THE DEVELOPMENT OF OBJECT PERMANENCE IN TURKEYS (*MELEAGRIS GALLOPAVO*) AND MUSCOVY DUCKS (*CAIRINA MOSCHATA*)

by

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of
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by

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Bachelor of Science
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DEDICATION

This is dedicated to my understanding and extremely patient wife Christen, as well as my awesome advisor Doris and her husband Kirk. I couldn't have done this without any of you!

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I would like to thank my wife, family, and friends who supported me through this entire process. My wife, Christen, helped me get over any mental hurdles. My advisor, Doris, helped me with almost every step of the process, and her husband, Kirk, took care of all my research subjects. Cecil Blevins, of Catlett, Virginia and Jason Biddle, of Louisa, Virginia helped to increase my sample sizes by providing turkeys and ducks, respectively. Dr. Luther and Dr. Flinn helped me see anything I might have missed in my research and manuscript. Finally, Sally from University Dissertation and Thesis Servicesmade sure my thesis was looking sharp.

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ABSTRACT

THE DEVELOPMENT OF OBJECT PERMANENCE IN TURKEYS (*MELEAGRIS GALLOPAVO*) AND MUSCOVY DUCKS (*CAIRINA MOSCHATA*)

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George Mason University, 2019

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Object permanence, the understanding that an object continues to exist when it is out of sight, is one aspect of cognition that can help to ensure an animal's survival by allowing it to keep track of both food and predators. Object permanence is not an all-or-nothing ability, instead occurring on a continuum. It is divided into six stages, with each stage building on the last. In avian species, the developmental timeline and final stage of object permanence reached can differ between species, possibly due to the effects of different environments and social structures on the evolution of this cognitive trait. In the current study two previously-unstudied avian species, turkeys (*Meleagris gallopavo*) and Muscovy ducks (*Cairina moschata*), were tested to determine the timeline of object permanence development and final stage of object permanence achieved using the Uzgiris and Hunt Scale 1 tasks. This scale is a set of 15 tasks that accurately assess which stage of object permanence an individual is in at a specific point in time. The Scale 1

tasks are also designed to easily compare the progression of object permanence development between species. Both wild type and domestic turkeys were tested in a preliminary attempt to determine whether domestication might affect the development and ultimate form of object permanence. Both the wild type and domestic turkeys could complete the tasks up to Task 3 (Stage 3 competence), while the Muscovy ducks were able to complete the tasks up to Task 4 (Stage 4 competence). These results support the idea that environmental pressures might affect the development of object permanence. This theory could be explored in future studies by administering the Scale 1 tasks to species either environmentally or genealogically similar to the Muscovy ducks.

INTRODUCTION

Object permanence is a fundamental cognitive concept that incorporates a variety of object-based sensory and memory processes, such as tracking an object or remembering where something is even if it is out of your line of sight. First studied in human infants by Jean Piaget in 1936, object permanence in humans begins to develop in the early stages of sensorimotor development (Pepperberg, Willner, & Gravitz, 1997). During this sensorimotor period, humans and animals go through stages in which they begin to learn a set of pleasurable actions built from innate reflexes and behaviors, modify the newly learned behaviors with outside objects, and finally recognize the objects themselves, as well as the potential to use them for a variety of tasks (Dore & Dumas, 1987). While the development of general sensorimotor intelligence is not the same in every species and has been tested in select avian species such as the Western scrub jay (*Aphelocoma californica*) (Salwiczek, Schlinger, Emery, & Clayton, 2009) and members of the corvid family (Seed, Emery, & Clayton, 2009), the stages of object permanence have been tested extensively in multiple avian species (Pepperberg & Kozak, 1986; Pollok, Prior, & Gunturkun, 2000; Zucca, Milos, & Vallortigara, 2007)

There are six Piagetian stages of object permanence. In the first stage, there is no awareness that objects continue to exist when they disappear from sight. The ability to track moving objects appears in Stage 2. Next, in Stage 3, early permanence is beginning

to emerge as the individual realizes when an object has left their sight. In human infants their eyes rapidly search the area, they become short of breath, and their heart rate begins to increase. In this stage, partially obscured objects can be retrieved. Stage 4 is split into 4a and 4b. In Stage 4a it is possible for an individual to find a completely hidden object only if a search for it has already begun as it disappears, such as watching a ball roll behind an object. In Stage 4b it is possible to find a completely hidden object without this prerequisite. One limitation of this stage is that, while finding a hidden object is possible, the search typically takes place where it was last found, not where it was seen to disappear. This is known as an A-not-B error or the perseveration error. Finally, in Stages 5 and 6, the A-not-B error is no longer evident (Stage 5a) and both single Stage 5b) and sequential (Stage 6) visible and invisible displacements (the act of placing an object behind or under multiple barriers that obscure the line of sight) are mastered (Marino, 2017).

