain were obtained from a commercial hatchery (Granny's Poultry, 84 Scurfield Boulevard, Winnipeg, Manitoba, R3Y-1G4) on July 20, October 13, and October 26, 1998. The incubation and hatching procedure for chickens was the same as for the ducklings, but with a shorter incubation time (21 days) to accommodate the chicken's embryonic development.

The chickens and ducklings used as models were housed in a different room than the subjects to eliminate the possible influences of vocal and other contacts. The models were housed singly if they were to be presented singly and in a brood if they were presented as a brood. This arrangement ensured that a model would not be overly excited or distressed if taken away from a familiar brood and separated (since reducing brood size is known to induce distress calls; Gaioni, Hoffman, Klein and DePaulo, 1977) or mixed with an unfamiliar brood. The models' age approximated that of the subjects.

During testing each stimulus model was confined in a round wire-mesh cage with a diameter of 41 cm and a height of 46 cm. The cages were located in the corners of the testing platform (Fig. 1, p. 29). The corners between the cages and the wood/wire mesh barrier around the platform were rounded off with pieces of wire mesh, because previous research (Darczewska & Shapiro, 1998) indicated that the corners themselves are attractive to ducklings. Blocking the corners also prevented the subjects from getting stuck there, which they often did in previous experiments.

No preference for any of the quadrants has previously been found (Shapiro & Agnew, 1975; Shapiro, 1977). Nevertheless, the models were randomly rotated so that each model occupied each quadrant twice. The models remained in the cages in the experimental chamber for a maximum of three hours at one time and were returned to their brood units between sessions so that they could eat and drink.

Inanimate Model. The only inanimate model (in the first experiment) was a red (7 pa on the Ostwald scale) cardboard pyramid seven cm high, with a base 10 cm square. The pyramid was presented in the same kind of cage as the live models and the two empty quadrants always contained empty cages so that the only difference among the quadrants was the cage content.

Apparatus

Testing Chamber. Testing occurred in an 11.5 cubic metre chamber (1.98 m by 2.41 m by 2.41 m), sound-deadened and heat-controlled, containing a 1.58 m square sand-filled platform (Figure 1, p. 29). The platform was enclosed by a 9 cm high wooden

barrier with wire mesh extensions which prevented subjects from escaping. It was subdivided into four equal quadrants by drawing slight indentations in the sand. The temperature inside was either the same as, or close to, the brooding room temperature (an average of 1 C difference).

Procedure

Testing. A subject was transferred in the transport box to the experimental chamber and placed in the middle of the platform, facing a quadrant with an empty cage (all handling was done in darkness). The experimenter then left the chamber, closed the door, and turned on the lights inside the chamber. The latency, the number of times each quadrant was entered, and the amount of time the subject spent in each quadrant over a 15-minute trial period was measured by a computer. The behaviour of the subjects and the models was simultaneously recorded by hand. At the end of each 15-minute trial the lights in the testing chamber were automatically turned off and the subject was returned to its brood unit. It was not used again.

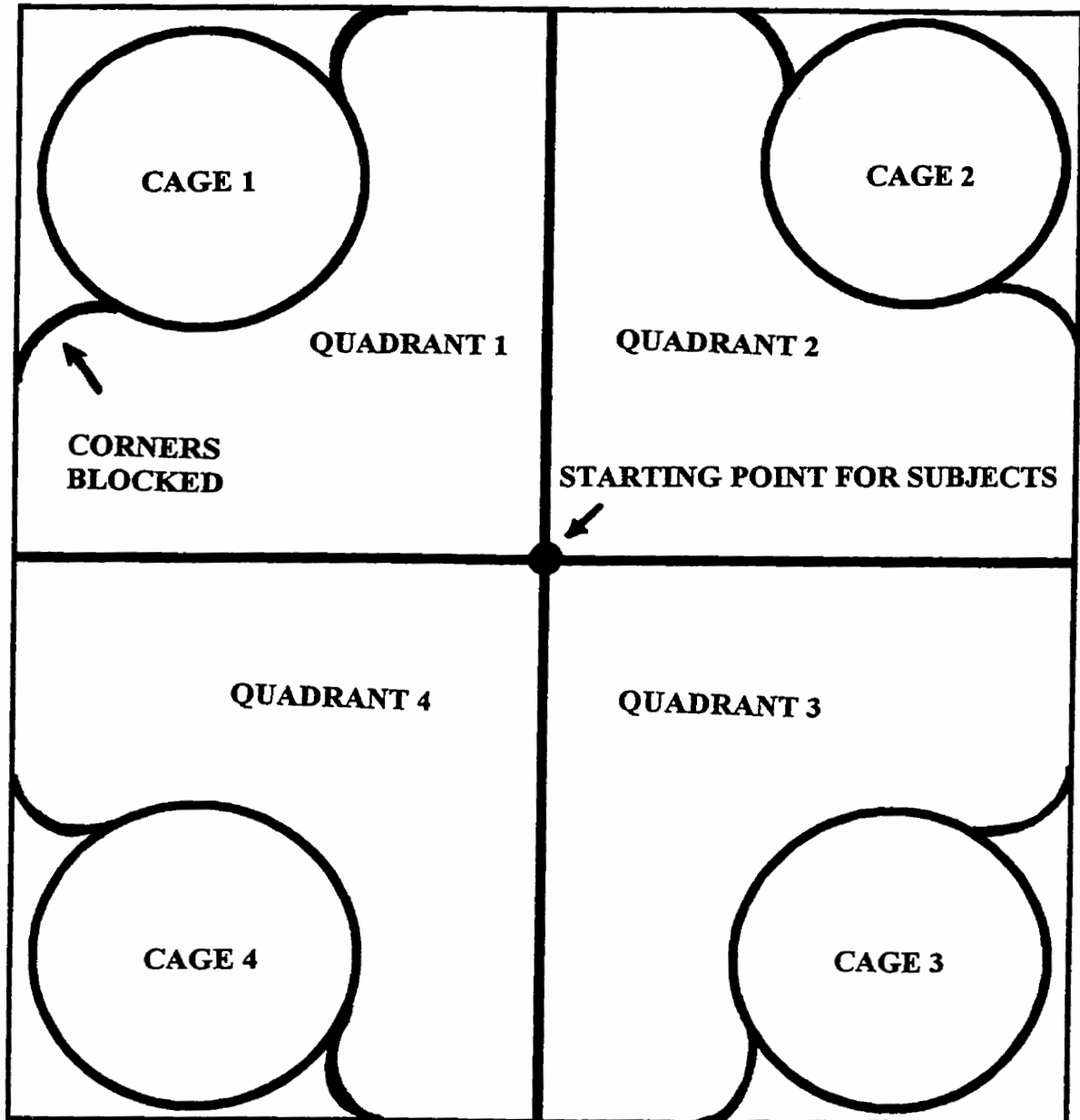


Figure 1. The experimental platform as seen from above. The models occupied two opposite cages, while the other two remained empty. The corners were blocked with wire mesh to prevent subjects from getting stuck there. The subject started from the middle and could move around the platform.

Measurements

Time Spent With Models. The main measurement of attraction consisted of an "approach and stay near" response, which was expressed as time spent with a particular model. Other experimenters used such measurements of attraction or attachment as approach and/or following the model, working for contact with the model, and displaying signs of distress upon the model's withdrawal (Zajonc, Markus & Wilson, 1974). Any one of these measurements could be ambiguous if interpreted alone; therefore, several measurements were taken in this study.

Other Measures. Other measures included frequency of entering each quadrant (which indicated a duckling's mobility), latency length, and detailed behavioural notes. Latency was defined as the time from the start of the testing session to the first observable response made by the subject. The behavioural notes included movements and vocalizations made by the subjects and the models. Especially important was the recording of distress vocalizations, which was a relatively sensitive measure of attachment or attraction to an object (that is, the lack of distress vocalization signified attachment), and was used by many other investigators (e.g. Eiserer, 1978; Gaioni, DePaulo & Hoffman, 1980; Zajonc, Markus & Wilson, 1974). Distress vocalizations in the ducklings were easily distinguishable from other sounds, loud enough to be heard by the experimenter through the baffles of the chamber walls, and their occurrence could be recorded by hand. Ducklings usually alternate distress calls, that is, they call one at a time (Gaioni and Platte, 1982). This fact made the recording easier beside being ecologically significant (it allows lost ducklings to find one another).

Statistical Analysis

The dependent variable measured was the time spent in each of the four quadrants. The independent variables were Models (a within-subject variable) and Age in days (a between-subject variable). By making Age a between-subject variable and testing different age groups, the problems associated with learning were avoided. One-tailed t-tests on difference scores were used to analyze the data and an analysis of variance (ANOVA) was used to see if there was a difference in the ducklings' preferences across seven days of testing. When an ANOVA was significant, a linear trend analysis was performed.

EXPERIMENT 1: PEER VERSUS PYRAMID.

The purpose of this experiment was to see if naive ducklings prefer a live peer over an artificial object, in this case a red cardboard pyramid of known dimensions and colour characteristics (see the Models section). Some investigators (e.g. Collias, 1952; Guiton, 1959, Taylor & Sluckin, 1964) have claimed that naive hatchlings (ducklings and chicks) are not particularly attracted to one another until after a period of continuous socialization and physical contact (at least 20 hours in Guiton, 1959). Others (e.g. Salzen & Cornell, 1958) have observed that eight days old isolated chicks do not prefer a sibling more than an empty goal box. On the other hand, Shapiro (1980c) observed a strong attraction to a sibling over an artificial object in naive ducklings one to five days old, as well as a preference for a brood over an empty quadrant (Bruce & Shapiro, 1977). In this experiment, singly-reared ducklings were given a choice of a same-age duckling, a

red pyramid, and two quadrants with empty cages. On the basis of the research described above, I hypothesized that the subjects would spend more time with both models than in the two empty quadrants, more time with a peer than in the two empty quadrants, and more time with a peer than with a pyramid.

Method

Subjects

The subjects were 56 White Peking ducklings reared in visual isolation from one another and from other living objects.

Models

The models were a peer (live duckling of approximately the same age as the tested subject) and a red pyramid.

Procedure

The apparatus and procedure were the same as described in the General Method section.

Results and Discussion

Data

Time Spent With Models. The data represented in Figure 2 (p. 35) indicates that the subjects spent most of their time with the peer and very little time in the other three quadrants. On Days 6 and 7 less time was spent with the peer (Figure 2, p. 35) because of two outliers (two and four standard deviations from the mean; see Appendices A and B for scatter plots and descriptive statistics) and a day-six subject with an unusually long

latency time, which “stole” time which could otherwise be spent with the models. The results with outliers excluded are presented in Figure 3 (p. 37). The dip on day two (less than average time spent with the peer and more with a pyramid) is interesting but unexplainable. Paired-samples t-tests revealed that the subjects spent significantly ($p < .001$) more time with both models than in the empty quadrants (Figure 4, p. 39), significantly ($p < .001$) more time with a peer than in the two empty quadrants, and significantly ($p < .001$) more time with a peer than with a pyramid (Figure 2, p. 35). Table 1 summarizes these results.

Table 1. Experiment 1: Paired Samples t-tests, one-tailed (df = 55).

Pairs of variables	Paired differences				
	Mean	SD	SE	t-value	significance
Models (Peer & Pyramid) vs. Empty Quadrants	5.61	2.41	0.32	17.39	$p < 0.001$
Peer vs. Empty Quadrants	10.92	5.28	0.71	15.48	$p < 0.001$
Peer vs. Pyramid	10.61	6.35	0.85	12.51	$p < 0.001$

When the results for the two models (peer and pyramid) were combined to be compared with the combined results for the two empty quadrants (Models vs. Empty Quadrants, Figure. 4, p. 39), the difference between them was still highly significant ($p < .001$ in Table 1), even though it was really the time spent with the peer that contributed to most of the difference between them.

Figure 2. Experiment 1: Time spent with a peer, a pyramid, or two empty quadrants.

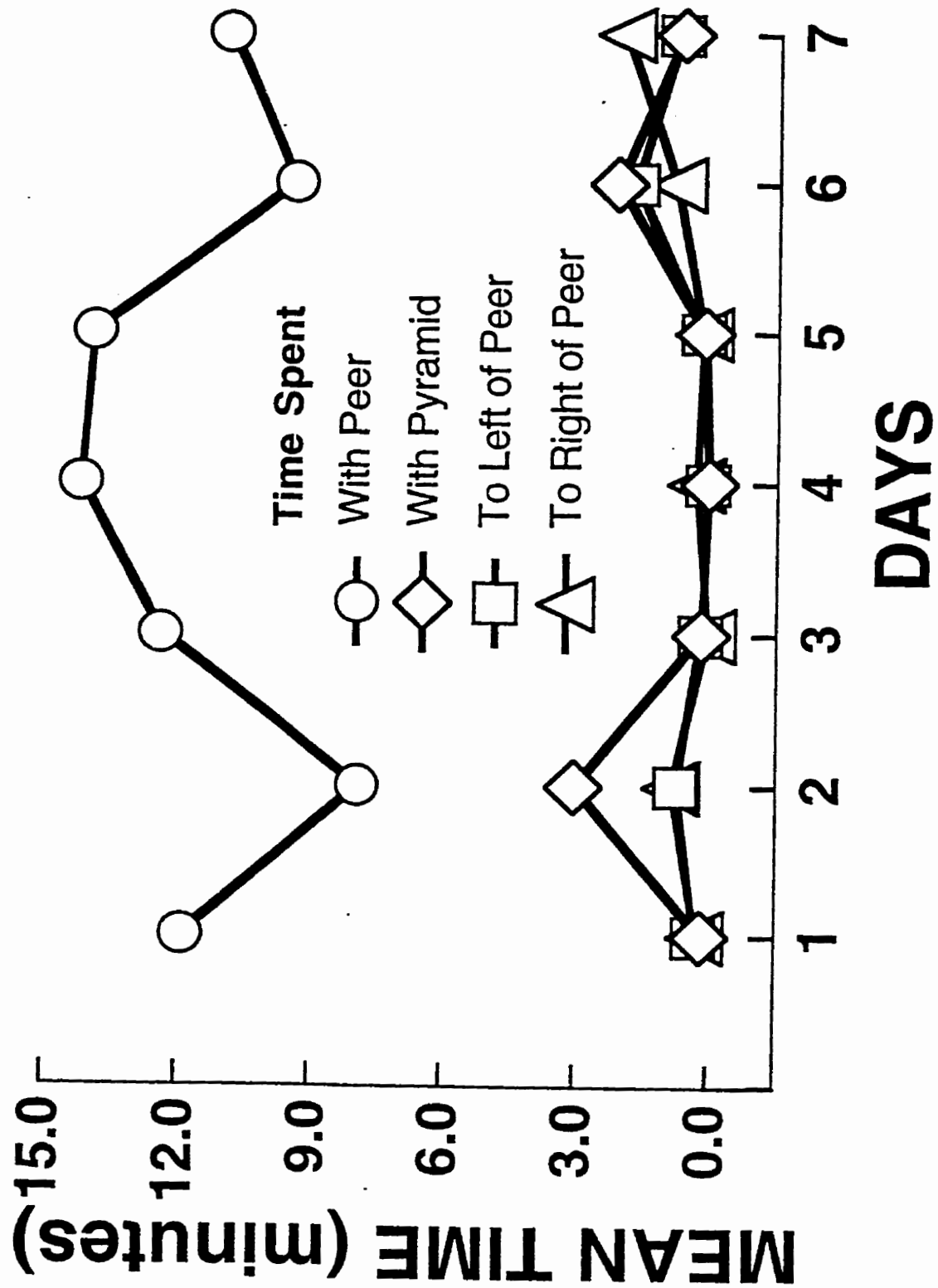


Figure 3. Experiment 1: Time spent with a peer, a pyramid, or two empty quadrants, outliers from Day 6 and 7 excluded.

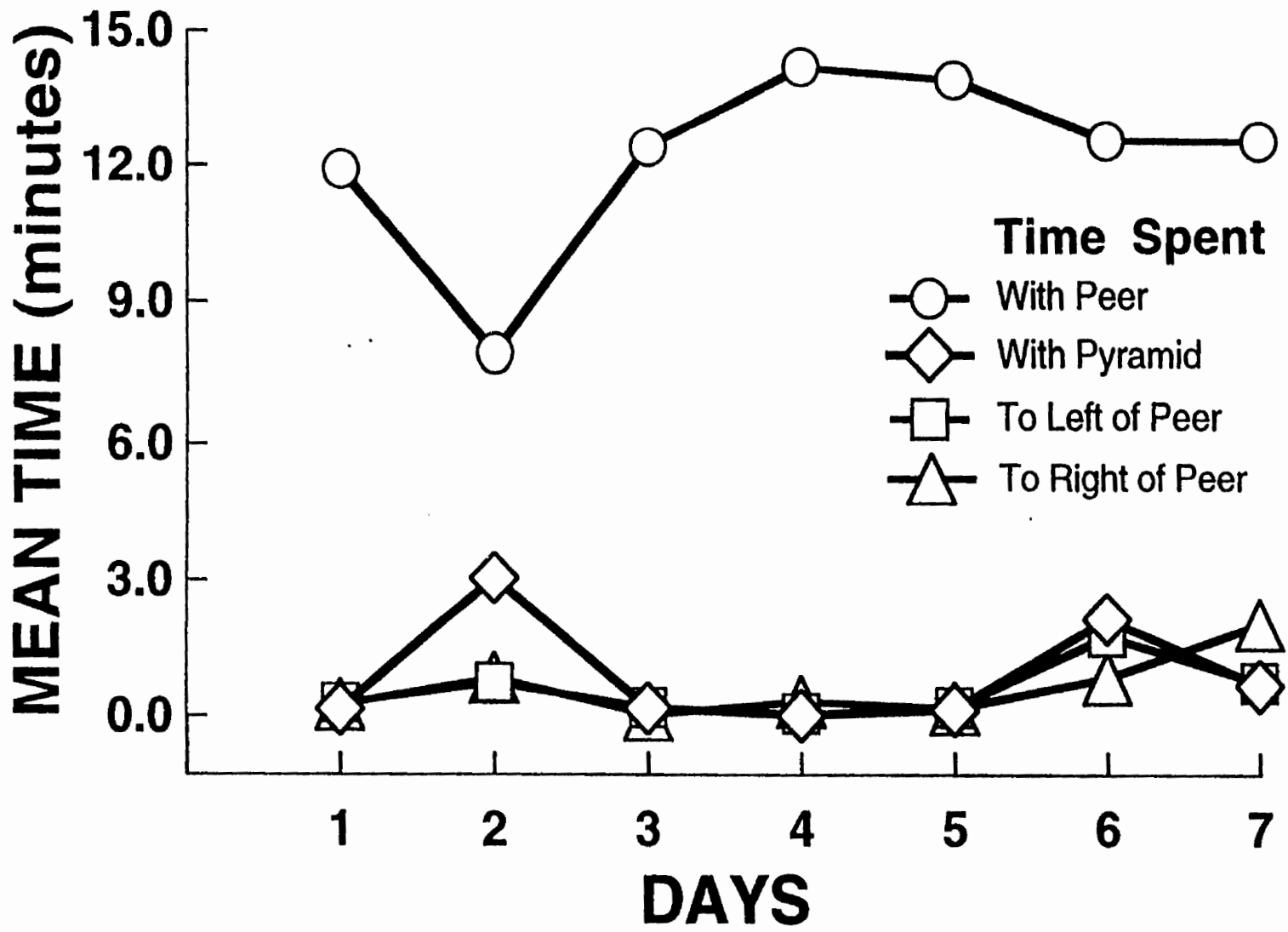
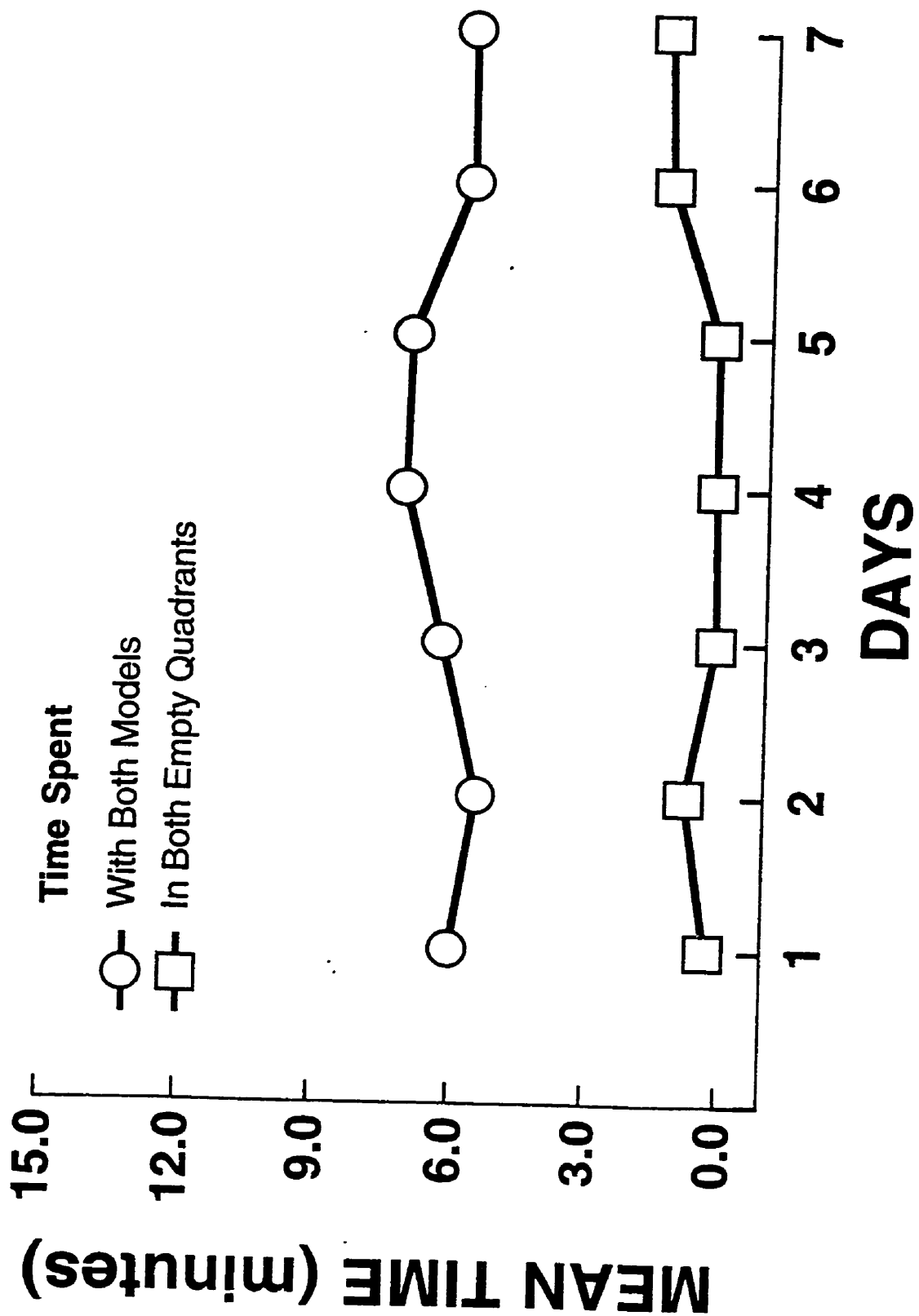


Figure 4. Experiment 1: Time spent with both the peer and the pyramid versus time spent in both empty quadrants.



The time spent with the pyramid was similar to the time spent in the empty quadrants. The simple ANOVA (indicating differences across days) was done separately for the time spent in each quadrant, and it was significant for the time spent with the peer ($p < .05$), the time spent with the pyramid ($p < .05$), the time spent in the empty quadrant to the right of the peer ($p < .05$), and in the combined empty quadrants ($p < .05$). A trend analysis was significant ($p < .05$) for the empty quadrant to the right and for both of the empty quadrants combined, but there is no meaningful explanation for these trends (see Appendix D for the ANOVA table and Appendix E for trend analysis calculations).

Entrance Measure. The frequency of entering the quadrants was rather variable across days (Figure 5, p. 42). It also tended to increase as the ducklings grew older. The overall average for all quadrants and subjects was 4.3 entrances.

Latency Measure. The mean latency length in Experiment 1 exhibited an age-dependent trend, also noticed in previous studies (Darczewska & Shapiro, 1997; 1998). The older the duckling, the shorter the latency (Figure 6, p. 44). The overall average for all subjects was 1.2 minutes.

Observations

The usual behaviour of a subject was as follows: when the lights went on, the subject sat motionless for a while. Then the subject stood up, looked around, and started distress vocalizing. After running around in what appeared to be a random manner, the subject chose the peer and usually remained close to it for the rest of the session.

Figure 5. Experiment 1: Mean frequency of entrances made to the quadrants containing a peer, a pyramid, or two empty cages, indicating the subjects' mobility.

