

THE EFFECT OF INTERACTION ON PREFERENCES IN WHITE PEKING
DUCKLINGS (*ANAS PLATYRHYNCHOS*)

by

Sarah M. Germain

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Department of Psychology
University of Manitoba
Winnipeg, Manitoba

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ABSTRACT

The purpose of the current set of experiments was to investigate the interaction component of avian attachment behaviour. The latter is viewed as the outcome of several components, all of which potentially interact with each other. In these experiments, the visual, brood size, animate vs. inanimate, and familiarity components of avian attachment behaviour were held constant so that the effects of interaction were evaluated unambiguously. The results for Time 1 (T1) yielded various results for both Condition A (Interaction with the other species/breed) and B (Interaction with same species/breed). For T2 (Condition A), the four Experiments yielded various results. For T2 (Condition B), the four Experiments yielded consistent results. When experimental subjects interacted with their own species/breed (white Peking duckling), the preference for their own species/breed (white Peking ducklings) increased while the preference for the other species/breed (domestic chicks or mallard ducklings) decreased. In Experiment 3 and Experiment 4, there was a complete reversal of preference from T1 to T2.

INTRODUCTION

For any species, passing on one's genes is an important objective. Forming attachments helps many organisms achieve this goal. Much avian research has focused on attachment behaviour and a major focus of this research has centered on imprinting. When Konrad Lorenz published *Companionship in Bird Life*, in Germany, in 1935, he referred to imprinting as the behaviour of a newly hatched duckling to follow the first moving object it would see. Since Lorenz published his influential paper, there has been much research on imprinting (Delannoy, 1967; Fabricius, 1962; Gottlieb, 1961; Gottlieb & Klopfer, 1962; Hess, 1959; Higuchi, 1976;; Lachman, 1997; Lorenz, 1970; Moriyama, 1981; Parsons & Rogers, 2000; Ratner & Hoffman, 1974; Salzen & Meyer, 1967; Waller & Waller, 1963).

There are two main problems accompany imprinting research. First, the term imprinting has been applied to species, other than avian species, with little research concerning the ecological demands being made on those species (Bischof, Geissler, & Rollenhagen, 2002; Burghardt & Hess, 1965, 1966; Csaba, Knippel, Karabelyos, Inczeffi-Gonda, Hantos, Tothfalusi, & Tekes, 2004; Hoffman & Ratner, 1973; Grassman, 1985, 1993; Grassman & Owens, 1987; Nicolaidis, 2008; Rowley & Chapman, 1986; Russock, 1986; Sadananda & Bischof, 2006; Simon & Simon, 1988; Steele, Grassman, Owens, & Matis, 1989; Ten Cate, Hilbers, & Hall, 1992; Ver, Vaysse, & Bouhouche, 1995). Second, researchers are creating a behavioural process when, in fact, there may not be one (Shapiro & Greenberg, 1974). Additionally, when the term imprinting is used without an in-depth knowledge of the behavioural process behind it, the phenomenon is simply named and not defined. In other words, it is reified (Shapiro, 1980a).

Much research has been done on different types of avian attachment. All such research treats attachment as a complete phenomenon. Attachment is not a single unit, however, but a compilation of components. These components include, – but are not limited to: visual components, brood size, animate versus inanimate components, familiarity and interaction opportunities. The research concerning these components includes the following: visual components (Beaudoin, 2006; Beaudoin & Shapiro, 2003; Cairns, 1966; Deng & Rogers, 2002; Einsiedel Jr., 1975; Goth & Hauber, 2004; Karen, 1994; Klopfer, 1967; Lorenz, 1935/1957; Ryan & Lea, 1989; Rheingold, 1985; Sable, 2004; Shapiro & Garretson, 1978; Spalding, 1873/1954; Vallortigara & Andrew, 1994), brood size (Germain & Shapiro, 2007; Kirvan & Shapiro, 1972; Rogan & Shapiro, 1972, 1974; Smith & Shapiro, 1975; Wereha & Shapiro, 2003), animate versus inanimate components (Cairns, 1966; Levy & Shapiro, 2003; Shapiro, 1980b; Shapiro & Agnew, 1975; Storey & Shapiro, 1972), familiarity (Beaudoin & Shapiro, 2003; Bruce & Shapiro, 1977b; Deng & Rogers, 2002; Dentry & Shapiro, 2003; Fabricius, 1951; Guiton, 1958; Rheingold, 1985; Shapiro & Garretson, 1978; Vallortigara & Andrew, 1994) and interaction opportunities (Hindman, 1979; Hutlet & Shapiro, 2008; Maple & Westlund, 1977; Mason & Kenny, 1974).

The problem associated with looking at just one of the components of avian attachment behaviour is that each component potentially confounds the other components. Hutlet and Shapiro (2008) conducted a pilot study looking at the interaction component of avian attachment behaviour while controlling for the confounding variables of a visual component and a familiarity component that is found in other studies. They achieved this by using a unique housing environment. In the first phase of the experiment, 17 experimental subjects (domestic chicks) were housed alone but allowed visual access to two species of stimulus objects (a brood

of 3 white Peking ducklings and a brood of 3 domestic chicks) without being allowed to physically interact with them. In the second phase of the experiment, experimental subjects were allowed to interact with one brood of stimulus objects while retaining visual access to the other, isolated, brood of stimulus objects. This procedure allowed the experimenters to test for an interaction effect while holding all of the other components of avian attachment behaviour constant (visual, brood size, animate versus inanimate and familiarity). Their results, however, did not produce what they predicted. Hutlet and Shapiro (2008) predicted that after the first 24 hours of visual exposure to both broods of stimulus objects, their experimental subjects would show a biological preference for their own species. No such preference was exhibited by the experimental subjects. They predicted that after a second period of 24 hours of interaction, the experimental subjects would show a preference for the species with which they had interacted. After 48 hours, the experimental subjects exhibited no preference for either stimulus object when they were allowed to interact with white Peking ducklings but they did exhibit a statistically significant preference for domestic chicks when housed with domestic chicks. The pilot experiment by Hutlet and Shapiro (2008) provided a puzzling set of results and suggested a series of experiments designed to answer the question of whether interaction is an important component in avian attachment behaviour.

DEVELOPMENTAL CONDITIONS AT HATCH

Skutch (1976) identified five different categories of birds according to their conditions at hatch. These categories are altricial, semialtricial, subprecocial, precocial, and superprecocial. Altricial birds are birds which are completely dependent upon their parents for survival in the

first week. They are hatched naked and are fed by their parents. These birds cannot thermoregulate or locomote at birth. An example of this type of bird is the American robin (*Turdus migratorius*) (Shapiro, 1980a). Semialtricial birds are birds which typically nest upon the ground (Shapiro, 1980a). These types of birds are slightly less dependent upon their parents for survival, as they are hatched with down feathers and can locomote. They cannot forage for food. An example of a semialtricial bird is a herring gull (*Larus argentatus*). Altricial and semialtricial species typically form attachments between the parents and their offspring (Sluckin, 1972). Subprecocial birds are similar to semialtricial birds with one major exception. Subprecocial birds follow their parents and are fed away from the nesting site (Shapiro, 1980a). An example of this type of bird is the American coot (*Fulica Americana*). Precocial birds are characterized by the ability to thermoregulate, locomote, and consume food soon after hatching. They do not have to be fed by a parent (Shapiro, 1980a). Precocial hatchlings typically follow their parent(s) after hatching (Sluckin, 1972). A common precocial bird is the mallard duck. Superprecocial birds are hatched independent of their parents. Shapiro (1980a) states there are only two known examples of a true superprecocial bird, the megapodes (family *Megapodiidae*) and the parasitic black-headed duck (*Heteronetta atricapilla*). Table 1 shows the developmental differences between the five categories of birds.

Wereha and Shapiro (2004) stated that a hatchling's attachment depends upon whether the parents are present, the hatchling's dependence upon the parents for survival, and the quality of the environment in which the hatchling is raised, i.e. its ecology. Shapiro (1980a) plotted these three factors (see Figure 1). He concluded that a hatchling which is more dependent upon the parent may be hatched in a more unfavourable environment. Conversely, a hatchling which is less dependent upon the parent would need to hatch in a more favourable environment. Shapiro

(1980a) describes Figure 1 as a “hypothetical representation of some of the factors attending the formation of an attachment with and without a parent present” (pp. 82). By considering these three factors, one can begin to comprehend avian attachment behaviour and its implications for different types of birds.

ECOLOGY OF THE MALLARD DUCK

The mallard duck is the most abundant wild duck species in North America and has a highly adaptive nature (Drilling, Titman, & McKinney, 2002). The mallard duck, therefore, inhabits many different habitats with the exception of the high arctic and desert areas in North America (Drilling, Titman, & McKinney, 2002). Since the mallard duck is a migratory species, it typically lives in two separate areas. In the winter, the mallard migrates to southern areas which are characterized by open water and an available food source. Mallards have been observed to migrate as far south as Mexico (Drilling et al., 2002).

The breeding season lasts from late April until mid-July. During this period, Ohde, Bishop, and Dinsmore (1983) found that drakes have a tendency to mate with more than one female. The drakes appear to pair with an average of two hens throughout the season. Ohde, et al. (1983) also found that mated drakes displayed short term pairing and became aggressive toward hens (other than the nesting female) during the prelaying, laying, and early incubation periods. Hens during this period of prelaying, laying and early incubation will typically pair with one male but would mate with another male if the first male was unavailable (Ohde et. al., 1983).

Mallard hens create nests in wetland areas that are near water and lay one egg a day until the clutch is complete. A clutch may vary in size from 1-13 eggs (Drilling et. al., 2002). Once the

clutch is laid, the female incubates the eggs for 23-30 days (average incubation time is 28 days) leaving the nest twice a day to eat, drink, and eliminate fecal material (Drilling et. al., 2002; Palmer, 1976). Two to three days before pipping occurs, the ducklings begin to vocalize inside the eggs. This process occurs to synchronize hatching (Drilling et. al., 2002). The hen will remain with the brood until they can fend for themselves and can fly. This event typically occurs 52-70 days after hatching (Drilling et. al., 2002).

TYPES OF AVIAN ATTACHMENT

Five possible types of avian attachment may occur. Mahoney (1986) outlines these types of attachment as: drake-to-duckling, duckling-to-drake, hen-to-duckling, duckling-to-hen, and duckling-to-duckling. Duckling-to-duckling attachment is often referred to as duckling-to-brood attachment. Primarily, avian attachment research has been concerned with mallard duckling-to-mallard hen attachments. Mallard duckling-to-mallard drake attachment has not been researched because, in the natural setting, the mallard drake is not present when the ducklings hatch (Drilling et. al., 2002). Ohde et al. (1983) found that drakes have a tendency to mate with more than one female during the mating season. They also found that mated drakes displayed short term pairing and became aggressive toward hens (other than their mates) during the prelaying, laying, and early incubation periods. After these periods the drake would desert the hen. Since the drake is absent during the development of the ducklings, there is no interaction between the drake and the ducklings. Mahoney (1986) feels that this lack of interaction is due to the brightly coloured plumage of the drake. If the drake were to stay with the hen during her full term of incubation, then predators may be attracted to the nest site because of that plumage.

The first documented naturalistic observations concerning the duckling-to-hen attachment was reported by Lorenz (1935/1957). It was originally proposed that this attachment, called imprinting by Lorenz (1935/1957), was formed to take care of the duckling's immediate biological needs (Shapiro, 1980b). Much research using both chicks and ducklings seems to support this assumption. Bateson (1964) found that day old Rhode Island Red x Light Sussex chicks were less avoidant of a novel model than were two and three day old chicks. He also found that when there was increased exposure to the model, there was an increased positive response (examples of positive responses include, but are not limited to: approaching the model, emitting a content vocalization, etc). It is assumed that the ability to distinguish between familiar and unfamiliar would be a biological mechanism for survival. Jaynes (1958) has done similar research with chicks. His results also indicated that a familiar stimulus is preferred. Johnson and Gottlieb (1985) found that a familiar mallard or pintail model was preferred over an unfamiliar model in a choice test at 48 hours and 72 hours. They also found that if both the familiar and unfamiliar models emitted a recorded mallard maternal call, the familiar model was only preferred in a choice test at 72 hours. Vocalization research was also done by Miller (1983). Miller (1983) looked at mallard ducklings and found that the ducklings would inhibit their vocal and locomotor behavior when they heard a maternal alarm call. Shapiro and Garretson (1978) conducted an experiment in which separate groups of white Peking ducklings were visually exposed to a model of a white Peking duck, a Rouen duck or to no model. The white Peking ducklings were found to prefer the model to which they were visually exposed.

Some research has indicated that the hen is preferred less when other stimuli are present. Shapiro (1980c) found that younger white Peking ducklings preferred a maternal mallard call significantly more than older white Peking ducklings. He also found that white Peking ducklings

raised in isolation displayed a stronger preference for a maternal mallard call as compared to white Peking ducklings raised communally. Morris (1969) has found that when chicks are housed with an orange balloon, and then given a preference test between their real mother and the balloon, the chicks will prefer the balloon significantly more. Beaudoin and Shapiro (2005) and Storey (1976) have shown that mallard ducklings prefer a brood of ducklings significantly more than they prefer a maternal call. Storey and Shapiro (1972) found that a brood of ducklings was preferred significantly more than a live or a stuffed hen. Dyer, Lickliter, and Gottlieb (1989) found that white Peking ducklings, raised socially or in peer-isolation, preferred stuffed ducklings to a stuffed mallard hen in a simultaneous choice test. This preference was found for the socially raised and the peer-isolated raised ducklings even when the hen was present and vocalizing during social rearing. They concluded that white Peking ducklings do not become visually imprinted to a hen until after they had left the nest. Dyer, Lickliter, and Gottlieb (1989) also concluded that other ducklings are more “visually attractive” than is the hen in early development. Darczewska and Shapiro (1997) found that mallard ducklings raised in isolation had no preference for hens with different coloured plumage (normal, cinnamon, or white). When a brood of three ducklings was added to any hen, a statistically significant preference for that hen was observed. Bruce and Shapiro (1977b) obtained results similar to those of Darczewska and Shapiro (1997). Lickliter and Gottlieb (1988) conducted a similar study. They looked at whether preference for a hen changed depending upon species of brood-mates. Domestic mallards (white Peking ducklings) were found to prefer a stuffed familiar mallard hen only when they were allowed to interact with a brood of same-aged wild mallards. There was no preference when the domestic mallard duckling interacted with a brood of same-aged domestic chicks or Muscovy ducklings (*Cairina moschata*).

Research looking at duckling-to-brood attachment has been investigated at length. Much research has been done in this area that indicates that the brood, or some aspect of it, is the most important type of attachment for an individual duckling or chick. Dyer, Lickliter, and Gottlieb (1989) concluded that siblings were more visually attractive than the hen in early postnatal development. Collias and Collias (1956) observed that whether the hen is nearby or not, the brood tends to stay clustered together. Raitasuo (1964) suggested that mallard ducklings will reject strangers after three days exposure to their siblings. Bruce and Shapiro (1977a) conducted a study concerning mallard ducklings and brood familiarity. They looked at whether or not a duckling could distinguish between a familiar versus unfamiliar brood of equal size. They found no evidence of brood recognition in mallard ducklings. Bruce and Shapiro (1977a) also looked at whether or not a duckling could distinguish between a familiar brood versus a larger unfamiliar brood. They found that the larger brood was preferred and concluded that a larger brood size is preferred because it enhances a duckling's survival rate. Beaudoin and Shapiro (2003) conducted similar studies using the domestic chick and also found no evidence of brood recognition. These findings were supported in Darczewska's (1999) experiments with white Peking ducklings. Darczewska found that these ducklings preferred an unfamiliar larger brood over a familiar single duckling. In similar research, Lindgren and Shapiro (1980) found that older mallard broods were preferred significantly more than younger broods of the same brood size.

Several studies have looked at whether an individual duckling or chick can recognize familiar versus unfamiliar chicks. Deng and Rogers (2002) tested domestic chicks monocularly three days after hatching. They found that when using the left eye, chicks could recognize familiar versus unfamiliar conspecifics, whereas, when using the right eye, chicks would approach familiar and non-familiar chicks at random. Deng and Rogers (2002) concluded that a

visual experience is needed before a domestic chick could become aware of the cues that distinguish different chicks. Their findings indicate that chicks can, in fact, distinguish familiar vs. unfamiliar chicks. They may, however, prefer a larger brood based on different factors, such as behavioural expressions.

Sigman, Lovern, and Schulman (1978) may provide an explanation for the conflicting experimental results of Beaudoin and Shapiro (2003) and Deng and Rogers (2002) concerning domestic chicks and recognition. Sigman, Lovern, and Schulman (1978) found that recognition in the white leghorn chick was not based upon individual features of chicks but upon the chick's behavioural expressions. They found that socially reared chicks showed no preference between a familiar or an unfamiliar socially reared chick and preferred an unfamiliar socially raised chick significantly more than an unfamiliar chick raised in isolation. They also found that chicks raised in isolation significantly prefer chicks which are socially raised as opposed to chicks which are raised in isolation. In other words, they found that socially-raised chicks and isolated-raised chicks exhibited different discernable behaviours. Their study indicated that leghorn chicks do not distinguish chicks based on familiarity but distinguish chicks based on the behaviour displayed by these other chicks.

Call patterns among ducklings have also been researched. Gaioni (1982) found that white Peking ducklings would alternate their patterns of distress calls when responding to conspecifics. Gaioni, Hoffman, Klein, and DePaulo (1977) conducted similar research looking at Khaki Campbell ducklings and found that when there was a large brood of ducklings there were few distress vocalizations emitted. When various numbers of ducklings were removed, they found a negative correlation between remaining brood size and distress vocalizations. Likewise, Hicinbothom and Miller (1999) found that isolated ducklings emit higher frequencies and more

notes per vocalization. They also found that ducklings vocalized significantly more when they were visually isolated from their broodmates. Marx, Leppelt, and Ellendorf (2001) found that larger broods were dominated by contentment vocalizations, whereas distress vocalizations were dominant in smaller broods thus, parenthetically, supporting the view that larger broods are preferred.

Another area of duckling-to-brood attachment concerns crèche behaviour. A crèche is formed when two or more broods amalgamate into one larger brood (Wereha, 2007). Some species of birds always form crèches while other species form crèches only when environmental circumstances require it. Williams (1995) described the former. He looked at how penguin chicks form crèches to conserve heat and to act as a defense against predators. Le Bohec, Gauthier-Clerc, and Le Maho (2005) found that the king penguin formed crèches which, throughout the winter, increased in size but the number of crèches formed decreased. They also found that these crèches were formed as a primary response to adult aggression – lone chicks were more likely to be attacked by unrelated adults compared with chicks in crèches.

Skutch (1976) has shown that crèche behaviour is more common in diving ducks than in dabbling ducks. The common eider (*Somateria m. mollissima*) is one of the most studied species with regards to environmental crèche behaviour. Munro and Bedard (1977) found that permanent crèches formed when two or more broods encountered each other, usually shortly after leaving the nest to find food and water (88% of broods observed formed crèches, 12% did not form crèches). They also concluded that the organization of crèches is based on a hierarchical ranking of hens involved in the tending of the young. Gorman and Milne (1972) found no evidence of hen to brood identification (meaning that the hens present cared for all young, not just their biological offspring) and observed that hens would spend, on average, four days with the crèche

and would then leave to feed themselves since their environment did not support the hens' dietary needs. These hens would then be replaced with other hens coming to the crèche with new broods. They also found that when the feeding grounds could sustain the hens and their broods, crèches did not form since the hens were able to stay with their broods. As the eider ducklings are abandoned by their mothers, Gorman and Milne (1972) postulated that ducklings must be strongly attracted to each other. This view supports the earlier premise that the brood is the most important attachment for the individual duckling. Crèche behaviour, or the attractiveness of the brood, may be the result of an environmental demand.

IMPRINTING AS A FORM OF ATTACHMENT

Essentially, avian attachment research began when Konrad Lorenz (1935/1957) published his paper concerning companionship in bird life in 1935. His naturalistic observations on the hen-duckling dyad led to the development of his hypothesis concerning avian attachment, which he called imprinting. Lorenz (1935/1970) characterized imprinting as an internal mechanism which had three basic components, the first two of which differentiated imprinting from learning. Learning is characterized by a permanent change in behaviour resulting from either practice or experience (Lachman, 1997).

The first component of imprinting is the period of time during which imprinting occurs. This time period has rigid parameters often referred to as the 'critical period'. Lorenz (1935/1970) said that imprinting will not occur after this critical period. Gottlieb (1961) measured this critical period from the onset of incubation to the time of hatching. He concluded that metabolic factors were the primary determinants of a duckling's ability to imprint. Gottlieb

and Klopfer (1962) looked at the differences between auditory and visual imprinting. They found that auditory imprinting occurred earlier than visual imprinting.

Ratner and Hoffman (1974) have argued that the Khaki Campbell duckling (*Anas platyrhynchos domesticus*) exhibits a critical period. Ratner and Hoffman (1974) found that newly hatched (10 hours post hatch) Khaki Campbell ducklings attempted to approach a novel stimulus whereas 5-day old ducklings attempted to escape a novel stimulus. They concluded that this evidence supported the concept of a critical period for imprinting.

More recently Parsons and Rogers (2000) were able to alter the critical period associated with imprinting using normal dark-reared white leghorn x australorp chicks in which they showed which receptors are involved in creating this behavioural mechanism. They conducted three experiments concerning imprinting and the NMDA receptors (ionotropic receptor for glutamate [*N*-methyl *D*-aspartate]). In the first experiment, the chicks were injected with a mixture of ketamine (a noncompetitive NMDA receptor antagonist) and xylazine (an alpha-sub-2-adrenergic receptor agonist), a single dose of ketamine, a single dose of xylazine, or saline. The chicks injected with the mixture of ketamine and xylazine were able to imprint at 192 hours (eight days) after hatching. The chicks in the other three conditions were only able to imprint at 48 hours (two days) after hatching. In the second experiment, the chicks were injected with a double dose of ketamine, a double dose of xylazine, or saline. Parsons and Rogers (2000) found that only the chicks which were given a double dose of ketamine were able to imprint at 192 hours (eight days) after hatching, while the other two groups lost the ability to imprint 48 hours (two days) after hatching. The third experiment injected chicks with either MK-801 (another noncompetitive NMDA receptor antagonist) or saline. They found that the chicks injected with MK-801 were able to imprint 192 hours (eight days) after hatching. Parsons and Rogers (2000)

concluded that the critical period was not simply determined by the onset of incubation as Gottlieb (1961) had postulated but, rather, there is evidence that the NMDA receptor system is involved in the mechanisms that control for the critical period in imprinting.

The second component discussed by Lorenz that differentiates imprinting from learning concerns the permanency of the process. Lorenz (1970) postulated that imprinting was an irreversible process that could occur after only one exposure. Research on this topic has been contradictory. Salzen and Meyer (1967) found that Cornish x White rock chicks housed with either a green or blue ball and then housed with the opposite colour changed their preference from the original colour to the opposite colour. Fabricius (1962) and Moriyama (1981) also concluded that the irreversibility of imprinting is not supported. Hess (1959), however, has contended that studies which find that imprinting can be reversed are methodologically flawed as they examine behaviour that occurs after the critical period has lapsed and, therefore, examine associative learning rather than imprinting.

The third and final component of imprinting proposed by Lorenz (1935/1970) stated that when imprinting occurs, later behaviour of the hatchling will be affected. In other words, the preferences which are developed during the critical period of imprinting are thought to affect a hatchling's later behaviour, including behaviour towards all members of the imprinted species. Higuchi (1976) found that chicks which were exposed either to a yellow cylinder or an adult pigeon during the critical period had a statistically significant increase in their body weight 10-days after exposure as compare to chicks that were not imprinted in the critical period. There was not a significant difference in the body weight between the group which was exposed to the yellow cylinder and the group which was exposed to the adult pigeon. The results indicated that

early exposure (referred by Higuchi as imprinting) changed the behaviour of the chicks, specifically an increase in body weight.

Delannoy (1967) conducted similar research and developed several experiments looking at motor patterns and pair formations in the mallard duck. He found that when mallards were exposed to another species during the critical period, they developed atypical mallard motor patterns (typical to the alien species). Delannoy (1967) concluded that species recognition was reliant upon the selective learning of specific characteristics acquired during imprinting's critical period. Waller and Waller (1963) conducted an experiment using white Peking ducklings looking at two different factors: pair-raised (two ducklings) versus isolate-raised (one duckling) and ducklings which were imprinted (exposed to a green cardboard cube during the critical period) versus ducklings which were not imprinted (not exposed to a green cardboard cube during the critical period). Waller and Waller (1963) wanted to see what affect these factors had on flocking behavior. Ducklings were assigned to four conditions to look at the two factors: ducklings that were imprinted and pair raised, ducklings that were imprinted and isolate raised, ducklings that were non-imprinted and which were pair raised, and ducklings that were non-imprinted and which were isolate raised. Waller and Waller (1963) found, for both isolate groups (imprinted and non-imprinted), imprinted-isolated ducklings were quicker to exhibit flocking behaviour than non-imprinted-isolated ducklings. They also found that both pair-raised groups were more likely to exhibit flocking behaviour than both isolate groups. In other words, the ducklings that were imprinted (or exposed to the green cardboard cube in the critical period) were faster at exhibiting flocking behaviours than ducklings that were raised in isolation. There was no significant difference between the imprinted and non-imprinted pair-raised groups for exhibiting flock behaviours. The interpretation of these results is problematic because of the

confounding associated with imprinting (exposure to the green cardboard cube) and pair-raising. When ducklings are pair-raised they are simultaneously exposed to the green cardboard cube and their brood mate. It is not possible to determine which of these variables was affecting flocking behaviour. The behaviour of the isolate-raised ducklings, however, indicates that the later behaviour of the imprinted ducklings was different from that of the non-imprinted ducklings.

PROBLEMS WITH IMPRINTING RESEARCH

The term 'imprinting' has evolved beyond its original definition. Lorenz (1935/1957) described imprinting as the behaviour a duckling exhibited when it followed the first moving thing that it saw. Different species, however, may possess different mechanisms that mediate their following behaviour (Shapiro, 1972). When the same term (i.e. imprinting) is used to describe different mechanisms in different species occurring at different developmental ages, it infers that all of these mechanisms are similar when, in fact, they may not be (Shapiro, 1972). Researchers have applied imprinting to many different biological situations and ecological scenarios. This is the first problem that one encounters when using the term 'imprinting'.

Simon and Simon (1988) conducted research with the Florida Burrowing Owl (*Athene cunicularia floridana*). They found that hand-fed owls had stronger approach-response behaviour towards the handlers (especially when food was associated with the approach). This study uses the term imprinting to describe the preference exhibited by the Florida Burrowing Owl for a human handler in an artificial environment. Rowley and Chapman (1986) reported that the galah (*Eolophus roseicapillus*) and the Major Mitchell's cockatoo (*Cacatua leadbeateri*) had similar nesting behaviours. This led to both species occasionally contributing eggs to the same clutch. In

one such instance, a Major Mitchell's cockatoo raised a combined clutch. The galah cockatoo (that was raised by the Major Mitchell's cockatoo) displayed behavioural Major Mitchell cockatoo characteristics and only associated with other Major Mitchell cockatoos. This study uses the term imprinting to describe the behavioural change exhibited by the galah cockatoo in a natural environment.

Recent avian imprinting research has concentrated on 'sexual imprinting'. Ten Cate, Hilbers, and Hall (1992) looked at whether cross fostering collard doves (*Streptopelia decaocto*) to white ring doves (*Streptopelia risoria*) would affect mate preference. The collard doves overwhelmingly preferred the white ring doves for mating preference. This study uses the term imprinting to describe the sexual preference change exhibited by the collard doves in an artificial environment. Bischof, Geissler, and Rollenhagen (2002) have shown that the critical period for imprinting in zebra finches (*Taeniopygia guttata guttata*) can be delayed by sensory deprivation or inadequate stimulation but this critical period cannot be delayed infinitely. Sadananda and Bischof (2006) conducted a tracing study of the lateral nidopallium in the zebra finch and found it to be connected to learning (imprinting) and song learning. These studies use the term imprinting to describe a vocalization behaviour exhibited by the zebra finch.