While object permanence has been studied in depth in a variety of non-human animals such as primates (Call, 2001; DeBlois, Novak, & Bond, 1998) and companion animals (Triana & Pasnak, 1981), only a select group of avian species have been studied. One early study used an African Grey parrot as the subject (Pepperberg & Kozak, 1986). Pepperberg and Funk (1990) later conducted research on four psitticine species. The same lab did further research on object permanence, again focused on the African Grey parrot (*Psittacus erithacus*) (Pepperberg, Willner, & Gravitz, 1997). The main goal of this study was to observe the development of object permanence in the grey parrot and compare the results to humans. To accomplish this, a single grey parrot named Griffin,

who was eight weeks old at the time, was adopted. A mature grey parrot named Alex was used as a control. The study concluded at week 52, by which time Griffin had completed all subsections of Stage 6. The tasks that took longer to master were those associated with sequential invisible displacement, such as placing the treat under a box and moving the box behind two screens (Pepperberg, Willner, & Gravitz, 1997).

To assess Griffin's level of object permanence during each week of the study, the researchers used what are known as the Uzgiris and Hunt Scale 1 tasks. Designed in 1975, this scale assesses which stage of object permanence an animal or human is in with 15 tasks, each grouped into the stage that they measure. The Scale 1 tasks are largely used for animal object permanence research due to the precision with which they can not only determine the stage an individual is in at a specific point in time, but also where in the stage it is. For example, Task 5 tests Stage 5a, while Task 8 tests Stage 5b (see Table 1). The accuracy and uniform nature of the Scale 1 tasks also allow for an objective and consistent way to compare results across species.

Table 1 | A Summary of the Ugiris and Hunt (1975) Scale 1 Tasks Through Stage 6
This table briefly describes the tasks associated with each stage of object permanence as well as a real-world example describing the stage in humans.

Stage of Object Permanence	Related Tasks	Real World Example
Stage 2	Tasks 1 & 2	A child tracking keys as they jingle, even if they disappear behind an object.
Stage 3	Task 3	A childfinding a specific toy, even if it is partially covered.
Stage 4a	Task 4	A child retrieving a ball if they see it roll behind the couch.

Stage 4b	Task 5	A child can retrieve an object if it is out of view, but they will always look in the first place they found it, even if they see it hidden somewhere else.
Stage 5a	Tasks 5-7	A child will search for an object in the last place they saw it disappear.
Stage 5b	Task 8 & 9	A child will find an object, even if it is placed in a box and the box is placed in a closet.
Stage 6	Tasks 10-15	A child can find an object no matter how many times it is hidden, if they know the general location of where it is hidden.

Another avian species to undergo object permanence testing is the magpie (*Pica pica*) (Pollok, Prior, & Gunturkun, 2000). The main goals of this study were to establish a timeframe for the development of object permanence in magpies, a predominantly food storing species which utilizes object permanence to recall the location of food caches, as well as to compare the findings to those of the grey parrot. The researchers found that the magpies were able to accomplish the tasks at a faster rate than African Grey parrots. Full mastery of Stage 6 never truly occurred, but general competency was achieved at approximately 17 weeks of age (Pollok, Prior, & Gunturkun, 2000).

Much of the object permanence research in birds has continued to be on species typically considered to be smart, such as psitticines (for example, see Auersperg, Szabo, von Bayern, & Bugnyar, 2014; Funk, 1996) and corvids (for example, see Ujfalussy, Miklósi, & Bugnyar, 2013). Another subset of this research has focused on species that

cache food (for example, see Salwiczek, Emery, Schlinger, & Clayton, 2009). Surprisingly little research has been conducted with species that live in different types of environments and exhibit a range of social and food acquisition behaviors. Research with more common and readily accessible birds has the potential to provide insights into the consistency of the development of object permanence across the class Aves.