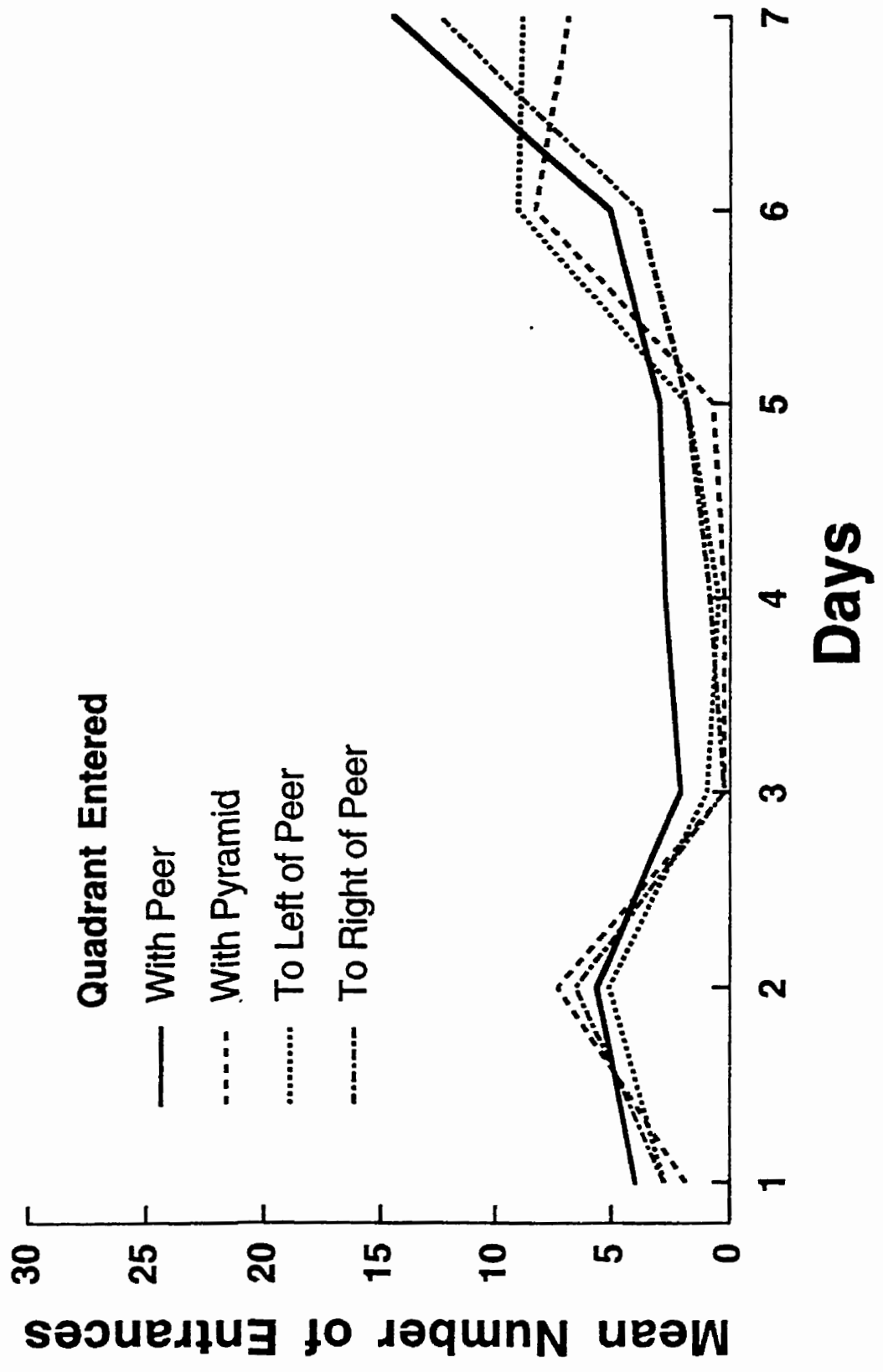
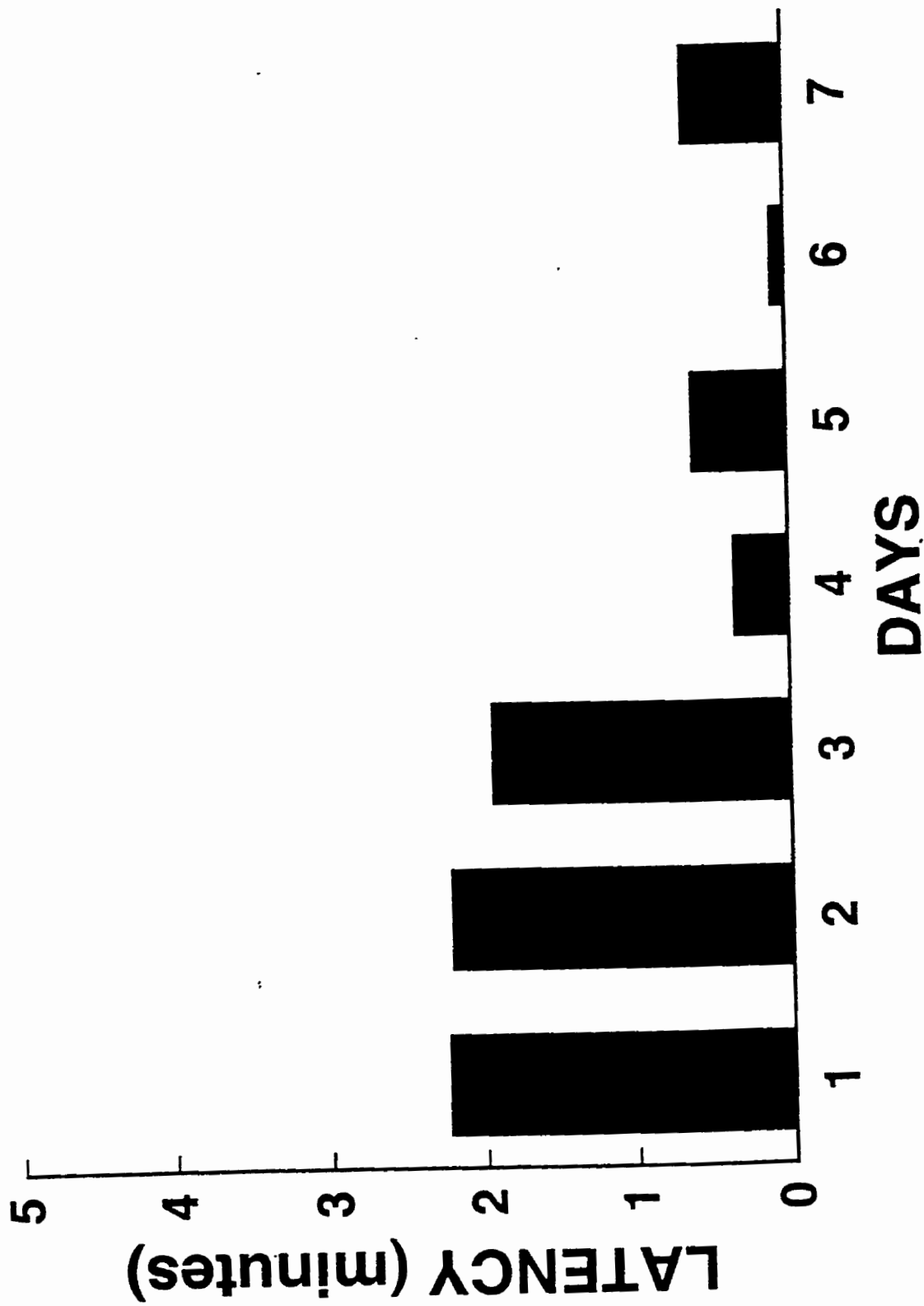


Figure 6. Experiment 1: Mean latency scores across the seven-day testing period.



As soon as it approached the peer, it stopped distress vocalizing; sometimes a contentment call (a "greeting") was emitted, and then both ducklings remained silent (that is, no vocalizations could be heard by the experimenter sitting outside the chamber).

The behaviour of the peer had some influence on the subject, and vice-versa: if the peer was active and vocalizing, it was noticed and chosen sooner than if the peer was asleep. However, the strong preference for a peer was apparent no matter what the peer did. Both ducklings usually tried to follow each other, walking on both sides of the cage wall. They also vigorously and repeatedly tried to come into closer contact by sticking their heads through the wires and trying to push their bodies through. The ducklings acted as though they were aware of the obstacle presented by the cage and they repeatedly tried to get on the same side of the cage wires as the peer. Both ducklings often engaged in exploratory behaviour, pecking the sand, the cage, and each other (not aggressively, however). These bouts of activity were usually interspersed with sitting quietly close together and falling asleep.

It is important to notice that the subjects did not stop distress vocalizing unless they remained close to the peer. Those subjects that wandered away and the ducklings which spent most of their time with the pyramid (one subject) or in the empty quadrants (two subjects) emitted distress vocalizations constantly. This behaviour suggested that these subjects were not satisfied with the choice they made.

Discussion

It is clear from the data that the subjects were attracted to the peer and preferred it over the inanimate object (the pyramid) and the empty quadrants at all age levels. This was true with no previous socialization or a chance to “imprint” on a peer. These results disagree with those studies which claimed a need for peer imprinting (Guiton, 1958; Lickliter and Gottlieb, 1986a and 1986b) or extensive socialization (Collias, 1952; Guiton, 1959, Taylor & Sluckin, 1964) in order for peer attraction to develop. One reason for this discrepancy may be the different species tested (ducklings in the present experiment and domestic chicks in Guiton, 1958, and Taylor & Sluckin, 1964). The difference between the present experiment and those by Lickliter and Gottlieb (1986 a and b) lies mainly in the theoretical explanation rather than the behaviours observed.

EXPERIMENT 2: DUCKLING VERSUS CHICKEN.

Because the ducklings preferred a live peer over an inanimate object, the purpose of the second experiment was to see if ducklings prefer a same-age conspecific over a same-age bird of a different species. Lickliter and Gottlieb (1987) indicated that group cohesion was better among conspecifics than among birds of different species. However, it may be that any live bird of similar size is attractive, since intra-specific families can be successfully raised among fowl (Cushing & Ramsay, 1949). Naïve, singly-reared ducklings were given a choice of a same-age duckling, a same-age chick, and two quadrants with empty cages. On the basis of the literature review and Experiment 1 results, I hypothesized that the subject would spend more time with both models

than in the two empty quadrants, more time with a duckling than in the two empty quadrants, and more time with a duckling than with a chick.

Method

Subjects

The subjects were 56 White Peking ducklings reared in visual isolation from one another and from other living objects.

Models

The models were a same-aged peer and a live domestic chick of approximately the same age as the subject and the peer.

Procedure

The apparatus and procedure were the same as those described in the General Method section.

Results and Discussion

Data

Time Spent With Model. The data represented in Figure 7 (p. 49) indicates an overall preference for the duckling. This preference did not look as straightforward on the graph as it did in the previous experiment, however. The paired-samples t-tests revealed that the subjects spent significantly ($p < .001$) more time with both models than in the two empty quadrants (Figure 8, p. 51), significantly ($p < .001$) more time with a duckling than in the two empty quadrants, and significantly ($p < .01$) more time with a duckling than with a chick (Figure 7, p. 49). These results are summarized in Table 2 (p. 52). The ANOVA for the preferences across the seven days of testing was significant

Figure 7. Experiment 2: Time spent with a duckling, a chick or two empty quadrants.

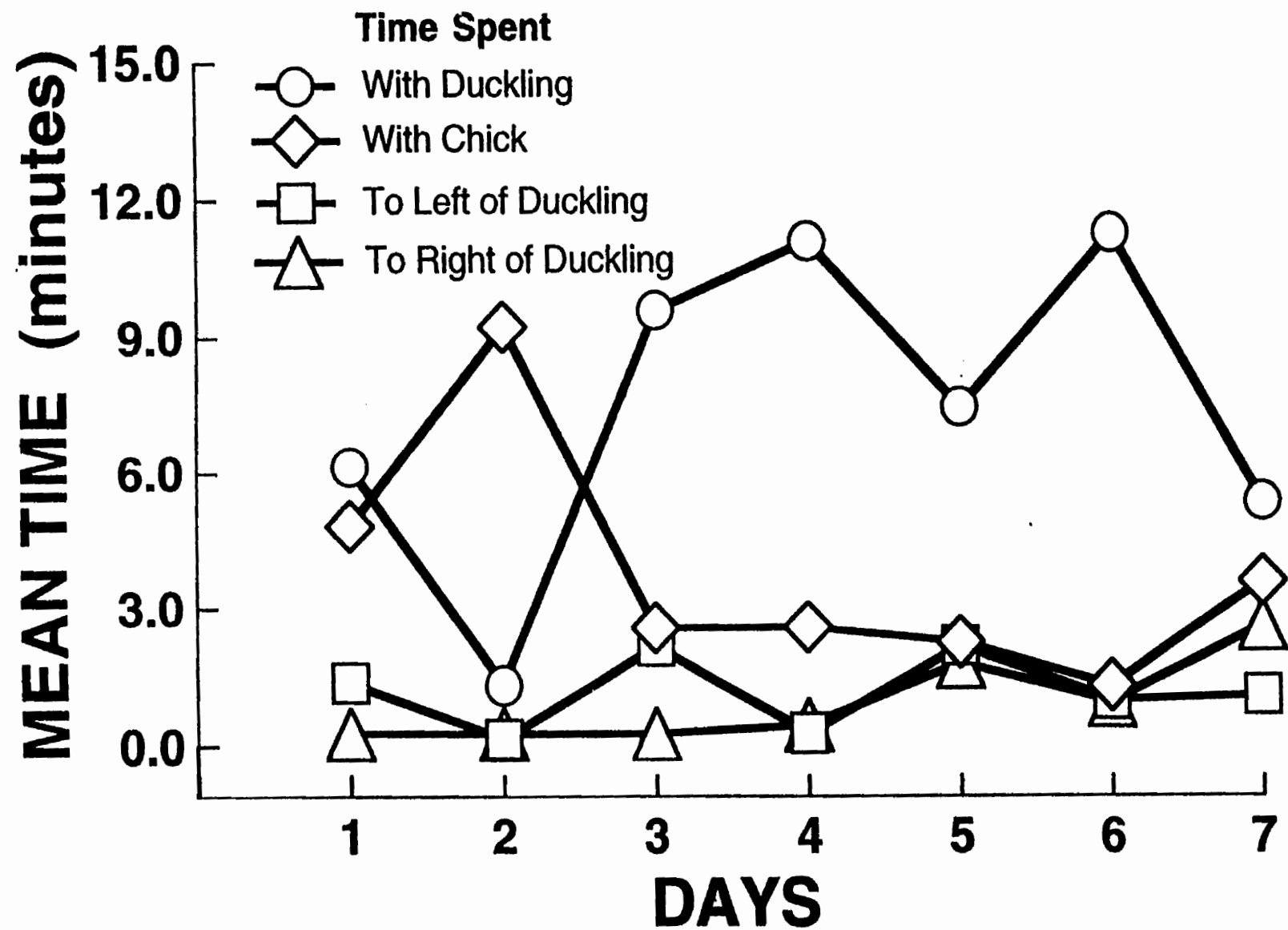
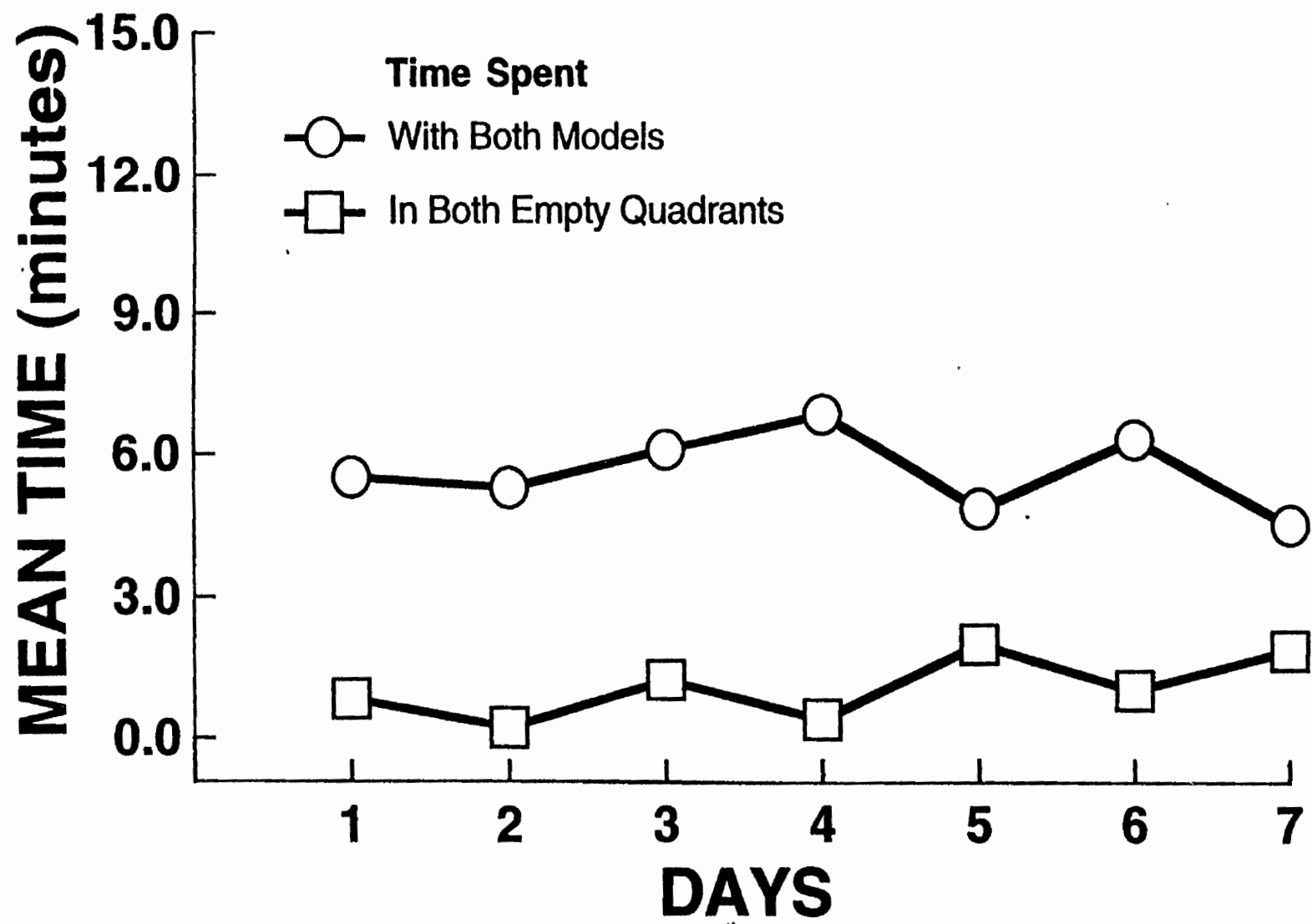


Figure 8. Experiment 2: Time spent with both the duckling and the chick versus time spent in both empty quadrants.



only for time spent with the duckling ($p < .01$) and time spent with the chick ($p < .05$), but there were no statistically significant linear trends.

Table 2. Experiment 2: Paired Samples t-tests, one-tailed (df = 55).

Pairs of variables	Paired differences				
	Mean	SD	SE	t-value	significance
Models (Duckling & Chick) vs. Empty Quadrants	4.55	3.33	0.45	10.22	$p < 0.001$
Duckling vs. Empty Quadrants	6.40	6.36	0.85	7.53	$p < 0.001$
Duckling vs. Chick	3.70	9.97	1.33	2.78	$p < 0.01$

As in Experiment 1, the second day looked markedly different from the other days (Figure 7, p. 49). Whereas the lower mean values for the time spent with a model duckling on days five and seven can be traced to outliers (Figure 9, p. 55), the reversal of preference on Day Two is much more extreme. On Day Two, five out of eight ducklings spent most of their time with the chick, and two others had unusually long latencies. Only one subject from the Day Two group preferred the same-age duckling over the chick, while the great majority of the subjects on other days preferred the duckling. In this, as in the previous experiment, the results of Day Two are unexplainably different from the predominating trend.

Entrance Measure. Older ducklings were more mobile than younger ones, as in Experiment 1. The subjects walked around the testing platform more than they did in the

previous experiment (Figure 10, p. 57), so the overall entrance average was higher (6.7 entrances).

Latency Measure. In Experiment 2, the average latency for all subjects was 1.3 minutes, which is very close to the average from Experiment 1. The latencies across days were not unusual (Figure 11, p. 59) except for Day Two, which was again radically different from the overall mean latency, and Day Seven which had an unusually long average latency (older ducklings normally have shorter latencies).

Observations

The general behaviour of the subjects at the start of the experimental session was the same as in the Experiment 1. They would look around, distress vocalize, and occasionally run around randomly before approaching a model. In this case, however, the subjects seemed to have more difficulty in choosing a model. The subjective impression of the experimenter was that they looked around more and vocalized more than in the previous experiment. The frequency of entering quadrants also suggested that the subjects had difficulty in choosing between a chick and a duckling. Some subjects ran back and forth between the two models. This behaviour might have been partially caused by both models' vocalizations. The model which was left alone usually emitted distress vocalizations; as the subject approached it, the model calmed down, while the other model, now alone, started its distress calls. The duckling model followed the subject around the inside perimeter of its cage more than did the chick (this is the experimenter's impression; the model duckling always followed the subject,

Figure 9. Experiment 2: Time spent with a duckling, a chick, or the two empty quadrants, outliers from Day 5 and 7 excluded.

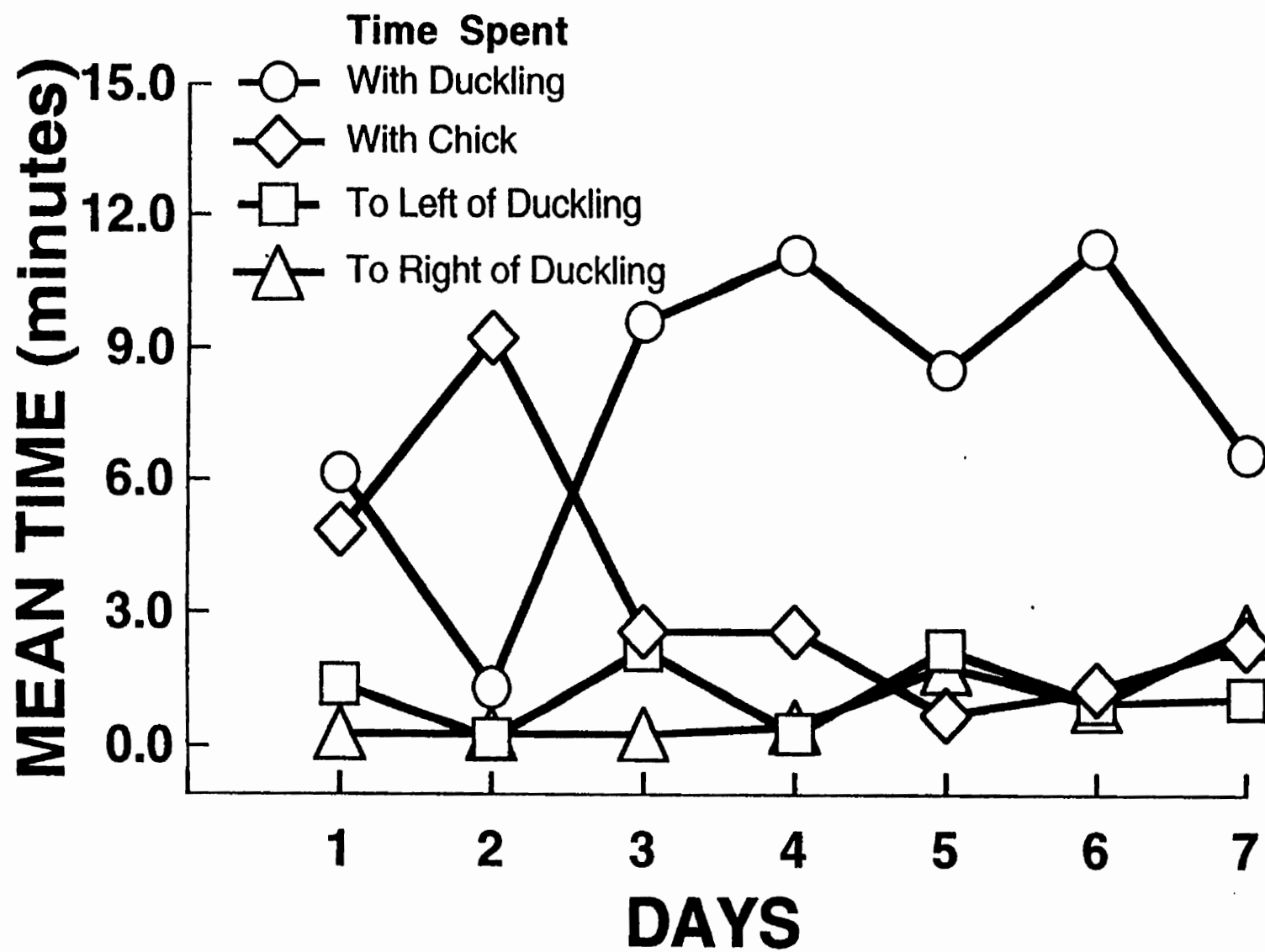


Figure 10. Experiment 2: Mean frequency of entrances made to the quadrants containing a duckling, a chick, or two empty cages, indicating the subjects' mobility.