Many researchers have used the imprinting phenomenon to describe imprinting-like processes in organisms other than birds. Russock (1986) determined that pisces cichlidae (*Sarotherodon (Oreochromis) mossambicus*) fry will significantly prefer whichever maternal stimuli model forms the closest match to their initial perceptual schema of the broody mother. These results indicate that cichlidae may go through a similar behavioural mechanism resembling imprinting. This study uses the term imprinting to describe the preference for different models exhibited by the cichlidae in an artificial environment. In the Reptilia class,

most imprinting research concerns different species of turtles. Grassman (1985, 1993) and Grassman and Owens (1987) propose that green sea turtles (*Chelonia mydas mydas*) ‘chemically-imprint’ on their home nests and this imprinting affects later behaviour. Burghardt and Hess (1965) conducted studies which looked at food preferences in snapping turtles (*Chelydra serpentina*). They found that the turtles significantly preferred diets which they were fed as hatchlings. Burghardt and Hess (1965) termed this behavioural mechanism ‘food-imprinting’. Steele, Grassman, Owens and Matis (1989) studied loggerhead sea turtles (*Caretta caretta*). They found that these turtles exhibited ‘chemical-imprinting’ and ‘food-imprinting’. These studies use the term imprinting to describe a preference for a chemical signature and to simultaneously describe a preference for a previously exposed diet exhibited by the different species of turtles in artificial and natural environments.

The term ‘imprinting’ has also been used to explain mammalian behaviour. Csaba, Knippel, Karabalyos, Inczeffi-Gonda, Hantos, Tothfalusi, and Tekes (2004) conducted research looking at wistar rats (*Rattus norvegicus*) and whether the serotonin antagonist (mianserin) could delay ‘neonatal imprinting’ to ‘non-neonatal imprinting’. Nicolaidis (2008) found that different conditions of ‘prenatal-imprinting’ of rats created different conditions of appetites. For example, imposed extracellular dehydration in pregnant rats caused a statistically significant enhancement of salt appetite in the pups. These studies used the term imprinting to describe sexual preferences displayed by rats which were injected with mianserin for three days after birth and to describe salt appetite of adult rats after being exposed to extracellular dehydration *in utero* in an artificial environment. Ver, Vaysse, and Bouhouche (1995) found that when Persian kittens (*Felis catus*) ‘imprinted’ or were only exposed to the mother cat, they exhibited stress behaviours around humans. When the kittens ‘imprinted’ to the mother cat and a human, the kittens exhibited

ambivalent behaviours towards humans. This study used the term imprinting to describe a preference exhibited by the Persian cat for a human handler in an artificial environment.

The term imprinting has been applied to primate and human research. Hoffman and Ratner (1973) summarized literature stating that early 'maternal imprinting' may dictate later behaviour. This review used the term imprinting to describe the behavioural change exhibited by humans in a natural environment.

Imprinting, sexual imprinting, chemically imprinting, food imprinting, neonatal imprinting, mammalian imprinting, and maternal imprinting are all very different behaviours which involve very different behavioural mechanisms. Using the term imprinting to describe all of these different behaviours infers that all the different types of 'imprinting' involve similar mediating mechanisms when, in fact, they do not (Shapiro, 1972).

The second problem associated with the term imprinting is that we "reify the concept" (Shapiro, 1980a p. 92) when researchers treat the term as a real phenomenon when, in fact, there may not be one (Shapiro & Greenberg, 1974). Additionally, when the term imprinting is used without an in depth knowledge of the behavioural process behind it, and the survival value associated with it, the phenomenon is simply named and not defined. This process is known as a nominal fallacy (Shapiro, 1980a). Shapiro (1970) has suggested that the term avian attachment behaviour should be used as an alternative to the term imprinting. There are several advantages to adopting such a strategy (L. J. Shapiro, personal communication, June 1, 2009). First, avian attachment behaviour can be studied independent of attachment behaviour in other organisms. Second, the unique ecological demands placed on a particular species of bird can be used to explain the behaviour of that bird without invoking hypothetical concepts. Third, the survival value of a young bird's behaviour can be related to the preference(s) it exhibits without

attributing special characteristics to that behaviour. Finally, the mechanisms thus invoked have explanatory power related to the real world instead of magical properties that explain nothing. For the purposes of this thesis, therefore, the term 'avian attachment behaviour' will be used in lieu of the term imprinting.

COMPONENTS OF ATTACHMENT

Much research has been done on the formation of avian attachments. All such research treats attachment as a complete phenomenon. The phenomenon of avian attachment is not a single unit, however, but a compilation of components. These components include, but are not limited to: visual components, brood size, animate versus inanimate components, familiarity and interaction opportunities.

The research concerning the visual component of avian attachment behaviour is extensive (Beaudoin, 2006; Beaudoin & Shapiro, 2003; Cairns, 1966; Einsiedel Jr., 1975; Goth & Hauber, 2004; Klopfer, 1967; Rheingold, 1985; Sable, 2004; Shapiro & Garretson, 1978; Vallortigara & Andrew, 1994). Researchers have observed the tendency of newly hatched ducklings/goslings to follow the first moving object or organism they see after hatching regardless of the biological appropriateness of the object followed (Karen, 1994; Lorenz, 1935/1957). Observations by Spalding (1873/1954) indicated that newly hatched chicks followed the first moving object they saw upon hatching, regardless of whether or not this object was their mother. Ducklings and goslings exhibit this same tendency (Lorenz, 1935/1957; Karen, 1994). Cairns (1966) speculated that animals which have been continuously exposed to an object will prefer that object in a preference test. This effect has also been observed by Einsiedel Jr. (1975), who found that

preference was a positive function of hours of exposure. Ryan and Lea (1989) found that when minor changes were made to an object, domestic chicks preferred the object most recently seen. Klopfer (1967) states that "... ducklings are ... capable of making learned discriminations as easily between any one pair of models as another" (pp. 1396). Shapiro and Garretson (1978) found that white Peking ducklings preferred any model with which they were previously exposed. Recently, Vallortigara and Andrew (1994) and Deng and Rogers (2002) found that domestic chicks were able to discriminate between familiar and strange social comparisons with their left eye but were unable to discriminate with their right eye. The visual component of attachment is not only important for basic survival but, according to Goth and Hauber (2004), the ability to discriminate between conspecifics and heterospecifics improves the fitness in social contexts (such as foraging, roosting, migrating, and antipredator behaviour).

A second component of avian attachment is brood size. Research in this area has looked at how brood size plays a role concerning the preferences of mallard ducklings, white Peking ducklings and domestic chicks. Kirvan and Shapiro (1972) began looking at the size of the brood. They found that a brood of nine white Peking ducklings was preferred significantly more than a brood of six or a brood of three white Peking ducklings. This experiment was repeated by Rogan and Shapiro (1972). They also found that a brood of nine white Peking ducklings was preferred significantly more than a brood of six or a brood of three white Peking ducklings. The results of these studies support the premise that there is preference for a larger brood size in white Peking ducklings. Rogan and Shapiro (1974) repeated the previous experiments using mallard ducklings. Their findings were similar to the experiments with white Peking ducklings; a brood of nine mallard ducklings was preferred significantly more than a smaller brood of six or of three mallard ducklings. Smith and Shapiro (1975) also tested the mallard duckling's

preference for larger broods. They, however, looked at whether the mallard duckling had a preference for a brood of nine, 12 or 15 ducklings. This experiment was done to determine whether a brood of nine had some special characteristic associated with it or if a larger brood would be preferred. Smith and Shapiro (1975) found that the larger brood of 15 mallard ducklings was preferred significantly more than a brood of nine or 12 mallard ducklings, indicating that a brood of nine has no special characteristic and that a larger brood is preferred, regardless of size.

There are several reasons why a larger brood may be preferred by mallard and white Peking ducklings. The heat provided from a brood is a necessary determinant for survival for a brood of ducklings (Rogan & Shapiro, 1974). A larger brood also offers a type of anti-predator behaviour; the more ducklings there are the less chance any one of them will be caught by a predator (Wereha & Shapiro, 2003). Finally, a larger brood, when swimming, stirs up more food (Wereha & Shapiro, 2003). Conversely, Dzus and Clark (1997) found that there was no difference in the brood temperature in broods of different sizes. What they found was that temperature variation within the brood was positively correlated with brood size. In other words, larger broods had higher temperatures. Dzus and Clark (1997) concluded that, in the natural environment, the temperature variation within large broods may, in fact, reduce duckling survival. This conclusion assumes that temperature variation is a factor of mortality for wild flocking birds.

Brood size preferences in domestic chicks is not apparent. Wereha and Shapiro (2003) tested brood size preferences in the domestic chick and did not find a preference for larger broods. These results have also been found by Germain and Shapiro (2007). Shapiro (1980b) clarifies this apparent contradiction. He argues that the domestic chick is essentially a “cardboard

organism” as the domestic chick has been pressed together to satisfy human needs as a food source. The domestic chick has the necessities of life (i.e. heat, food and protection from predation) provided for it. One can question if an organism raised in an artificial environment would have any need to exhibit a trait which would give it any sort of survival advantage. Natural selection in a hatchery would favour genes that make the chicken an appealing food source, rather than genes that help the chicken survive in the natural environment, like a brood size preference.

The animate component of avian attachment is under-represented in published research. Animals typically become more strongly attached to animate than to inanimate objects (Cairns, 1966). The small body of research that has looked at animate versus inanimate stimulus objects typically test for a preference using animate live subjects and biologically inappropriate, inanimate, stimulus objects. Some of this research, therefore, may have a confounding variable associated with it. Levy and Shapiro (2003), for example, tested domestic chicks for their preference for nine live age mates, a mirror and a fount. A statistically significant preference for the live age mates was found. These results were consistent with previous research (Shapiro, 1980b; Shapiro & Agnew, 1975; Storey & Shapiro, 1972). In the Levy and Shapiro (2003) study, however, brood size confounded the results of the study concerning the effects of animate vs. inanimate. The mirror presented one animate conspecific stimulus object, but the brood consisted of nine age mates. If a larger brood size is preferred, as was shown in previous research, then brood size may have confounded a preference for the animate stimulus object.

A fourth focus of avian attachment research has been familiarity. When a duckling hatches, it is able to hear, touch, see, smell and interact with its own species. Rheingold (1985) has made the argument that familiarity is arguably the most powerful determinant of behaviour

and development. Increased familiarity has been shown to increase an attachment (Fabricius, 1951; Guiton, 1958). This relationship has not always been found in research concerning brood recognition and individual recognition. Brood recognition concerns an experimental subject recognizing a brood of conspecifics, whereas individual recognition concerns an experimental subject recognizing a single stimulus object, whether it was genetically related or not. Bruce and Shapiro (1977) found that mallard ducklings preferred a larger unfamiliar brood to a smaller familiar brood. They also found that the mallard duckling was unable to discriminate between a familiar brood and an unfamiliar brood of the same size. Beaudoin and Shapiro (2003) looked at whether or not domestic chicks would be able to discriminate between a familiar brood and an unfamiliar brood of the same size and age. They found that the chick was unable to distinguish between the broods. Dentry and Shapiro (2003) found similar results with the domestic chick. In contrast, Deng and Rogers (2002) and Vallortigara and Andrew (1994) found that the domestic chick could, in fact, distinguish between a familiar and unfamiliar conspecific (with the left eye only). These studies (concerning mallard ducklings, white Peking ducklings, and domestic chicks) suggest a lack of brood recognition in ducklings, whereas the studies concerning domestic chicks suggest individual recognition is possible. These conflicting results imply the need for more research in this area of avian attachment.

In recent years, there has been a greater focus on the interaction component of avian attachment behaviour. Mason and Kenny (1974) pioneered a study which used rhesus monkeys as subjects and dogs as mother surrogates in order to test if there could be a redirection of filial (infant to mother) attachments from other monkeys to dogs. They found that, in fact, filial attachments could be redirected and that these attachments could be directed at biologically inappropriate, animate stimulus objects (i.e. monkeys became attached to dogs with which they

were housed). Eight rhesus monkeys were chosen as experimental subjects. Four were raised in enclosed isolation cages with cloth surrogates (two for less than one month and two until 10 months of age). The other four had prolonged contact with another monkey (two were raised by their natural mothers until three months of age and two were enclosed with a single peer monkey until 7 months of age). All eight monkeys were separated from their original environment conditions (at 7 months of age) and then (separately) gradually exposed to spayed female mix-breed dogs until the experimental subject and dog were cohabitating (6-8 weeks of integration). There were three testing phases for each experimental subject. In the first phase, the dog surrogate was placed in a clear plastic box while an unfamiliar dog was leashed at one end of the room. In the second phase, the dog surrogate was placed in a clear plastic box while an unfamiliar rhesus monkey of similar age was leashed at one end of the room. During the first two testing phases Mason and Kenny (1974) found that the familiar dog was preferred to either stranger to a statistically significant degree. In the third phase of the experiment, the experimental subjects were given a choice between an unfamiliar dog and an unfamiliar inanimate surrogate. The experimental subjects preferred the unfamiliar dog to the unfamiliar inanimate surrogate to a statistically significant degree. This study indicates that existing attachments may be “strong, specific, and exclusive, and yet can be redirected to an object that is physically quite different from the original attachment figure” (pp. 121).

Maple and Westlund (1977) found similar results. They used two infant rhesus monkeys and two infant savannah baboons. They were housed in pairs consisting of a rhesus monkey and a savannah baboon in the first phase of the experiment and then all four were group housed together in the second phase of the experiment. Maple and Westlund (1977) found that each subject had a significant preference for the ‘alien’ they were housed with. When the subjects

were group housed, their primary interaction locus (i.e. whom they spend the majority of time with) was with the original cohabiter. What was interesting to note in this study was that after group housing, the strong attachment remained strong and the weak attachment became weaker.

Within the realm of avian research, Hindman (1979) conducted a similar study. Hindman conducted a nine week study where domestic chicks were raised with a guinea pig (Experimental Group 1), a domestic chick (Experimental Group 2), or in isolation (Control Group). During Time 1 (week 1-3), the experimental subjects lived with their companion (a guinea pig or domestic chick). During Time 2 (week 4-6), the experimental subject lived with the alternate companion (i.e. if the experimental subject lived with a guinea pig for Time 1, they then lived with a domestic chick for Time 2). During Time 3 (week 7-9), the experimental subject lived with its original companion (i.e. if the experimental subject lived with a guinea pig for Time 1, with a domestic chick for Time 2, they would then live with a guinea pig for Time 3). Preference tests were conducted on all three groups at the end of week three, six and nine. The control group was found to have a statistically significant preference for domestic chicks rather than guinea pigs for each testing period, thus suggesting that domestic chicks have a biological preference for the domestic chick. For the two experimental groups, both preferred their original companion at the end of the first testing period regardless of the biological appropriateness of the companion. For the second and third testing periods, the original preference of the experimental groups decreased slightly but not significantly. These results indicate that the biological preference of domestic chicks for their own species can be changed by interacting with another organism. The results also indicate that the preference developed persists even when that organism is absent.

Domestic chicks have a predisposition to approach stimuli resembling conspecifics (Bolhuis, 1999). In other words, domestic chicks have an innate tendency to move toward and

stay near organisms that closely resemble themselves. In the Hindman (1979) study, it may be that the domestic chicks housed in isolation preferred domestic chicks, and not the guinea pigs, because guinea pigs lack a distinct head and neck region which is evident in birds such as domestic chicks or ducklings. It has also been shown that robotic chicks that peck the ground are preferred over robotic chicks that sway back and forth, suggesting that pecking behaviour may elicit an approach response in the domestic chick since the pecking behavior indicates a possible food source (Goth & Hauber, 2004). Shapiro (1980a) has argued that superprecocial birds, which have no parental supervision after hatching, potentially require a larger biological predisposition to prefer members of their own species. Birds who do not rely on their parents for survival would have more dependence upon being able to identify their own species for survival. This situation may explain why the mallard duckling, white Peking duckling and the domestic chick would exhibit a preference for their own species. The three studies by Maple and Westlund (1977), Mason and Kenny (1974) and Hindman (1979), while groundbreaking in their research design, did not control for both the visual or familiarity components of avian attachment behaviour. No study had been done that has controlled for the confounding variables of visual and familiarity components of attachment behaviour.

THE PURPOSE OF THESE EXPERIMENTS: TESTING THE “INTERACTION” COMPONENT OF ATTACHMENT

There are problems associated with testing for an interaction component of avian attachment behaviour. The biggest problem is one’s ability to limit confounding factors within the experimental design. In the first phase of the Mason and Kenny (1974) experiment, rhesus

monkeys were given a choice between a familiar dog and an unfamiliar dog. In the second phase of the experiment the experimental monkeys were given a choice between the familiar dog and an unfamiliar rhesus monkey. The results showed that the experimental subjects preferred the familiar dog over the unfamiliar stimulus objects. These two phases of the experiment have the visual, familiarity and interaction components confounded. For example, when the experimental subjects interacted with the dog, the dog became increasingly familiar to the subjects. It becomes increasingly difficult to determine which factors contributed to the preference of the experimental subjects for their dog surrogates. Was the preference developed because the experimental subjects could see the dog, interact with the dog, or because the dog was familiar to them? In the third phase of the Mason and Kenny (1974) experiment, the experimental monkey was given a choice between an unfamiliar dog and an unfamiliar inanimate cloth surrogate. The results showed that the experimental subjects preferred the unfamiliar dog over the unfamiliar cloth surrogate. This phase of the experiment did not look at the interaction between the subject and the stimulus object (the live, unfamiliar dog) but confounds the attachment components of animate versus inanimate and the physical difference between the animate dog and cloth surrogate. Similarly, the experiment conducted by Maple and Westlund (1977) confounded the attachment components of familiarity, and interaction. Since the rhesus monkeys and savannah baboons were housed together, they interacted and became increasingly familiar with their partner.

The Hindman (1979) experiment also confounded the attachment components of familiarity and interaction. For the first week of the experiment, the experimental subjects were interacting with their companion and becoming increasingly familiar with them. In the second week, they were placed with a completely new and unfamiliar companion. Finally, in the third

week of testing, they were placed back with their original companion (who was already familiar to them). The original companion from week one was preferred during the preference testing at the end of each week.

Hutlet and Shapiro (2008) conducted a study to control for the potentially confounding variables of vision and familiarity. Their experimental subjects were domestic chicks, housed by themselves for the first 24 hours, with visual access to a brood of three domestic chicks and a separate brood of three white Peking ducklings (stimulus objects). For the next 24 hours the experimental subjects were housed with either three domestic chicks or three white Peking ducklings, with visual access, but no physical access, to the other brood of stimulus objects. This experimental design allowed testing for an interaction effect between the experimental subject and the stimulus objects, while holding visual, brood size, animate versus inanimate and familiarity components constant. Hutlet and Shapiro's (2008) results did not produce what they predicted. After the first 24 hours of visual exposure, there was no preference for either the domestic chicks or the white Peking ducklings (indicating that there was no biological preference for the domestic chick). After 48 hours of exposure to a brood of three white Peking ducklings, the experimental subjects exhibited no preference for either stimulus object. When housed with the brood of three domestic chicks, the experimental subjects exhibited a statistically significant preference for the brood of three domestic chicks.

The experiment by Hutlet and Shapiro (2008) had several components which were improved upon in this experiment. The improvements were designed to obtain more accurate results. First, in these experiments, white Peking ducklings were used as experimental subjects as opposed to domestic chicks. Hutlet and Shapiro's finding that domestic chicks lack a preference for their own species provides support for Shapiro's view that the domestic chick is a "cardboard

organism” which does not exist in the natural environment and was created by humans to fulfill dietary needs (1980a). Shapiro (1977) has also suggested that the domestic chick lacks the survival skills that are common to precocial birds (1977). Hutlet and Shapiro (2008)’s results supported Shapiro’s position that the domestic chick is a poor subject to use in studies concerning the natural behaviour of precocial birds.

Second, in these experiments, mallard ducklings were used as stimulus objects as well as of domestic chicks. Domestic chicks are the same colour as white Peking ducklings but are physically different in body shape and beak shape. In the case of the Hindman (1979) study, the domestic chicks in the control group may have preferred their own species over guinea pigs because guinea pigs lack a distinct head and neck region. Goth and Hauber (2004) found that domestic chicks prefer robotic chicks that peck the ground over robotic chicks that sway back and forth. Goth and Hauber’s (2004) results suggest that pecking behaviour may elicit an approach response in the domestic chick since the pecking behavior indicates a possible food source. Similarly, a difference in body shape and beak shape may illicit an approach or withdrawal response in the white Peking duckling. By using mallard ducklings, one could control for the potentially confounding factor of body shape and beak shape.

Third, in these experiments, a longer period of exposure was used. Hindman (1979) has indicated that one week is an appropriate length of time to form attachments. Shapiro (1980a) has also used a one week period to test preferences since, he maintains, an attachment develops over a period of time. Therefore, experiments lengthening the time of exposure from 24 hours to one week were conducted to study the potential development of a subject’s preferences.

The purpose of the current set of experiments was to investigate the interaction component of avian attachment behaviour. The latter is viewed as the outcome of several

components, all of which potentially interact with each other. In these experiments, the visual, brood size, animate vs. inanimate, and familiarity components of avian attachment behaviour were held constant so that the effects of interaction were evaluated unambiguously.

GENERAL METHOD

Subjects

Egg Source-Experimental Subjects. The experimental subjects were 59 white Peking ducklings (*Anas platyrhynchos*). Eggs from which the subjects were hatched were obtained from Metzger Farms in California. The eggs were transported from the hatchery to the Avian Behaviour Laboratory by plane and by vehicular courier transport.

Egg Source-Stimulus Objects. Two sets of stimulus objects were used. The first set of stimulus objects were 177 white Peking ducklings (*Anas platyrhynchos*). Eggs from which the subjects were hatched were obtained from Metzger Farms in California. The second set of stimulus objects were 102 domestic chicks (*Gallus gallus domesticus*) or 75 mallard ducklings (*Anas platyrhynchos platyrhynchos*). The domestic chick eggs were obtained from Granny's Hatcheries (750 Pandora Avenue East, Winnipeg, Manitoba, Canada, R2C 4G5). The eggs were placed in insulated and heat-controlled containers and transported by car from Granny's Hatchery to the Department of Psychology's Avian Behaviour Laboratory located in the Psychology Department at the University of Manitoba. The total distance from Granny's Hatchery to the Avian Behaviour Laboratory is 29.35 kilometers and the total time spent in the car was approximately 26 minutes. The mallard eggs were obtained from a breeding flock of mallard ducks in the Avian Behaviour Laboratory in the Department of Psychology at the University of Manitoba. All eggs were hatched in the Avian Behaviour Laboratory at the University of Manitoba.

Incubation. Upon arrival at the Avian Behaviour Laboratory, both chick eggs and duck eggs were placed in a wooden Model 1 Petersime Incubator (Petersime Incubator Co., 300 North

Bridge, Gettysburg, OH 45328-out of business). The incubator holds eight trays which rotate 120° every two hours. The domestic chick eggs were added to the incubator nine days after the duck eggs. The incubator was kept at 37.2°C/99° F with a humidity level of 67%. Each day the incubator was turned off and all the eggs were removed for 15 min to cool. At the end of the 15 min period, the eggs were sprayed with lukewarm water and placed back into the incubator, which was turned on.

The eggs were checked weekly for defects. Each egg was candled to see which (if any) were infertile, dead or cracked. All eggs that were not viable were disposed of by incineration as per University of Manitoba laboratory standard operating procedure SOP-C3. The duck eggs were transferred to a Petersime Model H145 Hatcher on day 24.5 of their incubation schedule. The chick eggs were added to the hatcher on day 19 of their incubation schedule.

Hatching. The temperature of the hatcher was kept at 35.6°C/96° F and at 90% humidity. Upon pipping, the eggs were checked in the dark every four hours to determine which eggs had hatched. Hatching is defined as when a chick or duckling has removed itself completely from the egg without human assistance. Once a chick or duckling hatched and was dry, it was removed from the hatcher and transported in a wooden transport box (29 cm x 24 cm x 14 cm) to an animal holding room, where it was placed in a randomly designated observation box.

Housing/Rearing Conditions. For each experiment, cardboard boxes, measuring 60 cm x 60 cm x 30 cm, were used to house one experimental subject and two broods. Each brood consisted of three stimulus objects. Each box was divided into halves by a clear piece of plexiglass measuring 65 cm x 30 cm. This clear barrier allowed visual contact to be maintained throughout the experiment so that the familiarity component of avian attachment behaviour was

controlled. One half of each box was divided into quarters by a piece of cardboard measuring 30 cm x30 cm.

For the first phase of an experiment (the first period of exposure), an experimental subject was housed in the full half of the box and the two quartered sections each housed a brood of stimulus objects (refer to Figure 2 and Figure 3). For the second phase of an experiment (the second period of exposure), the experimental subjects were separated into two conditions. Condition A had the experimental subjects housed in the full half of the box along with the brood of the other species or breed of stimulus objects. One of the quartered sections housed the second brood of white Peking duckling stimulus objects. The other quartered section remained empty (refer to Figure 4 and Figure 5). Condition B had the experimental subjects housed in the full half of the box with the brood of white Peking duckling stimulus objects and one of the quartered sections housed the second brood of the other species or breed stimulus objects. The other quartered section remained empty (refer to Figure 6 and Figure 7). Food and water was continuously present. Bedding was changed, in the dark, by the experimenter, as needed.

Randomization of Subjects. The experimental subjects were chosen from the middle of the hatch since early and late hatching chicks may be different from other chicks. The experimental chicks and the stimulus objects were randomly assigned to observation boxes using a randomization chart. The boxes were filled with stimulus objects before experimental subjects were assigned. This procedure was followed to ensure that the experimental subjects were given equal visual exposure to both broods of stimulus objects. The placement of stimulus broods alternated in the cardboard boxes to prevent a placement bias. For half the experimental subjects, the brood of domestic chicks was in the right quarter and the brood of white Peking ducklings was in the left quarter. For the second half of the experimental subjects, the brood of domestic

chicks was in the left quarter and the brood of white Peking ducklings was in the right quarter. The experimental subjects were tested in the order of hatch in order to keep exposure time constant. For the second phase of the experiment, the odd numbered boxes had experimental subjects interacting with domestic chicks (Condition A) and the even numbered boxes had experimental subjects interacting with white Peking ducklings (Condition B). Extra ducklings or chicks were housed communally in a Petersime Model 2SD brood unit housed in another room and were used as replacement stimulus objects if designated stimulus objects fell ill or died. The unit consists of 10 compartments, each measuring 100 cm x 70 cm x 24 cm and is made of 1.5 cm mesh. A collection tray allows fecal material to be removed daily. Food and water were continuously present and replenished as needed by the experimenter.

Experimental Subjects. White Peking ducklings served as experimental subjects for each experiment. The animal holding room was maintained at 33.9°C/93° F. All experimental subjects were fed ad libitum a 21% protein non-medicated chick starter obtained from Feed-Rite (17 Speers Road, Winnipeg, Manitoba R2J 1M1).

Stimulus Objects. For each experimental subject, the stimulus objects used were a brood of three white Peking ducklings and either a brood of 3 domestic chicks or a brood of 3 mallard ducklings. The stimulus objects were housed in the same cardboard boxes as the experimental subjects and were subjected to the same routine of feeding, watering and bedding changing.

Apparatus

Experimental Chamber. Experimental subjects were tested in a heat-controlled, sound-attenuated experimental chamber measuring 2.4 m x 2.4 m x 2 m (Shapiro, 1970). Located inside the testing chamber is a 1.5 m² sand-covered table. The sand covered platform is enclosed by a 2.54 cm x 9 cm wooden retaining wall to which 1.0 cm mesh fencing, 9.2 cm high, is attached.