While not studied using the Scale 1 tasks, chickens have been tested for the maximum level of object permanence that they can reach (Marino, 2017). Multiple studies have shown that chickens are able to accomplish stage 3 object permanence (Marino, 2017). The first of three well-known studies tested newly hatched chicks on their ability to find a partially hidden object. To do this, researchers imprinted newly hatched chicks on a red triangle. The act of imprinting creates a strong bond between the chick and the first object they see, which in nature is usually the mother. Then, on their third day of life, the researchers presented the imprinted chicks with two options: a partially covered red triangle or separated fragments of one. The chicks chose the partially occluded option every time (Regolin & Vallortigara, 1995). In the second study, researchers Lea, Slater, and Ryan (1996) confirmed the results found by Regolin and Vallortigara by imprinting newly hatched chicks on two rod pieces behind a center obstruction. When given the choice between the rod pieces and a whole rod, the chicks chose the whole rod. Finally, Forkman (1998) tested adult hens on stage 3 by having them chose between a square and a circle. To get the reward, the hen had to peck at the one that appeared to be farther away. For ten trials, the square and circle never overlapped each other, but on the tenth trial, they did. The hens chose the partially

obstructed object showing that they were able to determine which was further away based on which was obstructed. Very little evidence has been found showing that chickens can reach level 4, with the only accessible study showing that newly hatched chicks had difficulty navigating vertical barriers that fully obstructed a cage mate (Regolin, Vallortigara, & Zandorlin, 1994).

The current study expands on the knowledge of object permanence in avian species by studying the development of object permanence in wild and domestic turkeys and Muscovy ducks. While the turkey and the Muscovy duck are native to the Americas and primarily ground dwelling, they are separated by approximately 54 million years of evolution. In addition, the environmental differences between the two species are large. The turkeys primarily live in forests near large clearings, searching for food and building their nests on the ground. Muscovy ducks, on the other hand, typically live in forested areas near lakes, streams, and other bodies of water. Unlike the turkeys, the Muscovy ducks primarily search for food in the water by repeatedly sticking their head under water to grab an item that was located during a previous dunk. Muscovy ducks usually build their nests inside hollowed out tree trunks, out of the line of sight of most predators.

To determine the evolutionary separation of these two species, a look into the phylogeny of each is necessary.

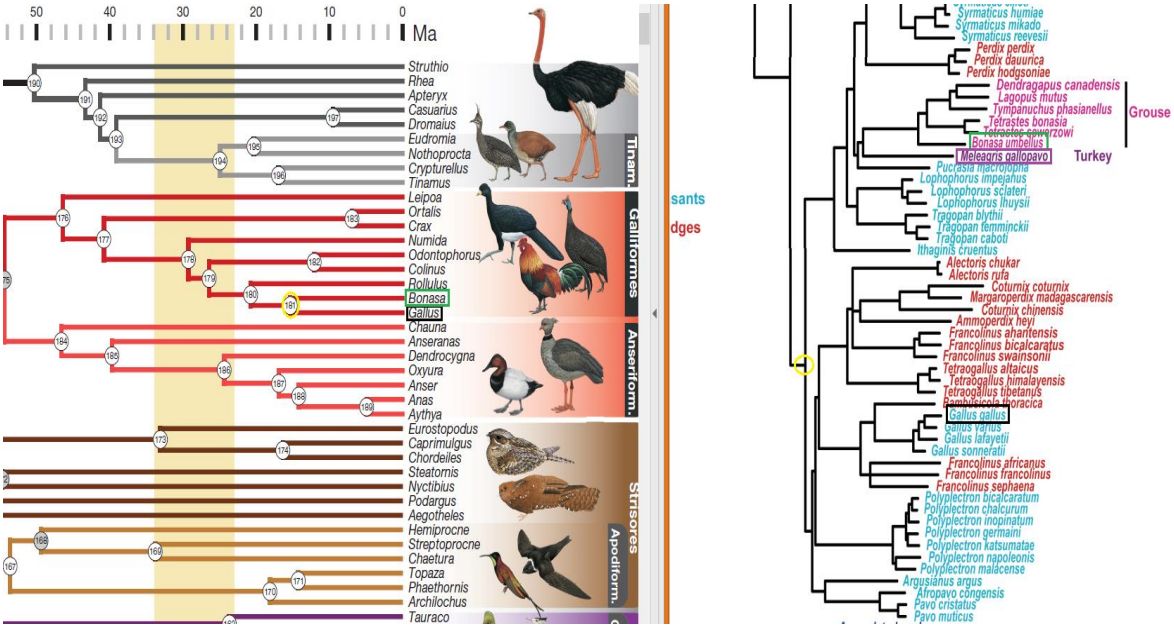

Figure 1 | A comparison of phylogeny 1
(Left image, Prum et al., 2015), (Right image, Wang et al., 2013). The left image shows the Galliformes and Anseriformes sections of a "Time-calibrated phylogeny of 198 species of birds inferred from a concatenated, Bayesian analysis of 259 anchored phylogenomic loci using ExaBayes (as cited in Prum et al., 2015). The right image shows the "Galliformes phylogeny based upon Bayesian MCMC analysis of the complete data matrix (Wang et al., 2013)".