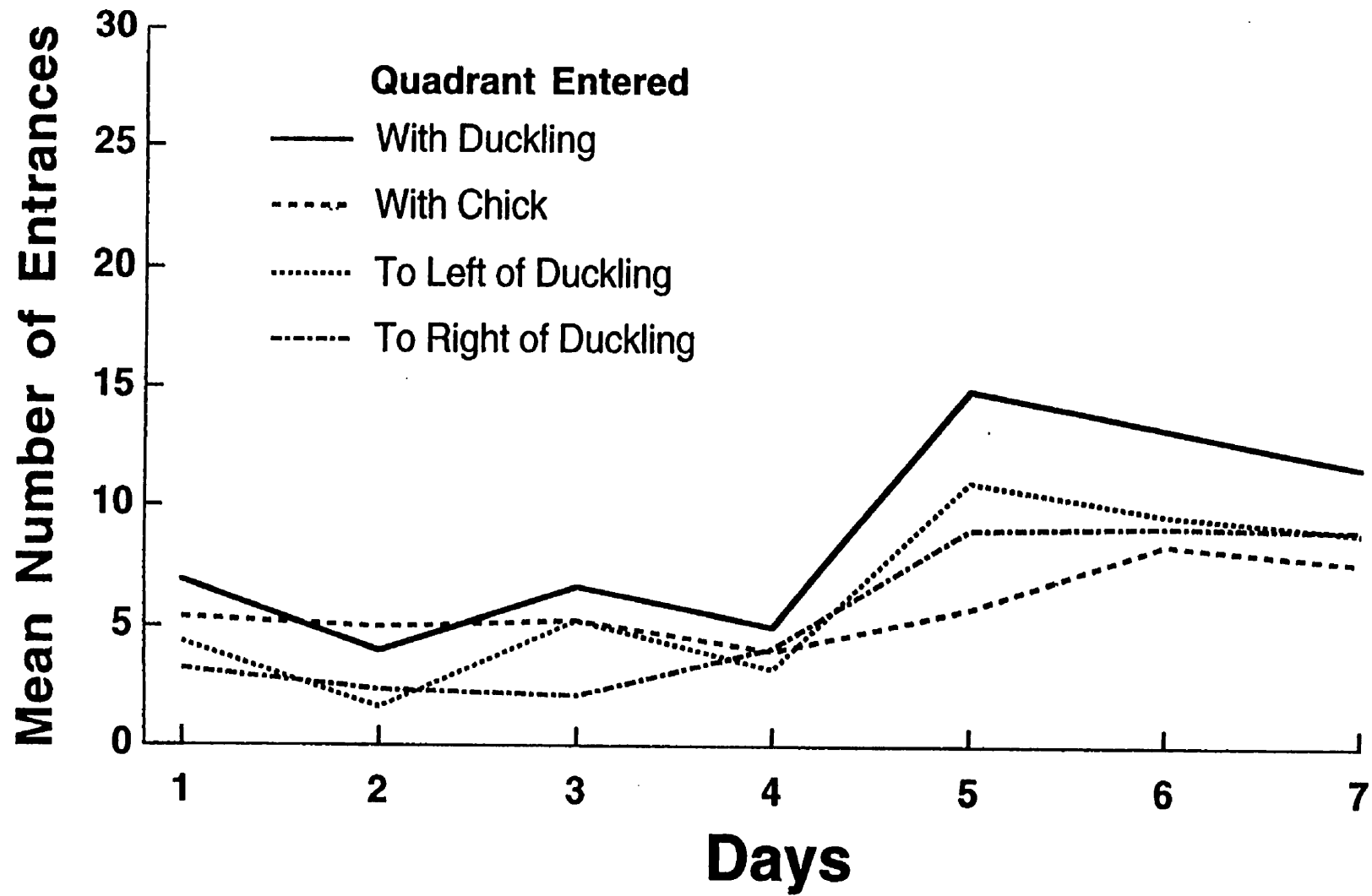
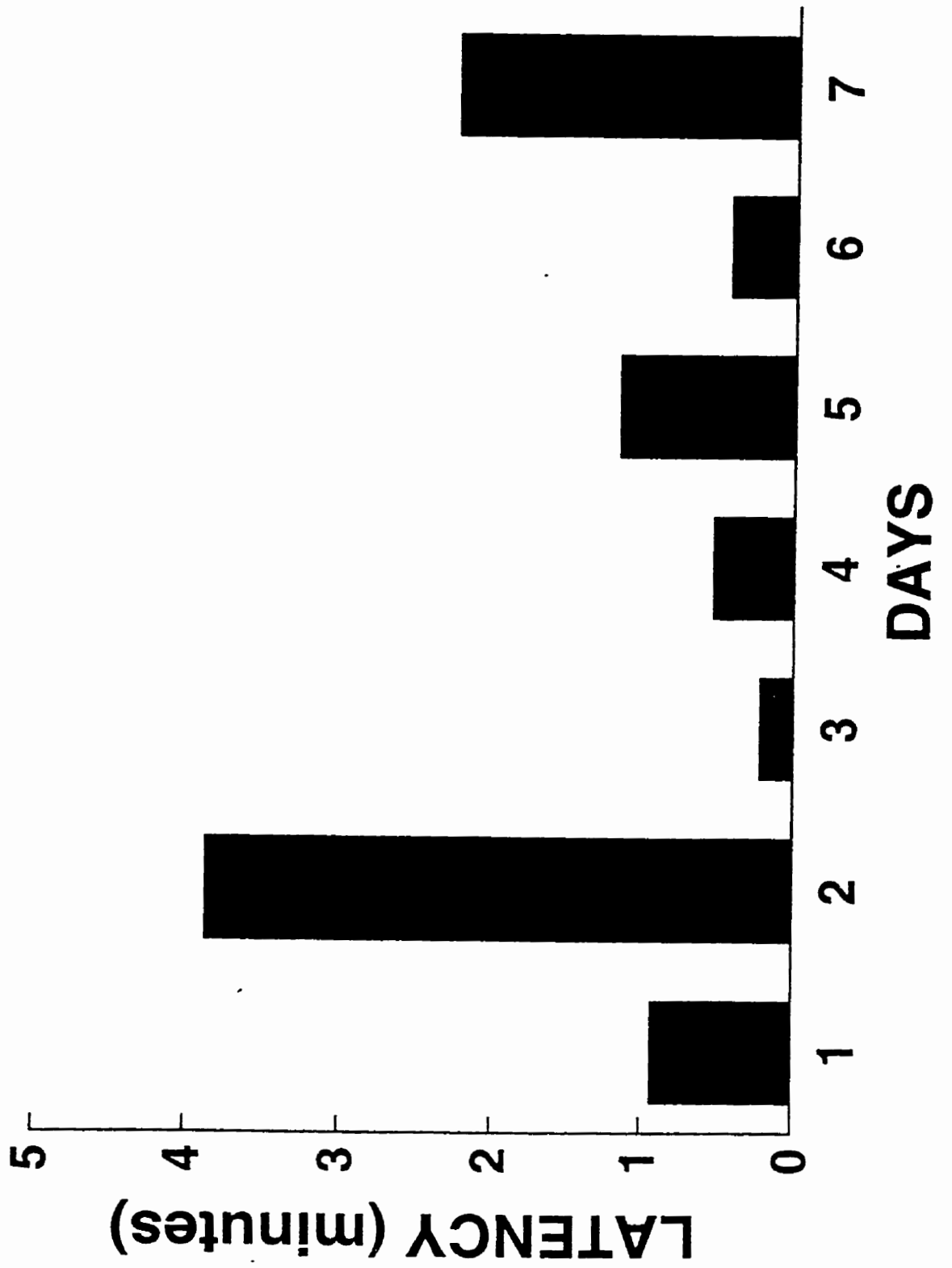


Figure 11. Experiment 2: Mean latency scores across the seven-day testing period.



while the chick did so only on a few occasions). The chick occasionally tried to get out of its cage (mostly by jumping, sometimes by sticking its head out), but it did not attempt to join the subject, while the model duckling tried it vigorously all the time. The chick also distress vocalized a lot, especially when left alone by the subject, which suggested that it might have been attracted to the subject.

Discussion

The subjects preferred the same-aged conspecific significantly more than a same-age bird of a different species. Such behaviour makes sense, because ducklings and chickens differ enough in their ecology to avoid mixing. Even if it is possible to create stable families of mixed species (Cushing & Ramsay, 1949), this experiment suggested that ducklings had definite unlearned preferences which they display when given a chance. However, the role of learning and experience should not be forgotten in the explanation of behaviour development. The slight attraction to the chick and the difficulty in choosing one of the models can be explained by the subject ducklings' lack of experience, since they had no previous visual contact with any living thing.

EXPERIMENT 3: BROOD VERSUS PEER.

The purpose of this experiment was to see if a brood of peers is preferred over a single peer, as previous experiments (e.g. Kirvan & Shapiro, 1972; Rogan & Shapiro, 1974) have suggested. Naive, singly-reared ducklings were given a choice of a same-age duckling, a brood of 10 ducklings (same age), and two quadrants with empty cages. On the basis of Experiment 1 and 2 results and the previous research cited above, I

hypothesized that the subject would spend more time with both models than in the two empty quadrants, more time with a brood than in the two empty quadrants, and more time with a brood than with a duckling.

Method

Subjects

The subjects were 56 White Peking ducklings reared in visual isolation from other living objects.

Models

The models were a brood of ten ducklings of similar age as the subject, and a single duckling of the same age.

Procedure

The apparatus and procedure were the same as described in the General Method section.

Results and Discussion

Data

Time Spent With Models. The data represented in Figure 12 (p. 64) indicates that the subjects preferred the brood most, the single duckling less, and that they spent almost no time in the two empty quadrants. The hypotheses were confirmed (Table 3, p. 62). The ducklings spent significantly ($p < .001$) more time with both models than in the two empty quadrants (Figure 13, p. 66), significantly ($p < .001$) more time with a brood than in the two empty quadrants (Figure 12, p. 64), and significantly ($p < .001$) more time with a brood than with a duckling (Figure 12, p. 64). The results were also clearer

than in the two previous experiments. Simple ANOVA was not significant for any model, suggesting that the subjects' preferences were similar across days.

Entrance Measure. The mobility of the subjects across quadrants (Figure 14, p. 68) looks less variable than in the previous experiments, and the overall average is lower: 1.8 entrances.

Latency measure. The overall mean latency length is 0.4 minutes, which is lower (Figure 15, p. 70) than in the previous two experiments.

Table 3. Experiment 3: Paired Samples t-tests, one-tailed (df = 55).

Pairs of variables	Paired differences				
	Mean	SD	SE	t-value	significance
Models (Peer & Brood) vs. Empty Quadrants	6.71	1.11	0.15	45.22	$p < 0.001$
Peer vs. Empty Quadrants	10.42	6.02	0.80	12.95	$p < 0.001$
Peer vs. Brood	7.42	11.34	1.52	4.90	$p < 0.001$

Observations

Of the three experiments done so far, the ducklings in this experiment were the quickest to react (hence short latencies) and to choose a model. They also emitted the least distress vocalizations and moved across the quadrants least, because they spent almost all their time with the brood. They attempted vigorously to enter the cage containing the brood and to join it, to the extent that they would sometimes get stuck between the cage wires. The ducklings from the brood sometimes exhibited interest in

Figure 12. Experiment 3: Time spent with a peer, a brood, or two empty cages.

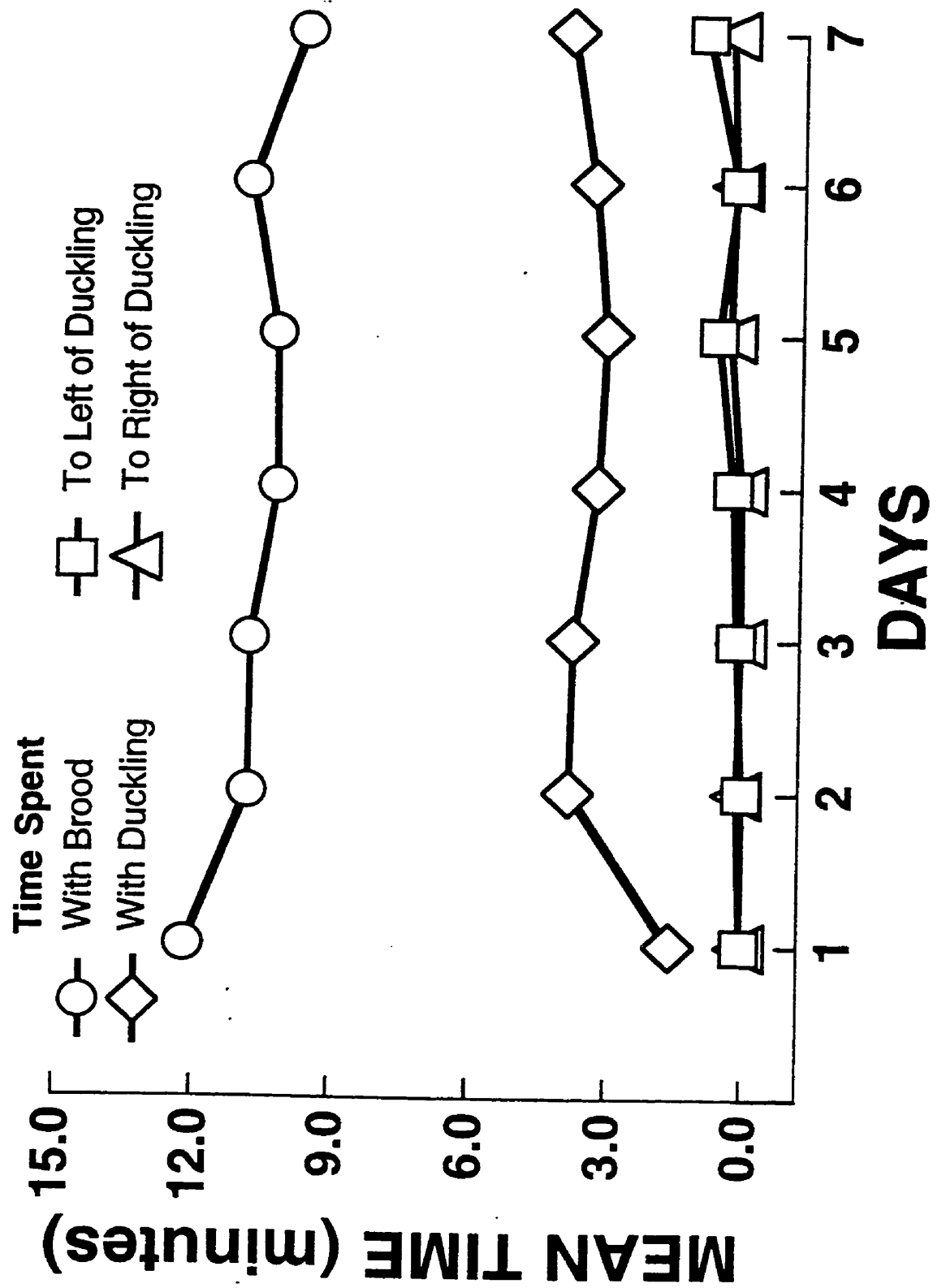


Figure 13. Experiment 3: Time spent with both the peer and the brood versus time spent in both empty quadrants.

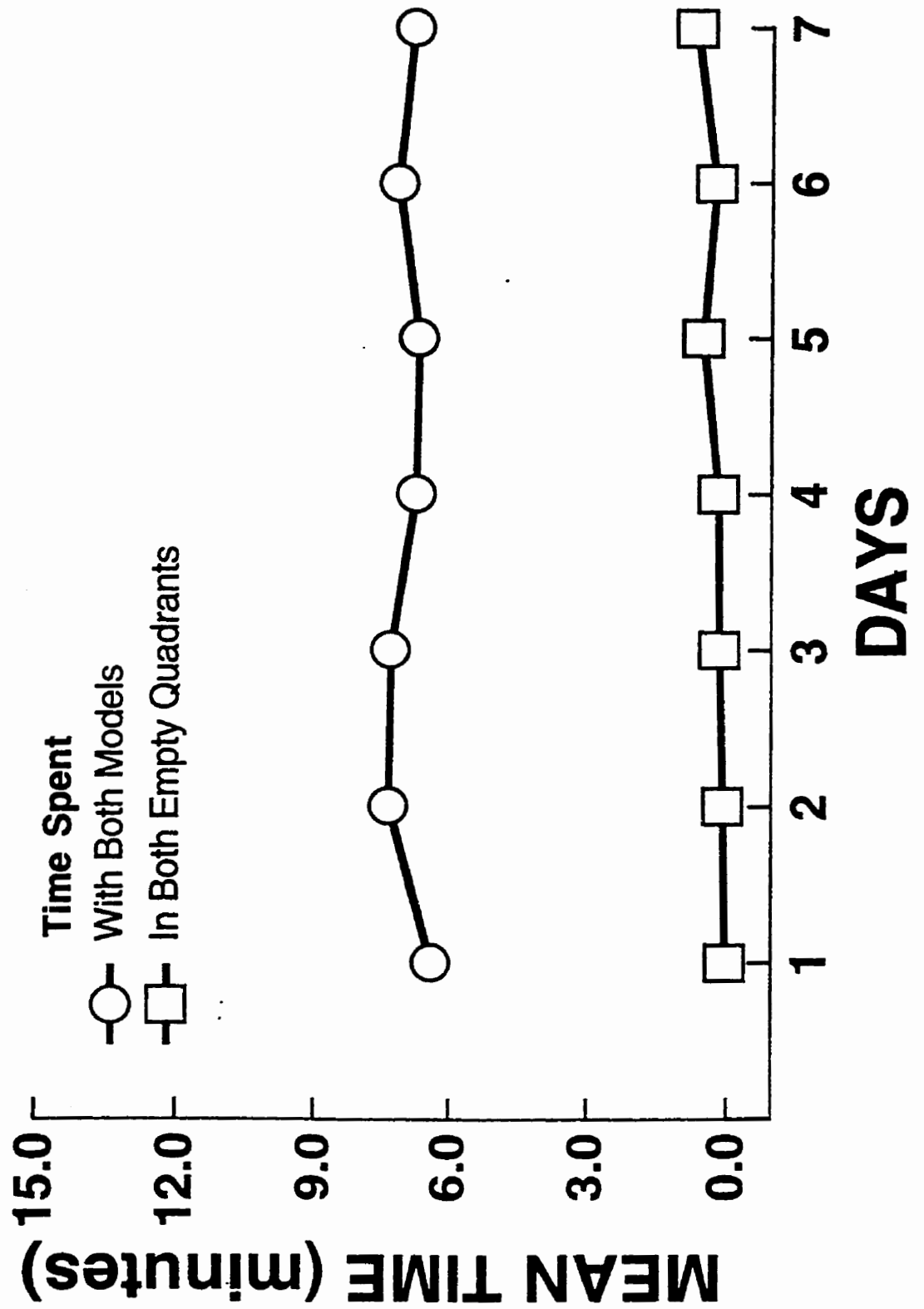


Figure 14. Experiment 3: Frequency of entrances made to the quadrants containing the peer, the brood, or two empty quadrants, indicating the subjects' mobility.

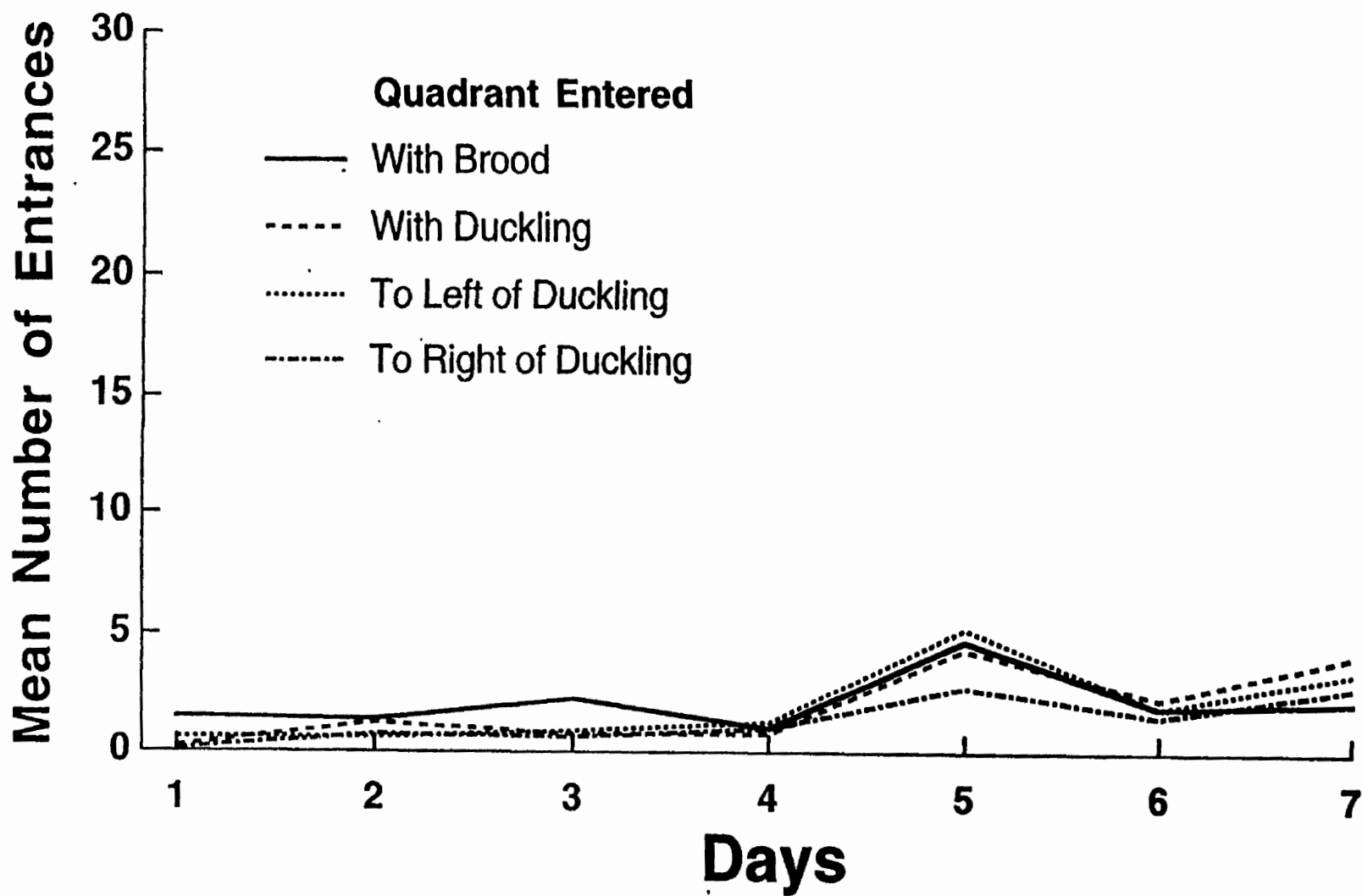
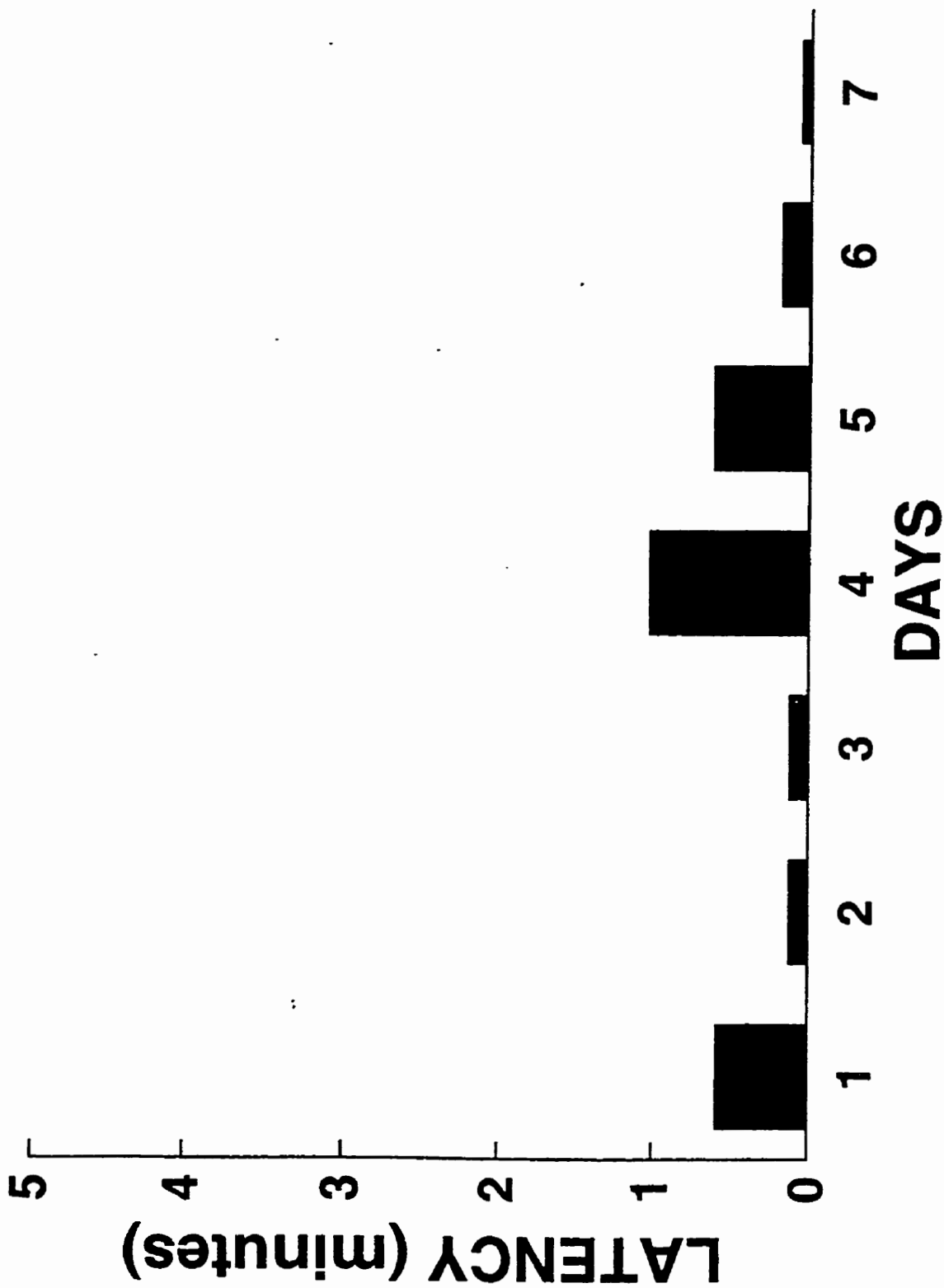


Figure 15. Experiment 3: Mean latency scores across the seven-day testing period.



the subject (trying to approach it and reaching to it through the cage wires), but this interest was not necessary for the subject to approach the brood. All ducklings except for the single model were silent or emitting contentment calls. The single model usually emitted a lot of distress calls and vigorously attempted to join the others by trying to “break” through its cage wires. Some subjects spent a little time with the single model before joining the brood, but only ten of the 56 subjects tested spent more time with the single duckling than with the brood of ducklings.

Discussion

The strong tendency to join and remain with a brood was apparent from the measures recorded. These results confirm other findings (e.g. Kirvan & Shapiro, 1972; Rogan & Shapiro, 1974). Again, no previous socialization was necessary for the ducklings to exhibit strong attraction to their peers. Such behaviour makes sense for a young precocial bird which has a higher chance of survival in a group rather than alone. A single bird was still attractive, but most subjects preferred to be with a larger brood.