This platform is divided into four equal quadrants by two lines drawn at right angles in the sand in the centre of the apparatus by the experimenter (See Figure 8). A circular 2.5 cm mesh pen (40 cm in diameter x 45 cm high) was located in each of the four corners. Darczewska and Shapiro (1998) have found that ducklings prefer corners. Concave guards (consisting of 1.0 cm, 13 cm high and 24 cm wide) were placed into the corners formed by the retaining wall intersecting with the circular pen. This configuration eliminated corners as a confounding variable. The temperature inside the chamber was maintained at the same temperature as the animal holding room.

Computer Program. A computer system was used to record data compiled within each 15 min trial. Depressing a specified key on the computer's keyboard started the experiment by turning on the lights in the experimental chamber and starting the latency timer. Latency is defined as the time it takes an experimental subject to leave the center of the testing apparatus and to enter one of the four quadrants. The four quadrants correspond to four keys which, when they are depressed, allow the experimenter to record the cumulative time an experimental subject spent in each of the four quadrants. When the experimental subject left the center of the testing platform at the beginning of a trial, the experimenter depressed a computer key corresponding to the quadrant into which the subject moved. Latency time was stopped and the time that the subject spent in the selected quadrant began.

Statistical Analysis

A paired samples t-test is a statistical test used to find out if there is a statistically significant difference between the mean of a sample population and the mean of the sample's total population, and can be used with small sample sizes and for the analysis of simple experimental designs. Four paired sample t-tests were conducted in each phase of the four

experiments. The paired samples t-test was used (1) to analyze the data after the first exposure of the experimental subjects to both sets of stimulus objects to determine if there was a difference between the mean time spent with ducklings or chicks, (2) to analyze the data after the second exposure of the experimental subjects to both the stimulus objects after the subjects interacted with either ducklings or chicks, (3) to analyze the data after the first exposure and after the second exposure of the experimental subjects to the white Peking duckling stimulus objects, and (4) to analyze the data after the first exposure and after the second exposure of the experimental subjects to the domestic chicks/mallard duckling stimulus objects. In these instances the paired samples t-test allows one to see if there is a difference between the mean times spent with either ducklings or chicks and, if so, if the object of the preference changed significantly.

The use of multiple t-tests requires that a familywise alpha be used. Each experiment required four paired sample t-tests, therefore the familywise alpha error is calculated to be $\alpha=0.0125$ ($0.05/4$).

EXPERIMENT 1: WILL INTERACTION CHANGE THE PREFERENCES OF WHITE PEKING DUCKLINGS GIVEN 24 HOURS OF EXPOSURE TO WHITE PEKING DUCKLINGS AND DOMESTIC CHICKS

Hutlet and Shapiro's (2008) finding that domestic chicks lack a preference for their own species provides support for Shapiro's position that the domestic chick is a "cardboard organism" which does not exist in the natural environment and was created by humans to fulfill dietary needs (1980a). He has also suggested that the domestic chick does not have the survival skills that are common to precocial birds (1977). Hutlet and Shapiro's (2008) results would

support Shapiro's position that the domestic chick is a poor subject to use in studies concerning the natural behaviour of precocial birds.

White Peking ducklings have been used as experimental subjects in avian attachment research (Gaioni, 1982; Kirvan & Shapiro, 1972; Rogan & Shapiro, 1972; Shapiro & Agnew, 1975; Shapiro & Garretson, 1978; Smith & Shapiro, 1975; Storey, 1976; Storey & Shapiro, 1972). It is suggested that the white Peking duckling is a more appropriate organism to be used in this type of research. It is hypothesized that when white Peking ducklings are reared in isolation, with visual access to a brood of white Peking ducklings (biologically appropriate) and a brood of domestic chicks (biologically inappropriate), the white Peking ducklings will exhibit a preference for their own species. As previous interaction research, Hindman (1979) indicates this initial predisposition of white Peking ducklings for other white Peking ducklings could be overridden by being allowed to physically interact with another species, in this case domestic chicks. Therefore, when allowed the opportunity to interact with domestic chicks, it was hypothesized that the preference of white Peking ducklings for white Peking ducklings would be replaced by a preference for the organism interacted with, i.e. domestic chicks.

Methods

Subjects

Experimental Subjects. Eighteen white Peking ducklings were obtained in the manner described in the General Methods section. Food and water were replenished after the experimental subjects had been exposed to the stimulus objects for 24 hr and had been tested for their preferences. The experimenter completed this task in the dark to minimize contact between the subjects and the experimenter. Food and water were changed after the first testing to minimize disturbances to the experimental subjects. All ducklings were kept on a continuous 24

hour light cycle, as was done in Hutlet and Shapiro (2008), except when having their food, water, and bedding changed.

Stimulus Objects. Fifty-four white Peking ducklings and 54 domestic chicks were obtained in the manner described in the General Methods section. The stimulus objects were housed in the same animal holding room as the experimental subjects and were subjected to the same routine concerning feeding, watering, bedding changes, and light exposure.

Procedure

Housing. The first phase of this experiment covered the first 24 hour period of visual exposure to a brood of three domestic chicks and a brood of three white Peking ducklings. The experimental subjects (white Peking ducklings) were housed in isolation with visual access to the domestic chicks and to the white Peking ducklings (see Figure 2) for 24 hours. After 24 hours of such visual exposure, the experimental subjects (WP) were tested for a preference for a brood of three domestic chicks, a brood of three white Peking ducklings, or two empty quadrants. The subjects were 24 hours of age. Testing was done in the experimental chamber.

The second phase of this experiment covered the second 24 hour period. Condition A had half of the experimental subjects (WP n=9) housed with a brood of three domestic chicks while maintaining visual access to the brood of white Peking ducklings and an empty quadrant (see Figure 4). Condition B had the other half of the experimental subjects (WP n=9) housed with a brood of three white Peking ducklings while maintaining visual access to the brood of domestic chicks and an empty quadrant (see Figure 6). After this period of exposure, the experimental subjects (WP) were 48 hours of age and they were tested for their preferences: a brood of domestic chicks, a brood of white Peking ducklings, or two empty quadrants. Testing was done in the experimental chamber.

Results

Figure 9 illustrates the latency scores obtained during the first and second testing sessions. Latency is defined as the time it takes a subject to move from the centre of the testing apparatus into any one of the four quadrants. Decades of research in the Avian Behaviour Laboratory, using ducklings and chicks, have provided baseline latency responses. Latency is not typically analyzed but compared to the baseline results to assess the health of the experimental subjects and the biological appropriateness of the stimulus objects. Latency times in this experiment were low, indicating that the subjects were healthy and responded quickly to biologically-appropriate stimulus objects.

Figure 10 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three domestic chicks after an average of 24 hrs (T1) of visual exposure to a brood of three domestic chicks and to a brood of three white Peking ducklings (n=9). A second subsequent assessment was made after a second average of 24 hrs (T2) of visual exposure to the brood of white Peking ducklings while interacting with a brood of domestic chicks (n=9). Figure 10 indicates that there was a preference for white Peking ducklings after the first period of exposure (T1) and after the second period of exposure (T2). The graph indicates that there was no change in preference after the experimental subjects interacted with a brood of three domestic chicks.

The paired samples t-tests (see Table 2) showed that, after an average of 24 hrs of visual exposure to the brood of three domestic chicks and a brood of three white Peking ducklings, there was a statistically significant preference for the time spent with the brood of ducklings ($t = 5.688, p = 0.000$) over the time spent with the brood of chicks. At a second average of 24 hrs of visual exposure to a brood of three white Peking ducklings while interacting with the brood of

domestic chicks, there was a statistically significant preference for the time spent with the brood of ducklings ($t = 5.245, p = 0.001$) over the time spent with the brood of chicks. The time spent with the brood of three white Peking ducklings at both T1 and T2 did not have statistically significantly difference. The time spent with the brood of three domestic chicks at both T1 and T2 did not have statistically significantly difference. SPSS output is found in Appendix A.

Figure 11 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three domestic chicks at T1 with visual exposure to a brood of three domestic chicks and a brood of three white Peking ducklings ($n=9$) and at T2 after visual exposure to the brood of domestic chicks while interacting with the brood of white Peking Ducklings ($n=9$). Figure 11 illustrates that at T1 the brood of white Peking ducklings was preferred over the brood of domestic chicks. At T2, after visual exposure to the brood of domestic chicks while interacting with a brood of white Peking ducklings, the preference for white Peking ducklings increased and the preference for domestic chicks decreased.

The data was analyzed using a paired samples t-test (see Table 3). At an average of 24 hr of visual exposure to the brood of three domestic chicks and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of ducklings or the brood of chicks. At a second average of 24 hr of visual exposure to a brood of three domestic chicks while interacting with the brood of white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of ducklings or the brood of chicks. However, preference for the brood of white Peking ducklings over the brood of domestic chicks approached significance ($t = 3.050, p = 0.016$). The time spent with the brood of three white Peking ducklings at an average of 24 hours and at a second average of 24

hours did not have statistically significantly difference. The time spent with the brood of three domestic chicks at an average of 24 hours and at a second average of 24 hours did not have statistically significantly difference. The original SPSS output is found in Appendix A.

Discussion

It was predicted that Experiment 1 would show a biological preference for white Peking ducklings at T1 (24 hours). That was indeed the case for Condition A and Condition B. After the first period of visual exposure (T1 or 24 hours) to both domestic chicks and white Peking ducklings, Condition A displayed a statistically significant preference for a brood of white Peking ducklings over a brood of domestic chicks (Figure 10, Table 2). Condition B displayed a non-statistically significant preference for a brood of white Peking ducklings over a brood of domestic chicks (Figure 11, Table 3). These results are similar to results found by Bolhuis (1999), Goth and Hauber (2004), and Shapiro (1980a) all of whom concluded that a displayed preference for an organism's own species would increase one's survival.

After the second period of visual exposure (T2 or a second period of 24 hours) it was predicted that interaction would affect initial preferences, i.e. that interacting with a brood of white Peking ducklings would maintain a preference for white Peking ducklings and that interacting with a brood of domestic chicks would decrease a preference for white Peking ducklings and increase a preference for domestic chicks. This was not the case for Condition A. After T2, Condition A displayed a statistically significant preference for a brood of white Peking ducklings over a brood of domestic chicks (Figure 10, Table 2). Figure 10 shows that the preference for a brood of white Peking ducklings or for a brood of domestic chicks changed little from T1 to T2, indicating that interaction with a brood of domestic chicks does not change initial preferences of a white Peking duckling for a brood of white Peking duckling. After T2,

Condition B displayed a non-statistically significant preference for a brood of white Peking ducklings over a brood of domestic chicks (Figure 11, Table3). Figure 11 shows that the preference for a brood of white Peking ducklings increased from T1 to T2 and the preference for a brood of domestic chicks decreased slightly from T1 to T2. These results indicate that interaction with a brood of white Peking ducklings does increase the initial preferences of a white Peking duckling for a brood of white Peking ducklings.

In this experiment there was a small number of subjects, small time frame (two time points), small range of values, high variability and large standard deviations (See Appendix A). As some tests approached significant results, a greater number of subjects would make the statistical tests stronger, decrease variability and standard deviations, and yield more consistent results with greater statistical significance.

EXPERIMENT 2: WILL INTERACTION CHANGE THE PREFERENCES OF WHITE PEKING DUCKLINGS GIVEN ONE WEEK OF EXPOSURE TO WHITE PEKING DUCKLINGS AND DOMESTIC CHICKS

Experiment 1 was found that interacting with stimulus objects had no effect on subsequent preferences. It is possible that the interaction period was not long enough. Hindman (1979) used one week of time to form attachments. Hindman (1979) also suggests avian attachment behaviour can occur outside the ‘critical period’ window of time. In this experiment, a study with a one week interaction period was conducted in order to shed light on this situation.

Methods

Subjects

Experimental Subjects. Sixteen white Peking ducklings were obtained in the manner described in the General Methods section. Food and water were replenished as needed throughout the study. The experimenter completed this task in the dark to minimize contact between the subjects and the experimenter. The ducklings were kept on a 12:12 day-night light cycle.

Stimulus Objects. Forty-eight white Peking ducklings and 48 domestic chicks were obtained in the manner described in the General Methods section. The stimulus objects were housed in the same animal holding room as the experimental subjects and were subjected to the same routine concerning feeding, watering, bedding changes, and light exposure.

Procedure

Housing. The first phase of this experiment covered the seven days of exposure. The experimental subjects (white Peking ducklings) were housed in isolation with visual access to a brood of three domestic chicks and to a brood of three white Peking ducklings (see Figure 2) for seven days of exposure. After one week of such exposure, the experimental subjects (WP) were tested for their preference for a brood of three domestic chicks, a brood of three white Peking ducklings, or two empty quadrants. Testing was done in the experimental chamber. The second phase of this experiment covered the next six days of exposure. Condition A had half of the experimental subjects (WP n=8) housed with a brood of three domestic chicks while maintaining visual access to the brood of white Peking ducklings and an empty quadrant (see Figure 4). Condition B had the other half of experimental subjects (WP n=8) housed with a brood of three white Peking ducklings while maintaining visual access to the brood of domestic chicks and an

empty quadrant (see Figure 6). After a second period of six days of exposure, the experimental subjects (WP) were tested for their preferences for a brood of domestic chicks, a brood of white Peking ducklings or two empty quadrants. Testing was done in the experimental chamber.

Results

Figure 12 illustrates the latency scores obtained during the first and second testing sessions. Latency is defined as the time it takes a subject to move from the centre of the testing apparatus into any one of the four quadrants. Latency times in this experiment were low, indicating that the subjects were healthy and responded quickly to biologically appropriate stimulus objects.

Figure 13 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three domestic chicks after an average of seven days (T1) of visual exposure to a brood of three domestic chicks and to a brood of three white Peking ducklings (n=8), and after a second average of six days (T2) of visual exposure to the brood of white Peking ducklings while interacting with a brood of domestic chicks (n=8). Figure 13 illustrates that at the first average of seven days of visual exposure, the brood of white Peking ducklings was not preferred over the brood of domestic chicks. After the second period of six days of visual exposure to the brood of white Peking ducklings while interacting with a brood of domestic chicks the preference for both white Peking ducklings and domestic chicks increased, however the preference increase was greater for the brood of domestic chicks.

The data was analyzed using a paired samples t-test (see Table 4). At an average of seven days of visual exposure to a brood of three domestic chicks and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the

brood of ducklings or the brood of chicks. At a second average of six days of visual exposure to a brood of three white Peking ducklings while interacting with the brood of domestic chicks, there were no statistically significant preferences for the time spent with either the brood of ducklings or the brood of chicks. The time spent with the brood of three white Peking ducklings at an average of seven days and at a second average of six days did not have a statistically significantly difference. The time spent with the brood of three domestic chicks at an average of seven days and at a second average of six days did not have statistically significantly difference. The original SPSS output is found in Appendix B.

Figure 14 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three domestic chicks after an average of seven days of visual exposure to a brood of three domestic chicks and a brood of three white Peking ducklings ($n=8$) and after a second average of six days of visual exposure to the brood of domestic chicks while interacting with the brood of white Peking Ducklings ($n=8$). Figure 14 illustrates that, at the first average of seven days of visual exposure (T1), the brood of domestic chicks was preferred over the brood of white Peking ducklings. After the second period of six days of visual exposure to the brood of domestic chicks while interacting with a brood of white Peking ducklings (T2), the preference for white Peking ducklings increased slightly and the preference for domestic chicks decreased.

The data was analyzed using a paired samples t-test (see Table 5). At an average of seven days of visual exposure to a brood of three domestic chicks and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of ducklings or the brood of chicks. At a second average of six days of visual exposure to a brood of three domestic chicks while interacting with the brood of white Peking ducklings,

there were no statistically significant preferences for the time spent with either the brood of ducklings or the brood of chicks. The time spent with the brood of three white Peking ducklings at an average of seven days and at a second average of six days did not have a statistically significantly difference. The time spent with the brood of three domestic chicks at an average of seven days and at a second average of six days did not have statistically significantly difference. The original SPSS output is found in Appendix B.

Discussion

It was predicted that Experiment 2 would have results similar to Experiment 1; i.e. that after the first period of exposure (T1 or seven days), the experimental subjects would show a preference for white Peking ducklings. This outcome was not the case for either Condition A or Condition B. After the first period of visual exposure (T1 or seven days) to both domestic chicks and white Peking ducklings, Condition A displayed no preference for a brood of white Peking ducklings or a brood of domestic chicks (Figure 13, Table 4). Condition B displayed a non-statistically significant preference for a brood of domestic chicks over a brood of white Peking ducklings (Figure 14, Table 5). These results are inconsistent with results found by Bolhuis (1999), Goth and Hauber (2004), and Shapiro (1980a) all of whom concluded that a displayed preference for an organism's own species would increase one's survival.

After the second period of visual exposure (T2 or a second period six days) it was predicted that interaction would affect initial preferences, i.e. that interacting with a brood of white Peking ducklings would maintain a preference for white Peking ducklings and that interacting with a brood of domestic chicks would decrease a preference for white Peking ducklings and increase a preference for domestic chicks. This was the case for Condition A. After T2, Condition A displayed a non-statistically significant preference for a brood of domestic

chicks over a brood of white Peking ducklings (Figure 13, Table 4). Figure 13 shows that the preference for a brood of domestic chicks increased from T1 to T2, indicating that interaction with a brood of domestic chicks does change the initial lack of preferences of a white Peking duckling. After T2, Condition B displayed a non-statistically significant preference for a brood of domestic chicks over a brood of white Peking ducklings (Figure 14, Table 5). Figure 14 also shows a non-significant decrease in preference for a brood of domestic chicks and a corresponding non-significant increase in preference for a brood of white Peking ducklings from T1 to T2. These results indicate that interaction with a brood of white Peking ducklings does increase the initial preferences of a white Peking duckling for a brood of white Peking ducklings, and decreases the initial preference for a brood of domestic chicks. These results are similar to Hindman's (1979) research which indicated that the initial preference of an organism can change after interacting with another species. The results of Condition B at T2 are consistent with Experiment 1 Condition B.

In this experiment there was a small number of subjects, small time frame (two time points), small range of values, high variability and large standard deviations (See Appendix B). As some tests approached significant results, a greater number of subjects would make the statistical tests stronger, decrease variability and standard deviations, and yield more consistent results with greater statistical significance.

EXPERIMENT 3: WILL INTERACTION CHANGE THE PREFERENCES OF WHITE PEKING DUCKLINGS GIVEN 24 HOURS OF EXPOSURE TO WHITE PEKING DUCKLINGS AND MALLARD DUCKLINGS

Domestic chicks are the same colour as white Peking ducklings but are physically different in body shape and beak shape. Using mallard ducklings may control the potentially confounding factor of body shape and beak shape. In the case of the Hindman (1979) study, the domestic chicks in the control group may have preferred their own species over guinea pigs because guinea pigs lack a distinct head and neck region. Goth and Hauber (2004) found that domestic chicks prefer robotic chicks that peck the ground over robotic chicks that sway back and forth. These results suggest that pecking behaviour may elicit an approach response in the domestic chick because the pecking behavior indicates a possible food source. Similarly, the difference in body shape and beak shape between chicks and white Peking ducklings may account for an approach or withdrawal response in white Peking ducklings.

Methods

Subjects

Experimental Subjects. Nine white Peking ducklings were obtained in the manner described in the General Methods section. Food and water were replenished after the experimental subjects had been exposed to the stimulus objects for 24 hr and had been tested for their preferences. The experimenter completed this task in the dark to minimize contact between the subjects and the experimenter. Food and water were changed after the first testing to minimize disturbances to the experimental subjects. All ducklings were kept on a continuous 24 hour light cycle, except for having their food and water replenished and their bedding changed.

Stimulus Objects. Twenty-seven white Peking ducklings and 27 mallard ducklings were obtained in the manner described in the General Method section. The stimulus objects were housed in the same animal holding room as the experimental subjects and were subjected to the same routine concerning feeding, watering, bedding changes, and light exposure.

Procedure

Housing. The first phase of this experiment covered the first 24 hour period of visual exposure to a brood of three mallard ducklings and a brood of three white Peking ducklings. The experimental subjects (white Peking ducklings) were housed in isolation with visual access to the mallard ducklings and to the white Peking ducklings (see Figure 3) for 24 hours. After 24 hours of such visual exposure, the experimental subjects (WP) were tested for a preference for a brood of three mallard ducklings, a brood of three white Peking ducklings, or two empty quadrants. The subjects were 24 hours of age. Testing was done in the experimental chamber. The second phase of this experiment covered the second 24 hour period. Condition A had half of the experimental subjects (WP) housed with a brood of three mallard ducklings while maintaining visual access to the brood of white Peking ducklings and an empty quadrant (see Figure 5). Condition B had the other half of the experimental subjects (WP) housed with a brood of three white Peking ducklings while maintaining visual access to the brood of mallard ducklings and an empty quadrant (see Figure 7). After this second period of exposure, the experimental subjects (WP) were 48 hours of age and they were tested for their preferences for a brood of mallard ducklings, for a brood of white Peking ducklings, or two empty quadrants. Testing was done in the experimental chamber.

Results

Figure 15 illustrates the latency scores obtained during the first and second testing sessions. Latency times in this experiment were low, indicating that the subjects were healthy and responded quickly to biologically appropriate stimulus objects.

Figure 16 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three mallard ducklings after an average of 24 hrs of visual exposure to the brood of three mallard ducklings and to a brood of three white Peking ducklings (n=5) and after a second average of 24 hrs of visual exposure to the brood of white Peking ducklings while interacting with a brood of mallard ducklings (n=5). Figure 16 illustrates that at the first average of 24 hr of visual exposure (T1), the brood of mallard ducklings was preferred over the brood of white Peking ducklings. After the second period of 24 hrs of visual exposure to the brood of white Peking ducklings while interacting with a brood of mallard ducklings (T2), the preference for white Peking ducklings increased and the preference for mallard ducklings decreased slightly.

The data was analyzed using a paired samples t-test (see Table 6). At an average of 24 hr of visual exposure to the brood of three mallard ducklings and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. However the preference for the brood of mallard ducklings over the brood of white Peking ducklings approached significance ($t = 2.449, p = 0.070$). At a second average of 24 hours of visual exposure to a brood of three white Peking ducklings while interacting with the brood of mallards, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. The time spent with the brood of three white Peking ducklings at an average

of 24 hours and at a second average of 24 hours did not have statistically significantly difference. The time spent with the brood of three mallards at an average of 24 hours and at a second average of 24 hours did not have a statistically significantly difference. SPSS output is found in Appendix C.

Figure 17 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three mallard ducklings after an average of 24 hrs of visual exposure to a brood of three mallard ducklings and a brood of three white Peking ducklings ($n=4$) and after a second average of 24 hrs of visual exposure to the brood of mallard ducklings while interacting with the brood of white Peking Ducklings ($n=4$). Figure 17 illustrates that at the first average of 24 hr of visual exposure (T1), the brood of mallard ducklings was preferred over the brood of white Peking ducklings. After the second period of 24 hr of visual exposure to the brood of mallard ducklings while interacting with a brood of white Peking ducklings (T2), the preference for white Peking ducklings increased and the preference for mallard ducklings decreased.

The data was analyzed using a paired samples t-test (see Table 7). At an average of 24 hr of visual exposure to the brood of three mallard ducklings and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. At a second average of 24 hours of visual exposure to a brood of three mallard ducklings while interacting with the brood of white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. However, preference for the brood white Peking ducklings approached significance ($t = -2.525, p = 0.086$). The time spent with the brood of three white Peking ducklings at an average of 24 hours and at a second average of 24

hours did not have statistically significantly difference. The time spent with the brood of three mallards at an average of 24 hours and at a second average of 24 hours did not have statistically significantly difference, however the decrease in preference approached significance ($t = 2.871$, $p = 0.064$). The original SPSS output is found in Appendix C.

Discussion

It was predicted that Experiment 3 would have results similar to Experiment 1; i.e. that after the first period of exposure (T1 or 24 hours), the experimental subjects would show a preference for white Peking ducklings. This outcome was not the case for either Condition A or Condition B. After the first period of visual exposure (T1 or 24 hours) to both mallard ducklings and white Peking ducklings, both Condition A and Condition B displayed a non-statistically significant preference for a brood of mallard ducklings or a brood of white Peking ducklings (Figure 16, Figure 17, Table 6, and Table 7). These results are inconsistent with Experiment 1 but are consistent with Experiment 2. As the white Peking duckling is the domestic counterpart of the Mallard duckling, these results are consistent with results found by Bolhuis (1999), Goth and Hauber (2004), and Shapiro (1980a) all of whom concluded that a displayed preference for an organism's own species would increase one's survival.

After the second period of visual exposure (T2 or a second 24 hours) it was predicted that interaction would affect initial preferences, i.e. that interacting with a brood of white Peking ducklings would maintain a preference for white Peking ducklings and that interacting with a brood of mallard ducklings would decrease a preference for white Peking ducklings and increase a preference for mallard ducklings. This was the case for Condition A. After T2, Condition A displayed a non-statistically significant preference for a brood of mallard ducklings over a brood of white Peking ducklings (Figure 16, Table 6). Figure 16 shows that the preference for a brood

of mallard ducklings decreased slightly and the preference for a brood of white Peking ducklings increased from T1 to T2. These results indicate that interaction with a brood of mallard ducklings does not change the initial preferences of a white Peking duckling for a brood of mallard ducklings; however, interaction with mallard ducklings changes the initial lack of preference for a white Peking duckling for a brood of white Peking ducklings. After T2, Condition B displayed a non-statistically significant preference for a brood of white Peking ducklings over a brood of mallard ducklings (Figure 17, Table 6). Figure 17 shows non-significant increase in preference for a brood of mallard ducklings and a corresponding non-significant decrease in preference for a brood of white Peking ducklings from T1 to T2. These results indicate a complete reversal of preference after interaction. These results are similar to Hindman's (1979) research which indicated that the initial preference of an organism can change after interacting with another species. Condition B at T2 results are consistent with Experiment 1 Condition B at T2 and Experiment 2 Condition B at T2.

In this experiment there was a small number of subjects, small time frame (two time points), small range of values, high variability and large standard deviations (See Appendix C). As some tests approached significant results, a greater number of subjects would make the statistical tests stronger, decrease variability and standard deviations, and yield more consistent results with greater statistical significance.

EXPERIMENT 4: WILL INTERACTION CHANGE THE PREFERENCES OF WHITE PEKING DUCKLINGS GIVEN ONE WEEK OF EXPOSURE TO WHITE PEKING DUCKLINGS AND MALLARD DUCKLINGS

Experiment 3 found that interacting with stimulus objects reversed the subjects' original preference but not to a statistically significant degree. A study with a longer exposure time may enhance such an effect. Hindman (1979) used one week of time to form attachments. Hindman (1979) suggests avian attachment behaviour can occur outside the 'critical period' window of time. Domestic chicks are the same colour as white Peking ducklings but are physically different in body shape and beak shape. Using mallard ducklings in this study may control for the potentially confounding factor of body shape and beak shape and enhance the effect found in Experiment 3. In this study a one week period of interaction was allowed between the experimental subjects (WP) and the stimulus objects (mallard ducklings or white Peking ducklings).

Methods

Subjects

Experimental Subjects. Sixteen white Peking ducklings were obtained in the manner described in the General Method section. Food and water were replenished as needed throughout the study. The experimenter completed this task in the dark to minimize contact between the subjects and the experimenter. The ducklings were kept on a 12:12 day-night light cycle. The experimental subjects were tested in two different time groups due to availability of hatch.

Stimulus Objects. Forty-eight white Peking ducklings and 48 domestic chicks were obtained in the manner described in the General Method section. The stimulus objects were housed in the same animal holding room as the experimental subjects and were subjected to the same regulations concerning feeding, watering, bedding changing, and light exposure.