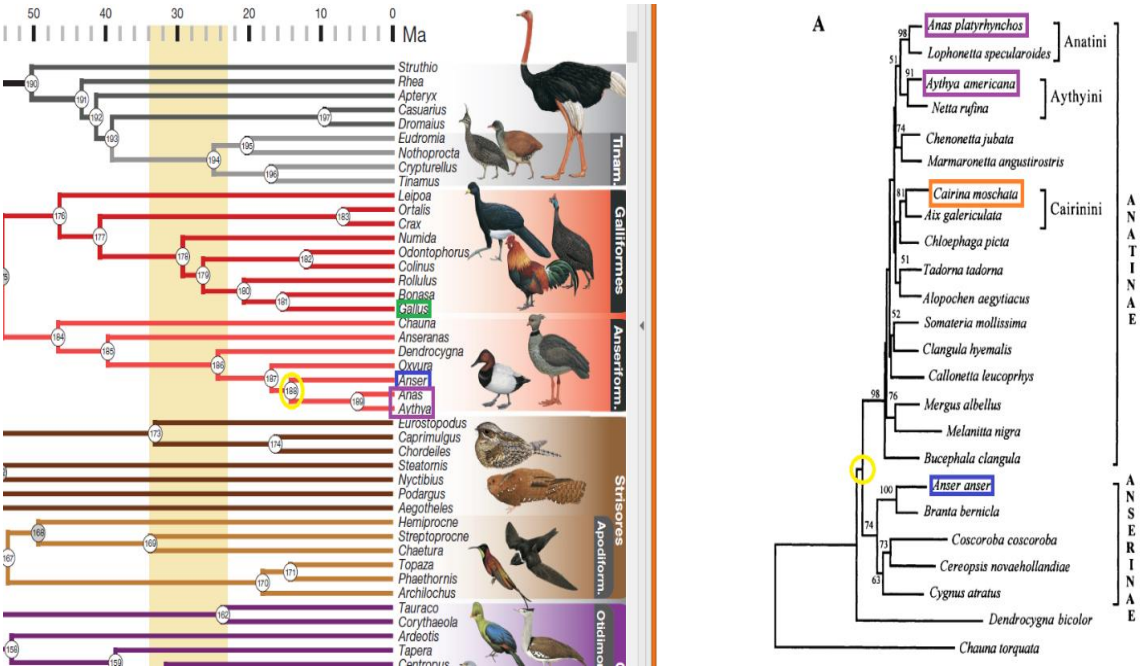

Figure 2 | A comparison of phylogeny 2
(Left image, Prum et al., 2015), (Right image, Donne-Groussé et al., 2001). The left image shows the Galliformes and Anseriformes sections of a "Time-calibrated phylogeny of 198 species of birds inferred from a concatenated, Bayesian analysis of 259 anchored phylogenomic loci using ExaBayes (as cited in Prum et al., 2015). The right image shows a distance analysis of the anseriformes phylogeny with a neighbor-joining method using a LogDet distance and a global gap removal option (Donne-Groussé et al., 2001)."

Using the comparison shown in figures 1 & 2 with the chicken as a point of reference (outlined in black in figure 1 and green in figure 2), it is possible to determine the evolutionary distance between turkeys and Muscovy ducks with relative accuracy. In figure 1 the turkey is outlined in green, with its closest cousin represented in both graphs, the ruffed grouse (*Bonasa umbellus*), outlined in green. In the left image, we see that the lineages of the chicken and that of the ruffed grouse separated approximately 15 million years ago, so we can assume the chicken and turkey lineages separated at about that time, as well.

In figure 2, the Muscovy duck is not on the left image, but the mallard (*Anas playtyrhynchos*) and redhead (*Aythya americana*) (outlined in purple), and the graylag goose (*Anser anser*, outlined in blue) are. We do see the Muscovy duck (*Cairina moschata*, outlined in orange) on the right image near the mallard and redhead showing that it shared a common ancestor with the three other species labeled in this figure. On the left side, we see that this split occurred approximately 14 million years ago. With the turkey and Mucovy duck accurately pinpointed on the left images, we finally see that their split occurred approximately 54 million years ago.