EXPERIMENT 4: BROOD VERSUS COMPANION.

The purpose of this experiment was to look for indications that the ducklings can recognize a companion, as Lorenz (1935) suggested, and to see whether a brood is still more attractive to them than a familiar peer. Since Experiment 3 demonstrated that a brood was preferred over a single, unfamiliar peer, in this experiment the ducklings were reared in pairs and given a choice of the familiar companion duckling, an unfamiliar

brood of 10 ducklings (same-age), and two quadrants with empty cages. On the basis of Lorenz (1935) observations and the results of the previous three experiments I hypothesized that the subjects would spend more time with both models than in the two empty quadrants, more time with a brood than in the two empty quadrants, and more time with a brood than with the companion.

Method

Subjects

The subjects were 56 White Peking ducklings reared in pairs with an age-mate, but in visual isolation from other living objects.

Models

The models were a brood of ten ducklings of similar age as the subject, and the Companion (the same-age peer that a subject was kept with).

Procedure

The apparatus and procedure were the same as described in the General Method section.

Results and Discussion

Data

Time Spent With Models. The data represented in Figure 16 (p. 75) indicate that, as predicted, the brood was preferred most, the companion was less preferred, and the two empty quadrants were not attractive at all. All three hypotheses were confirmed (Table 4, p. 73). The subjects spent significantly ($p < .001$) more time with both models than in the two empty quadrants (Figure 17, p. 77), significantly ($p < .001$) more time

with a brood than in the two empty quadrants (Figure 16, p. 75), and significantly (exact probability: .025) more time with a brood than with the companion (Figure 16, p. 75).

Table 4. Experiment 4: Paired Samples t-tests, one-tailed (df = 55).

Pairs of variables	Paired differences				
	Mean	SD	SE	t-value	significance
Models (Companion & Brood) vs. Empty Quadrants	6.83	1.02	0.14	50.22	$p < 0.001$
Brood vs. Empty Quadrants	8.45	6.29	0.84	10.03	$p < 0.001$
Brood vs. Companion	3.24	12.06	1.61	2.01	$p = 0.025$

A trend is suspected from looking at Figure 16 (p. 75). Over the seven-day testing period, the subjects' preference for the brood was decreasing and the preference for the familiar companion was increasing. This tendency was tested using a simple ANOVA for each time line (Table 5, p. 78). Only the significant or nearly significant results are presented here. For the remaining analyses see Appendix D. A trend analysis was significant ($p < .01$) for each effect (downward trend for Brood and upward trend for Companion, Table 6, p. 78). Again, day two was different from its adjacent days, breaking what would otherwise be a rather smooth slope on the graph.

Entrance Measure. The frequency of entrances was relatively low, with an overall average of 1.5 entrances (Figure 18, p. 81).

Latency Measure. The latencies were relatively low, with an overall average of 0.6 minutes (Figure 19, p. 83).

Figure 16. Experiment 4: Time spent with a companion, a brood, or two empty quadrants.

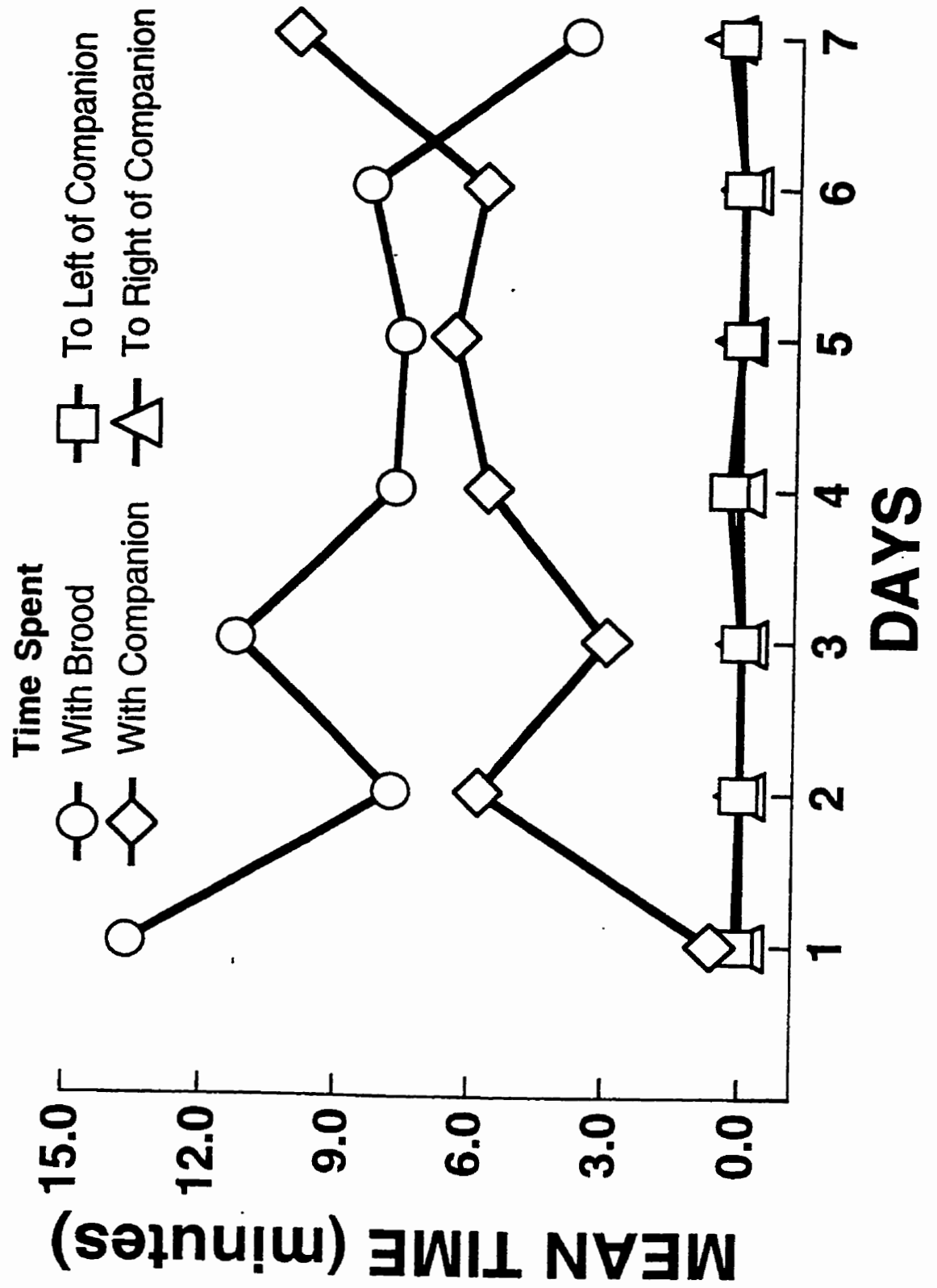


Figure 17. Experiment 4: Time spent with both the companion and the brood versus time spent in both empty quadrants.

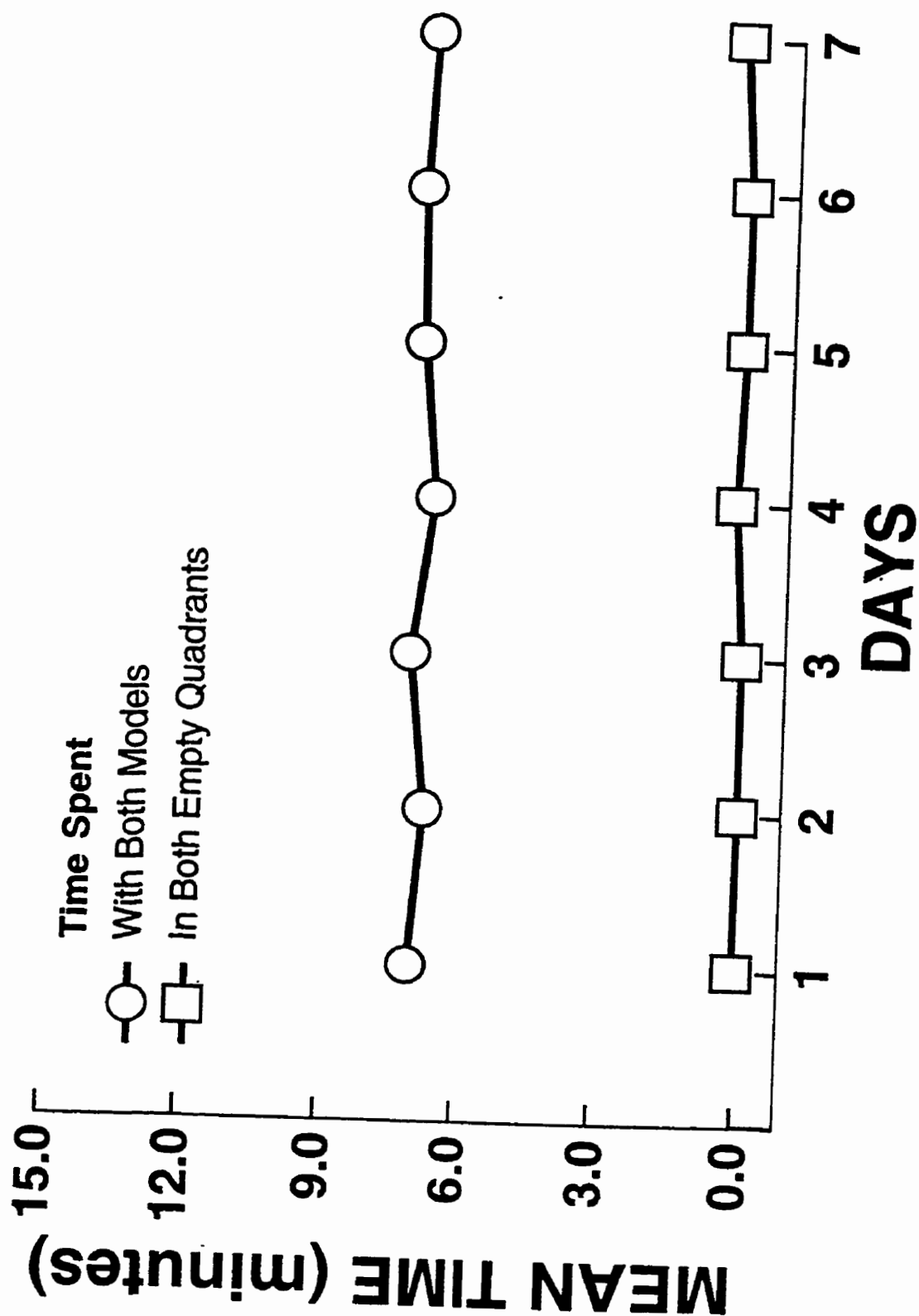


Table 5. Experiment 4: Simple Analysis of Variance

Effect	Source of Variation	SS	df	MS	F	significance
Brood	Age	470.18	6	78.36	2.348	0.045
	Residual	1635.61	49	33.38		
	Total	2105.79	55	38.287		
Companion	Age	414.72	6	69.119	2.174	0.061
	Residual	1557.77	49	31.791		
	Total	1972.49	55	35.863		

Table 6. Experiment 4: Trend Analysis

Effect	Linear Trend	SS	F	significance
Brood	32.17	295.688	8.894	0.01
Companion	31.72	287.474	9.0426	0.01

Observations

On Day one the subjects exhibited a uniform and overwhelming preference for the brood over other stimuli. Starting with Day two, they exhibited much more ambivalence: they looked around a lot, walked back and forth between the companion and the brood, and often stood in the middle of the testing arena, looking from one model to the other. During that time they constantly emitted distress calls and calmed down only when they joined either the brood or the companion and sat close to it. The companion duckling distress vocalized whenever the subject was not in reach and it vigorously tried to "break through" its cage wires, apparently in an effort to join the

subject duckling. The brood was calm at all times (quiet and/or emitting contentment calls), investigating its surroundings or sleeping.

Discussion

The results supported the hypothesis that the brood would be preferred over a single, even if familiar, duckling. The gradual reversal of preference was not anticipated. However, it can be explained by the increasing familiarity of the companion (each subsequent age group spent more time with their companions). In a natural situation, the ducklings would become familiar with their own brood and keep close to it. Mixing with strange broods was found to be progressively more difficult as ducklings got older (Munro & Bedard, 1982). Munro and Bedard (1982) found that the ducklings can recognize one another, do prefer familiar peers, and may be aggressive towards unfamiliar broods. No aggression was observed in this experiment, even when putting all the ducklings together for transport at the conclusion of each experiment.

Comparison of Experiments 3 and 4 (Figure 12 , p. 64 and Figure 16 , p. 75) suggests that the subjects were able to recognize a familiar peer. In Experiment 3, the preference for the brood was strong and stable over days and larger than the preference for the unfamiliar peer. In Experiment 4, the preference for the brood, while still dominating, was decreasing in favour of the familiar Companion. This tendency agrees with Lorenz' (1935) observations that ducklings soon learn to recognize their siblings but it is in contrast to the finding that they showed no preference for a familiar over a strange brood (Bruce & Shapiro, 1977b). Another experiment comparing a familiar peer with a single unfamiliar peer would be needed to confirm this tendency.

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Figure 18. Experiment 4: Mean frequency of entrances made to the quadrants containing the companion, the brood, and two empty quadrants, indicating the subjects' mobility.

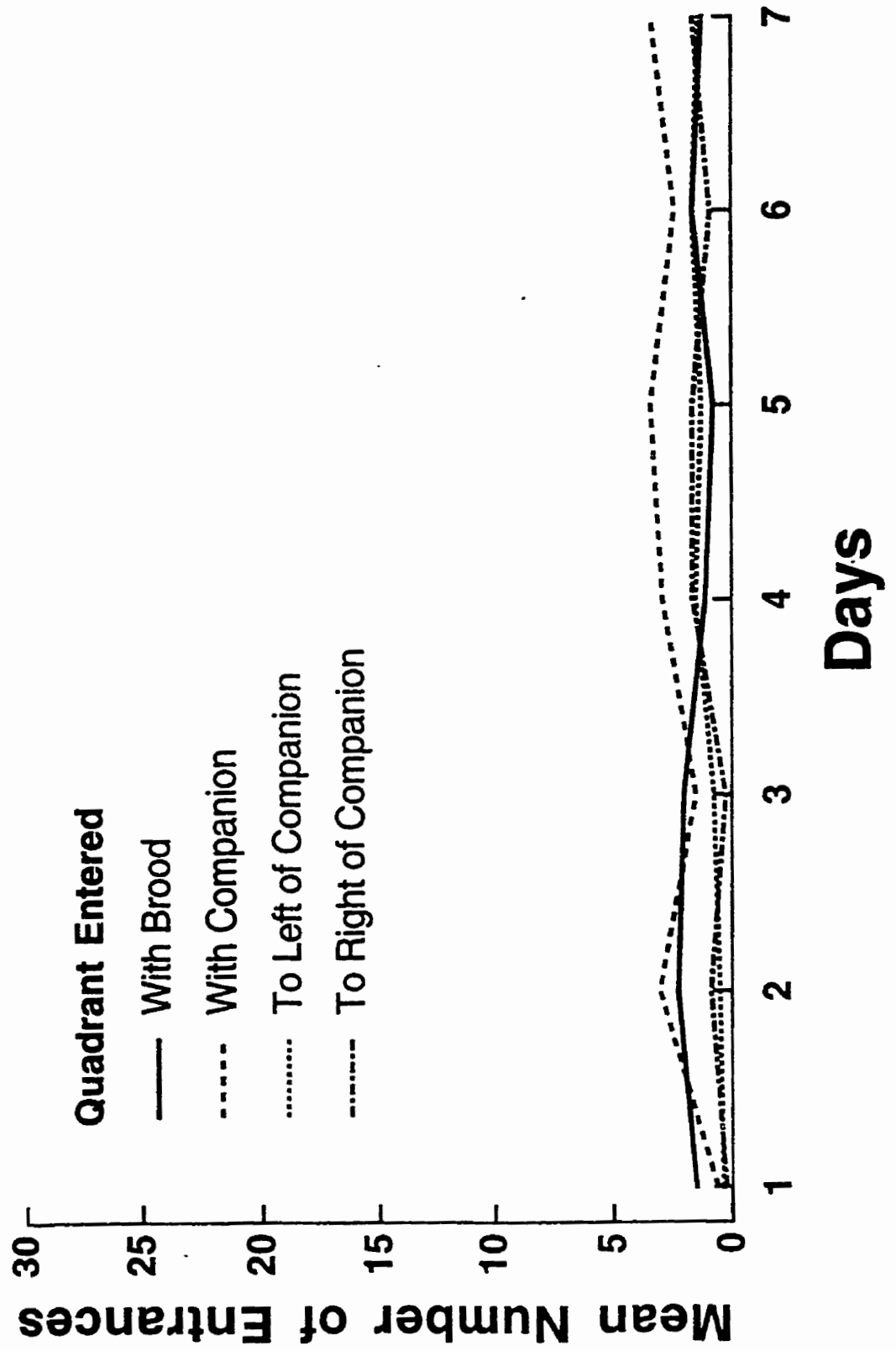
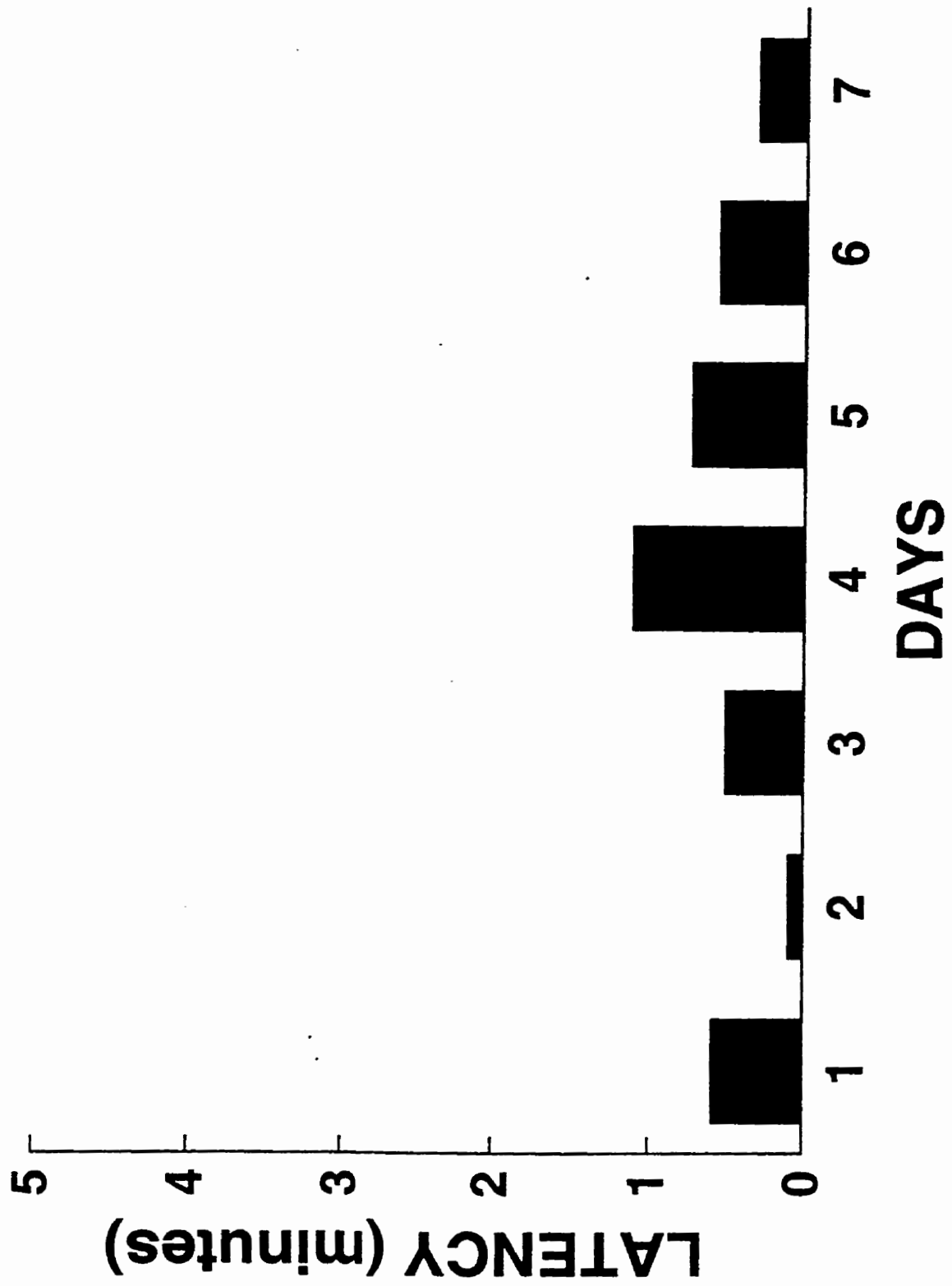


Figure 19. Experiment 4: Mean latency scores across the seven-day testing period.



EXPERIMENT 5: CHICKEN BROOD VERSUS COMPANION.

Experiment 5 depended on the outcome of the previous one; it would be unnecessary if the previous experiment demonstrated a preference for the single familiar duckling (the companion) over a brood of ducklings. However, the outcome of Experiment 4 did not allow such a conclusion. In Experiment 5 it was hypothesized that a brood, any brood, should be more attractive to a duckling than a single peer, due to the “safety in numbers” principle. In this experiment, the ducklings were again reared in pairs and given a choice of the familiar companion, a brood of 10 chicks, or two quadrants with empty cages. I hypothesized that the subjects would spend more time with both models than in the two empty quadrants, more time with a brood than in the two empty quadrants, and more time with a brood than with a companion.

Method**Subjects**

The subjects were 56 White Peking ducklings reared in pairs with an age-mate but in visual isolation from other living objects.

Models

The models were a Brood of ten chicks of similar age as the subject, and the Companion (the same-age peer that a subject was kept with).

Procedure

The apparatus and procedure were the same as described in the General Method section.

Results and Discussion

Data

Time Spent With Models. The data presented in the graphs suggested that, although the models were preferred over the empty quadrants (Figure 21, p. 89), it was the Companion that was the most attractive model (Figure 20, p. 87). Therefore, only the first two hypotheses were confirmed. The subjects spent significantly ($p < .001$) more time with both models than in the two empty quadrants and significantly ($p < .01$) more time with a brood of chicks than in the two empty quadrants (Table 7). The results pertaining to the third hypothesis were an interesting surprise. The directional t-test used was highly significant ($p < .001$, Table 7). My hypothesis, however, predicted that more time would be spent with the brood of chicks than with the companion. The results were exactly the opposite; hence, the third hypothesis is not supported.

Table 7. Experiment 5: Paired Samples t-tests, one-tailed ($df = 55$).

Pairs of variables	Paired differences				
	Mean	SD	SE	t-value	significance
Models (Companion & Brood) vs. Empty Quadrants	6.9	1.10	0.15	46.79	$p < 0.001$
Chicken Brood vs. Empty Quadrants	1.72	4.58	0.61	2.80	$p < 0.01$
Chicken Brood vs. Companion	10.37	9.06	1.21	8.57	$p < 0.001$

Figure 20. Experiment 5: Time spent with a brood of chicks, a duckling, or two empty quadrants, indicating subjects' preferences.