Procedure

Housing. The first phase of this experiment covered the first seven days exposure. The experimental subjects (white Peking ducklings) were housed in isolation with visual access to a brood of three mallard ducklings and to a brood of three white Peking ducklings (see Figure 3) for seven days of exposure. After seven days of such exposure, the experimental subjects (WP) were tested for their preference for a brood of three mallard ducklings, a brood of three white Peking ducklings, or two empty quadrants. Testing was done in the experimental chamber. The second phase of this experiment covered the next four days of exposure. Condition A had half of the experimental subjects (WP) housed with a brood of three mallard ducklings while maintaining visual access to the brood of white Peking ducklings and an empty quadrant (see Figure 5). Condition B had the other half of experimental subjects (WP) housed with a brood of three white Peking ducklings while maintaining visual access to the brood of mallard ducklings and an empty quadrant (see Figure 7). After a second period of four days of exposure, the experimental subjects (WP) were tested for their preferences for a brood of mallard ducklings, a brood of white Peking ducklings or two empty quadrants. Testing was done in the experimental chamber.

Results

Figure 18 illustrates the latency scores obtained during the first and second testing sessions. Latency times in this experiment were low, indicating that the subjects were healthy and responded quickly to biologically appropriate stimulus objects.

Figure 19 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three mallard ducklings after an average of seven days of visual exposure to a brood of three mallard ducklings and to a brood of three white Peking ducklings (n=8) and after a second average of four days of visual exposure to the brood of white Peking ducklings while interacting with a brood of mallard ducklings (n=8). Figure 19 illustrates that, after the first average of seven days of visual exposure (T1), the brood of white Peking ducklings was preferred slightly over the brood of mallard ducklings. After the second period of four days of visual exposure to the brood of white Peking ducklings while interacting with a brood of mallard ducklings (T2), the preference for white Peking ducklings decreased slightly and the preference for mallard ducklings decreased slightly.

The data was analyzed using a paired samples t-test (see Table 8). At an average of seven days of visual exposure to the brood of three mallard ducklings and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. At a second average of four days of visual exposure to a brood of three white Peking ducklings while interacting with the brood of mallards, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. The time spent with the brood of three white Peking ducklings at an average of seven days and at a second average of 4 days did not have statistically significantly difference. The time spent with the brood of three mallards at an

average of seven days and at a second average of four days did not have statistically significantly difference. SPSS output is found in Appendix D.

Figure 20 illustrates the mean time (minutes) that the experimental subjects spent with a brood of three white Peking ducklings or a brood of three mallard ducklings after an average of seven days of visual exposure to a brood of three mallard ducklings and a brood of three white Peking ducklings (n=8) and after a second average of four days of visual exposure to the brood of mallard ducklings while interacting with the brood of white Peking Ducklings (n=8). Figure 20 illustrates that at the first average of seven days of visual exposure (T1), the brood of mallard ducklings was preferred over the brood of white Peking ducklings. After the second period of four days of visual exposure to the brood of mallard ducklings while interacting with a brood of white Peking ducklings (T2), the preference for white Peking ducklings increased and the preference for mallard ducklings decreased.

The data was analyzed using a paired samples t-test (see Table 9). At an average of seven days of visual exposure to the brood of three mallard ducklings and a brood of three white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. At a second average of four days of visual exposure to a brood of three mallard ducklings while interacting with a brood of white Peking ducklings, there were no statistically significant preferences for the time spent with either the brood of mallards or the brood of white Peking ducklings. The time spent with the brood of three white Peking ducklings at an average of seven days and at a second average of four days did not have a statistically significantly difference. Similarly, the time spent with the brood of three mallards at an average of seven days and at a second average of four days did not have a statistically significantly difference. The original SPSS output is found in Appendix D.

Discussion

It was predicted that Experiment 4 would have results similar to Experiment 1; i.e. that after the first period of exposure (T1 or seven days), the experimental subjects would show a preference for white Peking ducklings. This outcome was the case for Condition A. After the first period of visual exposure (T1 or seven days) to both mallard ducklings and white Peking ducklings, Condition A displayed a non-statistically significant preference for a brood of white Peking ducklings over a brood of mallard ducklings (Figure 19, Table 8). These results are consistent with Experiment 1 but are inconsistent with Experiment 2 and Experiment 3. Condition B displayed a non-statistically significant preference for a brood of mallard ducklings over a brood of mallard ducklings (Figure 20, Table 9). These results are inconsistent with Experiment 1 but are consistent with Experiment 2 and Experiment 3. As the white Peking duckling is the domestic counterpart of the Mallard duckling, these seemingly conflicting results are consistent with results found by Bolhuis (1999), Goth and Hauber (2004), and Shapiro (1980a) all of whom concluded that a displayed preference for an organism's own species would increase one's survival.

After the second period of visual exposure (T2 or a second four days) it was predicted that interaction would affect initial preferences, i.e. that interacting with a brood of white Peking ducklings would maintain a preference for white Peking ducklings and that interacting with a brood of mallard ducklings would decrease a preference for white Peking ducklings and increase a preference for mallard ducklings. This was the case for Condition A. After T2, Condition A displayed a non-statistically significant preference for a brood of white Peking ducklings over a brood of mallard ducklings (Figure 19, Table 8). Figure 19 shows that the preference for a brood of mallard ducklings decreased slightly and the preference for a brood of white Peking ducklings

also decreased from T1 to T2. These results indicate that interaction with a brood of mallard ducklings does decrease the initial preferences of a white Peking duckling for a brood of white Peking ducklings and for a brood of mallard ducklings. These results are inconsistent with all other experiments. After T2, Condition B displayed a non-statistically significant preference for a brood of white Peking ducklings over a brood of mallard ducklings (Figure 20, Table 9). Figure 20 shows non-significant increase in preference for a brood of white Peking ducklings and a corresponding non-significant decrease in preference for a brood of mallard ducklings from T1 to T2. These results indicate a complete reversal of preference after interaction. These results are similar to Hindman's (1979) research which indicated that the initial preference of an organism can change after interacting with another species. Condition B at T2 results are consistent with Experiment 1 Condition B at T2 and Experiment 2 Condition B at T2 and Experiment 3 Condition B at T2.

In this experiment there was a small number of subjects, small time frame (two time points), small range of values, high variability and large standard deviations (See Appendix D). As some tests approached significant results, a greater number of subjects would make the statistical tests stronger, decrease variability and standard deviations, and yield more consistent results with greater statistical significance.

GENERAL DISCUSSION

The purpose of the current set of experiments was to investigate the interaction component of avian attachment behaviour. In these experiments, the visual, brood size, animate vs. inanimate, and familiarity components of avian attachment behaviour were held constant so that the effects of interaction were evaluated unambiguously. Each experiment looked at preferences of domestic chicks/mallard ducklings versus white Peking ducklings at T1, preferences of domestic chicks/mallard ducklings versus white Peking ducklings at T2, the change of preference for domestic chicks/mallard ducklings at T1 and T2, and the change of preference for white Peking ducklings at T1 and T2.

The First Period of Visual Exposure (T1)

It was predicted that all experiments would show a biological preference for white Peking ducklings at T1. Overwhelmingly, this was not the case. Experiment 1 (Condition A and Condition B) displayed a statistically significant preference for a brood of white Peking ducklings and Experiment 4 (Condition A) displayed a non-statistically significant preference for a brood of white Peking ducklings at the first period of visual exposure (T1). These results are consistent with results found by Bolhuis (1999), Goth and Hauber (2004), and Shapiro (1980a) who concluded that a displayed preference for an organism's own species would increase one's survival.

Experiment 2 (Condition A and Condition B), Experiment 3 (Condition A and Condition B), and Experiment 4 (Condition B) displayed a non-statistically significant preference for the other brood of species/breed (domestic chicks or mallard ducklings) at the first period of visual exposure (T1). These results are consistent with familiarity research by research by Cairns (1966), Deng and Rogers (2002), Einsiedel Jr. (1975), Ryan and Lea (1989), and Vallortigara

and Andrew (1994) who found that the more familiar an organism/object is, the more it is preferred. This does not explain, however, why the two brood of stimulus objects were not preferred equally at the first period of visual exposure. The white Peking ducklings, used in Experiment 3 and Experiment 4, are the domestic counterpart of the mallard duckling. This may explain the results found in this first period of visual exposure – either there was not enough genetic variability to distinguish the mallard duckling as a separate breed or the subjects were not sexually mature and did not need to distinguish one subject from the other on the basis of reproductive requirements but on survival requirements.

Condition A: Interaction with the other species/breed (T2)

It was predicted that all experiments would show an increase in preference for other species/breed after interacting with that species/breed at T2. The four experiments yielded various results. In Experiment 1, the significant preference for a brood of white Peking ducklings over a brood of domestic chicks remained the same. These results are consistent with the experiment by Hutlet and Shapiro (2008) who also found no change in preference. In Experiment 2, the non-statistically significant preference for a brood of domestic chicks increased and the non-statistically significant preference for a brood of white Peking ducklings also increased. These results partially support the research hypothesis and are consistent with experiments done by Hindman (1979), Maple and Westlund (1977), and Mason and Kenny (1974) who all found that interaction with another species/breed increased preference for that other species/breed. In Experiment 3 the non-statistically significant preferences for a brood of mallard ducklings decreased while the non-statistically significant preference for a brood of white Peking ducklings increased, while in Experiment 4, the non-statistically significant preference for a brood of mallard ducklings decreased and the non-statistically significant preference for a brood of white

Peking ducklings decreased. No other literature source cited a decrease in preference after interaction.

Condition B: Interaction with same species/breed (T2)

It was predicted that all experiments would show maintenance or an increase in preference for white Peking ducklings after interacting with white Peking ducklings at T2. The results of all four experiments yielded consistent results. When experimental subjects interacted with their white Peking duckling, the non-statistically significant preference for white Peking ducklings maintained or increased while the non-statistically significant preference for the other species/breed (domestic chicks or mallard ducklings) decreased. In Experiment 3 and Experiment 4, Figures 17 and 20 show a complete reversal of preference from T1 to T2. These results are consistent with all interaction research (Hindman, 1979; Maple & Westlund, 1977; Mason & Kenny, 1974). These results, however, are particularly consistent with Hindman's (1979) research with domestic chicks and guinea pigs. Hindman (1979) showed a reversal of preferences from their first companion to their second companion. The results of these experiments indicate that interaction appears to be a confounding variable only when white Peking ducklings are interacting with white Peking ducklings.

There are several possible explanations for the variety of results for Condition A and for the lack of statistical significance in all four experiments. First, the Duff Roblin Building, at the University of Manitoba, was subject to a massive fire in March, 2009. The upper levels of the building were closed for over a year and were under construction for most of that time. The environmental conditions in the building were not ideal, and may have affected the behaviour of the subjects. While all subjects were exposed to the same noise and disturbance, the noise may have differentially influenced how the subjects reacted. Second, there were problems with the

cardboard boxes. The two week exposure experiments (Experiment 2 and Experiment 4) were ended early due to an oversaturation of water in the cardboard boxes. The oversaturation of water degraded the integrity of the housing, the experiments were ended early to prevent the experimental subjects from interacting with the brood they were to only have visual exposure. Third, the alternative stimulus objects offered to the experimental subjects may not have been sufficiently different to elicit a preference. The alternatives offered to the experimental subjects all provided movement, warmth, contact, sound, and were not threatening. These factors may have minimized presumed differences among the stimulus objects. All other studies used different types of organisms as stimulus objects. These experiments may have unintentionally minimized differences between the stimulus objects used. This situation may have made the stimulus objects too similar. Fourth, this study utilized domestic birds as experimental subjects. Domesticated birds may not display behavioural characteristics that are needed for survival in the wild. Wild species, under similar circumstances, may display a difference in initial preference. Fifth, for all experiments, there was a small number of subjects, small time frame (two time points), small range of values, high variability and large standard deviations (See Appendix A, B, C, D). As some experiments approached significant results, a greater number of subjects would make the statistical tests stronger, yielding more consistent results with greater statistical significance.

Results support the importance of interaction. Condition B (in all four experiments) shows that interaction affects preference for white Peking ducklings when they interact with other white Peking ducklings. Under the conditions imposed upon the subjects in these experiments, however, it is not possible to conclude, one way or the other, just how important or unimportant interaction is.

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Table 1
Developmental differences between categories of birds from superprecocial to altricial

| Conditions at Hatch | 1 | 2 | 3 | 4 | 5 | Examples |
|---------------------|-----|-----|------|------|-----|---------------------------------|
| Superprecocial | Yes | Yes | Yes | No | No | Megapodes |
| Precocial 1 | Yes | Yes | Yes | No | Yes | Ducks, Shorebirds |
| Precocial 2 | Yes | Yes | Yes | No | Yes | Quail, Grouse, Murrelets |
| Subprecocial | Yes | Yes | Yes | Some | Yes | Grebs, rails, cranes |
| Semiprecocial | Yes | Yes | Some | Yes | Yes | Gulls, terns, petrels, penguins |
| Semialtricial 1 | Yes | Yes | No | Yes | Yes | Hawks, Herons |
| Semialtricial 2 | Yes | No | No | Yes | Yes | Owls |
| Altricial | No | No | No | Yes | Yes | Passerines, Woodpeckers |

Note. Numbers represent the physical state of the hatchling and the presence and influence of parents (1 = *presence of down*, 2 = *eyes open*, 3 = *ambulatory*, 4 = *parents feeding*, 5 = *parents attend [brood, etc.]*). From *Ornithology*, by F. Gill, 1990, pp. 378. New York: W. H. Freeman.

Table 2

Experiment 1: Paired Samples t-test to Assess Preferences at an Average of 24-hours of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Domestic Chicks and After a Second Average of 24-hours of Visual Exposure to a Brood of White Peking Ducklings While Interacting with a Brood of Domestic Chicks (n=9)

| Comparison Group | Mean | Std Dev | Std Error | t | df | sig (2- |
|-------------------|---------|---------|-----------|-------|----|---------|
| | | | Mean | | | tailed) |
| T1Ducks-T1Chicks | 679.778 | 358.554 | 119.518 | 5.688 | 8 | 0 |
| T2Ducks-T2Chicks | 677.556 | 387.574 | 129.191 | 5.245 | 8 | 0.001 |
| T1Ducks-T2Ducks | 3.333 | 574.627 | 191.542 | 0.017 | 8 | 0.987 |
| T1Chicks-T2Chicks | 1.111 | 5.819 | 1.94 | 0.573 | 8 | 0.582 |

Table 3

Experiment 1: Paired Samples t-test to Assess Preferences an Average of 24-hours of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Domestic Chicks and After a Second Average of 24-hours of Visual Exposure to a Brood of Domestic Chicks While Interacting with a Brood of White Peking Ducklings (n=9)

| Comparison Group | Mean | Std Dev | Std Error | t | df | sig (2-tailed) |
|-------------------|----------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Ducks-T1Chicks | 306.222 | 633.575 | 211.192 | 1.45 | 8 | 0.185 |
| T2Ducks-T2Chicks | 591.778 | 582.114 | 194.038 | 3.05 | 8 | 0.016 |
| T1Ducks-T2Ducks | -196.556 | 510.386 | 170.129 | -1.155 | 8 | 0.281 |
| T1Chicks-T2Chicks | 89 | 495.097 | 165.032 | 0.539 | 8 | 0.604 |

Table 4

Experiment 2: Paired Samples t-test to Assess Preferences at an Average Seven Days of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Domestic Chicks and After a Second Average of Six Days of Visual Exposure to a Brood of White Peking Ducklings While Interacting with a Brood of Domestic Chicks (n=8)

| Comparison Group | Mean | Std Dev | Std Error | t | df | sig (2-tailed) |
|-------------------|---------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Ducks-T1Chicks | 16.750 | 618.744 | 218.759 | 0.077 | 7 | 0.941 |
| T2Ducks-T2Chicks | 63.750 | 874.734 | 309.265 | 0.206 | 7 | 0.843 |
| T1Ducks-T2Ducks | -82.625 | 335.580 | 118.646 | -0.696 | 7 | 0.509 |
| T1Chicks-T2Chicks | -35.625 | 471.636 | 166.748 | -0.214 | 7 | 0.837 |

Table 5

Experiment 2: Paired Samples t-test to Assess Preferences at an Average Seven Days of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Domestic Chicks and After a Second Average of Six Days of Visual Exposure to a Brood of Domestic Chicks While Interacting with a Brood of White Peking Ducklings (n=8)

| Comparison Group | Mean | Std Dev | Std Error | t | df | sig (2-tailed) |
|-------------------|---------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Ducks-T1Chicks | 278.625 | 632.064 | 223.468 | 1.247 | 7 | 0.253 |
| T2Ducks-T2Chicks | 165.125 | 672.639 | 237.814 | 0.694 | 7 | 0.510 |
| T1Ducks-T2Ducks | 101.000 | 195.315 | 69.054 | 1.463 | 7 | 0.187 |
| T1Chicks-T2Chicks | -12.500 | 347.030 | 122.694 | -0.102 | 7 | 0.922 |

Table 6

Experiment 3: Paired Samples t-test to Assess Preferences at an Average of 24-hours of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Mallards and After a Second Average of 24-hours of Visual Exposure to a Brood of White Peking Ducklings While Interacting with a Brood of Mallards (n=5)

| Comparison Group | Mean | Std Dev | Std Error | T | df | sig (2-tailed) |
|------------------------|----------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Mallards-T1WPs | 536.200 | 489.482 | 218.903 | 2.449 | 4 | 0.070 |
| T2Mallards -T2WPs | 290.200 | 763.318 | 341.366 | 0.850 | 4 | 0.443 |
| T1Mallards -T2Mallards | 31.200 | 622.075 | 278.200 | 0.112 | 4 | 0.916 |
| T1WPs -T2WPs | -214.800 | 384.358 | 171.890 | -1.250 | 4 | 0.280 |

Table 7

Experiment 3: Paired Samples t-test to Assess Preferences at an Average of 24-hours of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Mallards and After a Second Average of 24-hours of Visual Exposure to a Brood of Mallards While Interacting with a Brood of White Peking Ducklings (n=4)

| Comparison Group | Mean | Std Dev | Std Error | T | df | sig (2-tailed) |
|------------------------|----------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Mallards-T1WPs | 254.250 | 769.088 | 384.544 | 0.661 | 3 | 0.556 |
| T2Mallards -T2WPs | -545.250 | 431.964 | 215.982 | -2.525 | 3 | 0.086 |
| T1Mallards -T2Mallards | 544.000 | 378.966 | 189.483 | 2.871 | 3 | 0.064 |
| T1WPs -T2WPs | -255.500 | 644.626 | 322.313 | -0.793 | 3 | 0.486 |

Table 8

Experiment 4: Paired Samples t-test to Assess Preferences at an Average Seven days of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Mallards and After a Second Average of Four Days of Visual Exposure to a Brood of White Peking Ducklings While Interacting with a Brood of Mallards (n=8)

| Comparison Group | Mean | Std Dev | Std Error | T | df | sig (2-tailed) |
|------------------------|---------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Mallards-T1WPs | -68.000 | 732.878 | 259.111 | -0.262 | 7 | 0.801 |
| T2Mallards -T2WPs | -36.625 | 721.266 | 255.006 | -0.144 | 7 | 0.890 |
| T1Mallards -T2Mallards | 46.875 | 636.904 | 255.180 | 0.208 | 7 | 0.841 |
| T1WPs -T2WPs | 78.250 | 632.604 | 223.659 | 0.350 | 7 | 0.737 |

Table 9

Experiment 4: Paired Samples t-test to Assess Preferences at an Average Seven days of Visual Exposure to a Brood of White Peking Ducklings and a Brood of Mallards and After a Second Average of Four Days of Visual Exposure to a Brood of Mallards While Interacting with a Brood of White Peking Ducklings (n=8)

| Comparison Group | Mean | Std Dev | Std Error | T | df | sig (2-tailed) |
|------------------------|----------|---------|-----------|--------|----|----------------|
| | | | Mean | | | |
| T1Mallards-T1WPs | 167.625 | 506.301 | 179.004 | 0.936 | 7 | 0.380 |
| T2Mallards -T2WPs | -331.250 | 667.892 | 236.135 | -1.403 | 7 | 0.203 |
| T1Mallards -T2Mallards | 189.125 | 477.618 | 168.863 | 1.120 | 7 | 0.300 |
| T1WPs -T2WPs | -309.750 | 505.286 | 178.645 | -1.734 | 7 | 0.127 |

Figure 1. Hypothetical representation of some of the factors attending the formation of an attachment with and without a parent present.

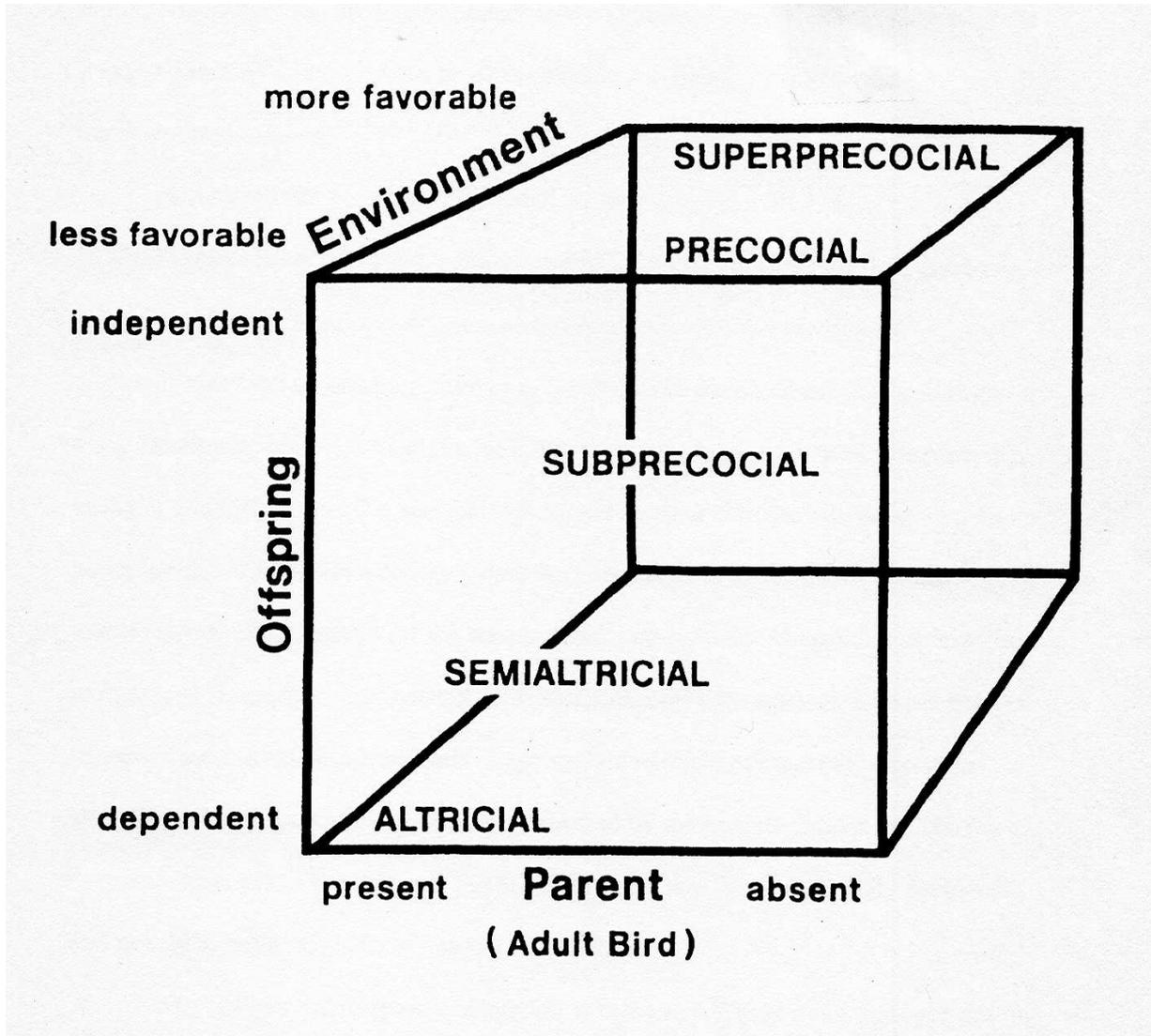


Figure 2. Top down visual of Phase 1 of Experiments 1 and 2.

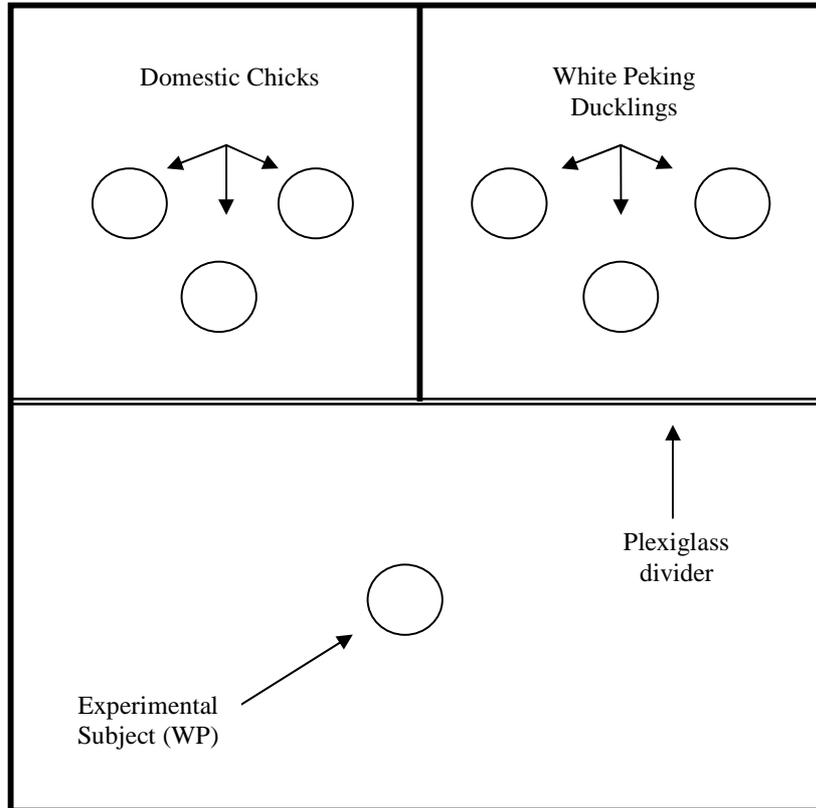


Figure 3. Top down visual of Phase One of Experiments 3 and 4.

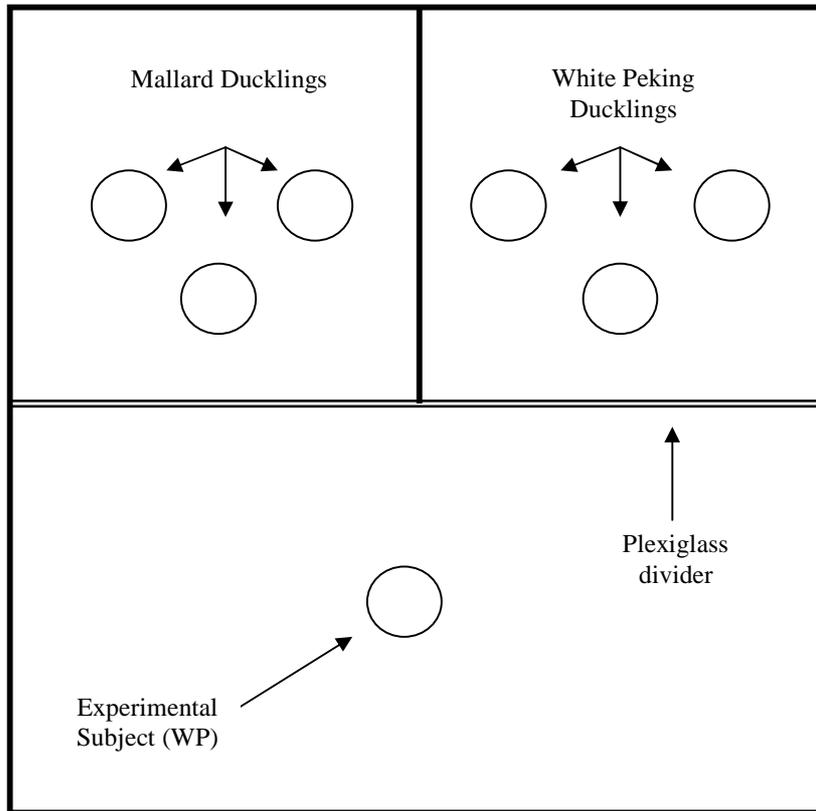


Figure 4. Top down visual of Phase Two of Experiments 1 and 2: Condition A (experimental subjects [WP] interacting with domestic chicks).