Hypotheses

The current study was designed to determine the timeline of object permanence development and the final stage of object permanence that could be reached by wild type turkeys, domestic turkeys and Muscovy ducks. This was accomplished by acquiring wild type turkeys, the domestic turkey breed known as Royal Palm, a breed known for their long history of domestication and selective breeding, and Muscovy ducks. The wild type turkeys were approximately 31 days of age, the domestic turkeys were approximately 29 days of age, and the Muscovy ducks were approximately 35 days of age at the start of the study. All subjects were tested using the Uzgiris and Hunt Scale 1 tasks to determine the highest stage of object permanence they could achieve, as well as to allow for an easy comparison of the results from each group.

The differences in foraging and nesting behavior mentioned earlier led to the belief that the development of object permanence could be different in turkeys and Muscovy ducks due to environmental differences encountered by the two species during

their evolution. The turkeys are part of the Galliformes order, which includes chickens, pheasants, quail and peafowl. Muscovy ducks are part of the Anseriformes order, which includes geese and swans. This difference is important due to the environments in which members of each order typically live. Turkeys and other Galliformes live in a relatively static environment where food on the ground does not often get covered up or leave the line of sight. Muscovy ducks and other Anseriformes live in a mutable, water-based environment where food sources can be covered up or leave the line of sight for extended periods of time. A second comparison is between the wild type and domestic turkeys. Using the Scale 1 tasks, the current study will make a preliminary determination as to whether domestication has had any significant effect on the development of object permanence in this species.

The hypotheses are as follows:

1. All three species will fully complete Stage 3 of object permanence based on the Uzgiri and Hunt (1975) Scale 1 tasks
    a. The Muscovy ducks will complete each stage earlier than the turkeys due to the environmental differences between the species. The Muscovy ducks not only locate, track, and catch their food which can be obscured underwater, they also have to remember the location of the tree trunk in which their nest is located.
2. The Muscovy ducks will reach a higher final stage of object permanence than the turkeys due to environmental pressures.

3. The wild type turkeys will complete each task faster than the domesticated turkeys due to the necessity of living in a less protected environment.

METHOD

Subjects/Housing

The subjects, some of which were hatched off site, varied in age at the time they joined the study. The wild type turkeys had six in their group that were approximately 31 days of age and two that were approximately 16 days in age. The domestic turkeys had four in their group and were all approximately 29 days of age. The Muscovy ducks had 10 in their group. Three began the study at 35 days of age, three at 25 days, one at 15 days, one at 13 days, and two at 9 days. Subjects were placed in housing that accommodated their needs at each stage in life. While small, the subjects were housed in an enclosed area approximately 3 feet by 2 feet, allowing for room to move and grow. When they outgrew this, they were moved into more standard coops suitable for the adult sizes of each species and, when possible, were allowed to free range during daylight hours. Straw was provided as bedding for all subjects. Age- and species-appropriate food and water were available at all times. Were they all tested at ~ the same ages, regardless of their age at arrival?

Procedures

During testing, each individual bird was moved to a holding area that had the same design as their current housing. In these areas, a clear, removeable barrier divided the experimental space into halves. To perform each of the Uzgiris and Hunt (1975) Scale

1 tasks, a variety of covers and treats were utilized and placed on the opposite side of the barrier from where the participant was. Then, when the setup was complete, the barrier was lifted allowing for the participant to attempt to accomplish the task. The Scale 1 tasks as well as the success criteria for each are listed below.

Stage 2 Object Permanence

Task 1. Before starting the test, the object is shaken in order to catch the bird's attention. The object is moved slowly around the bird along a horizontal plane through an arc of 180◦.

Success criterion: The bird had to follow the object continuously through an arc of 180◦.

Task 2. A moving object disappears from one side of a screen and reappears on the opposite side.

Success criterion: The bird looks at the point where the object disappears, or, after several presentations, its glance returns to the starting point or to the point of reappearance before the object reappears.

Stage 3 Object Permanence

Task 3. An object on which the bird focuses its attention is partially hidden under a single cover.

Success criterion: The hidden object is obtained by pulling it out from under the cover or by taking the object after removing the cover.

Stage 4 Object Permanence

Task 4. An object on which the bird focuses its attention is completely hidden under a single cover.

Success criterion: The hidden object is obtained by removing the cover and taking the object.