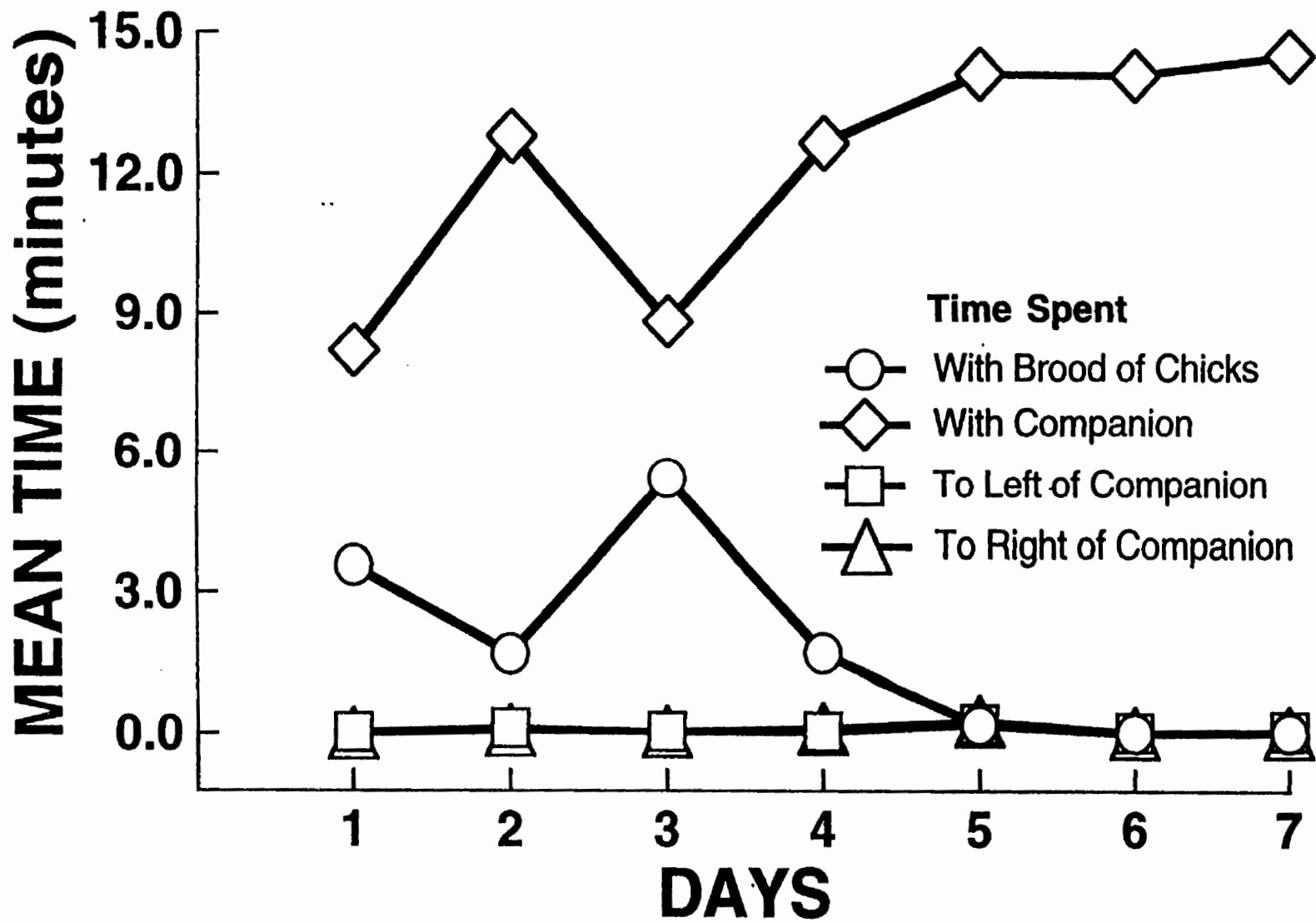
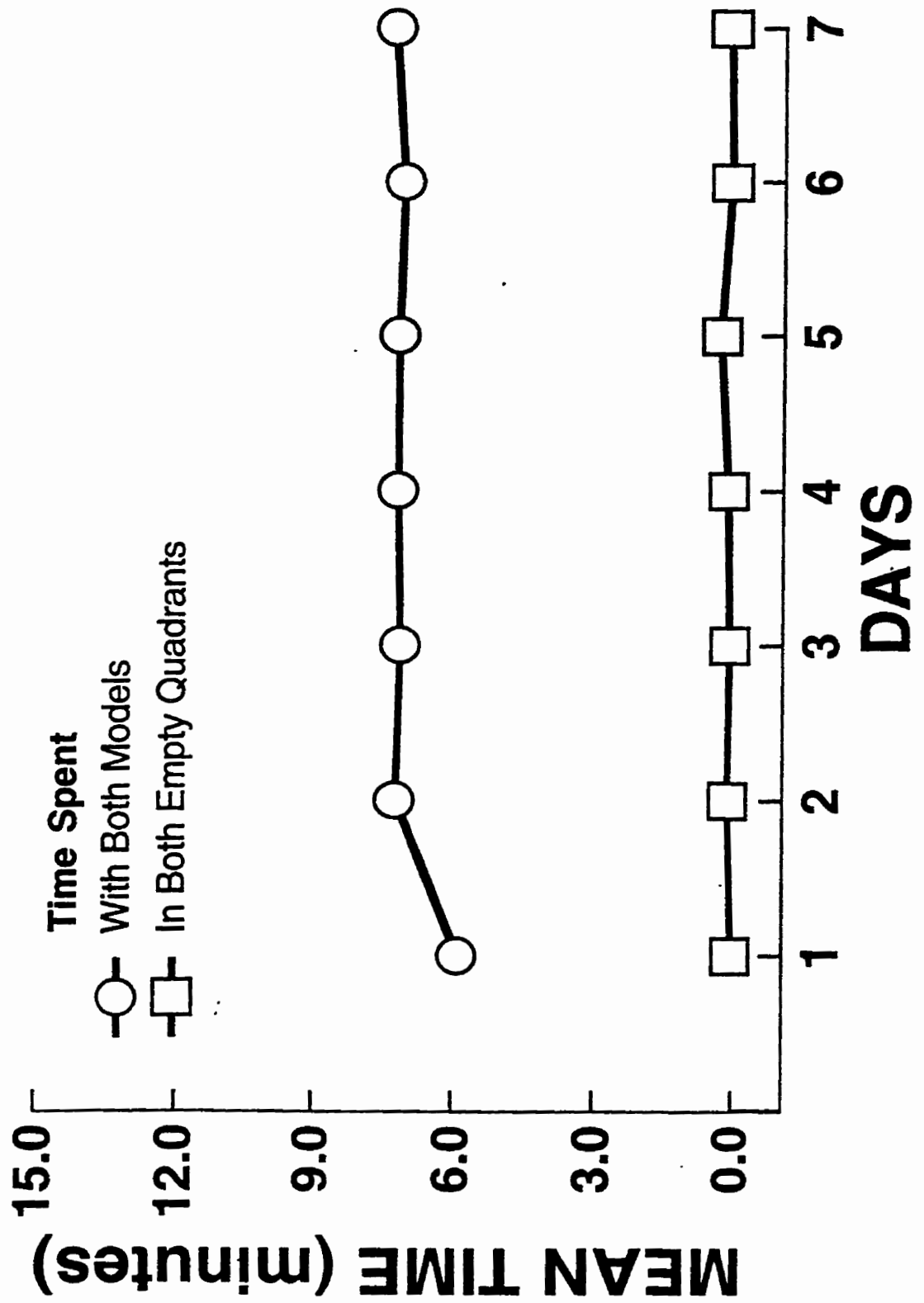


Figure 21. Experiment 5: Time spent with both the duckling and the brood of chicks versus time spent in both empty quadrants.



The graph also suggested a meaningful trend over days (Figure 20, p. 87), increasing for the Time Spent with a Companion and decreasing for the Time Spent with the Brood of Chicks. A trend analysis revealed that only the increase in Time Spent With a Companion was significant ($p < 0.05$; Table 8 and Table 9).

Table 8. Experiment 5: Simple Analysis of Variance.

Effect	Source of Variation	SS	df	MS	F	significance
Chicken Brood	Explained (Age)	201.68	6	33.61	1.75	0.13
	Residual	942.13	49	19.23		
	Total	1143.81	55	20.8		
Companion	Explained (Age)	321.99	6	53.67	2.87	0.018
	Residual	917.76	49	18.73		
	Total	1239.75	55	22.54		

Table 9. Experiment 5: Trend Analysis.

Effect	Linear Trend	SS	F	significance
Companion	26.7446	204.3639	10.91	0.01

Entrance Measure. The frequency of entering quadrants was low (Figure 22, p. 92), with an overall average of 1.5 entrances.

Latency Measure. The latencies were also low, with an average 0.8 minutes, except for higher latency values on Day One (Figure 23, p. 94), which is common.

Figure 22. Experiment 5: Mean frequency of entrances made to the quadrants containing a brood of chicks, a duckling, or two empty quadrants, indicating the subjects' mobility.

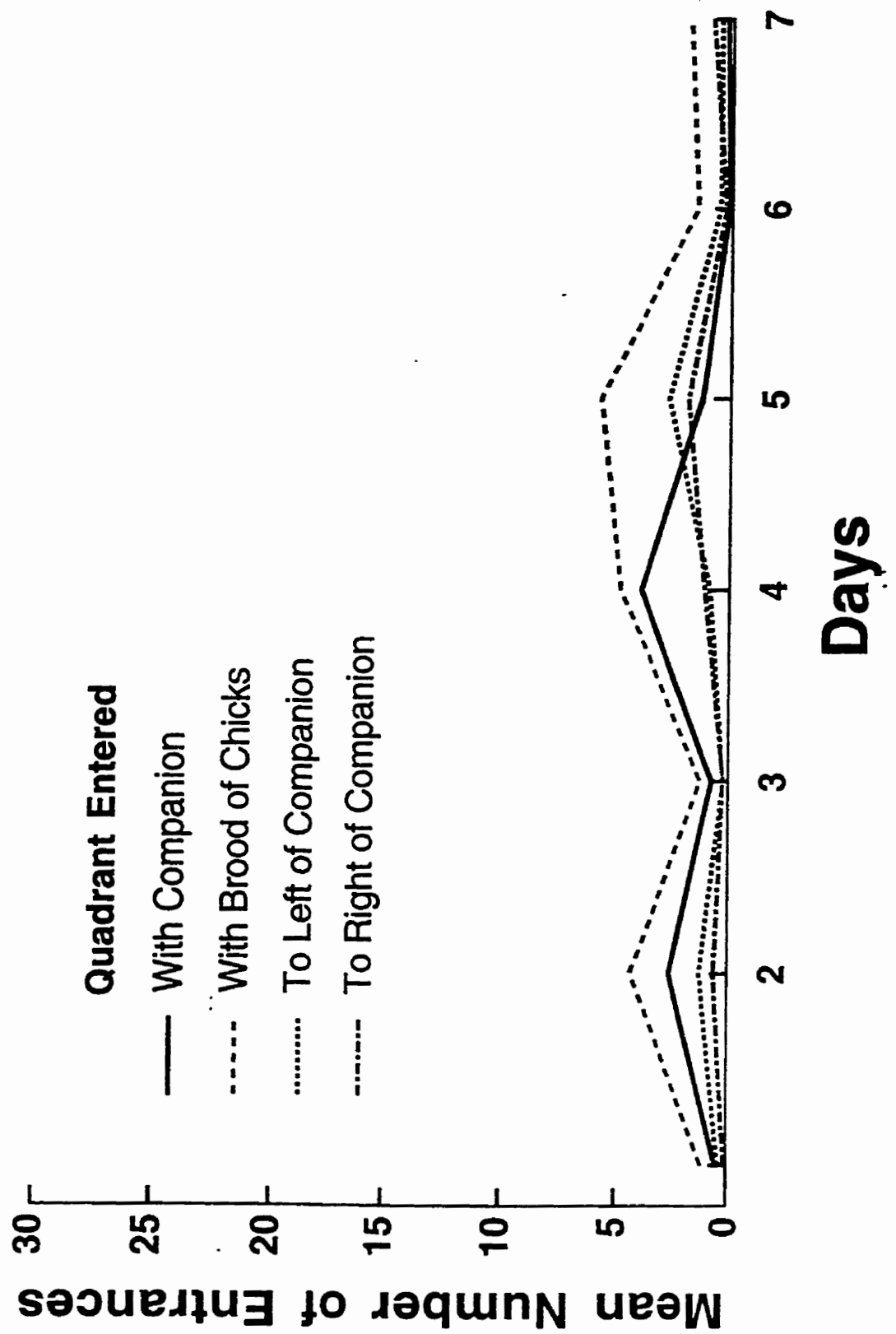
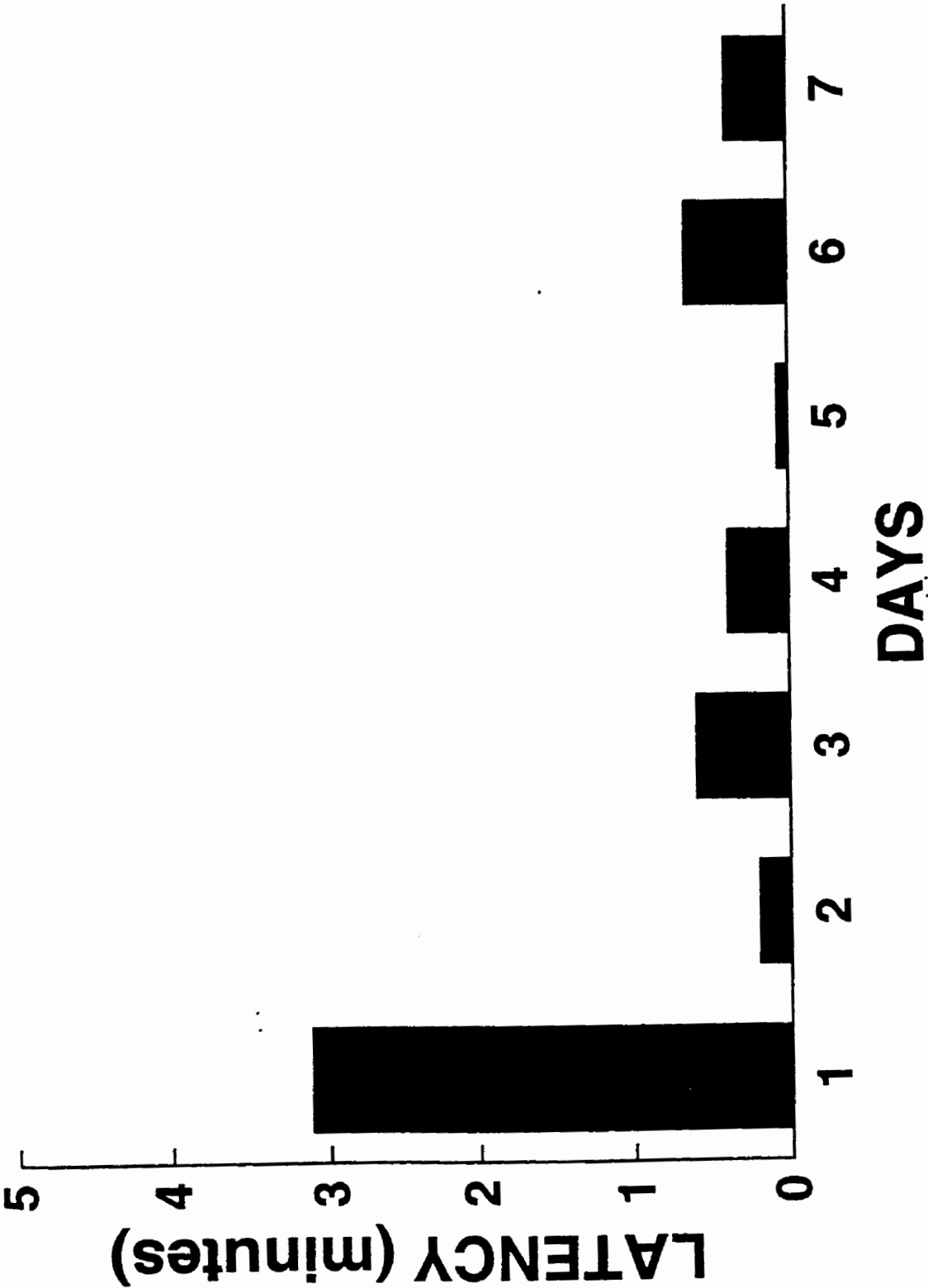


Figure 23. Experiment 5: Mean latency scores for the seven-day testing period.



Observations

Most subjects were immediately attracted to the familiar peer and did not spend any time with the brood of chicks. This was usually true even if the brood was active (e.g. pecking the sand as if there was food present) and the companion duckling was not. During the first four days of age, a few subjects did approach the chicks and stayed with them for some time. However, only two out of 56 subjects (aged one and three days) stayed exclusively with the brood of chicks, ignoring the companion. The chicks often pecked the subject duckling violently (which looked much different from the gentle exploratory pecks that ducklings sometimes exchanged). However, this behaviour did not seem to discourage the subject (it never caused immediate withdrawal; at most the subject would move out of reach, but not to a different quadrant). Rather, attraction to a conspecific sibling seemed to make it move away. After day four, the attraction to the brood of chicks dropped radically to values close to zero.

Vocalization patterns were similar to that in the previous experiments. The subjects initially emitted distress vocalizations, but stopped when they joined the companion or the brood. The companion was quiet if the subject was close, but it started distress vocalizing as soon as the subject moved away. When deserted by the subject, the companion vigorously pushed through its cage wires in an apparent attempt to get out of the cage and follow the subject. By contrast, the brood of chicks was calm, emitting some contentment calls and investigating their environment or sleeping.

Discussion

As in the previous experiments, the live models were preferred significantly more than the empty quadrants. However, the hypothesis that the brood would be the most attractive stimulus was not confirmed. The graph (Figure 20, p. 87) indicates that the strongest attraction was the familiar conspecific peer (the Companion). A more definitive statement on this situation will depend on additional experiments. The time spent with the companion was overwhelmingly larger than the time spent with the brood or in the empty quadrants. On the basis of previous results and observations, I am confident that this effect would be highly significant if an experiment was done with a prediction that subjects will spend more time with the companion than with chicks. Apparently, the ducklings can distinguish their own species and prefer it over chicks. The chicks evoked some interest only during the first four days. These results were in a great contrast to Experiments 3 and 4, where the brood was the most attractive stimulus. This tendency was reversed when the brood consisted of a different species.

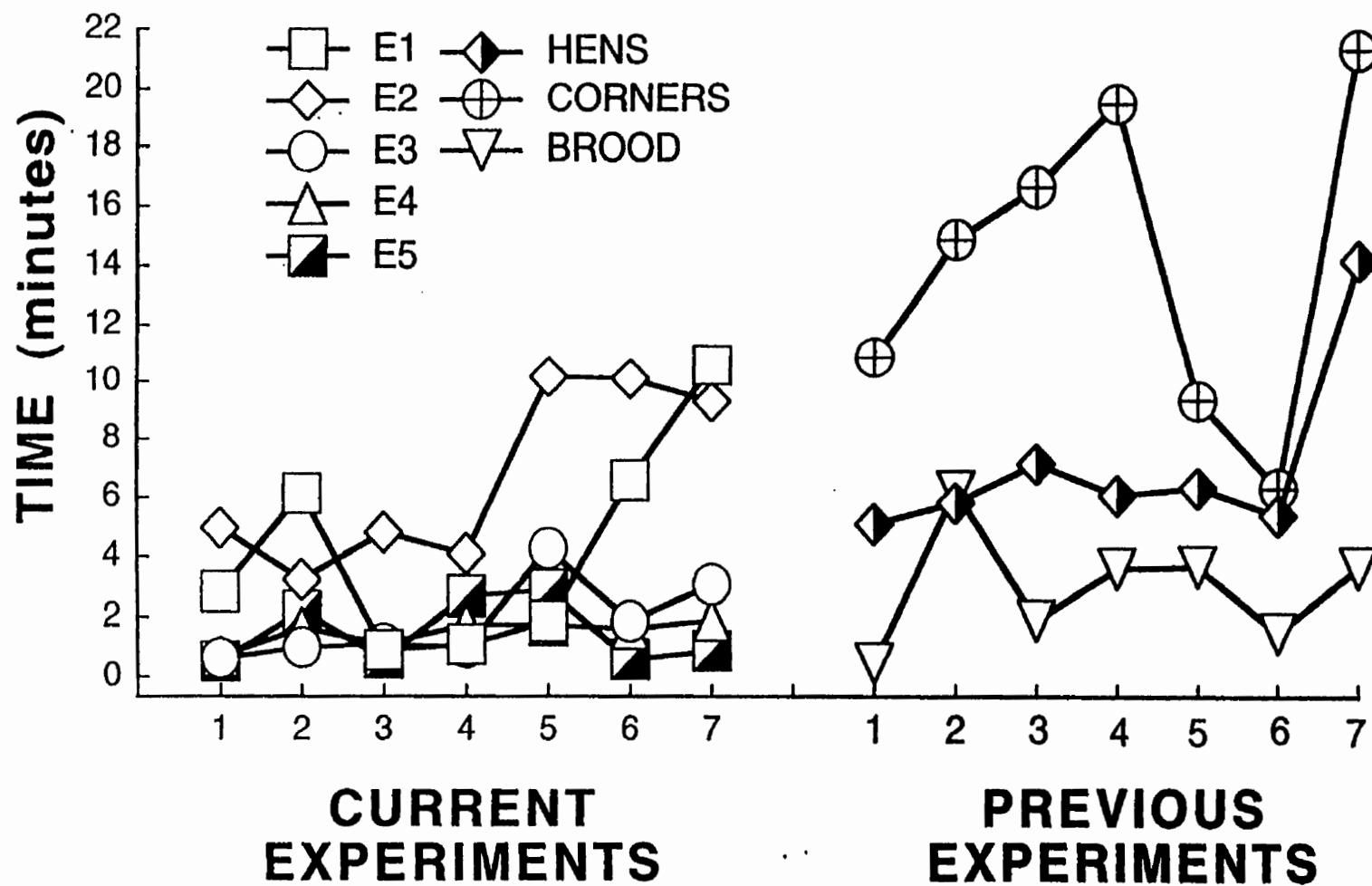
COMPARISON OF THE FREQUENCY OF ENTRANCE MEASURE ACROSS CURRENT AND PREVIOUS EXPERIMENTS

In addition to the time spent in quadrants containing various stimulus objects, the frequency with which subjects entered each quadrant was recorded in this series of experiments. Previous experiments and observations (Darczewska & Shapiro, 1997; 1998) suggested that an entrance measure, which indicates the subjects' level of mobility, may yield another clue about their preferences. Generally, subjects tend to get

more active as they get older. Conversely, they move less among quadrants as more attractive stimuli are presented to them.

In different, previous experiments (called “Hens” and “Brood” for convenience sake in this discussion) Darczewska and Shapiro used adult hens versus adult hens with a brood (1997), or only empty cages with no live models at all (experiment called “Corners”; Darczewska & Shapiro, 1998). The mobility between quadrants was always much lower when a brood or a sibling was presented to a subject (the present study, Figure 5, p. 42, Figure 10, p. 57, Figure 14, p. 68, Figure 18, p. 81, and Figure 22, p. 92), and it was higher when empty cages (“Corners”) or unfamiliar adult hens (“Hens”) were presented (Figure 24, p. 99; Darczewska & Shapiro, 1997; 1998). When a peer or a brood was present, a typical duckling looked around and sometimes circled the testing platform before choosing to stay in the vicinity of its peers. Hence, the frequency of entering each quadrant was low. When no peers were present, a typical duckling spent the entire session running around the testing table and distress vocalizing. The entrance scores, therefore, were very high (Darczewska & Shapiro, 1997;1998). These observations are supported by a statistical comparison of the overall mean of entrances for all five of the present experiments, in every one of which at least one peer was present, and the mean of all entrances for the two previous experiments with no peers present (“Hens” and “Corners”; Darczewska & Shapiro, 1997; 1998). The results of a t-test was highly significant ($p < .001$). On the other hand, a t-test comparing the mean entrances of the present five experiments to the mean for a previous experiment where peers were also present (“Brood”; Darczewska & Shapiro,

Figure 24. A comparison of mean entrance frequencies in three previous and five current (E1 - E5) experiments. In the three previous experiments (Darczewska & Shapiro, 1997; 1998) different models were used. In the experiment titled "Hens" unfamiliar conspecific hens were presented as models. In "Brood" the same hens were used, but one of them was accompanied by three ducklings. In "Corners" only empty cages were presented.



1997) was not significant (see Appendix F for statistical analyses). The frequency of entrance measure, thus, seems to be negatively correlated with attractiveness or attachment to an object, since ducklings normally do not wander far away from a highly attractive stimulus.

Although the earlier experiments (Darczewska & Shapiro, 1997; 1998) were done on wild mallard ducklings and the present study used domesticated Peking ducklings, I saw no obvious differences in their behaviour, although I am aware that some differences may exist. Therefore, it would be useful to perform another experiment comparing the mobility of these two groups, to make sure that the difference in entrance scores was due to model attractiveness and not to some intra-specific factors.

COMPARISON OF LATENCIES ACROSS EXPERIMENTS

A comparison of latencies across all five experiments and also four similarly structured experiments performed earlier on wild mallard ducklings (Darczewska & Shapiro, 1997; 1998) also showed an interesting tendency. Usually, the average latency got shorter as the birds got older, but the latencies were also generally shorter in those experiments in which an important model was presented to the ducklings (Figure 25, p. 102). The experiments with empty cages ("Corners"; Darczewska & Shapiro, 1998) and with unfamiliar adult hens ("Hens"; Darczewska & Shapiro, 1997) had the longest latencies, while the experiments with broods ("Brood"; Darczewska & Shapiro, 1997 and the present study, Experiment 3) had the shortest latencies (Figure 15, p. 70 and

Figure 25. A comparison of mean latency scores in the three previous and five current (E1 - E5) experiments. In the three previous experiments (Darczewska & Shapiro, 1997; 1998) different models were used. In the experiment titled "Hens" unfamiliar conspecific hens were presented as models. In "Brood" the same hens were used, but one of them was accompanied by three ducklings. In "Corners" only empty cages were presented.