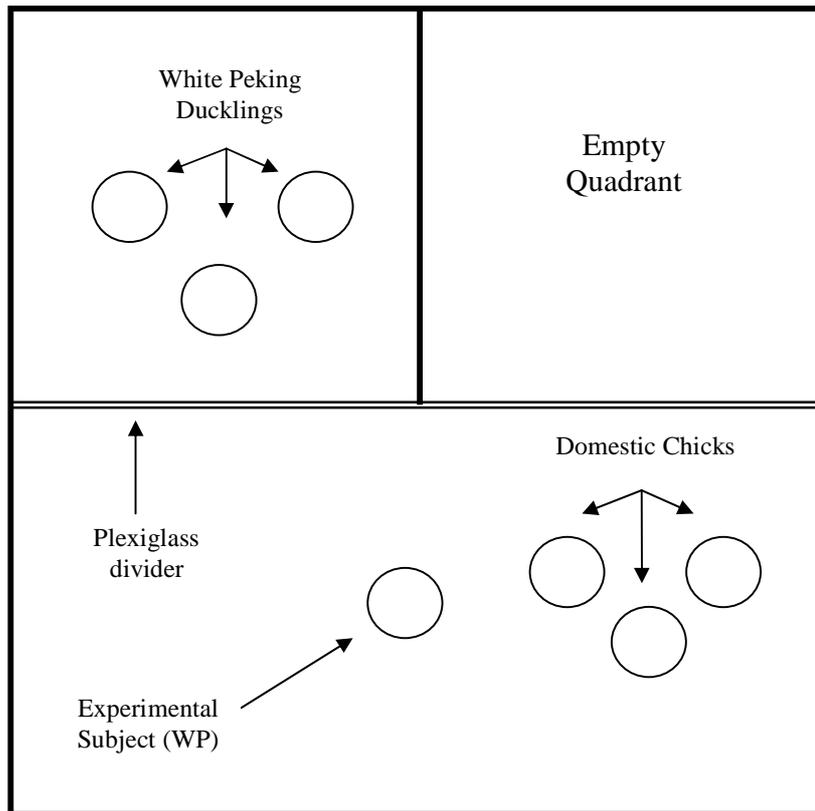


Figure 5. Top down visual of Phase Two of Experiments 3 and 4: Condition A (experimental subjects [WP] interacting with mallard ducklings).

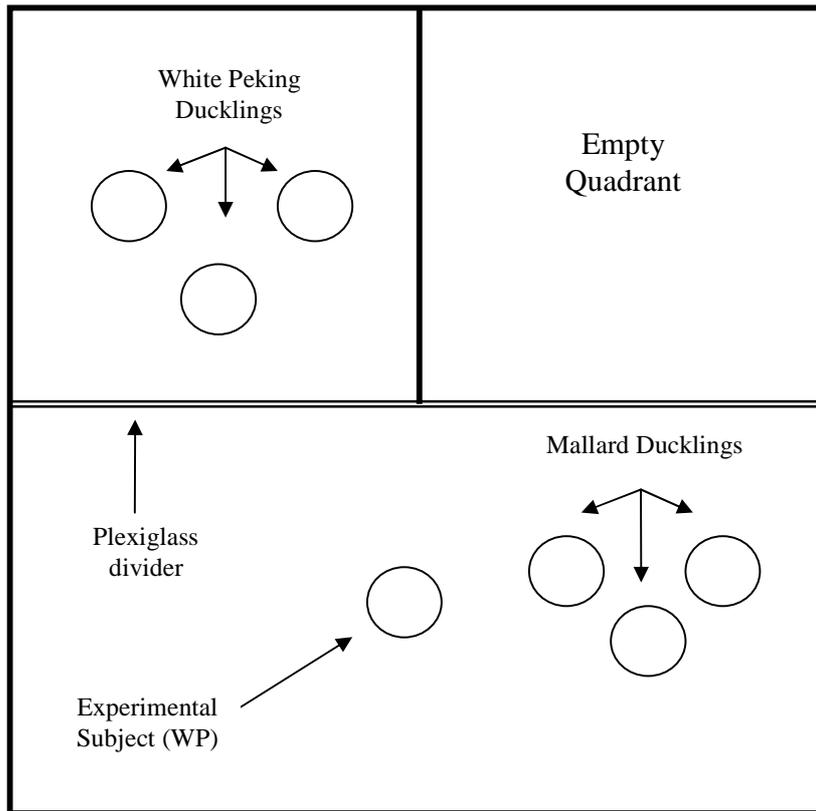


Figure 6. Top down visual of Phase Two of Experiments 1 and 2: Condition B (experimental subjects [WP] interacting with white Peking ducklings).

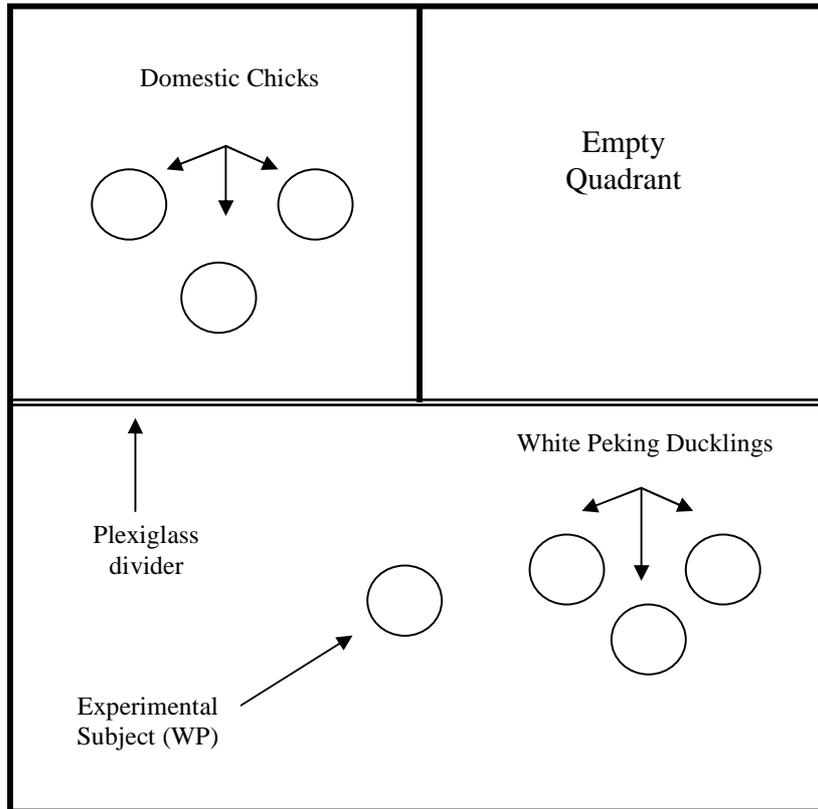


Figure 7. Top down visual of Phase Two of Experiments 3 and 4: Condition B (experimental subjects [WP] interacting with white Peking ducklings).

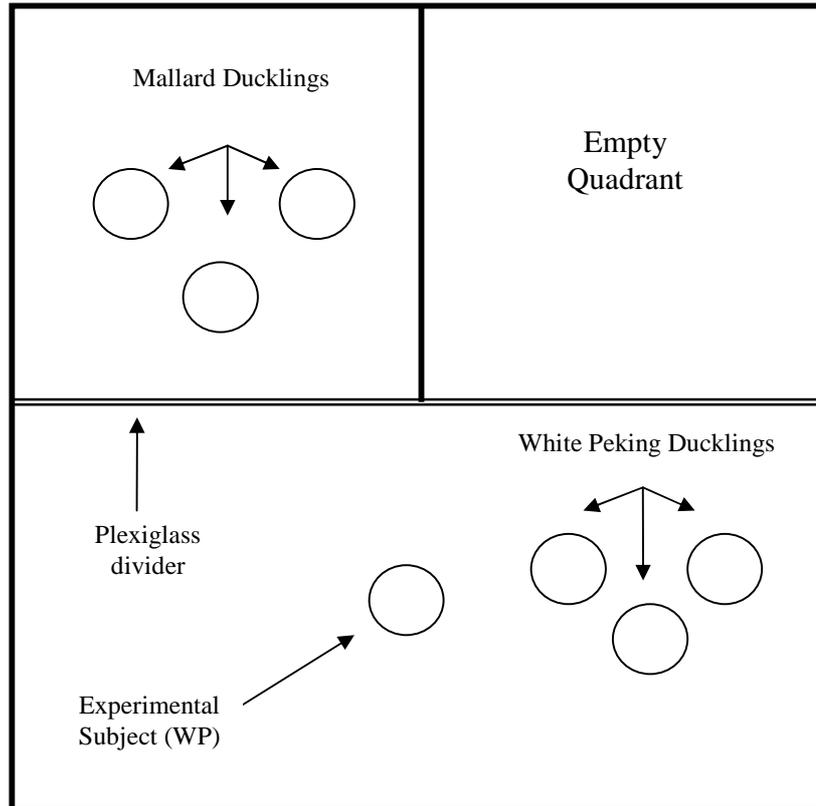


Figure 8. Top down visual of the experimental apparatus.

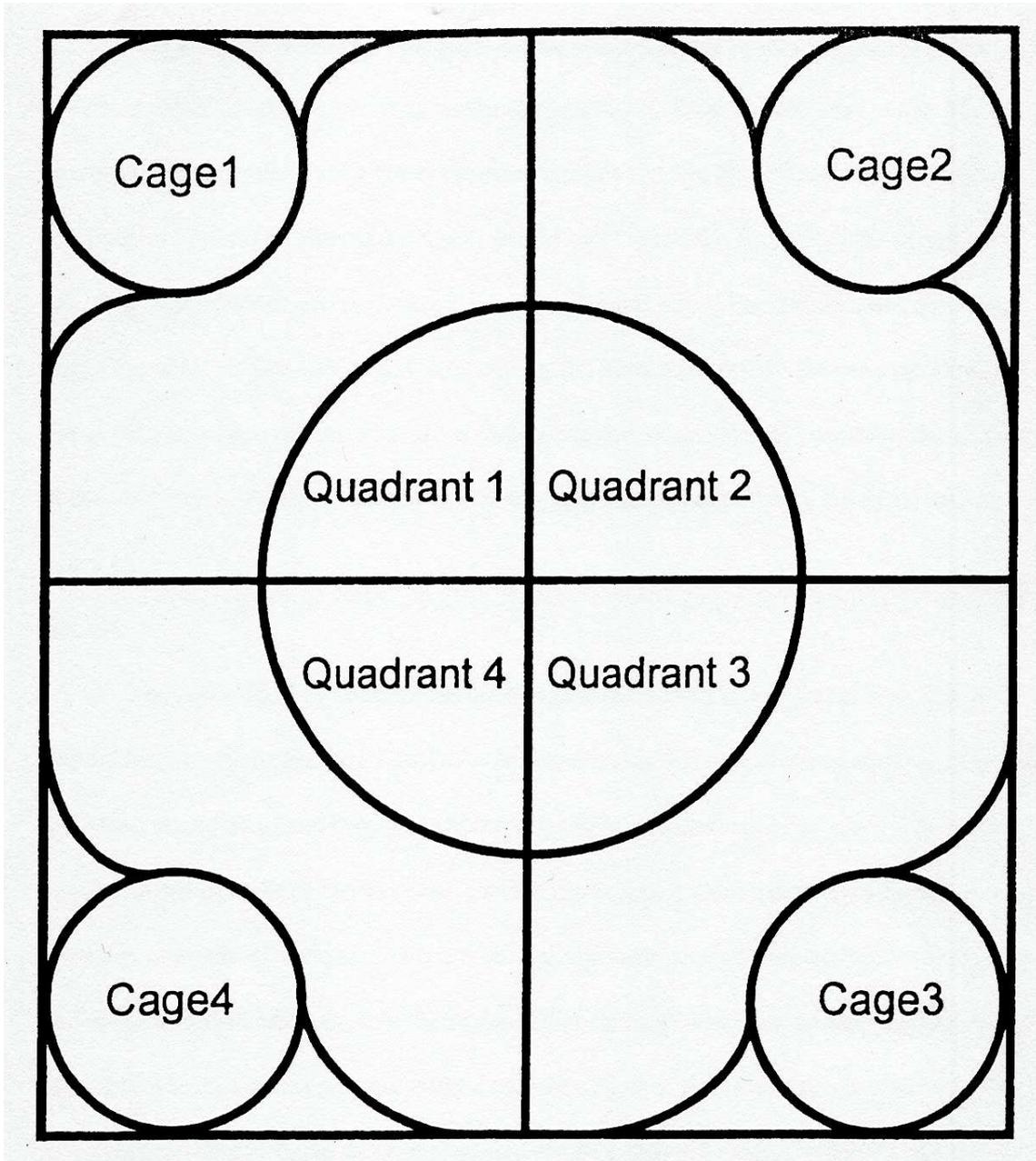


Figure 9. Experiment 1: Latency at an average of 24 hours of visual exposure to the stimulus objects (N=18) and after a second average of 24 hours of exposure to stimulus objects (N=18)

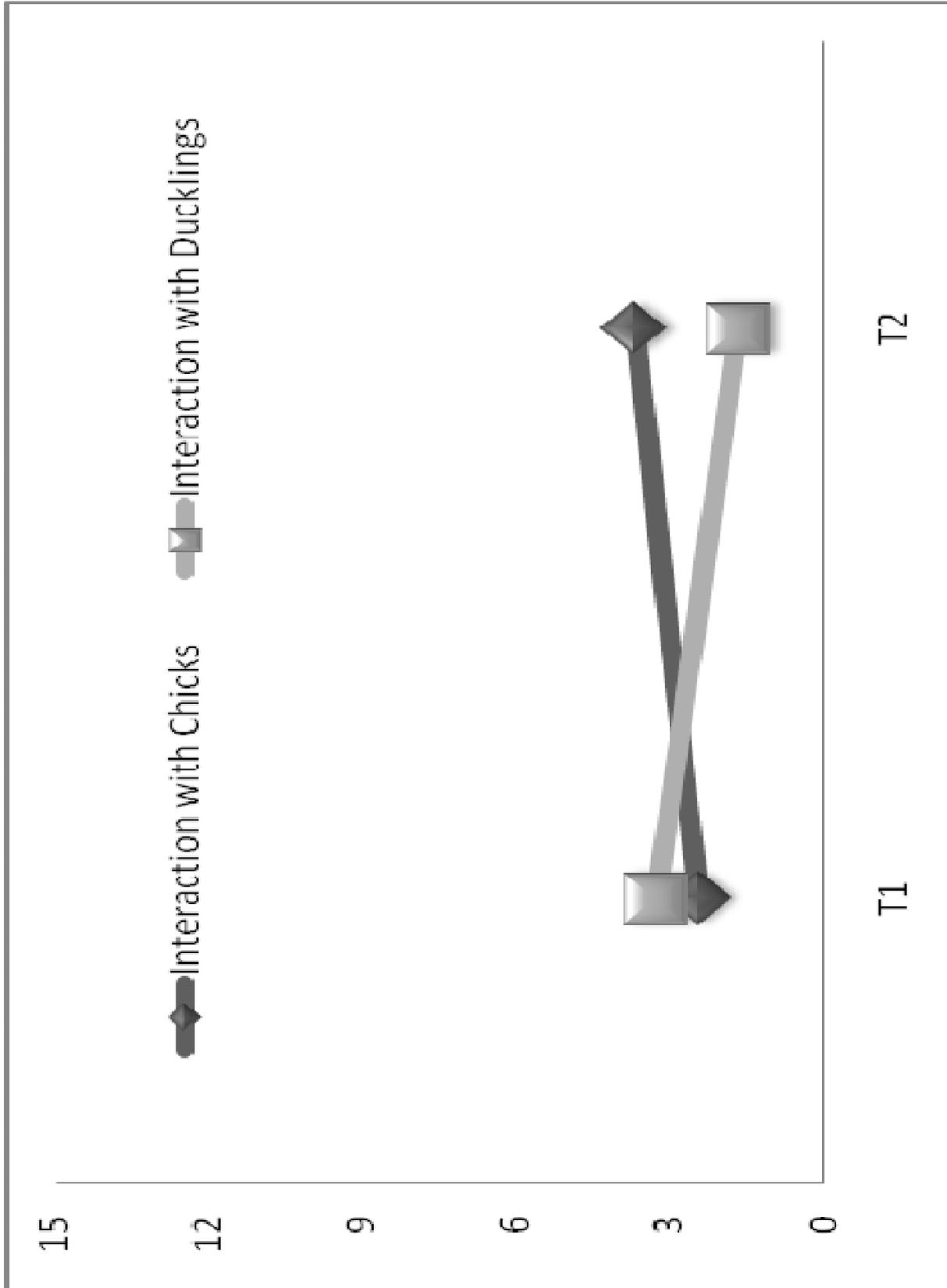


Figure 10. Experiment 1: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of domestic chicks or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three domestic chicks for an average of 24 hours (n=9) and after a second average of 24 hours of viewing a brood of three white Peking ducklings and interacting with a brood of three domestic chicks (n=9).

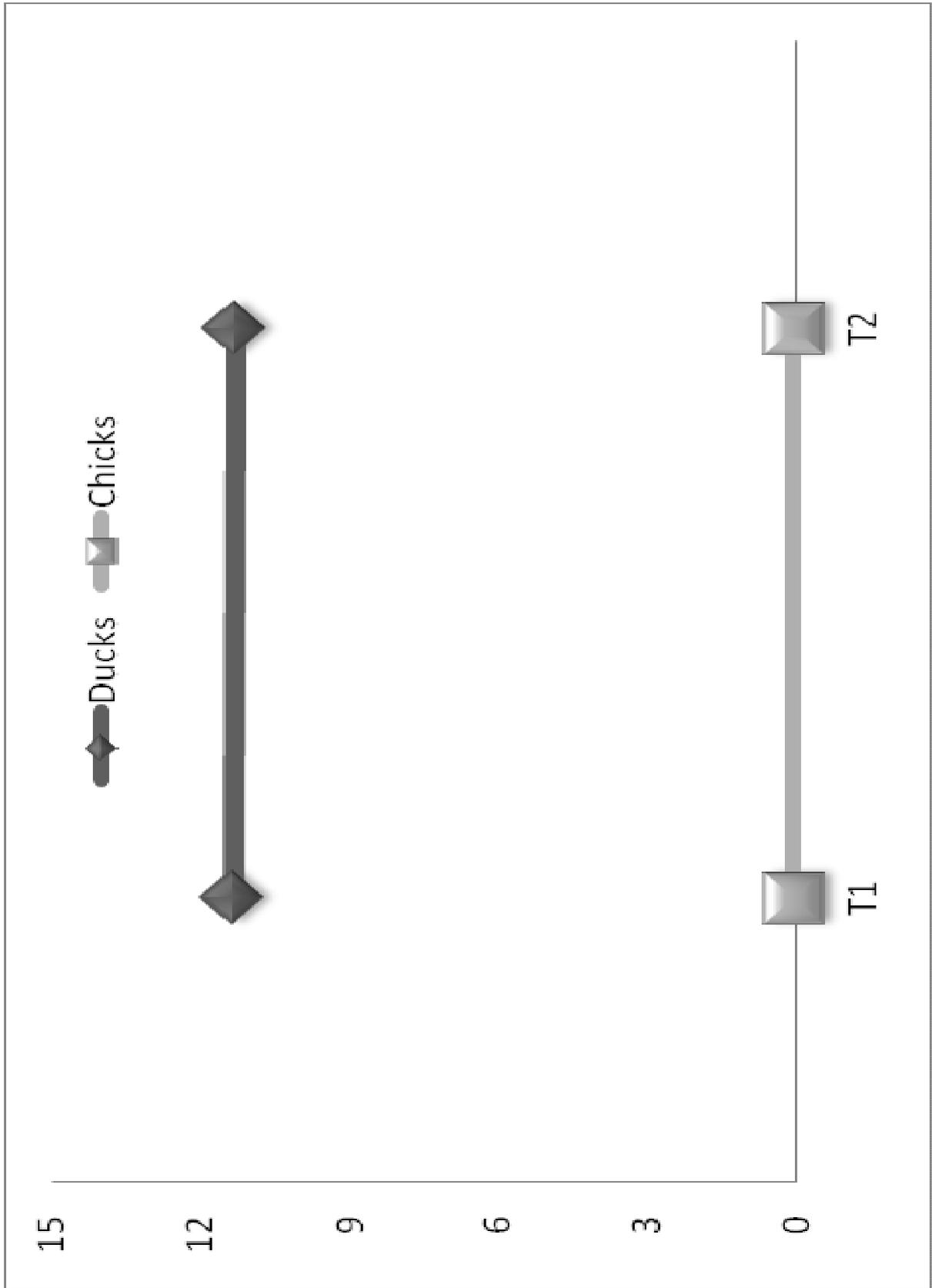


Figure 11. Experiment 1: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of domestic chicks or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three domestic chicks for an average of 24 hours (n=9) and after a second average of 24 hours of viewing a brood of three domestic chicks and interacting with a brood of three white Peking ducklings (n=9).

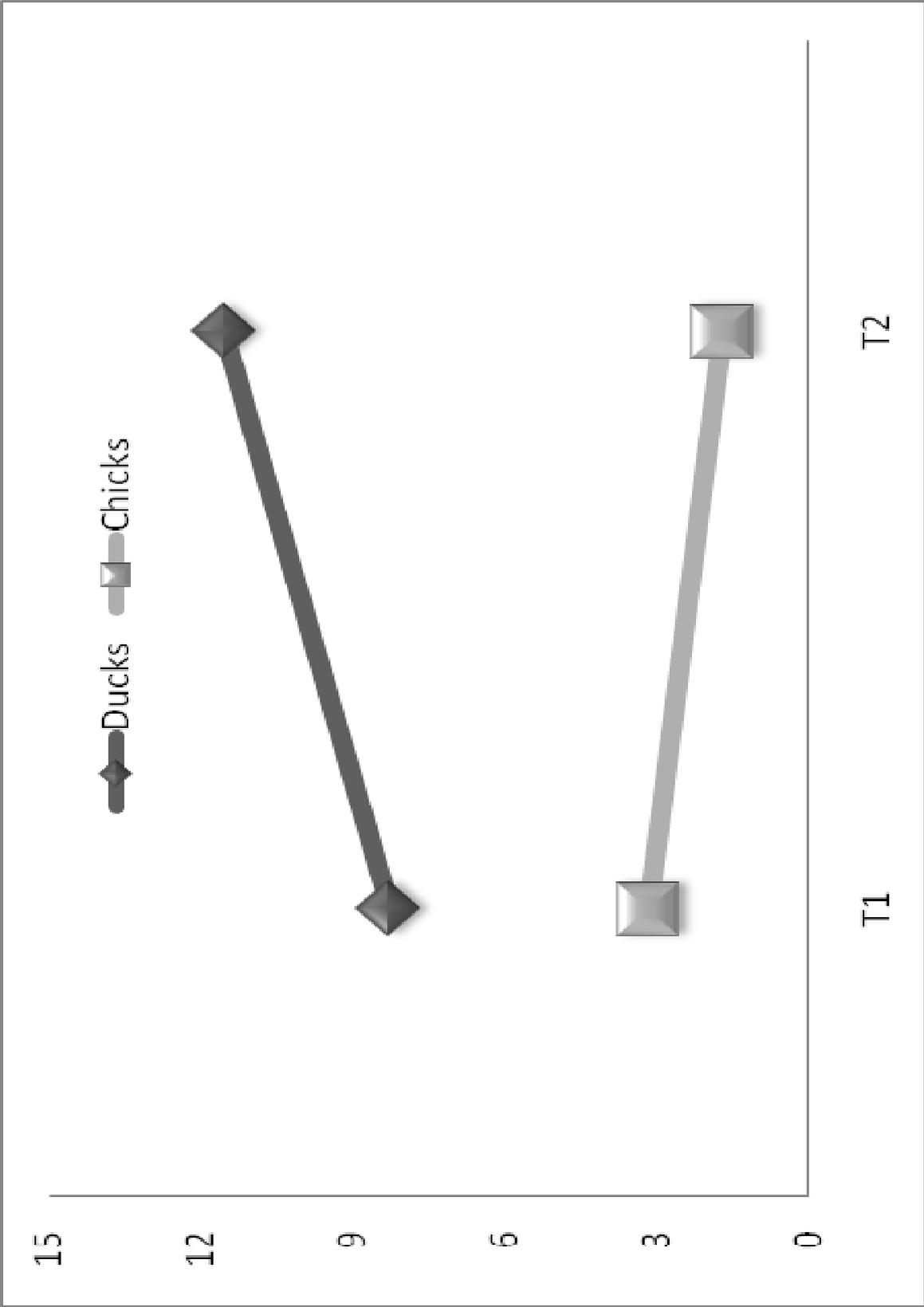


Figure 12. Experiment 2: Latency at an average of seven days of exposure to the stimulus objects (N=16) and after a second average of six days of exposure to stimulus objects (N=16).

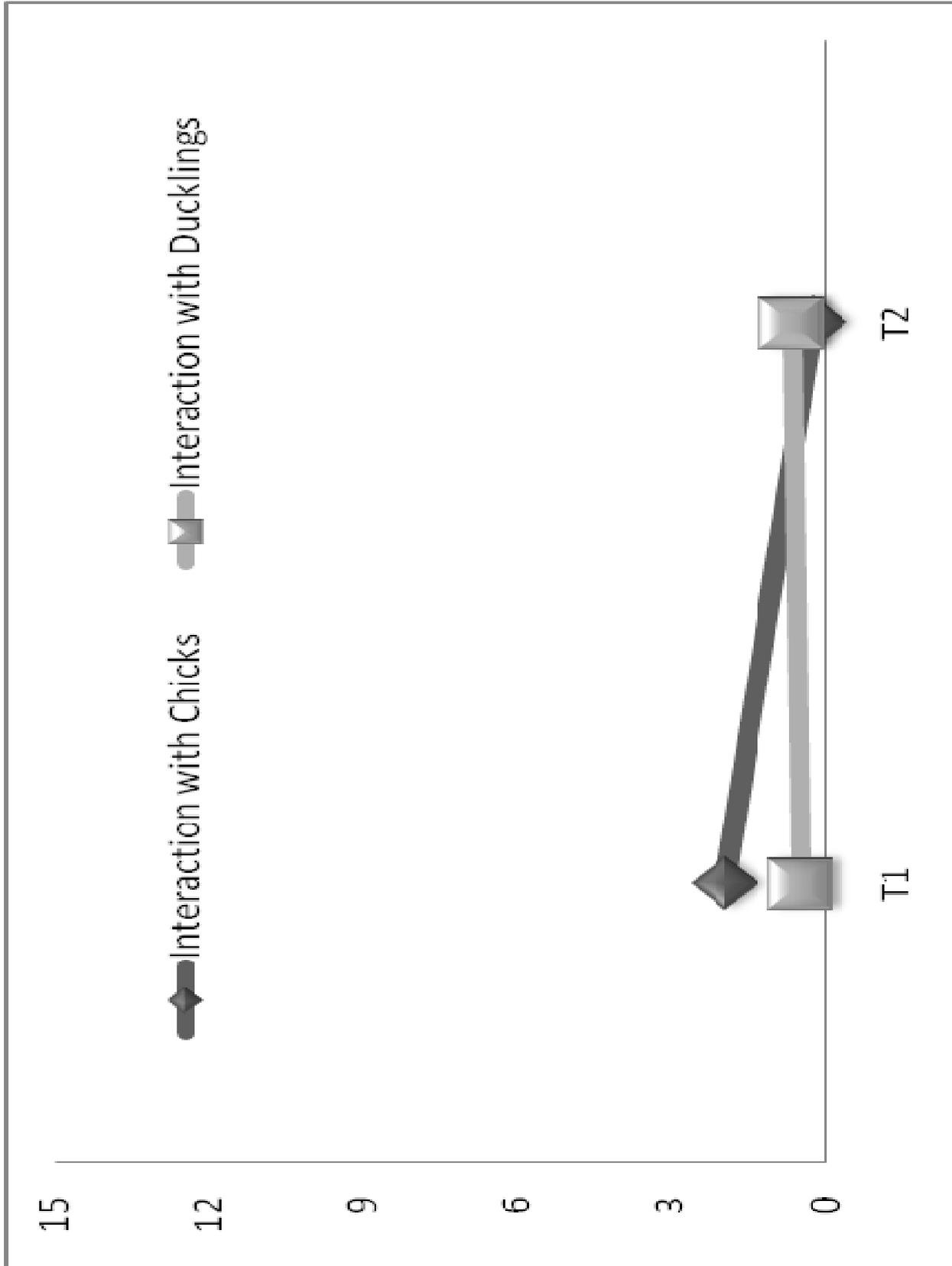


Figure 13. Experiment 2: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of domestic chicks or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three domestic chicks for an average of seven days (n=8) and after a second average of six days of viewing a brood of three white Peking ducklings and interacting with a brood of three domestic chicks (n=8).