Stage 5a Object Permanence

Task 5. Two screens are used. If the bird finds the object that was hidden under one screen (A) during two trials, the object is subsequently hidden under the second screen (B). The object is hidden in the same way as in the first presentation but twice under the second screen and then twice under the first screen.

Success criterion: The bird searches for the object in the place of its final disappearance, for instance, under the second screen during the first presentation. Searching under the first screen would indicate the "A-not-B error".

Task 6. The object is hidden alternately under each of the two different covers.

Success criterion: The bird searches under each cover according to the site of the last hiding of the object.

Task 7. The object is hidden at random under three different screens.

Success criterion: The bird searches under the screen where the object was hidden.

Stage 5b

Task 8. The object is hidden consecutively behind each of the three screens by moving the hand that holds the object from left to right or the other way around, temporarily

hiding the object behind each screen and finally hiding the object under the screen where it disappears for the last time. Check that the attention of the bird is constant during the complete presentation.

Success criterion: The bird immediately searches behind the last screen where the object last disappeared.

Task 9. The object is hidden under three superimposed screens. Cover the object with the first screen, then cover the first screen with the second one and finally cover the second screen with the third. Place the screens in such a way that it is not possible to remove all the screens at the same time.

Success criterion: The bird obtains the object after removing all the screens.

Design

Each task was administered no more than five times for each subject. An initial completion of the task and one successful repetition were required before moving on to the next task (if a subject was successful on the fifth trial for a given day, a sixth trial was administered). If an individual was successful at a task two times in a row their trials for that day stopped and, on the next day, they began the next task. Trials were run three days a week on Monday, Wednesday, and Friday. If a participant was unable to complete a task at least once in approximately 2 weeks they were considered finished.

Timelines

While the Scale 1 is comprised of 15 tasks that extend to full Stage 6 completion, it was extremely unlikely that the subjects would complete all of the trials. Based on prior

research with chickens, it was believed that both turkey types would be able to complete Stage 3 of object permanence but not progress further, which was found to be the case. This was not predicted to be the case for the Muscovy ducks, as it was believed that they would be able to complete Stage 4 due to the challenges of the environment in which they evolved. This also proved to be true. Below are the timelines depicting the range of days it took each type of bird to complete the task:

Wild Type Turkeys:

Task 1 (Stage 2) - 1 to 3 days. Due to the varying ages of the subjects, Stage 2 had already developed for some of the participants and was still developing for others.

Task 2 (Stage 2) - 1 to 8 days. Again, due to the varying ages of the subjects, Stage 3 had already developed for some of the participants and was still developing for others.

Task 3 (Stage 3) - 14 to 19 days. Similar to the evidence for Stage 3 development in chickens, the turkeys were able to complete this trial.

Task 4 (Stage 4) - 14+ days. It was unlikely that the turkeys would be able to fully complete this trial, and they did not. This is unsurprising since it would show development of Stage 4 object permanence, something that has not been demonstrated in related species.

Average age of final successful trial completion: 53 days of age.

Domestic Turkeys:

Task 1 (Stage 2) - 1 to 3 days. Due to the age of the subjects, Stage 2 had already developed or was in the process of finishing its development.

Task 2 (Stage 2) - 3 days. Due to the age of the participants, Stage 3 had already developed or was in the process of finishing its development.

Task 3 (Stage 3) - 8 to 10 days. Similar to the evidence for Stage 3 development in chickens, the turkeys were able to complete this trial.

Task 4 (Stage 4) - 14+ days. Like the wild type turkeys, it was unlikely that the turkeys would be able to fully complete this trial, and they did not. This is unsurprising since it would show development of Stage 4 object permanence, something that has not been demonstrated in related species.

Average age of final successful trial completion: 46 days of age.

Muscovy Ducks:

Task 1 (Stage 2) - 1 to 5 days. Due to the varying ages of the participants, Stage 2 had already developed for some of the participants and was still developing for others.

Task 2 (Stage 2) - 1 to 10 days. Again, due to the varying ages of the subjects, Stage 3 had already developed for some of the participants and was still developing for others.

Task 3 (Stage 3) - 3 to 12 days. It was believed that the natural environment of the Muscovy duck would allow them to easily complete Stage 3, which was the case with Task 3.

Task 4 (Stage 4) – 12 to 19 days. It was believed that the natural environment of the Muscovy duck would allow them to fully complete Stage 4, which is the case

with Task 4. The later trial was completed, but at a slower rate than the previous trial, possibly due to "pushing the limits" of Muscovy duck object permanence.