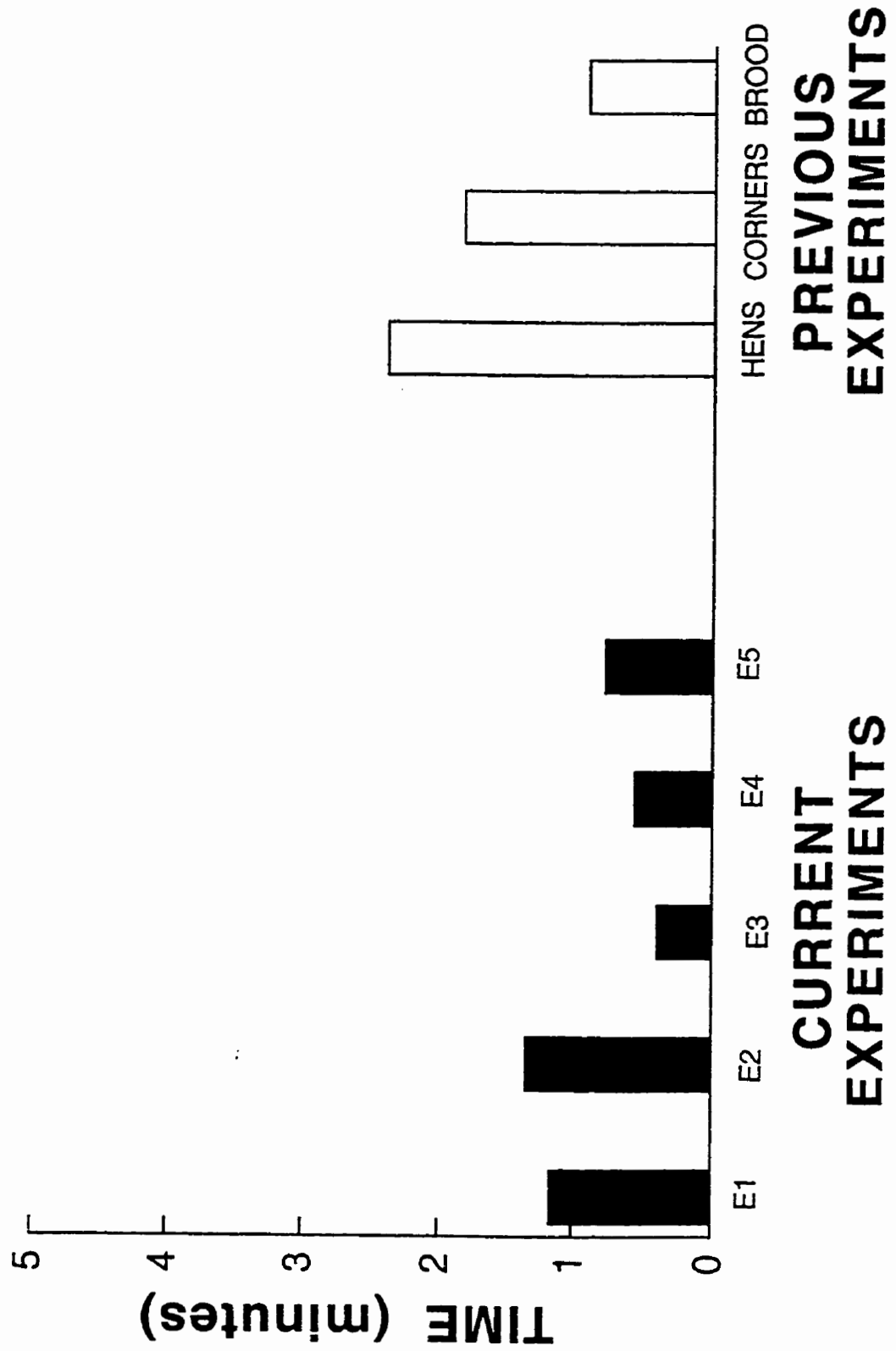


Figure 25, p. 102). This impression is supported by a statistical analysis. A t-test comparing an overall mean latency for the present five experiments containing peers and a combined mean for “Hens” and “Corners” (neither of which had peers) was highly significant ($p < .001$), while a mean latency for “Hens” did not differ significantly from a mean latency for “Corners” (see Appendix G for statistical analyses). It appears as if the conspecific adults were not more attractive to the ducklings than the empty cages. The latency length was never correlated with the time of testing (see Appendix H for the correlation analysis performed to make sure that ducklings’ activity level did not depend on the testing being done at a particular time during the day).

GENERAL DISCUSSION

The general tendency that all subjects in the present study exhibited was to go to a live model rather than to an empty quadrant or an apparently irrelevant artificial object. Thus, the expectation that ducklings will be primarily and strongly attracted to living things was confirmed. The next general tendency was to go to a conspecific rather than to a different-species bird. Finally, the ducklings were more attracted to a brood rather than to a single sibling. However, this last rule did not hold if the brood consisted of domestic chicks, a rather distant species from a different taxonomic order.

These results suggest that peers are the most attractive stimulus to White Peking ducklings and that there is no need for imprinting or any other form of learning in order for this preference to emerge. Siblings are attractive beyond the traditional

sensitive period of 25 hours. Apart from a few rare instances when the first response to a peer briefly resembled fear (a pause and withdrawal before finally approaching the peer), no subject was afraid of its peers, even if they were the first living things encountered. This finding was in contrast with the fear of unfamiliar conspecific adults observed previously by Darczewska and Shapiro (1997).

In the present study it was also discovered that the naive ducklings were still able to distinguish between their conspecifics and domestic chicks. This finding agreed with Lorenz' (1970) suggestion that, "In bird species in which siblings remain together for a long time after emergence from the nest (i.e. particularly in nidifugous species), the innate schema appears to be remarkably specific...so that there is very little room for imprinting (p. 234-235)." This is not to suggest that the preference for conspecific is purely instinctual. While behaviour theorists no longer maintain the opposition of instinct and learning, they do find clear unlearned preferences and at the same time recognize that organisms are not completely bound by these predispositions (Marler, 1993).

Other studies found that socially reared or group-tested birds were less responsive to the imprinting object (e.g. Moriyama, 1987) or that they failed to imprint (e.g. Lickliter & Gottlieb, 1986a; 1986b). These studies indicated the tendency that I found: that siblings or peers generally are the most attractive stimulus for ducklings and probably for other gregarious precocial hatchlings as well. It has been noticed quite early in the history of imprinting studies that a sibling is the only object causing a significant approach reaction in young domestic chicks and that, given this data, filial

imprinting theory might have to be drastically changed (Gray, 1961). Gray (1961) suggested that it was advantageous for a chick to be more attached to its siblings than to its mother, at least initially, so as to remain with the brood until it had the sufficient locomotor abilities needed in order to follow the mother. The same may be said for canvasback ducklings (*Aythya valisineria*). They were observed to remain together in the nest for several hours after hatching. During that time they did not follow the mother even if she left the nest; they did, however, venture together from the nest to feed (Collias & Collias, 1956).

Besides the general tendencies described above, other interesting phenomena were observed in the present study. The linear trends in Experiment 4 and 5 suggested that some preferences are not stable but change in the course of development. The strong attraction to a brood in Experiment 3 did not change over days, whereas the attraction to a brood when a familiar companion was present (Experiment 4) decreased steadily in favour of attraction to the companion. Many studies investigating attachment in young birds only lasted for two to three days. It would have been very misleading if the testing period had been similarly limited in this study. An even longer testing period, lasting weeks or even months, would have been necessary to understand the trends that started to appear during the first week.

In four out of five experiments, the trend that was observed across seven days of testing was disturbed and usually reversed on Day two (Experiments 1, 2 and 4) or three (Experiment 5), after which it returned to its previous course. A conspicuous difference was previously observed on day four (enhancement of the predominating

preference; Shapiro, 1977), and between days two and four (reversal of the predominating preference; Darczewska & Shapiro, 1997). A possible explanation for this puzzling phenomenon may be a yet undefined link between the ducklings' physiology and behaviour. Ducklings lose their yolk sac reserves around the third day of life (Marcstrom, 1966). At that time they have to start feeding if they are to survive. The observed behavioural changes do not always fall precisely on day three, but it is possible that the yolk sac is used up at different rates in different individuals or breeds, or that its reserves depend on other factors (for example, season, the mother's health, egg size, etc.). A whole new project would be needed to explain this phenomenon. It should be noticed, however, that the only experiment with no changes in preference at any time was the third one, in which the models were a brood and a single peer. It seemed that the brood was such a strong stimulus that no other factors could disturb its attractiveness.

Social isolation is normally not beneficial to a young bird of a most precocial species, and it was obvious in the present study that the ducklings strongly disliked being alone. Chicks that are left alone spend a lot of time "freezing" and vocalizing, which signifies fear and does not allow for efficient foraging or other life-supporting activities (Smith, 1957). The lone bird's random exploration is excessive, while being much less efficient than group exploration. Moreover, learning is slower in isolated chicks. Single chicks are very easily distracted by irrelevant objects (specks of dust etc.), and they may be extremely cautious in starting to eat when alone, even if they are hungry (Smith, 1957). Ducklings behave similarly; I observed that those kept in pairs

often ate more than those kept alone (this phenomenon is called social facilitation and is discussed later). On occasion, an isolated duckling would not start eating by itself. I could determine this without making contact with the subjects merely by checking the amount of feces under their units. If this condition lasted more than three days, it could be life-threatening. Hence, when an isolated duckling would not eat, I put it with another for “peer therapy”. It always started to eat and survived (of course, these ducklings were not used in the experiments).

Isolated chicks and ducklings usually show distress. Single domestic chicks often try to escape from an enclosure (Smith, 1957). I also observed this behaviour, accompanied by distress calls, in mallard ducklings (Darczewska, 1995; Darczewska & Shapiro, 1997). These behaviours did not happen when the bird had companions, however (Smith, 1957; Darczewska & Shapiro, 1997; the present study). It seemed that even naive birds displayed an unlearned need for company. Once a duckling had a chance to experience social contact, its attempts to escape from isolation were even more aggravated. Such a duckling also constantly displayed distress in the absence of peers, even in the environment which otherwise seemed to be perfectly comfortable (Hoffmann, 1996; the present study). In other studies, isolation seemed to produce some other, yet unexplained effects which made socially reared chicks avoid an isolate and prefer another socially reared individual (Sigman, Lovern & Schulman, 1978). It has also been demonstrated (Miller, 1994) that Peking ducklings reared and tested in a group are more selective, that is, more accurate in their responses to the hen’s alarm call, than are ducklings reared alone. The responses (e.g. freezing in reaction to the

mother's warning call) of group-reared ducklings resemble that of wild ducklings under natural conditions. The above observations again point to the importance of peer contact.

This powerful attraction to peers may have several ecological benefits. Young birds staying close together have a greater chance to find food and avoid predators, especially if their mother dies or abandons them. Many animals from various taxonomic groups (mammals, birds, fish etc.) congregate for defense against predators. Each individual in a group can spend less time scanning the environment and therefore has more time to feed, while the group as a whole is more vigilant than a single animal, simply because each individual adds to the probability of detecting a predator (Alcock, 1993, pp.369-372; Krebs & Davies, 1993, pp. 120-122). A big group also creates a dilution effect, which means that each group member has less chance to be eaten by a predator as the group gets larger (Alcock, 1993, pp.376-377; Krebs & Davies, 1993, pp. 123-126). An additional benefit of grouping in young birds is heat conservation.

Because of the above benefits, I expected the ducklings to prefer a brood of any kind over a single peer. However, they displayed much stronger preference for a single conspecific over a brood of chicks (Experiment 5). I apparently did not appreciate the abilities of young ducklings. Such species discrimination may have additional benefits, for example social facilitation.

Social facilitation has been observed in both adults and youngsters of many species, but especially in precocial birds, during activities such as feeding (e.g. Tolman & Wilson, 1969) and drinking (Clayton, 1976). Young birds feeding together with their

parents can learn from them about what is edible and where to find it (Turner, 1964). Social feeding also facilitates feeding in broods with no parents (Smith, 1957), and the more familiar the peers, the greater the facilitation (Turner, 1964). Precocial birds may learn to feed effectively through social facilitation, local enhancement, or imitation (Turner, 1964; Suboski, 1989). Local enhancement and social facilitation are related terms referring to a situation wherein actions performed by some members in a group of animals tend to spread until the entire group is engaging in the behaviour. Imitation, on the other hand, suggests observational learning (Immelmann & Beer, 1989, pp. 139, 175 and 274-275). Although slightly different, all of these processes rely on close social contact. It would not be beneficial for ducklings to join a brood of a different species if their dietary and other basic needs were different.

Since in this study the brood of chicks was not attractive to the ducklings, it would be interesting to see how a duckling would react to a brood of a different but more closely related species (other dabbling for example, such as the black duck, Anas rubripes) or a different race (such as the Rouen duck, which is also a domesticated form of mallard). Based on potential learning benefits, they should be ready to join any species with the same ecology, but Smith (1957) found that chicks differentiated between races and preferred to associate with their own race.

The extreme interest in peers observed in these studies, compared to the indifference exhibited by ducklings towards conspecific adult hens (Darczewska, 1995; Darczewska & Shapiro, 1997), coincides with Harris' (1998) suggestion that peers exert a relatively greater influence than parents do in human development. A direct

comparison between ducklings and human children is too far-fetched. For White Peking ducklings, however, peers seem more important than the parent-offspring relationship traditionally referred to as imprinting.

REFERENCES

- Alcock, J. (1993). Animal behavior. An evolutionary approach. Sunderland, Massachusetts: Sinauer Associates, 5th. ed.
- Alison, R.M. (1982). Oldsquaw brood behavior. In J.T. Ratti, L.D. Flake and W.A. Wentz (Eds.), Waterfowl Ecology and Management: Selected Readings. (pp. 304-307) Lawrence, Kansas: Allen Press, Inc.
- Barrows, E.M. (1995). Animal behavior desk reference. Boca Raton, Florida: CRC Press.
- Baer, D.M. and Gray, P.H. (1960). Imprinting to a different species without overt following. Perceptual and Motor Skills, 10, 171-174.
- Bruce, M. and Shapiro, L.J. (1977a). The importance of the brood in the hen-brood dyad in eliciting an approach response in mallard ducklings. Paper presented at the Northeastern Regional Meeting of the Animal Behaviour Society, St. John's, Newfoundland, October 1977.
- Bruce, M. and Shapiro, L.J. (1977b). Brood recognition in ducklings. Paper presented at the meeting of the Animal Behaviour Society, University Park, Pennsylvania, June 1977.
- Clayton, D.A. (1976). Social facilitation of drinking of a partially satiated duckling. Animal Learning and Behavior, 4, 391-395.
- Collias, N.E. (1952). The development of social behavior in birds. The Auk, 69, 127-159.

- Collias, N.E. and Collias, E.C. (1956). Some mechanisms of family integration in ducks. The Auk, 73, 378-400.
- Cushing, J.E. and Ramsay, A.O. (1949). The non-heritable aspects of family unity of birds. The Condor, 51, 82-87.
- Darczewska, M. (1995). Effects of the mallard hen's speculum in eliciting the "approach" and "stay near" response in mallard ducklings. Unpublished honours thesis, University of Winnipeg, Winnipeg, Canada.
- Darczewska, M. and Shapiro, L.J. (1997). What do mallard ducklings find more attractive, the hen or the brood? Poster presented at the Brain, Behaviour and Cognition Conference, University of Manitoba, Winnipeg, Canada, June 19-21, 1997.
- Darczewska, M. and Shapiro, L.J. (1998). Seeking comfort or seeking cover? Attraction to corners in mallard ducklings. Poster presented at the Prairie Universities Biology Symposium, University of Manitoba, Winnipeg, Canada, February 19-21, 1998.
- Donovan, R.J. (1984). The relative attractiveness of a brood, a brooding hen, and a non-brooding hen to mallard ducklings. Paper presented at the Psychology Undergraduate Research Conference, University of Winnipeg, Winnipeg, Manitoba, April 1984.
- Dyer, A.B. and Gottlieb, G. (1990). Auditory basis of maternal attachment in ducklings (*Anas platyrhynchos*) under simulated naturalistic imprinting conditions. Journal of Comparative Psychology, 104, 190-194.

Dyer, A. B. , Lickliter, R. and Gottlieb, G. (1989). Maternal and peer imprinting in mallard ducklings under experimentally simulated natural social conditions.

Developmental Psychobiology, 22, 463-475.

Eadie, J.M., Kehoe, F.P. and Nudds, T.D. (1988). Pre-hatch and post-hatch amalgamation in North American Anatidae: a review of hypotheses. Canadian Journal of Zoology, 66, 1709-1721.

Eiserer, L.A. (1978). The effects of tactile stimulation on imprinting in ducklings after the sensitive period. Animal Learning and Behavior, 6, 27-29.

Gaioni, S.J., DePaulo, P. and Hoffman, H.S. (1980). Effects of group rearing on the control exerted by an imprinting stimulus. Animal Learning and Behavior, 8, 673-678.

Gaioni, S.J., Hoffman, H.S., Klein, S.H., and DePaulo, P. (1977). Distress calling as a function of group size in newly hatched ducklings. Journal of Experimental Psychology: Animal Behavior Processes, 3, 335-342.

Gaioni, S.J. and Platte, P.L. (1982). Sibling interactions in mallard ducklings (*Anas platyrhynchos*). Behaviour Analysis Letters, 2, 189-196.

Gorman, M.L. and Milne, H. (1972). Creche behaviour in the common eider *Somateria m. mollissima* L. Ornis Scandinavica, 3, 21-25.

Gottlieb, G. (1971). Development of species identification in birds. An inquiry into the prenatal determinants of perception. Chicago: The University of Chicago Press.

- Gould, J.L. and Marler, P. (1991). Learning by instinct. In W. S-Y. Wang (Ed.). The Emergence of Language - Development and Evolution. Readings from Scientific American Magazine. New York: W.H. Freeman & Co.
- Grassman, M. and Owens, D. (1986). Chemosensory imprinting in juvenile green sea turtles, Chelonia mydas (Short communication). Animal Behaviour, 35, 929-931.
- Graves, H.B. (1973). Early social responses in Gallus: A functional analysis. Science, 182, 937-938.
- Graves, H.B. and Siegel, P.B. (1968). Prior experience and the approach response in domestic chicks. Animal Behaviour, 16, 18-23.
- Gray, P.H. (1961). The releasers of imprinting: Differential reactions to color as a function of maturation. Journal of Comparative and Physiological Psychology, 54, 597-601.
- Guhl, A.M. (1956). The social order of chickens. Scientific American, 194, 42-46.
- Guiton, P. (1958). The effect of isolation on the following response of Brown Leghorn chicks. Proceedings of the Royal Physical Society of Edinburgh, 27, 9-14.
- Guiton, P. (1959). Socialisation and imprinting in Brown Leghorn chicks. Animal Behaviour, 7, 26-34.
- Harlow, H.F. (1958). The nature of love. American Psychologist, 13, 673-685.
- Harris, J.R. (1998). The nurture assumption: why children turn out the way they do. New York: Free Press.

Hess, E.H. (1973). Imprinting. Early experience and the developmental psychobiology of attachment. New York: Van Nostrand Reinhold Company.

Hess, E.H. & Petrovich, S. B. (Eds.) (1977). Imprinting. Stroudsburg: Dowden, Hutchinson & Ross, Inc.

Hoffmann, H.S. (1996). Amorous turkeys and addicted ducklings. A search for the causes of social attachment. Boston: Authors Cooperative, Inc., Publishers.

Immelmann, K. and Beer, C. (1989). A dictionary of ethology. Cambridge, Mass.: Harvard University Press.

Johnston, T.D. and Gottlieb, G. (1981). Development of visual species identification in ducklings: What is the role of imprinting? Animal Behaviour, 29, 1082-1099.

Johnston, T.D. and Gottlieb, G. (1985). Effects of social experience on visually imprinted maternal preferences in Peking ducklings. Developmental Psychobiology, 18, 261-271.

Kirvan, B. A. and Shapiro, L.J. (1972). The effect of brood size on eliciting an approach response in white Peking ducklings. Paper presented at the 64 Annual Meeting of the Southern Society for Philosophy and Psychology, St. Louis, Missouri, March 30 - April 1, 1972.

Krebs, J.R. and Davies, N.B. (1993). An introduction to behavioural ecology. 3rd. ed., Oxford: Blackwell Scientific Publications.

Lamprecht, J. (1977). A comparison of the attachment to parents and siblings in juvenile geese (Branta canadensis and Anser indicus). Zeitschrift fur Tierpsychologie, 43, 415-424.

Lickliter, R., Dyer, A.B., and McBride, T. (1993). Perceptual consequences of early social experience in precocial birds. Behavioural Processes, 30, 185-200.

Lickliter, R. and Gottlieb, G. (1985). Social interaction with siblings is necessary for visual imprinting of species-specific maternal preferences in ducklings (Anas platyrhynchos). Journal of Comparative Psychology, 99, 371-379.

Lickliter, R., and Gottlieb, G. (1986a). Visually imprinted maternal preference in ducklings is redirected by social interaction with siblings. Developmental Psychobiology, 19, 265-277.

Lickliter, R. and Gottlieb, G. (1986b). Training ducklings in broods interferes with maternal imprinting. Developmental Psychobiology, 19, 555-567.

Lickliter, R. and Gottlieb, G. (1988). Social specificity: Interaction with own species is necessary to foster species-specific maternal preference in ducklings. Developmental Psychobiology, 21, 311-321.

Lindgren, C.J. and Shapiro, L.J. (1980). Preferences of mallard ducklings for strange broods of different ages. Bird Behaviour, 8, 79-86.

Lorenz, K.Z. (1937). The companion in the bird's world. The Auk, 54, 245-273.

Lorenz, K.Z. (1970). Studies in animal and human behaviour, Vol.1. London: Methuen & Co., Ltd.

Marcstrom, V. (1966). Mallard ducklings (Anas platyrhynchos) during the first days after hatching. Viltrevy, 4, 343-370.

Marler, P. (1993). The instinct to learn. In M.H. Johnson (Ed.). Brain Development and Cognition: A Reader. Cambridge, Mass.: Blackwell Publishers.

Martinson, R.K. and Hawkins, A.S. (1982). Lack of association among duck broodmates during migration and wintering. In J.T. Ratti, L.D. Flake and W.A. Wentz (Eds.), Waterfowl Ecology and Management: Selected Readings. (pp. 308-310) Lawrence, Kansas: Allen Press, Inc.

Miller, D.B. (1994). Social context affects the ontogeny of instinctive behaviour. Animal Behaviour, 48, 627-634.

Moriyama, T. (1987). Effects of pairing of chicks during the imprinting period of filial responses to an imprinting stimulus. The Annual of Animal Psychology, 37, 81-98.

Munro, J. and Bedard, J. (1982). Creche formation in the common eider. In J.T. Ratti, L.D. Flake and W.A. Wentz (Eds.), Waterfowl Ecology and Management: Selected Readings. (pp. 387-400) Lawrence, Kansas: Allen Press, Inc.

Nastase, A.J. and Sherry, D.A. (1997). Effect of brood mixing on location and survivorship of juvenile Canada geese. Animal Behaviour, 54, 503-507.

Raitasuo, K. (1964). Social behaviour of the Mallard, Anas platyrhynchos, in the course of the annual cycle. Helsinki: Motti Helminen.

Rajecki, D.W. and Lake, D. (1972). Social preference in chicks as a function of own color and rearing condition (1). Rev. Comp. Animal, 6, 151-156.

Rogan, J.C. and Shapiro, L.J. (1974). The effect of brood size on eliciting an approach response in mallard ducklings. Paper presented at the meeting of the Canadian Psychological Association, Windsor, Ontario, June 12-14, 1974.

Salzen, E.A. and Cornell, J.M. (1968). Self-perception and species recognition in birds. Behaviour, 30, 44-63.

Shapiro, L.J. (1977). Developing preferences for live female models of the same or other species in White Peking ducklings. Animal Behaviour, 25, 849-858.

Shapiro, L.J. (1980a). Species identification in birds: A review and synthesis. In M.A. Roy (Ed.), Species Identity and Attachment. New York: Garland STPM Press.

Shapiro, L.J. (1980b). The effects of isolated and communal rearing conditions on reactions to maternal calls in white Peking ducklings. The Psychological Record, 30, 553-560.

Shapiro, L.J. (1980c). The attractiveness of Plexiglass, a mirror, or an age mate to Peking ducklings and the relevance of these findings to imprinting experiments. Bulletin of the Psychonomic Society, 16, 34-36.

Shapiro, L.J. and Agnew, R.L. (1975). The development of preferences for live models in white peking ducklings. Bulletin of the Psychonomic Society, 5, 140-142.

Shapiro, L.J. and Garretson, K.L. (1978). Avian attachment behavior: An extension of Cairn's theory of mammalian social attachment. The Journal of Biological Psychology, 20, 9-12.]]

Shapiro, L.J. and Lundy, C.R. (1974). Brood units for rearing and maintaining birds communally or in isolation. Journal of Biological Psychology, 16, 40-44.

Sherrod, L. (1974). The role of sibling associations in the formation of social and sexual companion preferences in ducks (Anas platyrhynchos): An investigation of the "primacy versus recency" question. Zeitschrift fur Tierpsychologie, 34, 247-264.

Sigman, S.E., Lovern, D.R., and Schulman, A.H. (1978). Preferential approach to conspecifics as a function of different rearing conditions. Animal Learning and Behavior, 6, 231-234.

Skutch, A.F. (1976). Parent birds and their young. Austin: University of Texas Press.

Smith, W. (1957). Social learning in domestic chicks. Behaviour, 11, 40-55.

Sowls, L.K. (1982). Hen and brood behavior. In J.T. Ratti, L.D. Flake and W.A. Wentz (Eds.), Waterfowl Ecology and Management: Selected Readings. (pp. 292-298) Lawrence, Kansas: Allen Press, Inc.

Storey, A.E. (1976). The effects of live or inanimate models on the development of preferences in white Peking ducklings. Unpublished Master's thesis, University of Manitoba.

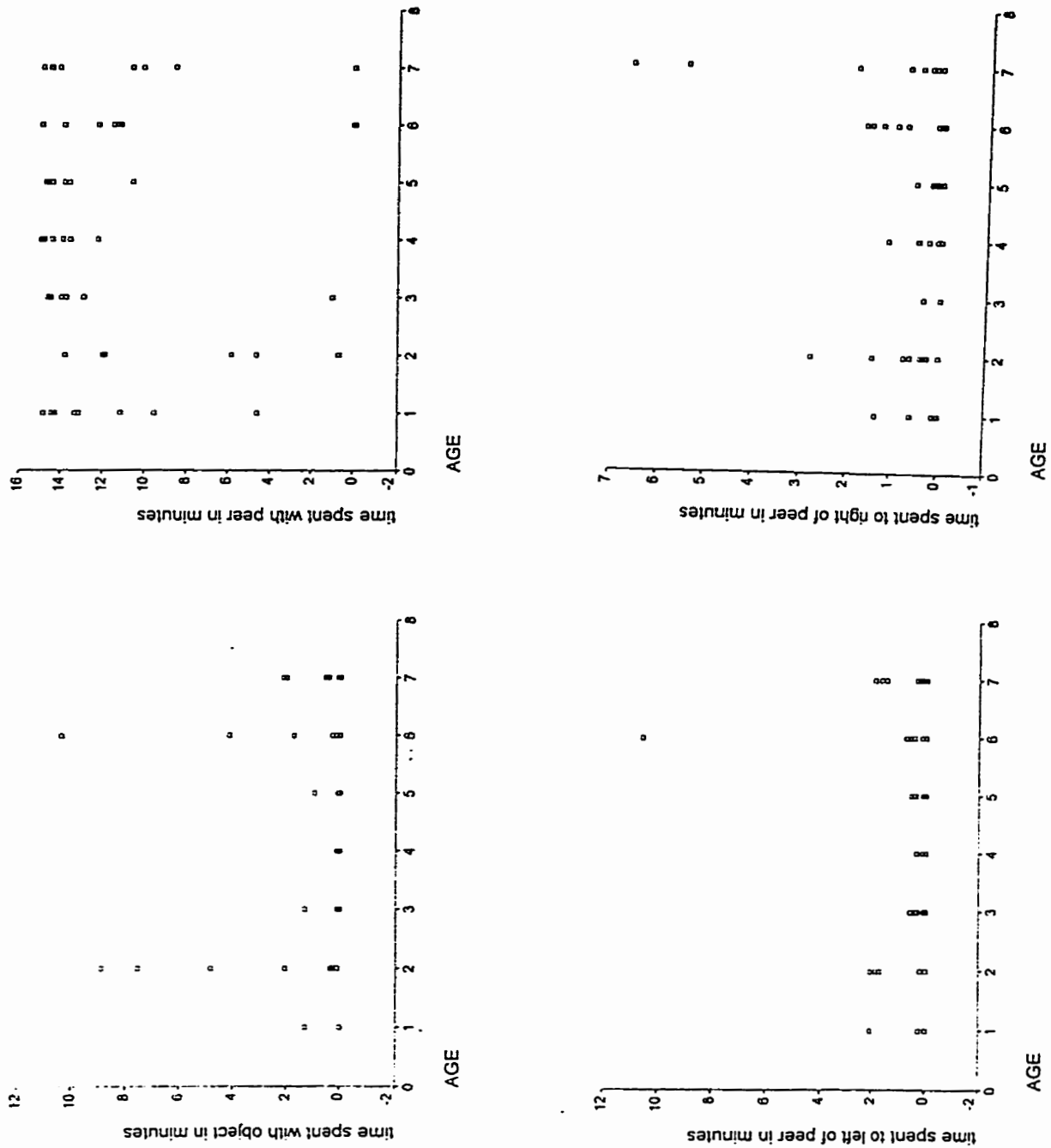
Storey, A.E. and Shapiro, L.J. (1979). Development of preferences in white Peking ducklings for stimuli in the natural post-hatch environment. Animal Behaviour, 27, 411-416.