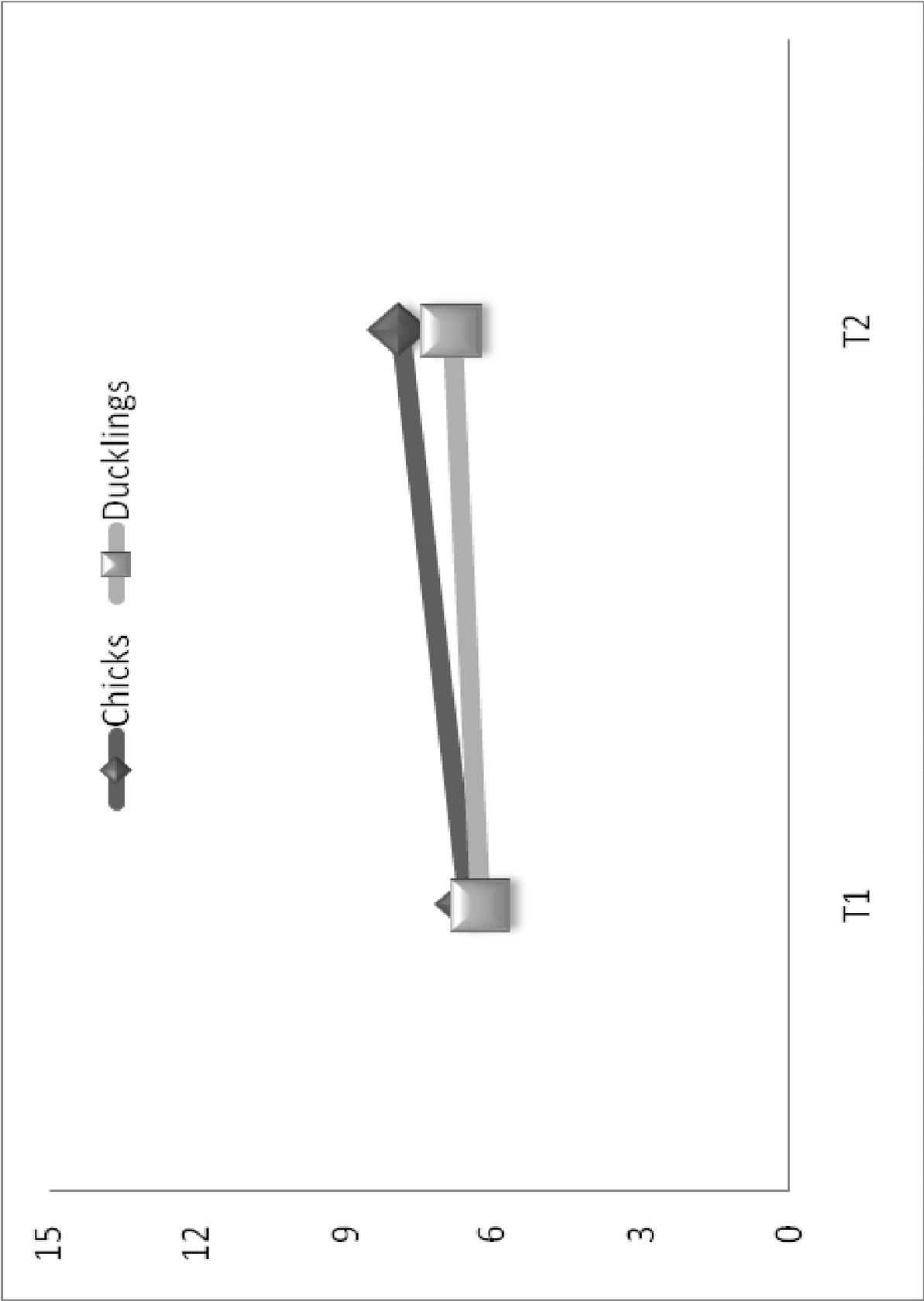


Figure 14. Experiment 2: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of domestic chicks or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three domestic chicks for an average of seven days (n=8) and after a second average of six days of viewing a brood of three domestic chicks and interacting with a brood of three white Peking ducklings (n=8).



Figure 15. Experiment 3: Latency at an average of 24 hours of exposure to the stimulus objects (N=9) and after a second average of 24 hours of exposure to stimulus objects (N=9).

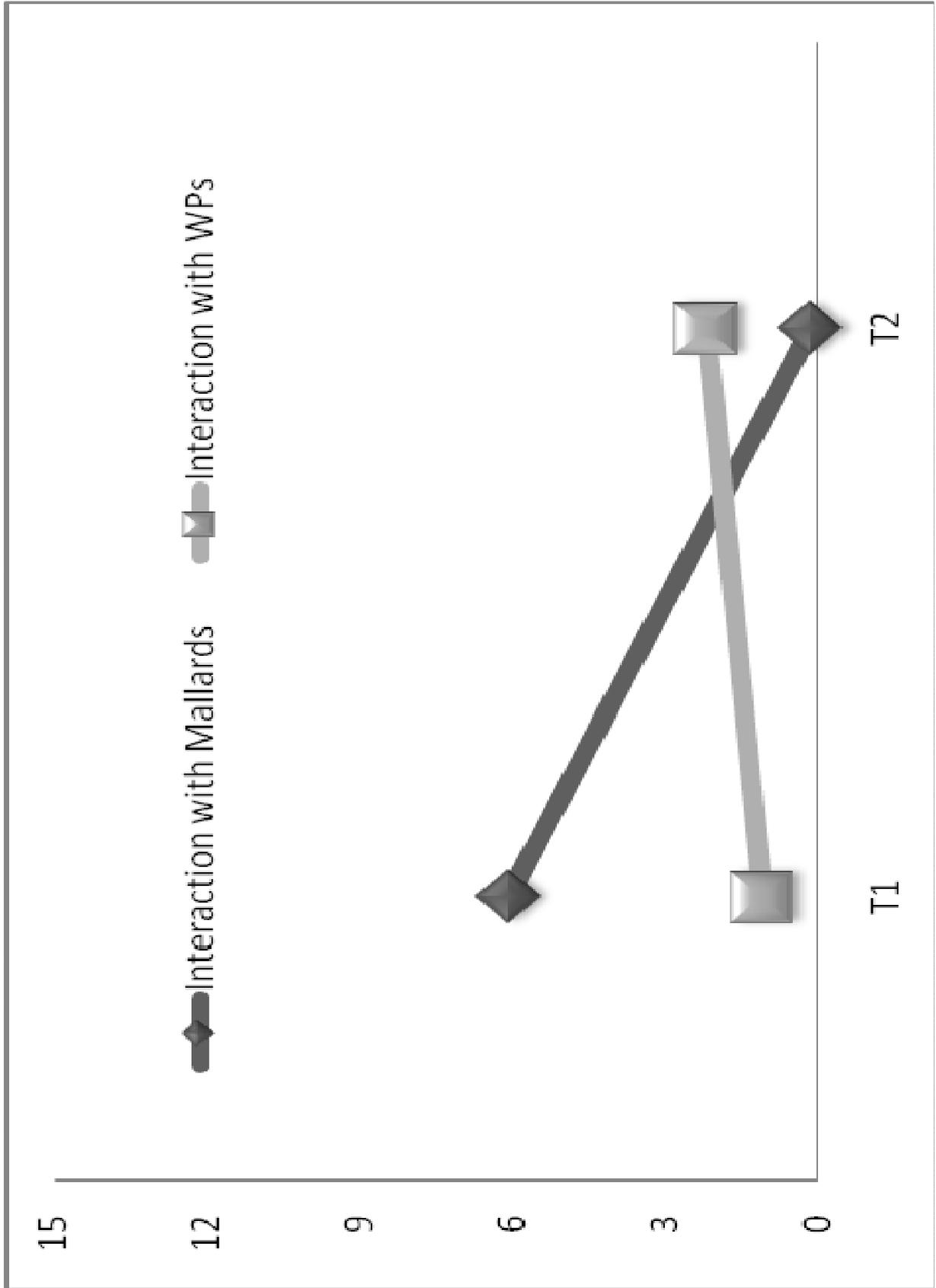


Figure 16. Experiment 3: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of mallards or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three mallards for an average of 24 hours (n=5) and after a second average of 24 hours of viewing a brood of three white Peking ducklings and interacting with a brood of three mallards (n=5).

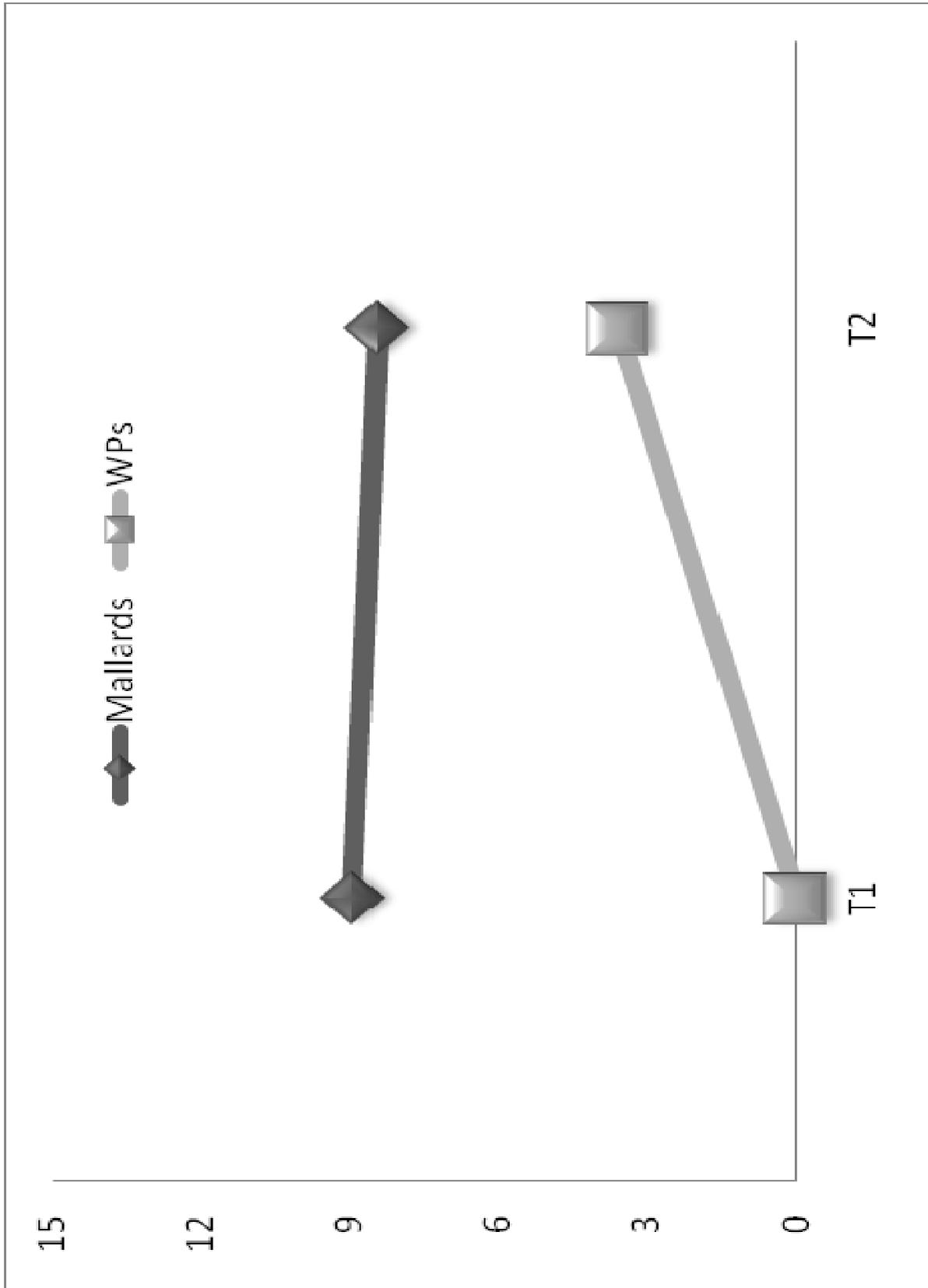


Figure 17. Experiment 3: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of mallards or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three mallards for an average of 24 hours (n=4) and after a second average of 24 hours of viewing a brood of three mallards and interacting with a brood of three white Peking ducklings (n=4).

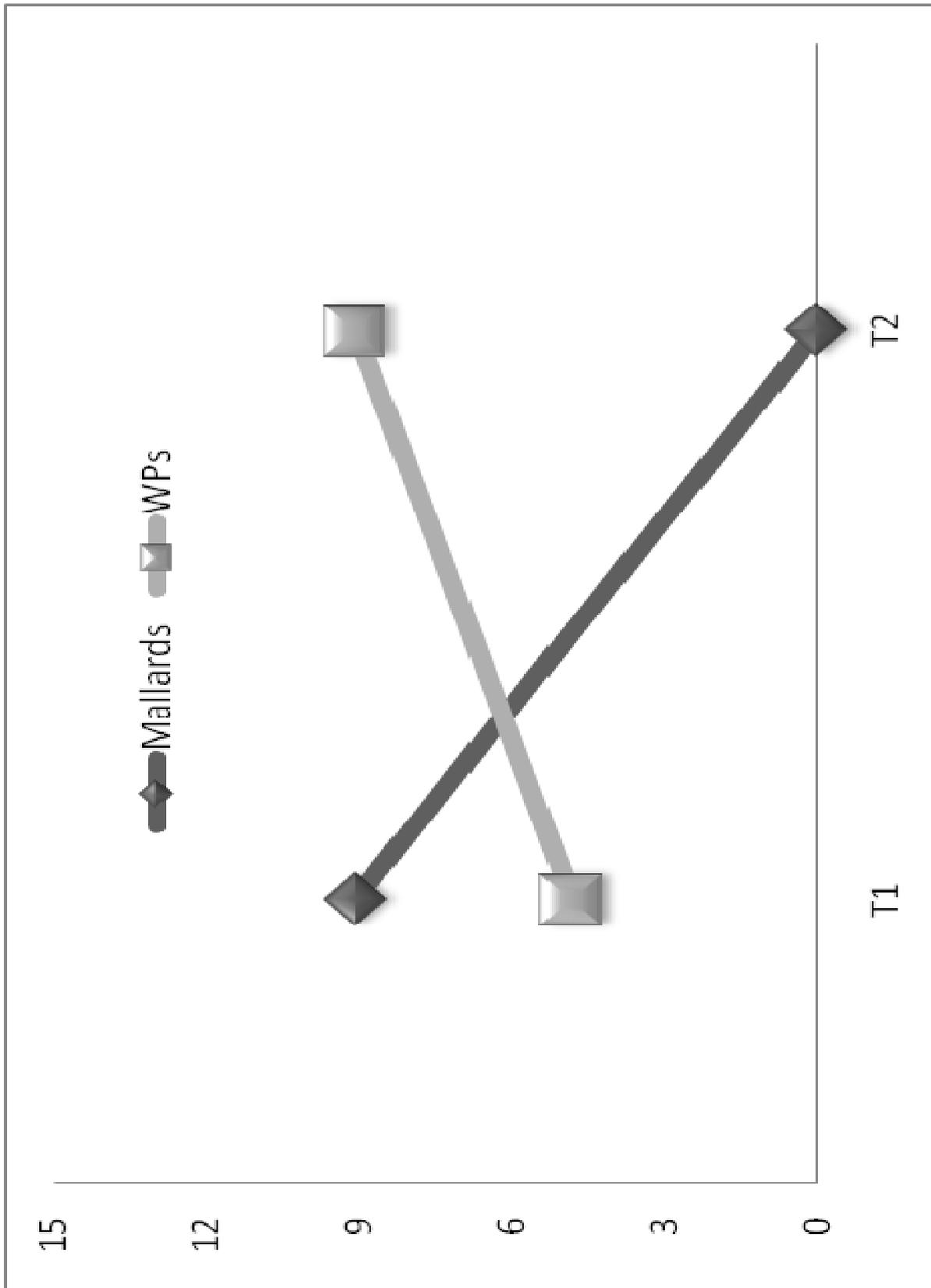


Figure 18. Experiment 4: Latency at an average of seven days of exposure to the stimulus objects (N=16) and after a second average of four days of exposure to stimulus objects (N=16).

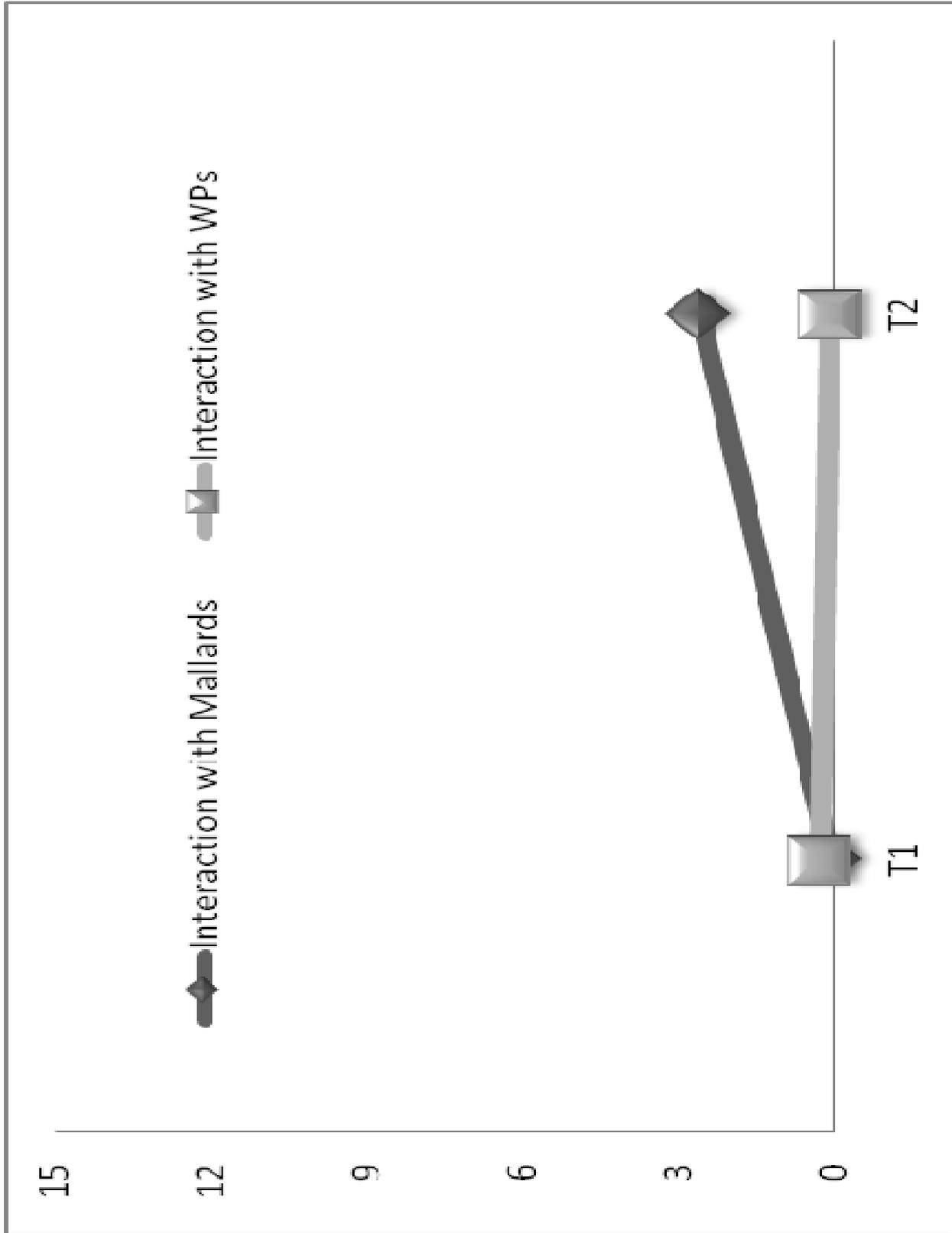


Figure 19. Experiment 4: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of domestic chicks or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three mallards for an average of seven days (n=8) and after a second average of four days of viewing a brood of three white Peking ducklings and interacting with a brood of three mallards (n=8).

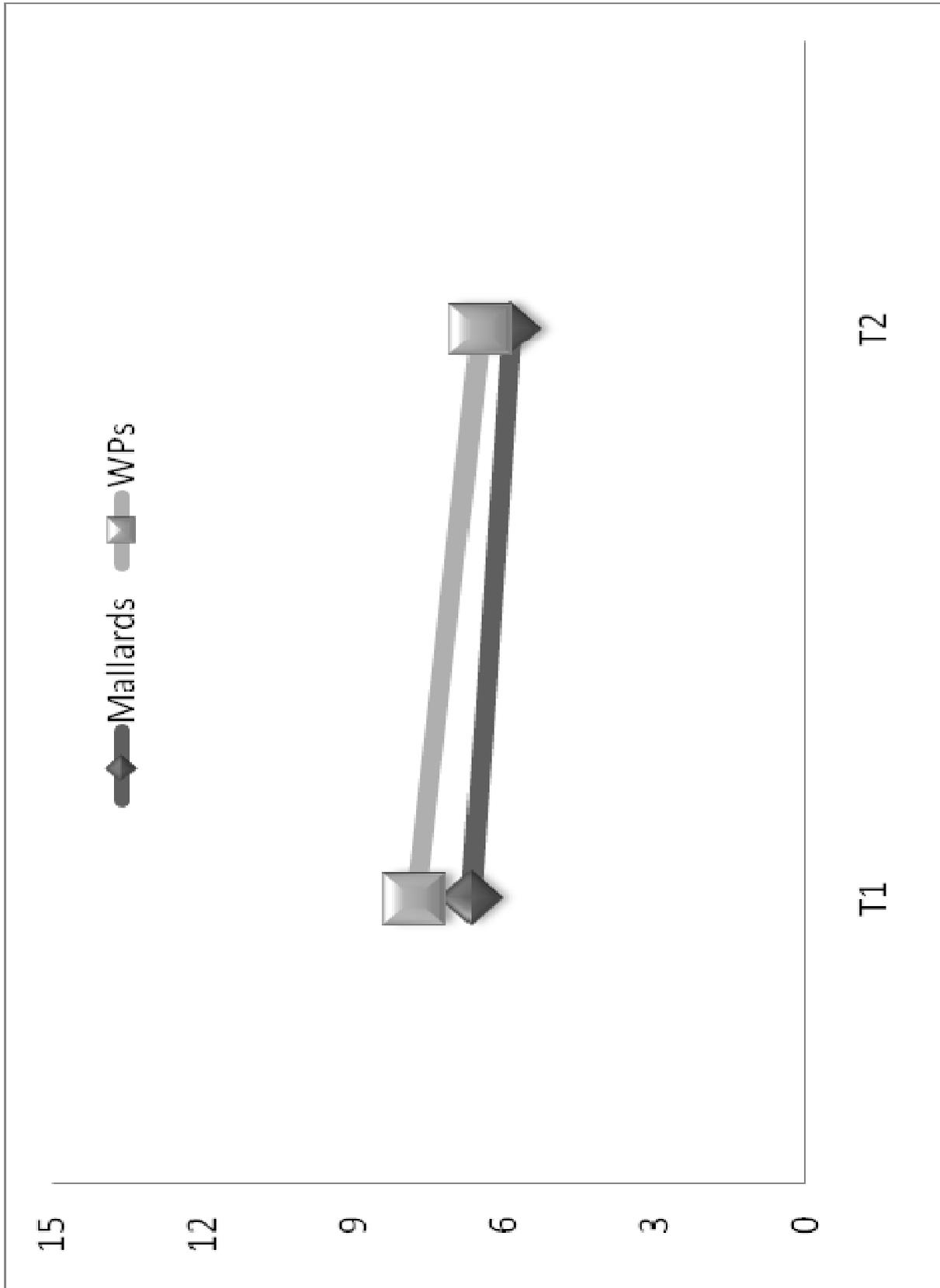
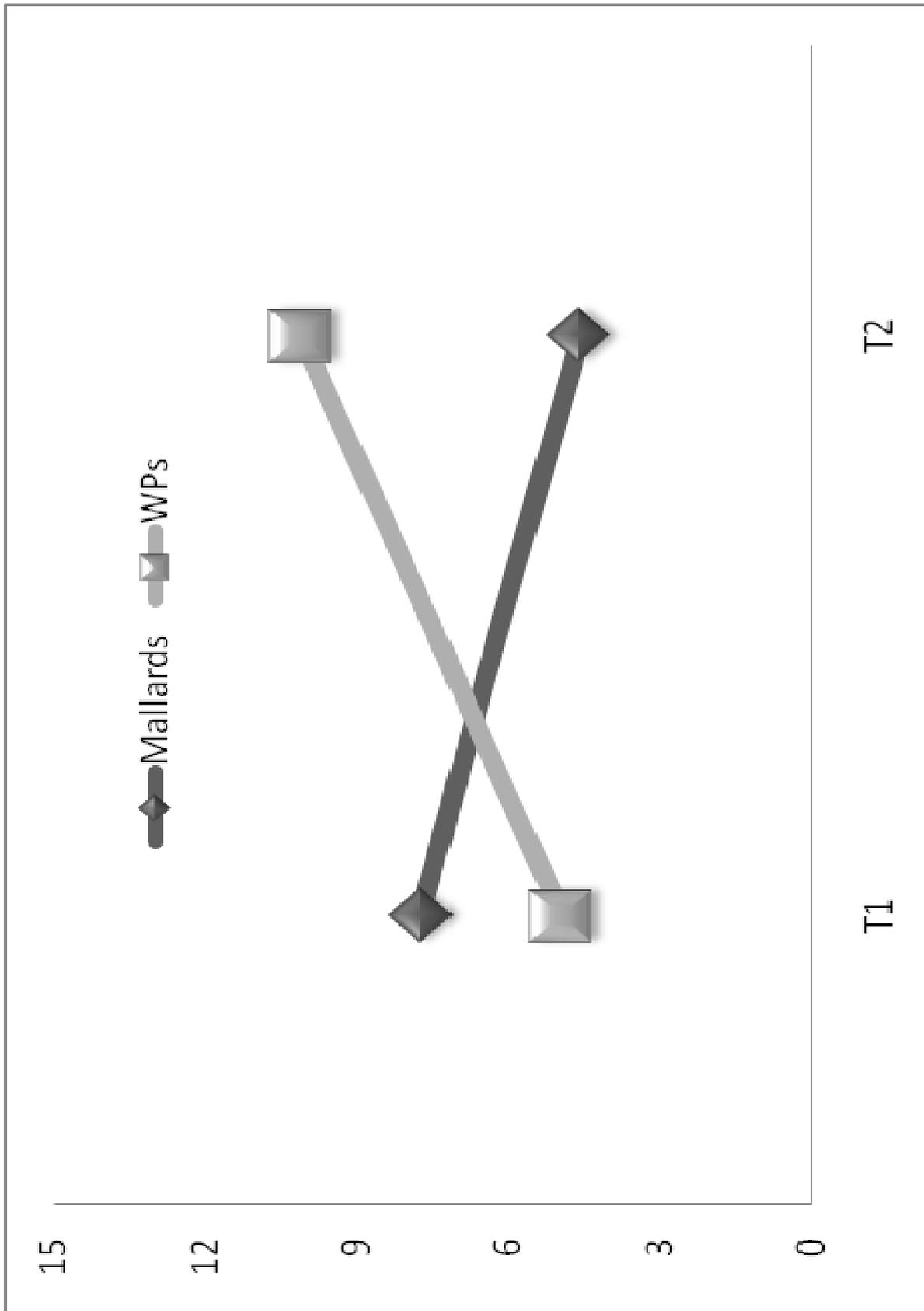


Figure 20. Experiment 4: Preferences of white Peking ducklings for a brood of white Peking ducklings, a brood of mallards or two empty quadrants after viewing a brood of three white Peking ducklings and a brood of three mallards for an average of seven days (n=8) and after a second average of four days of viewing a brood of three mallards and interacting with a brood of three white Peking ducklings (n=8).