Task 5 (Stage 5) - 14+ days. The Muscovy ducks were not able to complete any trials related to Stages 5 and 6.

Approximate age of final successful trial completion: 59 days of age.

Data Analysis

In previous studies involving the development of object permanence in avian species using the Uzgiris and Hunt Scale 1 tasks, the comparison of development was done by mapping it day by day. The researchers marked the day on which each success criterion was met by the individual subjects. The average number of days it took to meet criterion was used as a basis for their arguments. When comparing two separate avian species, a line graph charting the days or weeks of age and stage mastered for each species was presented. This allowed for a clear, easy to understand method of descriptive comparison. When comparing the species statistically in the current study, two analyses were used. First, a nonparametric test known as the Kruskal-Wallis H-test was used to determine if there were any significant differences between the average amount of time it took each species to complete tasks 1, 2, and 3. When significant differences were found, a Mann-Whitney *post-hoc* test was used to compare the species individually to determine which pairs had significant differences. Since multiple tests were being run with the same test, the Bonferroni correction was used to adjust the critical value accordingly to the value of 0.009.

RESULTS

Wild Type Turkeys

Table 2 and Figure 4 shows the results and average ages at the time of successful completion for each task. These trials were based on the Scale 1 tasks and these species began testing approximately 16 to 31 days after hatching. Unlike previously studied avian species, the wild type turkeys did not fully complete the Scale 1 tasks and as such, only the successful tasks and the failed final task will be discussed in this section.

Visual Pursuit

Task 1 (arc). Out of the group of eight wild type turkeys, the two younger wild types did not complete the first task during the first session. It was not until the second session when both completed Task 1. For the older wild types, not every participant completed Task 1 during their first session. Two of the wild type turkeys completed Task 1 during the first session, while the other four did not complete it until the second session. At the time of completion, all the wild type turkeys followed the coin with their eyes as it moved in an arc.

Task 2 (object disappearance). The younger turkeys took much longer to complete Task 2 when compared to Task 1. It was not until the fourth session, at 30 days of age when both completed Task 2. For the older individuals, all the wild type turkeys

completed the second task at approximately 35 days of age. As the coin was moved out of sight, the wild type turkeys moved to the opposite side of the screen from where the coin was about to reemerge, indicating that the coin was likely an aversive stimulus

Simple Visual Displacements

Task 3 (partial hiding). Since the wild type turkeys showed no real preference for any treats or toys, their food was moved to a new location and then partially covered. The progress through the Scale 1 tasks slowed when the both the younger and older wild type turkeys began Task 3. On average, all the wild type turkeys completed this stage at approximately 54 days of age +/- one session. While it took them this long to meet the success criteria specified in the procedures section, the turkeys showed competence throughout the unsuccessful sessions by completing the task on occasion, with the successes occurring more frequently until they met the criterion for advancement.

Task 4 (complete hiding). This task marks the end of the Scale 1 tasks for the wild type turkeys, which did not complete the task before the two-week trial cutoff. Like the chickens tested by Regolin, Vallortigara, and Zandorlin (1994), the turkeys were able to master Stage 3, but failed to show Stage 4 competence through successful completion of this task. As soon as their food was completely covered, they lost interest and proceeded to other activities. On the few occasions the cover was removed, it appeared to be unintentional.

Table 2| Number of Sessions to complete each task for Wild Type Turkeys (n=8)
This table lists the number of sessions it took each bird to complete the task.

Turkey Number	Task 1 (arc)	Task 2 (object disappearance)	Task 3 (partial hiding)	Task 4 (complete hiding)
Wild 1	1	1	7	N/A
Wild 2	1	1	9	N/A
Wild 3	2	1	8	N/A
Wild 4	2	1	8	N/A
Wild 5	2	1	8	N/A
Wild 6	2	1	8	N/A
Wild 7 (younger)	2	4	10	N/A
Wild 8 (younger)	2	4	9	N/A
Mean (Standard Deviation)	1.75 (+/- 0.46)	1.75 (+/- 1.39)	8.37 (+/- 0.92)	N/A

Domestic Turkeys

Table 4 and Figure 4 shows the results and average ages at the time of successful completion for each trial. As mentioned before, these trials are based on the Scale 1 tasks and this species began testing approximately 29 days after hatching. Unlike previously studied avian species, the domestic turkeys did not fully complete the Scale 1 tasks and as such, only the successful task and the final failed task will be discussed in this section.