Suboski, M.D. (1989). Recognition learning in birds. In P.P.G. Bateson and P.H. Klopfer (Eds.), Perspectives in Ethology, Vol. 8, (pp. 137-171). New York: Plenum Press.

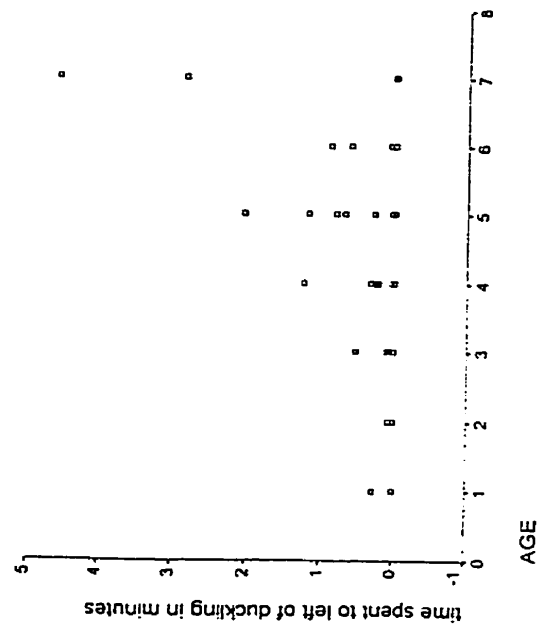
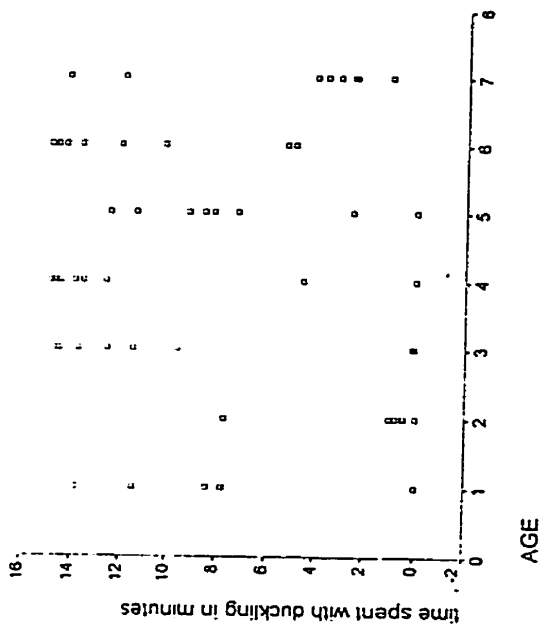
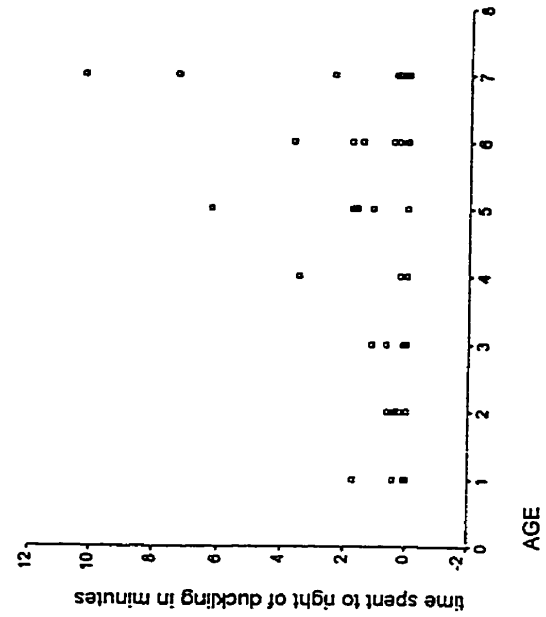
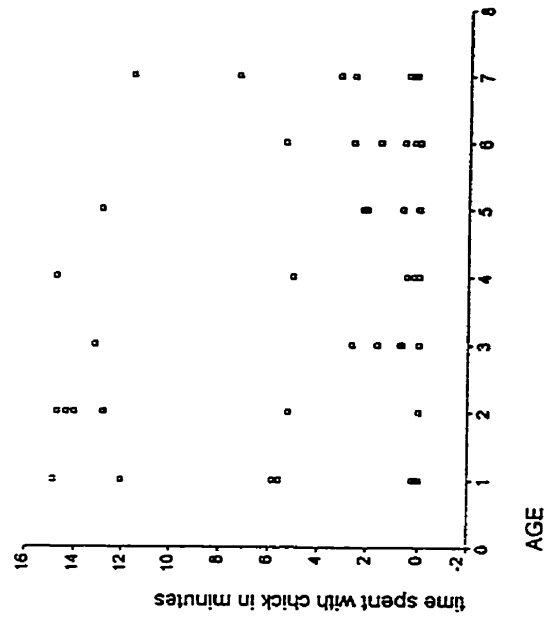
- Taylor, K.F. and Sluckin, W. (1964). Flocking of domestic chicks. Nature, 201, 108-109.
- ten Cate, C. (1994). Perceptual mechanisms in imprinting and song learning. In J.A. Hogan and J.J. Bolhuis (Eds.), Causal Mechanisms in Behavioural Development. Cambridge University Press.
- Tolman, C.W. and Wilson, G.F. (1969). Social feeding in domestic chicks. In R.B. Zajonc, (Ed.), Animal Social Psychology. A Reader of Experimental Studies, (pp. 17-24) New York: John Wiley & Sons, Inc.
- Turner, E.R.A. (1964). Social feeding in birds. In R.B. Zajonc, (Ed., 1969), Animal Social Psychology. A Reader of Experimental Studies, (pp. 79-83) New York: John Wiley & Sons, Inc.
- Williams, T.D. (1995). The penguins. New York: Oxford University Press.
- Zajonc, R.B. (1969). Animal social psychology. A reader of experimental studies. New York: John Wiley & Sons, Inc.
- Zajonc, R.B., Markus, H. and Wilson, W.R. (1974). Exposure, object preference and distress in the domestic chick. Journal of Comparative and Physiological Psychology, 86, 581-585.

APPENDIX A: SCATTERPLOTS

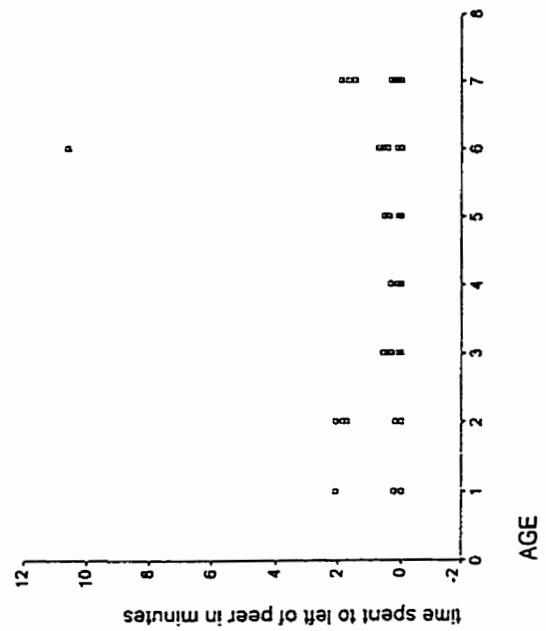
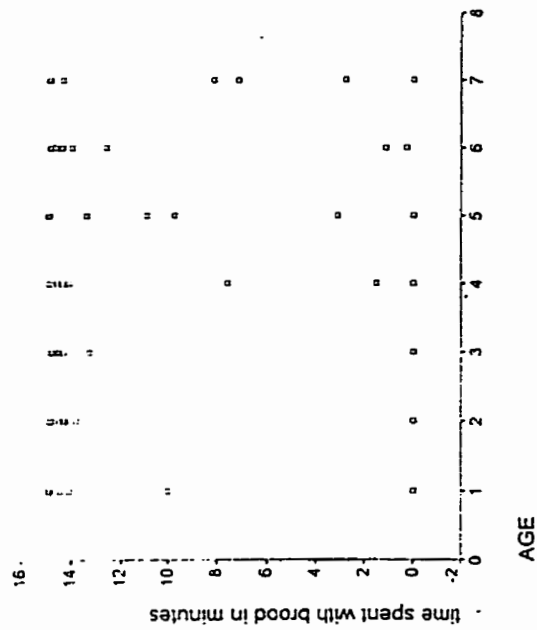
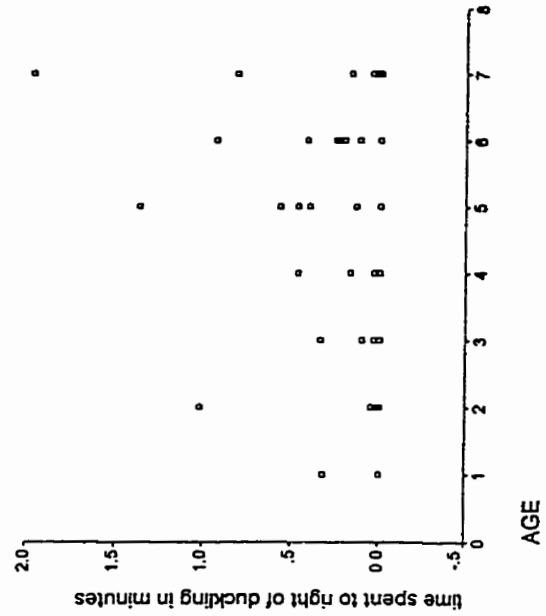
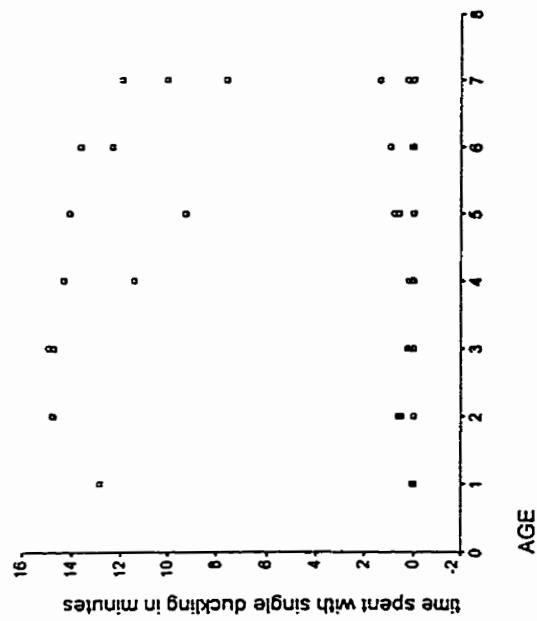
EXPERIMENT 1



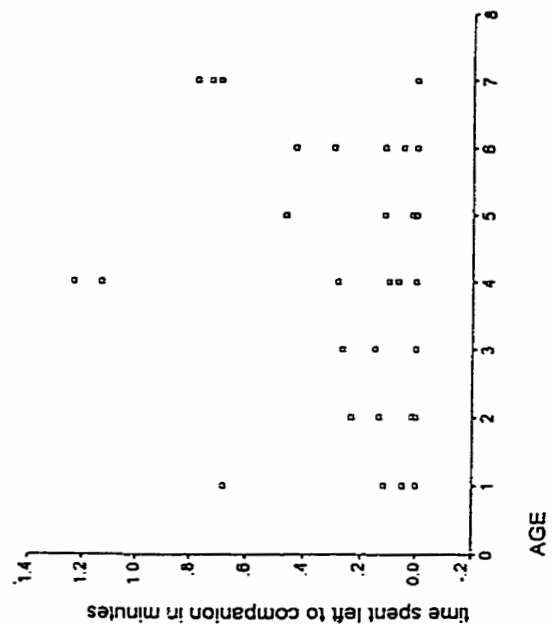
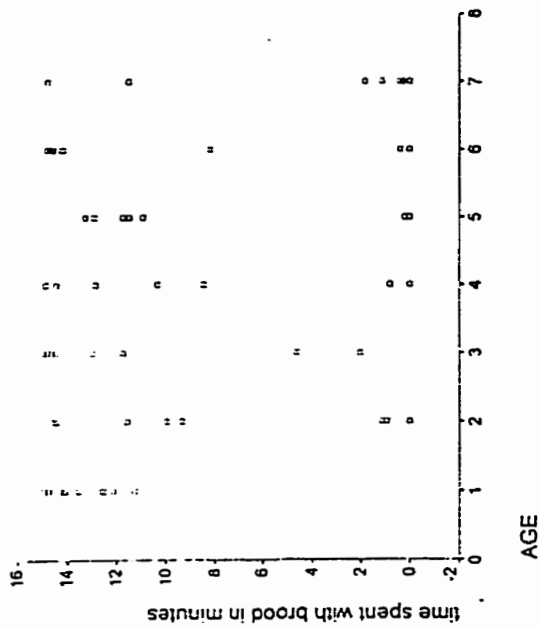
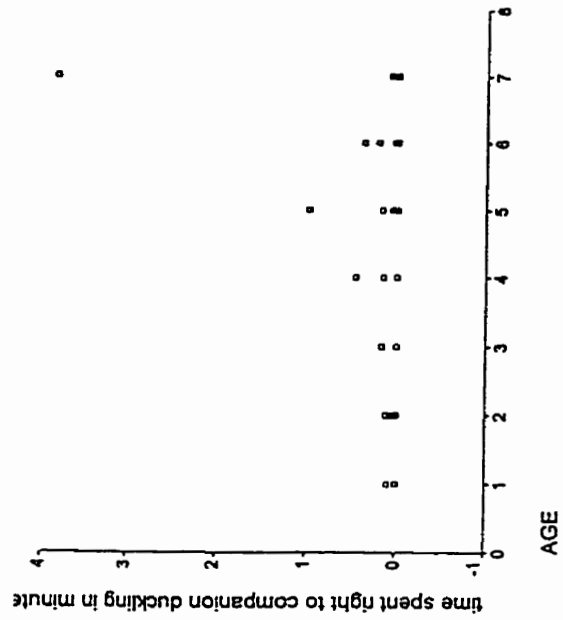
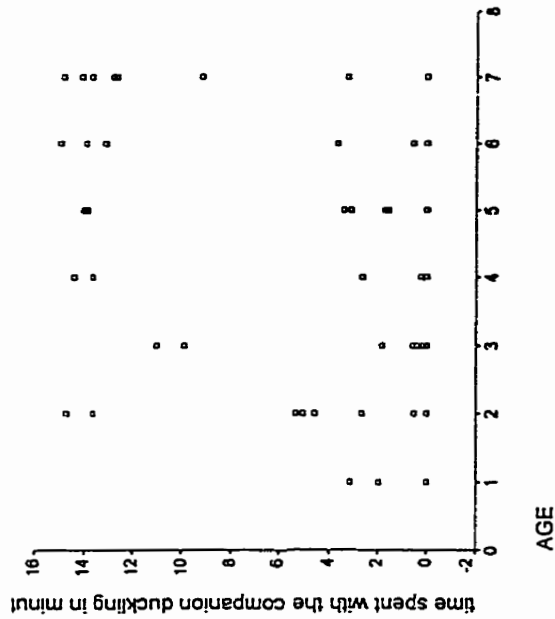
EXPERIMENT 2



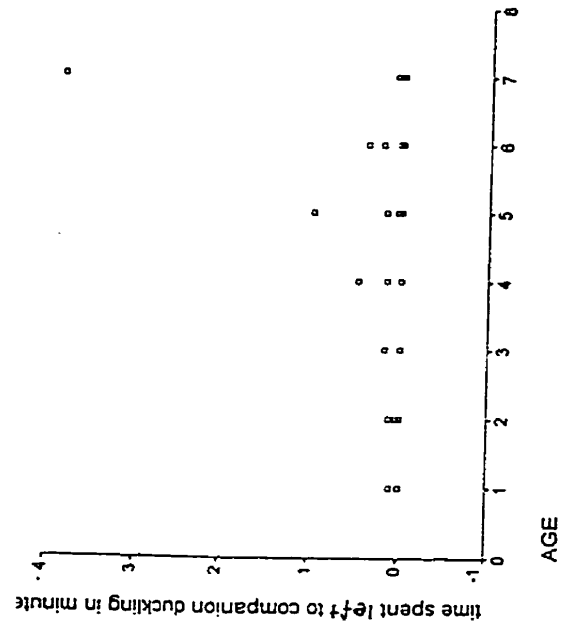
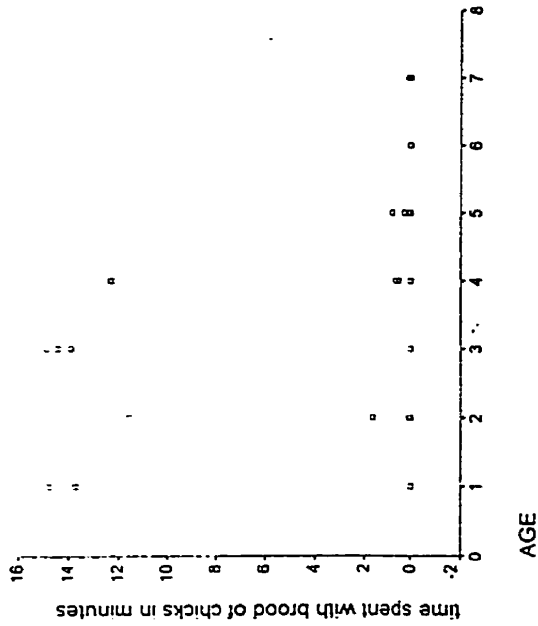
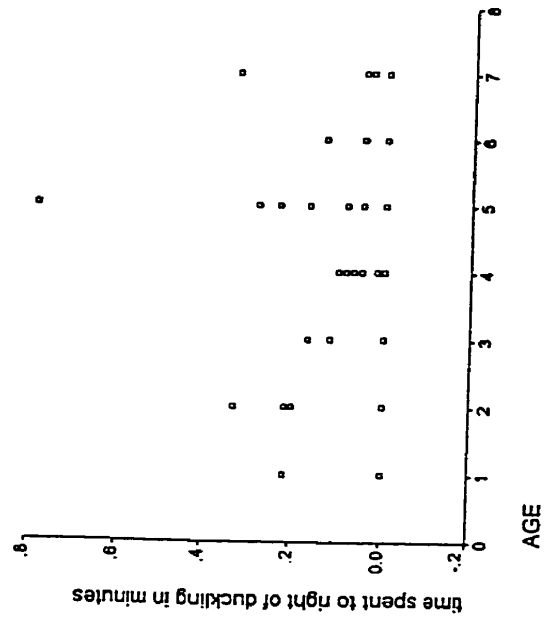
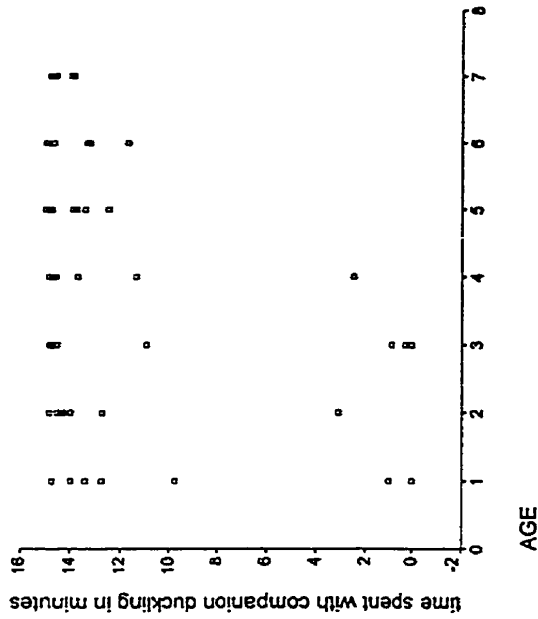
EXPERIMENT 3



EXPERIMENT 4



EXPERIMENT 5



APPENDIX B: DESCRIPTIVE STATISTICS

EXPERIMENT 1 DESCRIPTIVES IN MINUTES

Number of valid observations (listwise) = 56.00

Variable LMIN time spent to left of peer in minutes

Mean	.562	S.E. Mean	.199
Std Dev	1.490	Variance	2.219
Range	10.600	Minimum	.00
Maximum	10.60		

Valid observations - 56 Missing observations - 0

Variable RMIN time spent to right of peer in minutes

Mean	.630	S.E. Mean	.163
Std Dev	1.219	Variance	1.486
Range	6.683	Minimum	.00
Maximum	6.68		

Valid observations - 56 Missing observations - 0

Variable OMIN time spent with object in minutes

Mean	.900	S.E. Mean	.291
Std Dev	2.177	Variance	4.739
Range	10.400	Minimum	.00
Maximum	10.40		

Valid observations - 56 Missing observations - 0

Variable LATMIN latency in minutes

Mean	1.161	S.E. Mean	.348
Std Dev	2.602	Variance	6.769
Range	14.000	Minimum	.03
Maximum	14.03		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable PMIN time spent with peer in minutes

Mean	11.514	S.E. Mean	.611
Std Dev	4.571	Variance	20.896
Range	14.967	Minimum	.00
Maximum	14.97		

Valid observations - 56 Missing observations - 0

EXPERIMENT 1 DESCRIPTIVES

Number of valid observations (listwise) = 56.00

Variable LATMIN latency in minutes

Mean	1.161	S.E. Mean	.348
Std Dev	2.602	Variance	6.769
Range	14.000	Minimum	.03
Maximum	14.03		

Valid observations - 56 Missing observations - 0

Variable OENTER number of times quadrant with inanimate

Mean	3.679	S.E. Mean	1.138
Std Dev	8.513	Variance	72.477
Range	43.000	Minimum	0
Maximum	43		

Valid observations - 56 Missing observations - 0

Variable LENTER number of times quadrant to the left en

Mean	4.071	S.E. Mean	1.139
Std Dev	8.526	Variance	72.686
Range	40.000	Minimum	0
Maximum	40		

Valid observations - 56 Missing observations - 0

Variable RENTER number of times quadrant to the right en

Mean	4.089	S.E. Mean	1.078
Std Dev	8.066	Variance	65.065
Range	40.000	Minimum	0
Maximum	40		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable PENTER number of times quadrant with peer was e

Mean	5.304	S.E. Mean	1.125
Std Dev	8.416	Variance	70.833
Range	43.000	Minimum	0
Maximum	43		

Valid observations - 56 Missing observations - 0

Experiment 2 - descriptives in minutes

Number of valid observations (listwise) = 56.00

Variable RMIN time spent to right of duckling in minut

Mean	.954	S.E. Mean	.258
Std Dev	1.929	Variance	3.720
Range	10.267	Minimum	.00
Maximum	10.27		

Valid observations - 56 Missing observations - 0

Variable LMIN time spent to the left of duckling in mi

Mean	1.176	S.E. Mean	.315
Std Dev	2.359	Variance	5.564
Range	14.050	Minimum	.00
Maximum	14.05		

Valid observations - 56 Missing observations - 0

Variable LATMIN latency in minutes

Mean	1.338	S.E. Mean	.420
Std Dev	3.146	Variance	9.899
Range	14.967	Minimum	.03
Maximum	15.00		

Valid observations - 56 Missing observations - 0

Variable CMIN time spent with chick in minutes

Mean	3.762	S.E. Mean	.692
Std Dev	5.176	Variance	26.794
Range	14.867	Minimum	.00
Maximum	14.87		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable DMIN time spent with duckling in minutes

Mean	7.466	S.E. Mean	.756
Std Dev	5.659	Variance	32.028
Range	14.933	Minimum	.00
Maximum	14.93		

Valid observations - 56 Missing observations - 0

EXPERIMENT 2 DESCRIPTIVES

Number of valid observations (listwise) = 56.00

Variable LATMIN latency in minutes

Mean	1.338	S.E. Mean	.420
Std Dev	3.146	Variance	9.899
Range	14.967	Minimum	.03
Maximum	15.00		

Valid observations - 56 Missing observations - 0

Variable RENTER number of times quadrant to the right en

Mean	5.571	S.E. Mean	1.158
Std Dev	8.667	Variance	75.122
Range	40.000	Minimum	0
Maximum	40		