Appendix A

T-Test interaction with CHICKS

[DataSet5] C:\Documents and Settings\germain\Desktop\Germain\Experiments\NEW ANALYSIS\CHICK_WP_2DAY\CHICK_WP_2DAY_DATASET.sav

Paired Samples Test

| | | Paired Differences | | |
|---------|-----------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 192.111 | 381.439 | 127.146 |
| Pair 2 | T1Quad1 - T1Quad3 | -191.444 | 716.731 | 238.910 |
| Pair 3 | T1Quad1 - T1Quad4 | 77.667 | 524.549 | 174.850 |
| Pair 4 | T1Quad2 - T1Quad3 | -383.556 | 452.461 | 150.820 |
| Pair 5 | T1Quad2 - T1Quad4 | -114.444 | 281.317 | 93.772 |
| Pair 6 | T1Quad3 - T1Quad4 | 269.111 | 605.390 | 201.797 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | 9.000 | 17.263 | 5.754 |
| Pair 8 | T1LeftofDucks - T1Ducks | -672.556 | 355.080 | 118.360 |
| Pair 9 | T1LeftofDucks - T1Chicks | 7.222 | 18.505 | 6.168 |
| Pair 10 | T1RightofDucks - T1Ducks | -681.556 | 359.414 | 119.805 |
| Pair 11 | T1RightofDucks - T1Chicks | -1.778 | 5.333 | 1.778 |
| Pair 12 | T2Quad1 - T2Quad2 | -.333 | 448.004 | 149.335 |
| Pair 13 | T2Quad1 - T2Quad3 | .111 | 448.250 | 149.417 |
| Pair 14 | T2Quad1 - T2Quad4 | -279.667 | 615.884 | 205.295 |
| Pair 15 | T2Quad2 - T2Quad3 | .444 | 447.753 | 149.251 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -101.089 | 485.311 |
| Pair 2 | T1Quad1 - T1Quad3 | -742.373 | 359.484 |
| Pair 3 | T1Quad1 - T1Quad4 | -325.537 | 480.870 |
| Pair 4 | T1Quad2 - T1Quad3 | -731.348 | -35.764 |
| Pair 5 | T1Quad2 - T1Quad4 | -330.684 | 101.795 |
| Pair 6 | T1Quad3 - T1Quad4 | -196.233 | 734.455 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | -4.269 | 22.269 |
| Pair 8 | T1LeftofDucks - T1Ducks | -945.494 | -399.617 |
| Pair 9 | T1LeftofDucks - T1Chicks | -7.002 | 21.447 |
| Pair 10 | T1RightofDucks - T1Ducks | -957.825 | -405.286 |
| Pair 11 | T1RightofDucks - T1Chicks | -5.877 | 2.322 |
| Pair 12 | T2Quad1 - T2Quad2 | -344.699 | 344.033 |
| Pair 13 | T2Quad1 - T2Quad3 | -344.444 | 344.667 |
| Pair 14 | T2Quad1 - T2Quad4 | -753.077 | 193.744 |
| Pair 15 | T2Quad2 - T2Quad3 | -343.729 | 344.618 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | 1.511 | 8 | .169 |
| Pair 2 | T1Quad1 - T1Quad3 | -.801 | 8 | .446 |
| Pair 3 | T1Quad1 - T1Quad4 | .444 | 8 | .669 |
| Pair 4 | T1Quad2 - T1Quad3 | -2.543 | 8 | .035 |
| Pair 5 | T1Quad2 - T1Quad4 | -1.220 | 8 | .257 |
| Pair 6 | T1Quad3 - T1Quad4 | 1.334 | 8 | .219 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | 1.564 | 8 | .156 |
| Pair 8 | T1LeftofDucks - T1Ducks | -5.682 | 8 | .000 |
| Pair 9 | T1LeftofDucks - T1Chicks | 1.171 | 8 | .275 |
| Pair 10 | T1RightofDucks - T1Ducks | -5.689 | 8 | .000 |
| Pair 11 | T1RightofDucks - T1Chicks | -1.000 | 8 | .347 |
| Pair 12 | T2Quad1 - T2Quad2 | -.002 | 8 | .998 |
| Pair 13 | T2Quad1 - T2Quad3 | .001 | 8 | .999 |
| Pair 14 | T2Quad1 - T2Quad4 | -1.362 | 8 | .210 |
| Pair 15 | T2Quad2 - T2Quad3 | .003 | 8 | .998 |

Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 16 | T2Quad2 - T2Quad4 | -279.333 | 614.794 | 204.931 |
| Pair 17 | T2Quad3 - T2Quad4 | -279.778 | 615.827 | 205.276 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -.111 | .333 | .111 |
| Pair 19 | T2LeftofDucks - T2Ducks | -678.222 | 387.974 | 129.325 |
| Pair 20 | T2LeftofDucks - T2Chicks | -.667 | 1.658 | .553 |
| Pair 21 | T2RightofDucks - T2Ducks | -678.111 | 387.904 | 129.301 |
| Pair 22 | T2RightofDucks - T2Chicks | -.556 | 1.667 | .556 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 16 | T2Quad2 - T2Quad4 | -751.906 | 193.239 |
| Pair 17 | T2Quad3 - T2Quad4 | -753.145 | 193.589 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -.367 | .145 |
| Pair 19 | T2LeftofDucks - T2Ducks | -976.446 | -379.999 |
| Pair 20 | T2LeftofDucks - T2Chicks | -1.941 | .608 |
| Pair 21 | T2RightofDucks - T2Ducks | -976.281 | -379.942 |
| Pair 22 | T2RightofDucks - T2Chicks | -1.837 | .726 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|--------|----|-----------------|
| Pair 16 | T2Quad2 - T2Quad4 | -1.363 | 8 | .210 |
| Pair 17 | T2Quad3 - T2Quad4 | -1.363 | 8 | .210 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -1.000 | 8 | .347 |
| Pair 19 | T2LeftofDucks - T2Ducks | -5.244 | 8 | .001 |
| Pair 20 | T2LeftofDucks - T2Chicks | -1.206 | 8 | .262 |
| Pair 21 | T2RightofDucks - T2Ducks | -5.244 | 8 | .001 |
| Pair 22 | T2RightofDucks - T2Chicks | -1.000 | 8 | .347 |

T-Test interaction with DUCKLNCS

[DataSet5] C:\Documents and Settings\germain\Desktop\Germain\Experiments\NEW ANALYSIS\CHICK_WP_2DAY\CHICK_WP_2DAY_DATASET.sav

Paired Samples Test

| | | Paired Differences | | |
|---------|-----------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 85.556 | 495.922 | 165.307 |
| Pair 2 | T1Quad1 - T1Quad3 | 142.444 | 315.772 | 105.257 |
| Pair 3 | T1Quad1 - T1Quad4 | -135.222 | 639.420 | 213.140 |
| Pair 4 | T1Quad2 - T1Quad3 | 56.889 | 334.520 | 111.507 |
| Pair 5 | T1Quad2 - T1Quad4 | -220.778 | 575.812 | 191.937 |
| Pair 6 | T1Quad3 - T1Quad4 | -277.667 | 468.658 | 156.219 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | 14.111 | 42.360 | 14.120 |
| Pair 8 | T1LeftofDucks - T1Ducks | -480.333 | 364.427 | 121.476 |
| Pair 9 | T1LeftofDucks - T1Chicks | -174.111 | 345.373 | 115.124 |
| Pair 10 | T1RightofDucks - T1Ducks | -494.444 | 363.341 | 121.114 |
| Pair 11 | T1RightofDucks - T1Chicks | -188.222 | 336.734 | 112.245 |
| Pair 12 | T2Quad1 - T2Quad2 | 194.111 | 599.013 | 199.671 |
| Pair 13 | T2Quad1 - T2Quad3 | -5.444 | 743.538 | 247.846 |
| Pair 14 | T2Quad1 - T2Quad4 | 210.333 | 575.056 | 191.685 |
| Pair 15 | T2Quad2 - T2Quad3 | -199.556 | 548.190 | 182.730 |

Paired Samples Test

| | | Paired Differences | |
|---------|-----------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -295.644 | 466.755 |
| Pair 2 | T1Quad1 - T1Quad3 | -100.279 | 385.168 |
| Pair 3 | T1Quad1 - T1Quad4 | -626.724 | 356.279 |
| Pair 4 | T1Quad2 - T1Quad3 | -200.246 | 314.024 |
| Pair 5 | T1Quad2 - T1Quad4 | -663.386 | 221.831 |
| Pair 6 | T1Quad3 - T1Quad4 | -637.909 | 82.576 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | -18.450 | 46.672 |
| Pair 8 | T1LeftofDucks - T1Ducks | -760.456 | -200.210 |
| Pair 9 | T1LeftofDucks - T1Chicks | -439.588 | 91.366 |
| Pair 10 | T1RightofDucks - T1Ducks | -773.733 | -215.156 |
| Pair 11 | T1RightofDucks - T1Chicks | -447.059 | 70.614 |
| Pair 12 | T2Quad1 - T2Quad2 | -266.331 | 654.553 |
| Pair 13 | T2Quad1 - T2Quad3 | -576.978 | 566.089 |
| Pair 14 | T2Quad1 - T2Quad4 | -231.694 | 652.360 |
| Pair 15 | T2Quad2 - T2Quad3 | -620.931 | 221.820 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|-----------------------------------|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | .518 | 8 | .619 |
| Pair 2 | T1Quad1 - T1Quad3 | 1.353 | 8 | .213 |
| Pair 3 | T1Quad1 - T1Quad4 | -.634 | 8 | .544 |
| Pair 4 | T1Quad2 - T1Quad3 | .510 | 8 | .624 |
| Pair 5 | T1Quad2 - T1Quad4 | -1.150 | 8 | .283 |
| Pair 6 | T1Quad3 - T1Quad4 | -1.777 | 8 | .113 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | .999 | 8 | .347 |
| Pair 8 | T1LeftofDucks - T1Ducks | -3.954 | 8 | .004 |
| Pair 9 | T1LeftofDucks - T1Chicks | -1.512 | 8 | .169 |
| Pair 10 | T1RightofDucks - T1Ducks | -4.082 | 8 | .004 |
| Pair 11 | T1RightofDucks - T1Chicks | -1.677 | 8 | .132 |
| Pair 12 | T2Quad1 - T2Quad2 | .972 | 8 | .359 |
| Pair 13 | T2Quad1 - T2Quad3 | -.022 | 8 | .983 |
| Pair 14 | T2Quad1 - T2Quad4 | 1.097 | 8 | .304 |
| Pair 15 | T2Quad2 - T2Quad3 | -1.092 | 8 | .307 |

Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 16 | T2Quad2 - T2Quad4 | 16.222 | 424.171 | 141.390 |
| Pair 17 | T2Quad3 - T2Quad4 | 215.778 | 528.930 | 176.310 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -4.556 | 15.581 | 5.194 |
| Pair 19 | T2LeftofDucks - T2Ducks | -691.444 | 306.355 | 102.118 |
| Pair 20 | T2LeftofDucks - T2Chicks | -99.667 | 299.377 | 99.792 |
| Pair 21 | T2RightofDucks - T2Ducks | -686.889 | 307.855 | 102.618 |
| Pair 22 | T2RightofDucks - T2Chicks | -95.111 | 301.440 | 100.480 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 16 | T2Quad2 - T2Quad4 | -309.825 | 342.269 |
| Pair 17 | T2Quad3 - T2Quad4 | -190.793 | 622.349 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -16.532 | 7.421 |
| Pair 19 | T2LeftofDucks - T2Ducks | -926.930 | -455.959 |
| Pair 20 | T2LeftofDucks - T2Chicks | -329.788 | 130.455 |
| Pair 21 | T2RightofDucks - T2Ducks | -923.527 | -450.250 |
| Pair 22 | T2RightofDucks - T2Chicks | -326.818 | 136.596 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|---------|-------------------|-----------------|
| | | Pair 16 | T2Quad2 - T2Quad4 | .115 |
| Pair 17 | T2Quad3 - T2Quad4 | 1.224 | 8 | .256 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -.877 | 8 | .406 |
| Pair 19 | T2LeftofDucks - T2Ducks | -6.771 | 8 | .000 |
| Pair 20 | T2LeftofDucks - T2Chicks | -.999 | 8 | .347 |
| Pair 21 | T2RightofDucks - T2Ducks | -6.694 | 8 | .000 |
| Pair 22 | T2RightofDucks - T2Chicks | -.947 | 8 | .372 |

Appendix B

T-Test INTERACTION WITH CHICKS

[DataSet2] C:\Documents and Settings\germain\Desktop\Experiments\NEW ANALYSIS
 \CHICK_WP_2WEEK\CHICK_WP_2WEEK_DATASET.sav

Paired Samples Test

| | | Paired Differences | | |
|---------|-----------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 415.875 | 450.739 | 159.360 |
| Pair 2 | T1Quad1 - T1Quad3 | 360.875 | 383.252 | 135.500 |
| Pair 3 | T1Quad1 - T1Quad4 | 302.875 | 636.519 | 225.044 |
| Pair 4 | T1Quad2 - T1Quad3 | -55.000 | 206.643 | 73.059 |
| Pair 5 | T1Quad2 - T1Quad4 | -113.000 | 273.117 | 96.562 |
| Pair 6 | T1Quad3 - T1Quad4 | -58.000 | 393.209 | 139.020 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | 1.000 | 21.607 | 7.639 |
| Pair 8 | T1LeftofDucks - T1Ducks | -380.750 | 351.344 | 124.219 |
| Pair 9 | T1LeftofDucks - T1Chicks | -364.000 | 340.138 | 120.257 |
| Pair 10 | T1RightofDucks - T1Ducks | -381.750 | 355.268 | 125.606 |
| Pair 11 | T1RightofDucks - T1Chicks | -365.000 | 334.084 | 118.117 |
| Pair 12 | T2Quad1 - T2Quad2 | 620.875 | 397.916 | 140.684 |
| Pair 13 | T2Quad1 - T2Quad3 | 586.625 | 402.455 | 142.289 |
| Pair 14 | T2Quad1 - T2Quad4 | 404.250 | 794.030 | 280.732 |
| Pair 15 | T2Quad2 - T2Quad3 | -34.250 | 90.583 | 32.026 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | 39.048 | 792.702 |
| Pair 2 | T1Quad1 - T1Quad3 | 40.469 | 681.281 |
| Pair 3 | T1Quad1 - T1Quad4 | -229.269 | 835.019 |
| Pair 4 | T1Quad2 - T1Quad3 | -227.758 | 117.758 |
| Pair 5 | T1Quad2 - T1Quad4 | -341.332 | 115.332 |
| Pair 6 | T1Quad3 - T1Quad4 | -386.731 | 270.731 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | -17.064 | 19.064 |
| Pair 8 | T1LeftofDucks - T1Ducks | -674.481 | -87.019 |
| Pair 9 | T1LeftofDucks - T1Chicks | -648.362 | -79.638 |
| Pair 10 | T1RightofDucks - T1Ducks | -678.761 | -84.739 |
| Pair 11 | T1RightofDucks - T1Chicks | -644.301 | -85.699 |
| Pair 12 | T2Quad1 - T2Quad2 | 288.209 | 953.541 |
| Pair 13 | T2Quad1 - T2Quad3 | 250.165 | 923.085 |
| Pair 14 | T2Quad1 - T2Quad4 | -259.576 | 1068.076 |
| Pair 15 | T2Quad2 - T2Quad3 | -109.980 | 41.480 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | 2.610 | 7 | .035 |
| Pair 2 | T1Quad1 - T1Quad3 | 2.663 | 7 | .032 |
| Pair 3 | T1Quad1 - T1Quad4 | 1.346 | 7 | .220 |
| Pair 4 | T1Quad2 - T1Quad3 | -.753 | 7 | .476 |
| Pair 5 | T1Quad2 - T1Quad4 | -1.170 | 7 | .280 |
| Pair 6 | T1Quad3 - T1Quad4 | -.417 | 7 | .689 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | .131 | 7 | .900 |
| Pair 8 | T1LeftofDucks - T1Ducks | -3.065 | 7 | .018 |
| Pair 9 | T1LeftofDucks - T1Chicks | -3.027 | 7 | .019 |
| Pair 10 | T1RightofDucks - T1Ducks | -3.039 | 7 | .019 |
| Pair 11 | T1RightofDucks - T1Chicks | -3.090 | 7 | .018 |
| Pair 12 | T2Quad1 - T2Quad2 | 4.413 | 7 | .003 |
| Pair 13 | T2Quad1 - T2Quad3 | 4.123 | 7 | .004 |
| Pair 14 | T2Quad1 - T2Quad4 | 1.440 | 7 | .193 |
| Pair 15 | T2Quad2 - T2Quad3 | -1.069 | 7 | .320 |

Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 16 | T2Quad2 - T2Quad4 | -216.625 | 401.145 | 141.826 |
| Pair 17 | T2Quad3 - T2Quad4 | -182.375 | 434.678 | 153.682 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | .750 | 1.753 | .620 |
| Pair 19 | T2LeftofDucks - T2Ducks | -470.875 | 438.826 | 155.148 |
| Pair 20 | T2LeftofDucks - T2Chicks | -407.125 | 436.101 | 154.185 |
| Pair 21 | T2RightofDucks - T2Ducks | -471.625 | 437.928 | 154.831 |
| Pair 22 | T2RightofDucks - T2Chicks | -407.875 | 436.976 | 154.494 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 16 | T2Quad2 - T2Quad4 | -551.991 | 118.741 |
| Pair 17 | T2Quad3 - T2Quad4 | -545.775 | 181.025 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -.715 | 2.215 |
| Pair 19 | T2LeftofDucks - T2Ducks | -837.743 | -104.007 |
| Pair 20 | T2LeftofDucks - T2Chicks | -771.715 | -42.535 |
| Pair 21 | T2RightofDucks - T2Ducks | -837.742 | -105.508 |
| Pair 22 | T2RightofDucks - T2Chicks | -773.196 | -42.554 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|--------|----|-----------------|
| Pair 16 | T2Quad2 - T2Quad4 | -1.527 | 7 | .171 |
| Pair 17 | T2Quad3 - T2Quad4 | -1.187 | 7 | .274 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | 1.210 | 7 | .265 |
| Pair 19 | T2LeftofDucks - T2Ducks | -3.035 | 7 | .019 |
| Pair 20 | T2LeftofDucks - T2Chicks | -2.640 | 7 | .033 |
| Pair 21 | T2RightofDucks - T2Ducks | -3.046 | 7 | .019 |
| Pair 22 | T2RightofDucks - T2Chicks | -2.640 | 7 | .033 |

T-Test INTERACTION WITH DUCKLINGS

[DataSet2] C:\Documents and Settings\germain\Desktop\Experiments\NEW ANALYSIS
 \CHICK_WP_2WEEK\CHICK_WP_2WEEK_DATASET.sav

Paired Samples Test

| | | Paired Differences | | |
|---------|-----------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 211.125 | 647.128 | 228.794 |
| Pair 2 | T1Quad1 - T1Quad3 | 209.625 | 603.992 | 213.543 |
| Pair 3 | T1Quad1 - T1Quad4 | 226.875 | 608.132 | 215.007 |
| Pair 4 | T1Quad2 - T1Quad3 | -1.500 | 506.466 | 179.063 |
| Pair 5 | T1Quad2 - T1Quad4 | 15.750 | 435.320 | 153.909 |
| Pair 6 | T1Quad3 - T1Quad4 | 17.250 | 461.499 | 163.164 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | 126.500 | 313.526 | 110.848 |
| Pair 8 | T1LeftofDucks - T1Ducks | -370.000 | 623.789 | 220.543 |
| Pair 9 | T1LeftofDucks - T1Chicks | -91.375 | 483.460 | 170.929 |
| Pair 10 | T1RightofDucks - T1Ducks | -496.500 | 389.186 | 137.598 |
| Pair 11 | T1RightofDucks - T1Chicks | -217.875 | 303.164 | 107.185 |
| Pair 12 | T2Quad1 - T2Quad2 | 146.375 | 531.884 | 188.049 |
| Pair 13 | T2Quad1 - T2Quad3 | 192.125 | 442.604 | 156.484 |
| Pair 14 | T2Quad1 - T2Quad4 | -32.875 | 709.090 | 250.701 |
| Pair 15 | T2Quad2 - T2Quad3 | 45.750 | 329.831 | 116.613 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -329.888 | 752.138 |
| Pair 2 | T1Quad1 - T1Quad3 | -295.325 | 714.575 |
| Pair 3 | T1Quad1 - T1Quad4 | -281.536 | 735.286 |
| Pair 4 | T1Quad2 - T1Quad3 | -424.917 | 421.917 |
| Pair 5 | T1Quad2 - T1Quad4 | -348.186 | 379.686 |
| Pair 6 | T1Quad3 - T1Quad4 | -368.573 | 403.073 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | -135.614 | 388.614 |
| Pair 8 | T1LeftofDucks - T1Ducks | -891.501 | 151.501 |
| Pair 9 | T1LeftofDucks - T1Chicks | -495.557 | 312.807 |
| Pair 10 | T1RightofDucks - T1Ducks | -821.867 | -171.133 |
| Pair 11 | T1RightofDucks - T1Chicks | -471.326 | 35.576 |
| Pair 12 | T2Quad1 - T2Quad2 | -298.291 | 591.041 |
| Pair 13 | T2Quad1 - T2Quad3 | -177.901 | 562.151 |
| Pair 14 | T2Quad1 - T2Quad4 | -625.689 | 559.939 |
| Pair 15 | T2Quad2 - T2Quad3 | -229.996 | 321.496 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | .923 | 7 | .387 |
| Pair 2 | T1Quad1 - T1Quad3 | .982 | 7 | .359 |
| Pair 3 | T1Quad1 - T1Quad4 | 1.055 | 7 | .326 |
| Pair 4 | T1Quad2 - T1Quad3 | -.008 | 7 | .994 |
| Pair 5 | T1Quad2 - T1Quad4 | .102 | 7 | .921 |
| Pair 6 | T1Quad3 - T1Quad4 | .106 | 7 | .919 |
| Pair 7 | T1LeftofDucks - T1RightofDucks | 1.141 | 7 | .291 |
| Pair 8 | T1LeftofDucks - T1Ducks | -1.678 | 7 | .137 |
| Pair 9 | T1LeftofDucks - T1Chicks | -.535 | 7 | .609 |
| Pair 10 | T1RightofDucks - T1Ducks | -3.608 | 7 | .009 |
| Pair 11 | T1RightofDucks - T1Chicks | -2.033 | 7 | .082 |
| Pair 12 | T2Quad1 - T2Quad2 | .778 | 7 | .462 |
| Pair 13 | T2Quad1 - T2Quad3 | 1.228 | 7 | .259 |
| Pair 14 | T2Quad1 - T2Quad4 | -.131 | 7 | .899 |
| Pair 15 | T2Quad2 - T2Quad3 | .392 | 7 | .706 |

Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 16 | T2Quad2 - T2Quad4 | -179.250 | 466.936 | 165.087 |
| Pair 17 | T2Quad3 - T2Quad4 | -225.000 | 502.164 | 177.542 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -30.500 | 90.361 | 31.948 |
| Pair 19 | T2LeftofDucks - T2Ducks | -359.750 | 485.079 | 171.501 |
| Pair 20 | T2LeftofDucks - T2Chicks | -194.625 | 395.063 | 139.676 |
| Pair 21 | T2RightofDucks - T2Ducks | -329.250 | 542.362 | 191.754 |
| Pair 22 | T2RightofDucks - T2Chicks | -164.125 | 448.586 | 158.599 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------|---|---------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 16 | T2Quad2 - T2Quad4 | -569.618 | 211.118 |
| Pair 17 | T2Quad3 - T2Quad4 | -644.820 | 194.820 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -106.044 | 45.044 |
| Pair 19 | T2LeftofDucks - T2Ducks | -765.286 | 45.786 |
| Pair 20 | T2LeftofDucks - T2Chicks | -524.906 | 135.656 |
| Pair 21 | T2RightofDucks - T2Ducks | -782.676 | 124.176 |
| Pair 22 | T2RightofDucks - T2Chicks | -539.152 | 210.902 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------|---------|-------------------|-----------------|
| | | Pair 16 | T2Quad2 - T2Quad4 | -1.086 |
| Pair 17 | T2Quad3 - T2Quad4 | -1.267 | 7 | .246 |
| Pair 18 | T2LeftofDucks - T2RightofDucks | -.955 | 7 | .372 |
| Pair 19 | T2LeftofDucks - T2Ducks | -2.098 | 7 | .074 |
| Pair 20 | T2LeftofDucks - T2Chicks | -1.393 | 7 | .206 |
| Pair 21 | T2RightofDucks - T2Ducks | -1.717 | 7 | .130 |
| Pair 22 | T2RightofDucks - T2Chicks | -1.035 | 7 | .335 |

Appendix C

T-Test INTERACTION WITH MALLARDS

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Paired Samples Test

| | | Paired Differences | | |
|--------|---|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | -357.400 | 489.390 | 218.862 |
| Pair 2 | T1Quad1 - T1Quad3 | .200 | .447 | .200 |
| Pair 3 | T1Quad1 - T1Quad4 | -178.400 | 399.474 | 178.650 |
| Pair 4 | T1Quad2 - T1Quad3 | 357.600 | 489.664 | 218.984 |
| Pair 5 | T1Quad2 - T1Quad4 | 179.000 | 747.616 | 334.344 |
| Pair 6 | T1Quad3 - T1Quad4 | -178.600 | 399.362 | 178.600 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -.200 | .447 | .200 |

Paired Samples Test

| | | Paired Differences | |
|--------|--------------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -965.058 | 250.258 |
| Pair 2 | T1Quad1 - T1Quad3 | -.355 | .755 |
| Pair 3 | T1Quad1 - T1Quad4 | -674.412 | 317.612 |
| Pair 4 | T1Quad2 - T1Quad3 | -250.398 | 965.598 |
| Pair 5 | T1Quad2 - T1Quad4 | -749.287 | 1107.287 |
| Pair 6 | T1Quad3 - T1Quad4 | -674.473 | 317.273 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -.755 | .355 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|--------|--------------------------------------|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | -1.633 | 4 | .178 |
| Pair 2 | T1Quad1 - T1Quad3 | 1.000 | 4 | .374 |
| Pair 3 | T1Quad1 - T1Quad4 | -.999 | 4 | .375 |
| Pair 4 | T1Quad2 - T1Quad3 | 1.633 | 4 | .178 |
| Pair 5 | T1Quad2 - T1Quad4 | .535 | 4 | .621 |
| Pair 6 | T1Quad3 - T1Quad4 | -1.000 | 4 | .374 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -1.000 | 4 | .374 |

Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 8 | T1LeftofMallards - T1Mallards | -536.200 | 489.482 | 218.903 |
| Pair 10 | T1RightofMallards - T1Mallards | -536.000 | 489.299 | 218.821 |
| Pair 11 | T1RightofMallards - T1WPs | .200 | .447 | .200 |
| Pair 12 | T2Quad1 - T2Quad2 | 227.400 | 702.190 | 314.029 |
| Pair 13 | T2Quad1 - T2Quad3 | 237.800 | 657.586 | 294.082 |
| Pair 14 | T2Quad1 - T2Quad4 | 220.600 | 720.531 | 322.231 |
| Pair 15 | T2Quad2 - T2Quad3 | 10.400 | 570.218 | 255.009 |
| Pair 16 | T2Quad2 - T2Quad4 | -6.800 | 596.164 | 266.613 |
| Pair 17 | T2Quad3 - T2Quad4 | -17.200 | 578.891 | 258.888 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -161.600 | 371.493 | 166.137 |
| Pair 19 | T2LeftofMallards - T2Mallards | -499.400 | 462.212 | 206.707 |
| Pair 20 | T2LeftofMallards - T2WPs | -209.200 | 388.027 | 173.531 |
| Pair 21 | T2RightofMallards - T2Mallards | -337.800 | 751.739 | 336.188 |
| Pair 22 | T2RightofMallards - T2WPs | -47.600 | 597.689 | 267.295 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 8 | T1LeftofMallards - T1Mallards | -1143.972 | 71.572 |
| Pair 10 | T1RightofMallards - T1Mallards | -1143.545 | 71.545 |
| Pair 11 | T1RightofMallards - T1WPs | -.355 | .755 |
| Pair 12 | T2Quad1 - T2Quad2 | -644.484 | 1099.284 |
| Pair 13 | T2Quad1 - T2Quad3 | -578.701 | 1054.301 |
| Pair 14 | T2Quad1 - T2Quad4 | -674.057 | 1115.257 |
| Pair 15 | T2Quad2 - T2Quad3 | -697.619 | 718.419 |
| Pair 16 | T2Quad2 - T2Quad4 | -747.035 | 733.435 |
| Pair 17 | T2Quad3 - T2Quad4 | -735.989 | 701.589 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -622.869 | 299.669 |
| Pair 19 | T2LeftofMallards - T2Mallards | -1073.312 | 74.512 |
| Pair 20 | T2LeftofMallards - T2WPs | -690.999 | 272.599 |
| Pair 21 | T2RightofMallards - T2Mallards | -1271.208 | 595.608 |
| Pair 22 | T2RightofMallards - T2WPs | -789.729 | 694.529 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------------|--------|----|-----------------|
| Pair 8 | T1LeftofMallards - T1Mallards | -2.449 | 4 | .070 |
| Pair 10 | T1RightofMallards - T1Mallards | -2.449 | 4 | .070 |
| Pair 11 | T1RightofMallards - T1WPs | 1.000 | 4 | .374 |
| Pair 12 | T2Quad1 - T2Quad2 | .724 | 4 | .509 |
| Pair 13 | T2Quad1 - T2Quad3 | .809 | 4 | .464 |
| Pair 14 | T2Quad1 - T2Quad4 | .685 | 4 | .531 |
| Pair 15 | T2Quad2 - T2Quad3 | .041 | 4 | .969 |
| Pair 16 | T2Quad2 - T2Quad4 | -.026 | 4 | .981 |
| Pair 17 | T2Quad3 - T2Quad4 | -.066 | 4 | .950 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -.973 | 4 | .386 |
| Pair 19 | T2LeftofMallards - T2Mallards | -2.416 | 4 | .073 |
| Pair 20 | T2LeftofMallards - T2WPs | -1.206 | 4 | .294 |
| Pair 21 | T2RightofMallards - T2Mallards | -1.005 | 4 | .372 |
| Pair 22 | T2RightofMallards - T2WPs | -.178 | 4 | .867 |

T-Test INTERACTION WITH WPS

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Paired Samples Test

| | | Paired Differences | | |
|---------|---|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 192.750 | 409.094 | 204.547 |
| Pair 2 | T1Quad1 - T1Quad3 | -7.250 | 585.080 | 292.540 |
| Pair 3 | T1Quad1 - T1Quad4 | -145.500 | 744.964 | 372.482 |
| Pair 4 | T1Quad2 - T1Quad3 | -200.000 | 411.116 | 205.558 |
| Pair 5 | T1Quad2 - T1Quad4 | -338.250 | 427.497 | 213.748 |
| Pair 6 | T1Quad3 - T1Quad4 | -138.250 | 752.055 | 376.028 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -1.250 | 1.893 | .946 |
| Pair 8 | T1LeftofMallards - T1Mallards | -544.000 | 378.966 | 189.483 |
| Pair 9 | T1LeftofMallards - T1WPs | -289.750 | 397.612 | 198.806 |
| Pair 10 | T1RightofMallards - T1Mallards | -542.750 | 377.814 | 188.907 |
| Pair 11 | T1RightofMallards - T1WPs | -288.500 | 398.488 | 199.244 |
| Pair 12 | T2Quad1 - T2Quad2 | 222.000 | 444.000 | 222.000 |
| Pair 13 | T2Quad1 - T2Quad3 | -101.500 | 754.885 | 377.442 |
| Pair 14 | T2Quad1 - T2Quad4 | -2.000 | 728.319 | 364.159 |
| Pair 15 | T2Quad2 - T2Quad3 | -323.500 | 425.679 | 212.840 |
| Pair 16 | T2Quad2 - T2Quad4 | -224.000 | 448.000 | 224.000 |
| Pair 17 | T2Quad3 - T2Quad4 | 99.500 | 758.383 | 379.191 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -224.250 | 448.500 | 224.250 |
| Pair 20 | T2LeftofMallards - T2WPs | -545.250 | 431.964 | 215.982 |
| Pair 21 | T2RightofMallards - T2Mallards | 224.250 | 448.500 | 224.250 |
| Pair 22 | T2RightofMallards - T2WPs | -321.000 | 844.870 | 422.435 |

Paired Samples Test

| | | Paired Differences | |
|---------|---|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -458.211 | 843.711 |
| Pair 2 | T1Quad1 - T1Quad3 | -938.242 | 923.742 |
| Pair 3 | T1Quad1 - T1Quad4 | -1330.904 | 1039.904 |
| Pair 4 | T1Quad2 - T1Quad3 | -854.178 | 454.178 |
| Pair 5 | T1Quad2 - T1Quad4 | -1018.493 | 341.993 |
| Pair 6 | T1Quad3 - T1Quad4 | -1334.938 | 1058.438 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -4.262 | 1.762 |
| Pair 8 | T1LeftofMallards - T1Mallards | -1147.020 | 59.020 |
| Pair 9 | T1LeftofMallards - T1WPs | -922.439 | 342.939 |
| Pair 10 | T1RightofMallards - T1Mallards | -1143.937 | 58.437 |
| Pair 11 | T1RightofMallards - T1WPs | -922.584 | 345.584 |
| Pair 12 | T2Quad1 - T2Quad2 | -484.503 | 928.503 |
| Pair 13 | T2Quad1 - T2Quad3 | -1302.690 | 1099.690 |
| Pair 14 | T2Quad1 - T2Quad4 | -1160.917 | 1156.917 |
| Pair 15 | T2Quad2 - T2Quad3 | -1000.851 | 353.851 |
| Pair 16 | T2Quad2 - T2Quad4 | -936.868 | 488.868 |
| Pair 17 | T2Quad3 - T2Quad4 | -1107.256 | 1306.256 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -937.914 | 489.414 |
| Pair 20 | T2LeftofMallards - T2WPs | -1232.601 | 142.101 |
| Pair 21 | T2RightofMallards - T2Mallards | -489.414 | 937.914 |
| Pair 22 | T2RightofMallards - T2WPs | -1665.376 | 1023.376 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|---|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | .942 | 3 | .416 |
| Pair 2 | T1Quad1 - T1Quad3 | -.025 | 3 | .982 |
| Pair 3 | T1Quad1 - T1Quad4 | -.391 | 3 | .722 |
| Pair 4 | T1Quad2 - T1Quad3 | -.973 | 3 | .402 |
| Pair 5 | T1Quad2 - T1Quad4 | -1.582 | 3 | .212 |
| Pair 6 | T1Quad3 - T1Quad4 | -.368 | 3 | .738 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -1.321 | 3 | .278 |
| Pair 8 | T1LeftofMallards - T1Mallards | -2.871 | 3 | .064 |
| Pair 9 | T1LeftofMallards - T1WPs | -1.457 | 3 | .241 |
| Pair 10 | T1RightofMallards - T1Mallards | -2.873 | 3 | .064 |
| Pair 11 | T1RightofMallards - T1WPs | -1.448 | 3 | .243 |
| Pair 12 | T2Quad1 - T2Quad2 | 1.000 | 3 | .391 |
| Pair 13 | T2Quad1 - T2Quad3 | -.269 | 3 | .805 |
| Pair 14 | T2Quad1 - T2Quad4 | -.005 | 3 | .996 |
| Pair 15 | T2Quad2 - T2Quad3 | -1.520 | 3 | .226 |
| Pair 16 | T2Quad2 - T2Quad4 | -1.000 | 3 | .391 |
| Pair 17 | T2Quad3 - T2Quad4 | .262 | 3 | .810 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -1.000 | 3 | .391 |
| Pair 20 | T2LeftofMallards - T2WPs | -2.525 | 3 | .086 |
| Pair 21 | T2RightofMallards - T2Mallards | 1.000 | 3 | .391 |
| Pair 22 | T2RightofMallards - T2WPs | -.760 | 3 | .503 |

Appendix D

T-Test INTERACTION WITH MALLARDS

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Paired Samples Test

| | | Paired Differences | | |
|---------|---|--------------------|----------------|--------------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 36.125 | 517.942 | 183.120 |
| Pair 2 | T1Quad1 - T1Quad3 | 222.750 | 392.593 | 138.802 |
| Pair 3 | T1Quad1 - T1Quad4 | -242.125 | 728.317 | 257.499 |
| Pair 4 | T1Quad2 - T1Quad3 | 186.625 | 236.210 | 83.513 |
| Pair 5 | T1Quad2 - T1Quad4 | -278.250 | 495.603 | 175.222 |
| Pair 6 | T1Quad3 - T1Quad4 | -464.875 | 372.675 | 131.761 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | 4.500 | 50.237 | 17.761 |
| Pair 8 | T1LeftofMallards - T1Mallards | -381.125 | 392.244 | 138.679 |
| Pair 9 | T1LeftofMallards - T1WPs | -449.125 | 347.289 | 122.785 |
| Pair 10 | T1RightofMallards - T1Mallards | -385.625 | 393.110 | 138.985 |
| Pair 11 | T1RightofMallards - T1WPs | -453.625 | 343.525 | 121.455 |
| Pair 12 | T2Quad1 - T2Quad2 | -192.625 | 465.163 | 164.460 |
| Pair 13 | T2Quad1 - T2Quad3 | -109.750 | 317.024 | 112.085 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------------|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -396.886 | 469.136 |
| Pair 2 | T1Quad1 - T1Quad3 | -105.466 | 550.966 |
| Pair 3 | T1Quad1 - T1Quad4 | -851.014 | 366.764 |
| Pair 4 | T1Quad2 - T1Quad3 | -10.851 | 384.101 |
| Pair 5 | T1Quad2 - T1Quad4 | -692.585 | 136.085 |
| Pair 6 | T1Quad3 - T1Quad4 | -776.439 | -153.311 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -37.499 | 46.499 |
| Pair 8 | T1LeftofMallards - T1Mallards | -709.049 | -53.201 |
| Pair 9 | T1LeftofMallards - T1WPs | -739.466 | -158.784 |
| Pair 10 | T1RightofMallards - T1Mallards | -714.273 | -56.977 |
| Pair 11 | T1RightofMallards - T1WPs | -740.819 | -166.431 |
| Pair 12 | T2Quad1 - T2Quad2 | -581.511 | 196.261 |
| Pair 13 | T2Quad1 - T2Quad3 | -374.789 | 155.289 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|--------------------------------------|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | .197 | 7 | .849 |
| Pair 2 | T1Quad1 - T1Quad3 | 1.605 | 7 | .153 |
| Pair 3 | T1Quad1 - T1Quad4 | -.940 | 7 | .378 |
| Pair 4 | T1Quad2 - T1Quad3 | 2.235 | 7 | .061 |
| Pair 5 | T1Quad2 - T1Quad4 | -1.588 | 7 | .156 |
| Pair 6 | T1Quad3 - T1Quad4 | -3.528 | 7 | .010 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | .253 | 7 | .807 |
| Pair 8 | T1LeftofMallards - T1Mallards | -2.748 | 7 | .029 |
| Pair 9 | T1LeftofMallards - T1WPs | -3.658 | 7 | .008 |
| Pair 10 | T1RightofMallards - T1Mallards | -2.775 | 7 | .028 |
| Pair 11 | T1RightofMallards - T1WPs | -3.735 | 7 | .007 |
| Pair 12 | T2Quad1 - T2Quad2 | -1.171 | 7 | .280 |
| Pair 13 | T2Quad1 - T2Quad3 | -.979 | 7 | .360 |

Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------------|--------------------|----------------|-----------------|
| | | | | |
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 14 | T2Quad1 - T2Quad4 | -207.875 | 430.648 | 152.257 |
| Pair 15 | T2Quad2 - T2Quad3 | 82.875 | 605.129 | 213.945 |
| Pair 16 | T2Quad2 - T2Quad4 | -15.250 | 638.203 | 225.639 |
| Pair 17 | T2Quad3 - T2Quad4 | -98.125 | 586.943 | 207.516 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -2.625 | 8.568 | 3.029 |
| Pair 19 | T2LeftofMallards - T2Mallards | -350.750 | 371.920 | 131.494 |
| Pair 20 | T2LeftofMallards - T2WPs | -387.375 | 404.244 | 142.922 |
| Pair 21 | T2RightofMallards - T2Mallards | -348.125 | 373.615 | 132.093 |
| Pair 22 | T2RightofMallards - T2WPs | -384.750 | 402.560 | 142.327 |

Paired Samples Test

| | | Paired Differences | |
|---------|--------------------------------------|---|---------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 14 | T2Quad1 - T2Quad4 | -567.906 | 152.156 |
| Pair 15 | T2Quad2 - T2Quad3 | -423.025 | 588.775 |
| Pair 16 | T2Quad2 - T2Quad4 | -548.801 | 518.301 |
| Pair 17 | T2Quad3 - T2Quad4 | -588.822 | 392.572 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -9.788 | 4.538 |
| Pair 19 | T2LeftofMallards - T2Mallards | -661.683 | -39.817 |
| Pair 20 | T2LeftofMallards - T2WPs | -725.331 | -49.419 |
| Pair 21 | T2RightofMallards - T2Mallards | -660.475 | -35.775 |
| Pair 22 | T2RightofMallards - T2WPs | -721.299 | -48.201 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|---|--------|----|-----------------|
| Pair 14 | T2Quad1 - T2Quad4 | -1.365 | 7 | .214 |
| Pair 15 | T2Quad2 - T2Quad3 | .387 | 7 | .710 |
| Pair 16 | T2Quad2 - T2Quad4 | -.068 | 7 | .948 |
| Pair 17 | T2Quad3 - T2Quad4 | -.473 | 7 | .651 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -.867 | 7 | .415 |
| Pair 19 | T2LeftofMallards - T2Mallards | -2.667 | 7 | .032 |
| Pair 20 | T2LeftofMallards - T2WPs | -2.710 | 7 | .030 |
| Pair 21 | T2RightofMallards - T2Mallards | -2.635 | 7 | .034 |
| Pair 22 | T2RightofMallards - T2WPs | -2.703 | 7 | .030 |

T-Test INTERACTION WITH WPS

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Paired Samples Test

| | | Paired Differences | | |
|---------|--------------------------------------|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1Quad1 - T1Quad2 | 167.250 | 360.760 | 127.548 |
| Pair 2 | T1Quad1 - T1Quad3 | -86.500 | 462.686 | 163.584 |
| Pair 3 | T1Quad1 - T1Quad4 | 26.750 | 525.393 | 185.754 |
| Pair 4 | T1Quad2 - T1Quad3 | -253.750 | 453.572 | 160.362 |
| Pair 5 | T1Quad2 - T1Quad4 | -140.500 | 355.701 | 125.759 |
| Pair 6 | T1Quad3 - T1Quad4 | 113.250 | 638.179 | 225.631 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | 90.875 | 271.702 | 96.061 |
| Pair 8 | T1LeftofMallards - T1Mallards | -357.750 | 516.001 | 182.434 |
| Pair 9 | T1LeftofMallards - T1WPs | -190.125 | 442.315 | 156.382 |
| Pair 10 | T1RightofMallards - T1Mallards | -448.625 | 306.478 | 108.356 |
| Pair 11 | T1RightofMallards - T1WPs | -281.000 | 276.681 | 97.822 |
| Pair 12 | T2Quad1 - T2Quad2 | 203.625 | 508.258 | 179.696 |
| Pair 13 | T2Quad1 - T2Quad3 | -61.500 | 605.640 | 214.126 |
| Pair 14 | T2Quad1 - T2Quad4 | 199.625 | 537.730 | 190.116 |
| Pair 15 | T2Quad2 - T2Quad3 | -265.125 | 559.609 | 197.852 |
| Pair 16 | T2Quad2 - T2Quad4 | -4.000 | 448.537 | 158.582 |
| Pair 17 | T2Quad3 - T2Quad4 | 261.125 | 568.067 | 200.842 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -7.000 | 28.097 | 9.934 |
| Pair 19 | T2LeftofMallards - T2Mallards | -271.500 | 326.402 | 115.401 |
| Pair 20 | T2LeftofMallards - T2WPs | -602.750 | 341.963 | 120.902 |
| Pair 21 | T2RightofMallards - T2Mallards | -264.500 | 307.111 | 108.580 |
| Pair 22 | T2RightofMallards - T2WPs | -595.750 | 362.917 | 128.311 |

Paired Samples Test

| | | Paired Differences | |
|---------|---|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1Quad1 - T1Quad2 | -134.353 | 468.853 |
| Pair 2 | T1Quad1 - T1Quad3 | -473.315 | 300.315 |
| Pair 3 | T1Quad1 - T1Quad4 | -412.489 | 465.989 |
| Pair 4 | T1Quad2 - T1Quad3 | -632.946 | 125.446 |
| Pair 5 | T1Quad2 - T1Quad4 | -437.873 | 156.873 |
| Pair 6 | T1Quad3 - T1Quad4 | -420.281 | 646.781 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | -136.273 | 318.023 |
| Pair 8 | T1LeftofMallards - T1Mallards | -789.137 | 73.637 |
| Pair 9 | T1LeftofMallards - T1WPs | -559.909 | 179.659 |
| Pair 10 | T1RightofMallards - T1Mallards | -704.847 | -192.403 |
| Pair 11 | T1RightofMallards - T1WPs | -512.311 | -49.689 |
| Pair 12 | T2Quad1 - T2Quad2 | -221.289 | 628.539 |
| Pair 13 | T2Quad1 - T2Quad3 | -567.828 | 444.828 |
| Pair 14 | T2Quad1 - T2Quad4 | -249.928 | 649.178 |
| Pair 15 | T2Quad2 - T2Quad3 | -732.970 | 202.720 |
| Pair 16 | T2Quad2 - T2Quad4 | -378.986 | 370.986 |
| Pair 17 | T2Quad3 - T2Quad4 | -213.790 | 736.040 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -30.489 | 16.489 |
| Pair 19 | T2LeftofMallards - T2Mallards | -544.379 | 1.379 |
| Pair 20 | T2LeftofMallards - T2WPs | -888.638 | -316.862 |
| Pair 21 | T2RightofMallards - T2Mallards | -521.252 | -7.748 |
| Pair 22 | T2RightofMallards - T2WPs | -899.157 | -292.343 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|---|--------|----|-----------------|
| Pair 1 | T1Quad1 - T1Quad2 | 1.311 | 7 | .231 |
| Pair 2 | T1Quad1 - T1Quad3 | -.529 | 7 | .613 |
| Pair 3 | T1Quad1 - T1Quad4 | .144 | 7 | .890 |
| Pair 4 | T1Quad2 - T1Quad3 | -1.582 | 7 | .158 |
| Pair 5 | T1Quad2 - T1Quad4 | -1.117 | 7 | .301 |
| Pair 6 | T1Quad3 - T1Quad4 | .502 | 7 | .631 |
| Pair 7 | T1LeftofMallards - T1RightofMallards | .946 | 7 | .376 |
| Pair 8 | T1LeftofMallards - T1Mallards | -1.961 | 7 | .091 |
| Pair 9 | T1LeftofMallards - T1WPs | -1.216 | 7 | .263 |
| Pair 10 | T1RightofMallards - T1Mallards | -4.140 | 7 | .004 |
| Pair 11 | T1RightofMallards - T1WPs | -2.873 | 7 | .024 |
| Pair 12 | T2Quad1 - T2Quad2 | 1.133 | 7 | .294 |
| Pair 13 | T2Quad1 - T2Quad3 | -.287 | 7 | .782 |
| Pair 14 | T2Quad1 - T2Quad4 | 1.050 | 7 | .329 |
| Pair 15 | T2Quad2 - T2Quad3 | -1.340 | 7 | .222 |
| Pair 16 | T2Quad2 - T2Quad4 | -.025 | 7 | .981 |
| Pair 17 | T2Quad3 - T2Quad4 | 1.300 | 7 | .235 |
| Pair 18 | T2LeftofMallards - T2RightofMallards | -.705 | 7 | .504 |
| Pair 19 | T2LeftofMallards - T2Mallards | -2.353 | 7 | .051 |
| Pair 20 | T2LeftofMallards - T2WPs | -4.985 | 7 | .002 |
| Pair 21 | T2RightofMallards - T2Mallards | -2.436 | 7 | .045 |
| Pair 22 | T2RightofMallards - T2WPs | -4.643 | 7 | .002 |

T-Test

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Paired Samples Test

| | | Paired Differences | | |
|---------|---|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1LatencyG2 - T1LatencyG1 | -25.250 | 48.624 | 24.312 |
| Pair 2 | T1Quad1G2 - T1Quad1G1 | -424.250 | 496.704 | 248.352 |
| Pair 3 | T1Quad2G2 - T1Quad2G1 | -132.000 | 238.994 | 119.497 |
| Pair 4 | T1Quad3G2 - T1Quad3G1 | 418.250 | 467.296 | 233.648 |
| Pair 5 | T1Quad4G2 - T1Quad4G1 | 163.000 | 780.844 | 390.422 |
| Pair 6 | T1LeftofMallardsG2 - T1LeftofMallardsG1 | -5.500 | 34.933 | 17.467 |
| Pair 7 | T1RightofMallardsG2 - T1RightofMallardsG1 | -30.250 | 48.678 | 24.339 |
| Pair 8 | T1MallardsG2 - T1MallardsG1 | -91.000 | 267.947 | 133.973 |
| Pair 9 | T1WPsG2 - T1WPsG1 | 151.750 | 337.446 | 168.723 |
| Pair 10 | T2LatencyG2 - T2LatencyG1 | 5.000 | 11.402 | 5.701 |
| Pair 11 | T2Quad1G2 - T2Quad1G1 | 75.500 | 397.706 | 198.853 |
| Pair 12 | T2Quad2G2 - T2Quad2G1 | 44.500 | 701.584 | 350.792 |
| Pair 13 | T2Quad3G2 - T2Quad3G1 | -95.500 | 699.054 | 349.527 |

Paired Samples Test

| | | Paired Differences | |
|---------|---|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 1 | T1LatencyG2 - T1LatencyG1 | -102.621 | 52.121 |
| Pair 2 | T1Quad1G2 - T1Quad1G1 | -1214.617 | 366.117 |
| Pair 3 | T1Quad2G2 - T1Quad2G1 | -512.292 | 248.292 |
| Pair 4 | T1Quad3G2 - T1Quad3G1 | -325.322 | 1161.822 |
| Pair 5 | T1Quad4G2 - T1Quad4G1 | -1079.498 | 1405.498 |
| Pair 6 | T1LeftofMallardsG2 - T1LeftofMallardsG1 | -61.087 | 50.087 |
| Pair 7 | T1RightofMallardsG2 - T1RightofMallardsG1 | -107.708 | 47.208 |
| Pair 8 | T1MallardsG2 - T1MallardsG1 | -517.363 | 335.363 |
| Pair 9 | T1WPsG2 - T1WPsG1 | -385.201 | 688.701 |
| Pair 10 | T2LatencyG2 - T2LatencyG1 | -13.143 | 23.143 |
| Pair 11 | T2Quad1G2 - T2Quad1G1 | -557.338 | 708.338 |
| Pair 12 | T2Quad2G2 - T2Quad2G1 | -1071.877 | 1160.877 |
| Pair 13 | T2Quad3G2 - T2Quad3G1 | -1207.851 | 1016.851 |

Paired Samples Test

| | | Paired Differences | | |
|---------|---|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 1 | T1LatencyG2 - T1LatencyG1 | -1.039 | 3 | .375 |
| Pair 2 | T1Quad1G2 - T1Quad1G1 | -1.708 | 3 | .186 |
| Pair 3 | T1Quad2G2 - T1Quad2G1 | -1.105 | 3 | .350 |
| Pair 4 | T1Quad3G2 - T1Quad3G1 | 1.790 | 3 | .171 |
| Pair 5 | T1Quad4G2 - T1Quad4G1 | .417 | 3 | .704 |
| Pair 6 | T1LeftofMallardsG2 - T1LeftofMallardsG1 | -.315 | 3 | .773 |
| Pair 7 | T1RightofMallardsG2 - T1RightofMallardsG1 | -1.243 | 3 | .302 |
| Pair 8 | T1MallardsG2 - T1MallardsG1 | -.679 | 3 | .546 |
| Pair 9 | T1WPsG2 - T1WPsG1 | .899 | 3 | .435 |
| Pair 10 | T2LatencyG2 - T2LatencyG1 | .877 | 3 | .445 |
| Pair 11 | T2Quad1G2 - T2Quad1G1 | .380 | 3 | .729 |
| Pair 12 | T2Quad2G2 - T2Quad2G1 | .127 | 3 | .907 |
| Pair 13 | T2Quad3G2 - T2Quad3G1 | -.273 | 3 | .802 |

Paired Samples Test

| | | Paired Differences | | |
|---------|---|--------------------|----------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean |
| Pair 14 | T2Quad4G2 - T2Quad4G1 | -29.250 | 653.662 | 326.831 |
| Pair 15 | T2LeftofMallardsG2 - T2LeftofMallardsG1 | -2.250 | 3.202 | 1.601 |
| Pair 16 | T2RightofMallardsG2 - T2RightofMallardsG1 | -11.250 | 43.805 | 21.903 |
| Pair 17 | T2MallardsG2 - T2MallardsG1 | -13.000 | 411.040 | 205.520 |
| Pair 18 | T2WPsG2 - T2WPsG1 | 21.750 | 431.959 | 215.980 |

Paired Samples Test

| | | Paired Differences | |
|---------|---|---|----------|
| | | 95% Confidence Interval of the Difference | |
| | | Lower | Upper |
| Pair 14 | T2Quad4G2 - T2Quad4G1 | -1069.372 | 1010.872 |
| Pair 15 | T2LeftofMallardsG2 - T2LeftofMallardsG1 | -7.344 | 2.844 |
| Pair 16 | T2RightofMallardsG2 - T2RightofMallardsG1 | -80.954 | 58.454 |
| Pair 17 | T2MallardsG2 - T2MallardsG1 | -667.057 | 641.057 |
| Pair 18 | T2WPsG2 - T2WPsG1 | -665.594 | 709.094 |

Paired Samples Test

| | | t | df | Sig. (2-tailed) |
|---------|---|--------|----|-----------------|
| Pair 14 | T2Quad4G2 - T2Quad4G1 | -.089 | 3 | .934 |
| Pair 15 | T2LeftofMallardsG2 - T2LeftofMallardsG1 | -1.406 | 3 | .255 |
| Pair 16 | T2RightofMallardsG2 - T2RightofMallardsG1 | -.514 | 3 | .643 |
| Pair 17 | T2MallardsG2 - T2MallardsG1 | -.063 | 3 | .954 |
| Pair 18 | T2WPsG2 - T2WPsG1 | .101 | 3 | .926 |