Valid observations - 56 Missing observations - 0

Variable CENTER number of times quadrant with chick ente

Mean	5.911	S.E. Mean	.994
Std Dev	7.440	Variance	55.356
Range	27.000	Minimum	0
Maximum	27		

Valid observations - 56 Missing observations - 0

Variable LENTER number of times quadrant to the left en

Mean	6.304	S.E. Mean	1.232
Std Dev	9.220	Variance	85.015
Range	46.000	Minimum	0
Maximum	46		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable DENTER number of times quadrant with duckling w

Mean	9.071	S.E. Mean	1.575
Std Dev	11.787	Variance	138.940
Range	61.000	Minimum	0
Maximum	61		

Valid observations - 56 Missing observations - 0

Experiment 3 - descriptives in minutes

Number of valid observations (listwise) = 56.00

Variable RMIN time spent to right of duckling in minut

Mean	.190	S.E. Mean	.050
Std Dev	.378	Variance	.143
Range	1.967	Minimum	.00
Maximum	1.97		

Valid observations - 56 Missing observations - 0

Variable LMIN time spent to left of duckling in minute

Mean	.326	S.E. Mean	.105
Std Dev	.788	Variance	.620
Range	4.600	Minimum	.00
Maximum	4.60		

Valid observations - 56 Missing observations - 0

Variable LATMIN latency in minutes

Mean	.385	S.E. Mean	.154
Std Dev	1.150	Variance	1.322
Range	7.267	Minimum	.03
Maximum	7.30		

Valid observations - 56 Missing observations - 0

Variable DMIN time spent with single duckling in minut

Mean	3.262	S.E. Mean	.745
Std Dev	5.577	Variance	31.105
Range	14.917	Minimum	.00
Maximum	14.92		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable BMIN time spent with brood in minutes

Mean	10.678	S.E. Mean	.783
Std Dev	5.857	Variance	34.310
Range	14.933	Minimum	.00
Maximum	14.93		

Valid observations - 56 Missing observations - 0

EXPERIMENT 3 DESCRIPTIVES

Number of valid observations (listwise) = 56.00

Variable RENTER number of times quadrant to the right en

Mean	1.339	S.E. Mean	.334
Std Dev	2.503	Variance	6.265
Range	13.000	Minimum	0
Maximum	13		

Valid observations - 56 Missing observations - 0

Variable DENTER number of times quadrant with duckling w

Mean	1.964	S.E. Mean	.469
Std Dev	3.511	Variance	12.326
Range	17.000	Minimum	0
Maximum	17		

Valid observations - 56 Missing observations - 0

Variable LENTER number of times quadrant to the left en

Mean	1.964	S.E. Mean	.536
Std Dev	4.013	Variance	16.108
Range	19.000	Minimum	0
Maximum	19		

Valid observations - 56 Missing observations - 0

Variable BENTER number of times quadrant with brood ente

Mean	2.125	S.E. Mean	.447
Std Dev	3.342	Variance	11.166
Range	23.000	Minimum	0
Maximum	23		

Valid observations - 56 Missing observations - 0

Experiment 4 - descriptives in minutes

Number of valid observations (listwise) = 56.00

Variable RMIN time spent right to companion duckling i

Mean	.130	S.E. Mean	.070
Std Dev	.527	Variance	.278
Range	3.833	Minimum	.00
Maximum	3.83		

Valid observations - 56 Missing observations - 0

Variable LMIN time spent left to companion in minutes

Mean	.149	S.E. Mean	.038
Std Dev	.286	Variance	.082
Range	1.233	Minimum	.00
Maximum	1.23		

Valid observations - 56 Missing observations - 0

Variable LATMIN latency in minutes

Mean	.550	S.E. Mean	.129
Std Dev	.967	Variance	.936
Range	4.600	Minimum	.03
Maximum	4.63		

Valid observations - 56 Missing observations - 0

Variable CMIN time spent with the companion duckling i

Mean	5.344	S.E. Mean	.800
Std Dev	5.989	Variance	35.863
Range	14.950	Minimum	.00
Maximum	14.95		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable BMIN time spent with brood in minutes

Mean	8.584	S.E. Mean	.827
Std Dev	6.188	Variance	38.287
Range	16.483	Minimum	.00
Maximum	16.48		

Valid observations - 56 Missing observations - 0

EXPERIMENT 4 DESCRIPTIVES

Number of valid observations (listwise) = 56.00

Variable RENTER number of times quadrant to the right en

Mean	1.018	S.E. Mean	.267
Std Dev	1.995	Variance	3.981
Range	10.000	Minimum	0
Maximum	10		

Valid observations - 56 Missing observations - 0

Variable LENTER number of times quadrant to the left en

Mean	1.054	S.E. Mean	.245
Std Dev	1.833	Variance	3.361
Range	8.000	Minimum	0
Maximum	8		

Valid observations - 56 Missing observations - 0

Variable BENTER number of times quadrant with brood ente

Mean	1.500	S.E. Mean	.196
Std Dev	1.465	Variance	2.145
Range	8.000	Minimum	0
Maximum	8		

Valid observations - 56 Missing observations - 0

Variable CENTER number of times quadrant with companion

Mean	2.446	S.E. Mean	.423
Std Dev	3.162	Variance	9.997
Range	13.000	Minimum	0
Maximum	13		

Valid observations - 56 Missing observations - 0

Experiment 5 - descriptives in minutes

Number of valid observations (listwise) = 56.00

Variable LMIN time spent to right of duckling in minut

Mean	.071	S.E. Mean	.018
Std Dev	.134	Variance	.018
Range	.783	Minimum	.00
Maximum	.78		

Valid observations - 56 Missing observations - 0

Variable RMIN time spent to right of duckling in minut

Mean	.080	S.E. Mean	.041
Std Dev	.309	Variance	.095
Range	2.233	Minimum	.00
Maximum	2.23		

Valid observations - 56 Missing observations - 0

Variable LATMIN latency in minutes

Mean	.775	S.E. Mean	.293
Std Dev	2.192	Variance	4.803
Range	14.967	Minimum	.03
Maximum	15.00		

Valid observations - 56 Missing observations - 0

Variable BMIN time spent with brood of chicks in minut

Mean	1.792	S.E. Mean	.609
Std Dev	4.560	Variance	20.797
Range	14.900	Minimum	.00
Maximum	14.90		

Valid observations - 56 Missing observations - 0

Number of valid observations (listwise) = 56.00

Variable CMIN time spent with companion duckling in mi

Mean	12.160	S.E. Mean	.634
Std Dev	4.748	Variance	22.541
Range	14.967	Minimum	.00
Maximum	14.97		

Valid observations - 56 Missing observations - 0

EXPERIMENT 5 DESCRIPTIVES

Number of valid observations (listwise) = 56.00

Variable RENTER number of times quadrant to the right en

Mean	.732	S.E. Mean	.289
Std Dev	2.162	Variance	4.672
Range	15.000	Minimum	0
Maximum	15		

Valid observations - 56 Missing observations - 0

Variable LENTER number of times quadrant to the left en

Mean	.929	S.E. Mean	.237
Std Dev	1.777	Variance	3.158
Range	11.000	Minimum	0
Maximum	11		

Valid observations - 56 Missing observations - 0

Variable BENTER number of times quadrant with brood ente

Mean	1.179	S.E. Mean	.393
Std Dev	2.943	Variance	8.658
Range	17.000	Minimum	0
Maximum	17		

Valid observations - 56 Missing observations - 0

Variable CENTER number of times quadrant with companion

Mean	2.964	S.E. Mean	.535
Std Dev	4.004	Variance	16.035
Range	18.000	Minimum	0
Maximum	18		

Valid observations - 56 Missing observations - 0

APPENDIX C: T-TESTS

Experiment 1 in minutes

t-tests for Paired Samples

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
LRMIN	lmin and rmin 56	-.615	.000	.5960	1.015	.136
POMIN	pmin and omin			6.2068	1.654	.221

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
-5.6109	2.414	.323	-17.39	55	.000
95% CI (-6.257, -4.964)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
LRMIN	lmin and rmin 56	-.638	.000	.5960	1.015	.136
PMIN	time spent with peer in minutes			11.5140	4.571	.611

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
-10.9180	5.277	.705	-15.48	55	.000
95% CI (-12.331, -9.505)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
OMIN	time spent with object in minute 56	-.739	.000	.8997	2.177	.291
PMIN	time spent with peer in minutes			11.5140	4.571	.611

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
-10.6143	6.351	.849	-12.51	55	.000
95% CI (-12.315, -8.914)					

□

Experiment 2 in minutes

t-tests for Paired Samples

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
DCMIN	dmin and cmin 56	-.644	.000	5.6140	2.138	.286
LRMIN	lmin and rmin			1.0653	1.524	.204

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
4.5487	3.330	.445	10.22	55	.000
95% CI (3.657, 5.441)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
DMIN	time spent with duckling in minu 56	-.355	.007	7.4664	5.659	.756
LRMIN	lmin and rmin			1.0653	1.524	.204

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
6.4010	6.362	.850	7.53	55	.000
95% CI (4.697, 8.105)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
CMIN	time spent with chick in minutes 56	-.692	.000	3.7616	5.176	.692
DMIN	time spent with duckling in minu			7.4664	5.659	.756

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
-3.7043	9.968	1.332	-2.78	55	.007
95% CI (-6.374, -1.035)					

Experiment 3 in minutes

t-tests for Paired Samples

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BDMIN	bmin and dmin 56	-.566	.000	6.9699	.761	.102
LRMIN	lmin and rmin			.2582	.485	.065

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
6.7118	1.111	.148	45.22	55	.000
95% CI (6.414, 7.009)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BMIN	time spent with brood in minutes 56	-.298	.026	10.6777	5.857	.783
LRMIN	lmin and rmin			.2582	.485	.065

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
10.4195	6.020	.804	12.95	55	.000
95% CI (8.807, 12.032)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BMIN	time spent with brood in minutes 56	-.966	.000	10.6777	5.857	.783
DMIN	time spent with single duckling			3.2622	5.577	.745

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
7.4155	11.336	1.515	4.90	55	.000
95% CI (4.390, 10.451)					

Experiment 4 in minutes

t-tests for Paired Samples

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BCMIN bmin and cmin	56	-.427	.001	6.9641	.832	.111
LRMIN lmin and rmin				.1391	.330	.044

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
6.8250	1.017	.136	50.22	55	.000
95% CI (6.553, 7.097)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BMIN time spent with brood in minutes	56	-.314	.018	8.5842	6.188	.827
LRMIN lmin and rmin				.1391	.330	.044

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
8.4451	6.299	.842	10.03	55	.000
95% CI (6.758, 10.132)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BMIN time spent with brood in minutes	56	-.963	.000	8.5842	6.188	.827
CMIN time spent with the companion du				5.3440	5.989	.800

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
3.2402	12.064	1.612	2.01	55	.049
95% CI (.009, 6.471)					

Experiment 5 in minutes

t-tests for Paired Samples

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BCMIN	bmin and cmin 56	-.045	.741	6.9757	1.083	.145
LRMIN	lmin and rmin			.0757	.171	.023

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
6.9000	1.104	.147	46.79	55	.000
95% CI (6.604, 7.196)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BMIN	time spent with brood of chicks 56	-.115	.397	1.7917	4.560	.609
LRMIN	lmin and rmin			.0757	.171	.023

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
1.7159	4.583	.612	2.80	55	.007
95% CI (.489, 2.943)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
BMIN	time spent with brood of chicks 56	-.893	.000	1.7917	4.560	.609
CMIN	time spent with companion duckli			12.1598	4.748	.634

Paired Differences			t-value	df	2-tail Sig
Mean	SD	SE of Mean			
-10.3682	9.055	1.210	-8.57	55	.000
95% CI (-12.793, -7.943)					

APPENDIX D: ANOVA CALCULATIONS

EXPERIMENT 1

PTIME TREND ANALYSIS

* * * A N A L Y S I S O F V A R I A N C E * * *

by PMIN time spent with peer in minutes
 AGE

UNIQUE sums of squares
 All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	253.322	6	42.220	2.309	.048
AGE	253.322	6	42.220	2.309	.048
Explained	253.322	6	42.220	2.309	.048
Residual	895.937	49	18.284		
Total	1149.259	55	20.896		

56 cases were processed.
 0 cases (.0 pct) were missing.

* * * A N A L Y S I S O F V A R I A N C E * * *

by OMIN time spent with object in minutes
 AGE

UNIQUE sums of squares
 All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	68.455	6	11.409	2.909	.017
AGE	68.455	6	11.409	2.909	.017
Explained	68.455	6	11.409	2.909	.017
Residual	192.198	49	3.922		
Total	260.653	55	4.739		

56 cases were processed.
 0 cases (.0 pct) were missing.

EXPERIMENT 1

* * * ANALYSIS OF VARIANCE * * *

LMIN time spent to left of peer in minutes
by AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	16.025	6	2.671	1.234	.305
AGE	16.025	6	2.671	1.234	.305
Explained	16.025	6	2.671	1.234	.305
Residual	106.017	49	2.164		
Total	122.043	55	2.219		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

RMIN time spent to right of peer in minutes
by AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	21.782	6	3.630	2.968	.015
AGE	21.782	6	3.630	2.968	.015
Explained	21.782	6	3.630	2.968	.015
Residual	59.939	49	1.223		
Total	81.721	55	1.486		

56 cases were processed.
0 cases (.0 pct) were missing.

EXPERIMENT 2

* * * A N A L Y S I S O F V A R I A N C E * * *

by DMIN time spent with duckling in minutes
 AGE

UNIQUE sums of squares
 All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	608.810	6	101.468	4.313	.001
AGE	608.810	6	101.468	4.313	.001
Explained	608.810	6	101.468	4.313	.001
Residual	1152.754	49	23.526		
Total	1761.565	55	32.028		

56 cases were processed.
 0 cases (.0 pct) were missing.

* * * A N A L Y S I S O F V A R I A N C E * * *

by CMIN time spent with chick in minutes
 AGE

UNIQUE sums of squares
 All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	339.524	6	56.587	2.445	.038
AGE	339.524	6	56.587	2.445	.038
Explained	339.524	6	56.587	2.445	.038
Residual	1134.152	49	23.146		
Total	1473.676	55	26.794		

56 cases were processed.
 0 cases (.0 pct) were missing.

EXPERIMENT 2

* * * ANALYSIS OF VARIANCE * * *

by LMIN time spent to the left of duckling in mi
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	30.456	6	5.076	.903	.501
AGE	30.456	6	5.076	.903	.501
Explained	30.456	6	5.076	.903	.501
Residual	275.545	49	5.623		
Total	306.001	55	5.564		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

by RMIN time spent to right of duckling in minut
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	40.280	6	6.713	2.002	.083
AGE	40.280	6	6.713	2.002	.083
Explained	40.280	6	6.713	2.002	.083
Residual	164.333	49	3.354		
Total	204.613	55	3.720		

56 cases were processed.
0 cases (.0 pct) were missing.

EXPERIMENT 3

* * * ANALYSIS OF VARIANCE * * *

BMIN time spent with brood in minutes
by AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	30.322	6	5.054	.133	.991
AGE	30.322	6	5.054	.133	.991
Explained	30.322	6	5.054	.133	.991
Residual	1856.704	49	37.892		
Total	1887.026	55	34.310		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

DMIN time spent with single duckling in minut
by AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	29.697	6	4.949	.144	.989
AGE	29.697	6	4.949	.144	.989
Explained	29.697	6	4.949	.144	.989
Residual	1681.091	49	34.308		
Total	1710.788	55	31.105		

56 cases were processed.
0 cases (.0 pct) were missing.

EXPERIMENT 3

* * * ANALYSIS OF VARIANCE * * *

by LMIN time spent to left of duckling in minute
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	5.548	6	.925	1.586	.171
AGE	5.548	6	.925	1.586	.171
Explained	5.548	6	.925	1.586	.171
Residual	28.569	49	.583		
Total	34.117	55	.620		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

by RMIN time spent to right of duckling in minut
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1.007	6	.168	1.203	.321
AGE	1.007	6	.168	1.203	.321
Explained	1.007	6	.168	1.203	.321
Residual	6.833	49	.139		
Total	7.840	55	.143		

56 cases were processed.
0 cases (.0 pct) were missing.

Experiment 4 in minutes

* * * A N A L Y S I S O F V A R I A N C E * * *

by BMIN time spent with brood in minutes
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	470.180	6	78.363	2.348	.045
AGE	470.180	6	78.363	2.348	.045
Explained	470.180	6	78.363	2.348	.045
Residual	1635.608	49	33.380		
Total	2105.787	55	38.287		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * A N A L Y S I S O F V A R I A N C E * * *

by CMIN time spent with the companion duckling 1
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	414.716	6	69.119	2.174	.061
AGE	414.716	6	69.119	2.174	.061
Explained	414.716	6	69.119	2.174	.061
Residual	1557.773	49	31.791		
Total	1972.489	55	35.863		

56 cases were processed.
0 cases (.0 pct) were missing.

EXPERIMENT 4

* * * ANALYSIS OF VARIANCE * * *

LMIN time spent left to companion in minutes
by AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.677	6	.113	1.448	.216
AGE	.677	6	.113	1.448	.216
Explained	.677	6	.113	1.448	.216
Residual	3.818	49	.078		
Total	4.495	55	.082		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

RMIN time spent right to companion duckling i
by AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1.429	6	.238	.841	.544
AGE	1.429	6	.238	.841	.544
Explained	1.429	6	.238	.841	.544
Residual	13.869	49	.283		
Total	15.298	55	.278		

56 cases were processed.
0 cases (.0 pct) were missing.

EXPERIMENT 5

* * * ANALYSIS OF VARIANCE * * *

by BMIN time spent with brood of chicks in minut
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	201.684	6	33.614	1.748	.130
AGE	201.684	6	33.614	1.748	.130
Explained	201.684	6	33.614	1.748	.130
Residual	942.126	49	19.227		
Total	1143.810	55	20.797		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

by CMIN time spent with companion duckling in mi
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	321.989	6	53.665	2.865	.018
AGE	321.989	6	53.665	2.865	.018
Explained	321.989	6	53.665	2.865	.018
Residual	917.764	49	18.730		
Total	1239.753	55	22.541		

56 cases were processed.
0 cases (.0 pct) were missing.

EXPERIMENT 5

* * * ANALYSIS OF VARIANCE * * *

by IMIN time spent to right of duckling in minut
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.208	6	.035	2.157	.063
AGE	.208	6	.035	2.157	.063
Explained	.208	6	.035	2.157	.063
Residual	.787	49	.016		
Total	.995	55	.018		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

by RMIN time spent to right of duckling in minut
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.424	6	.071	.718	.637
AGE	.424	6	.071	.718	.637
Explained	.424	6	.071	.718	.637
Residual	4.820	49	.098		
Total	5.243	55	.095		

56 cases were processed.
0 cases (.0 pct) were missing.

* * * ANALYSIS OF VARIANCE * * *

by BCMIN bmin and cmin
AGE

UNIQUE sums of squares
All effects entered simultaneously

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	11.395	6	1.899	1.754	.128
AGE	11.395	6	1.899	1.754	.128
Explained	11.395	6	1.899	1.754	.128
Residual	53.060	49	1.083		
Total	64.455	55	1.172		

APPENDIX E: TREND ANALYSIS CALCULATIONS

EXPERIMENT 4

1) TREND ANALYSIS FOR "CTIME" (TIME SPENT WITH COMPANION)

UPWARD LINEAR TREND

$$n = 8$$

$$\hat{\psi}_{lin} = -3(0.64) - 2(5.81) - 1(2.99) + \\ + 0(5.66) + 1(6.45) + 2(5.78) + \\ + 3(10.08) = 31.72$$

$$SS_{\psi} = \frac{8(31.72)^2}{28} = 287.47$$

$$F = \frac{SS_{lin}}{MS_w} = \frac{287.47}{31.79} = 9.04$$

significant at $p = .01$

2) DOWNWARD LINEAR TREND FOR "BTIME" (TIME SPENT WITH BROOD)

$$n = 8$$

$$\hat{\psi}_{lin} = 3(13.64) + 2(7.75) + 1(11.29) + \\ + 0(7.73) - 1(7.57) - 2(8.36) - 3(3.75) = \\ = 32.17$$

$$SS_{\psi} = n(\hat{\psi}_{lin})^2 / \sum_{j=1}^q c_j^2 =$$

$$= 8(32.17)^2 / 28 = 295.68$$

$$F = \frac{SS_{lin}}{MS_w} = \frac{295.68}{33.25} = 8.89$$

significant at $p = .01$

EXPERIMENT 5

TREND ANALYSIS:

UPWARD LINEAR TREND FOR "CTIME" (TIME SPENT WITH COMPANION)

$$F = \frac{SS_{\text{lin}}}{MS_W}$$

$$SS_{\psi} = \frac{n(\hat{\psi}_{\text{lin}})^2}{\sum_{j=1}^k c_j^2} \quad n = 8$$

$$\begin{aligned} \hat{\psi}_{\text{lin}} &= -3(8.2) - 2(12.78) - 1(8.83) + \\ &\quad + 0(12.63) + 1(14.11) + 2(14.07) + \\ &\quad + 3(14.49) = 26.74 \end{aligned}$$

$$SS_{\psi} = \frac{8(26.74)^2}{28} = 204.36$$

$$F = \frac{204.36}{18.73} = 10.91$$

significant at $p = .01$

$$df_{\text{num.}} = 2 - 1 = 1, \quad df_{\text{denom.}} = 56 - 7 = 49$$

$$\begin{aligned} \sum c_j^2 &= (-3)^2 + (-2)^2 + (-1)^2 + 0^2 + 1^2 + \\ &\quad + 2^2 + 3^2 = 28 \end{aligned}$$

APPENDIX F: ENTRANCES

t-tests for Independent Samples of EXPERIME

Comparing Experiments 1-5 (15) to Corners + Hens (0)

Variable	Number of Cases	Mean	SD	SE of Mean
ENTER1 mean of all entrances				
EXPERIME 15	56	3.1607	2.548	.340
EXPERIME 0	56	10.7768	7.947	1.062

Mean Difference = -7.6161

Levene's Test for Equality of Variances: F= 36.725 P= .000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-6.83	110	.000	1.115	(-9.826, -5.406)
Unequal	-6.83	66.19	.000	1.115	(-9.843, -5.390)

t-tests for Independent Samples of EXPERIME

Comparing Corners (7) to Hens (8)

Variable	Number of Cases	Mean	SD	SE of Mean
ENTER1 mean of all entrances				
EXPERIME 7	56	14.0938	12.374	1.654
EXPERIME 8	54	7.0694	6.050	.823

Mean Difference = 7.0243

Levene's Test for Equality of Variances: F= 24.509 P= .000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	3.76	108	.000	1.868	(3.321, 10.727)
Unequal	3.80	80.52	.000	1.847	(3.349, 10.700)

t-tests for Independent Samples of EXPERIME

Comparing Experiments 1-5 (15) to Brood (6)

Variable	Number of Cases	Mean	SD	SE of Mean
ENTER1 mean of all entrances				
EXPERIME 15	56	3.1607	2.548	.340
EXPERIME 6	56	3.0223	4.358	.582

Mean Difference = .1384

Levene's Test for Equality of Variances: F= 5.738 P= .018

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	.21	110	.836	.675	(-1.199, 1.475)
Unequal	.21	89.66	.836	.675	(-1.202, 1.478)

APPENDIX G: LATENCIES

11 = all studies with ducklings as models present
 0 = all studies with no ducklings as models

t-tests for Independent Samples of EXPERIME

Variable	Number of Cases	Mean	SD	SE of Mean
LATENCY latency in minutes				
EXPERIME 11	56	.8512	.936	.125
EXPERIME 0	56	2.3235	2.346	.313

Mean Difference = -1.4723

Levene's Test for Equality of Variances: F= 28.444 P= .000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-4.36	110	.000	.338	(-2.141, -.803)
Unequal	-4.36	72.09	.000	.338	(-2.145, -.800)

comparison of Experiment 1 (1) and Hen+Brood (6)

Variable	Number of Cases	Mean	SD	SE of Mean
LATENCY latency in minutes				
EXPERIME 1	56	1.1613	2.602	.348
EXPERIME 6	56	.8982	1.462	.195

Mean Difference = .2631

Levene's Test for Equality of Variances: F= 4.297 P= .041

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	.66	110	.511	.399	(-.527, 1.053)
Unequal	.66	86.60	.511	.399	(-.530, 1.056)

t-tests for Independent Samples of EXPERIME

comparison of mean of Experiments 1 to 5 (15) and Experiments with no ducklings (0)

Variable	Number of Cases	Mean	SD	SE of Mean
LATENCY latency in minutes				
EXPERIME 15	56	.8413	1.033	.138
EXPERIME 0	56	2.3235	2.346	.313

Mean Difference = -1.4817

Levene's Test for Equality of Variances: F= 23.812 P= .000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-4.33	110	.000	.342	(-2.150, -.803)
Unequal	-4.33	75.41	.000	.342	(-2.164, -.800)

APPENDIX H: CORRELATIONS

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EXPERIMENT 1
-- Correlation Coefficients --
LATENCY    TIME
( 56)      ( 56)
P= .      P= .941

TIME       1.0000
( 56)      ( 56)
P= .941    P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

EXPERIMENT 2
-- Correlation Coefficients --
LATENCY    TIME
( 56)      ( 56)
P= .      P= .080

TIME       1.0000
( 56)      ( 56)
P= .080    P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

EXPERIMENT 3
-- Correlation Coefficients --
LATENCY    TIME
( 56)      ( 56)
P= .      P= .842

TIME       1.0000
( 56)      ( 56)
P= .842    P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

EXPERIMENT 4
-- Correlation Coefficients --
LATENCY    TIME
( 56)      ( 56)
P= .      P= .282

TIME       1.0000
( 56)      ( 56)
P= .282    P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

EXPERIMENT 5
-- Correlation Coefficients --
LATENCY    TIME
( 56)      ( 56)
P= .      P= .513

TIME       1.0000
( 56)      ( 56)
P= .513    P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

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