Visual Pursuit

Task 1 (arc). Like the wild type turkeys, not every domestic turkey completed Task 1 during the first session. Only one of the domestic turkeys completed Task 1 during the first session, while the other three did not complete it until the second session. At the time of completion, all the domestic turkeys followed the coin with their eyes, but they would move away from it in a manner similar to the wild type turkeys.

Task 2 (object disappearance). The domestic turkeys did not complete Task 2 until the second testing session when they were approximately 34 days old. Like the wild types, they moved to the opposite side of the screen from where the coin was about to reemerge, indicating that the coin was likely an aversive stimulus for them, as well. When the coin moved towards them (still behind the screen), they would hurry to the side from which it would not appear.

Simple Visual Displacements

Task 3 (partial hiding). Like the wild type turkeys, progress on the Scale 1 tasks slowed when Task 3 began. On average, the domestic turkeys completed this stage at approximately 46 days of age +/- one session. While it took them longer to complete Task 3 compared to the previous two tasks, they were still able to complete it faster than the wild type turkeys. This was not due to a treat or toy preference though, as the domestic turkeys showed the same disinterest as the wild types, so their food was used instead.

Task 4 (complete hiding). This task marks the end of the Scale 1 tasks for the domestic turkeys. The domestic turkeys mirrored the wild types almost exactly and

showed no trial completions before the 2-week trial cutoff condition. Like the chickens tested by Regolin, Vallortigara, and Zandorlin, (1994), the turkeys were able to master Stage 3, but failed to show Stage 4 competence through successful completion of this task. Like the wild type turkeys, once the cover went on, all interest was lost. On the few occasions the cover was removed, it appeared to be unintentional.

Table 3 | Number of Sessions to complete each task for Domestic Turkeys (n=4)
This table lists the number of sessions it took each bird to complete the task.

Turkey Number	Task 1 (arc)	Task 2 (object disappearance)	Task 3 (partial hiding)	Task 4 (complete hiding)
Domestic 1	1	2	4	N/A
Domestic 2	2	2	5	N/A
Domestic 3	2	2	5	N/A
Domestic 4	2	2	5	N/A
Mean (Standard Deviation)	1.75 (+/- 0.5)	2 (+/- 0)	4.75 (0.5)	N/A

Muscovy Ducks

Table 6 ad Figure 4 shows the results and average ages at the time of successful completion for each trial. As mentioned before, these trials are based on the Scale 1 tasks and this species began testing approximately 9 to 35 days after hatching. Unlike previously studied avian species, the Muscovy ducks did not fully complete the Scale 1 tasks and as such, only the successful tasks and the final failed task will be discussed in this section.

Visual Pursuit

Task 1 (arc). All ten of the Muscovy ducks completed Task 1 within 3 sessions. The ages at which they completed this task are as follows (starting from the youngest and working up): 13 days, 15 days, two ducks at 16 days, three ducks at 25 days, and three ducks at 37 days.

Task 2 (object disappearance). Again, the younger group of Muscovy ducks completed Task 2 at a variety of different ages. Two of the three oldest in this group completed Task 2 during the second session at age 32 days, while the third completed it during the third session at 34 days of age. The two middle individuals completed Task 2 during the fourth session at age 27 and 25 days of age. The youngest of this group took five sessions to complete Task 2 at 27 days of age.

The older group of Muscovy ducks completed Task 2 during the first session at approximately 40 days of age. All were able to predict the location where a treat and the coin would emerge after it had disappeared behind the wall on one side.

Simple Visual Displacements

Task 3 (partial hiding). For the younger group, while it took a variety of different sessions (seen in table 7), all completed Task 3 at an age of 39 +/- 2 days. For the older group, completing Task 3 took an average of 3 sessions, and they were 46 days +/- 2 days old when it occurred. The Muscovy ducks were easily able to locate the treat after it had been partially covered with the same cover that was used with the turkeys.

Task 4 (complete hiding). Similar to Stage 3 for the wild type turkeys, Task 4 is when all of the Muscovy ducks began to slow their progression through the tasks. While they were able to successfully complete individual trials during a testing session, it was not until they were an average of 60 +/- 5 days of age when they successfully completed Task 4. Using the same cover that was used with the turkeys, the Muscovy ducks were able to locate both the coin and the treats when they were completely hidden under a cover.

Task 5 (two sites, visible). While the ducks were able to master Task 4, they were not able to successfully complete Task 5. They would enthusiastically search for the treat under cover A the first two times and even the third time, although they had been shown that it was placed under cover B.

Table 4 | Number of Sessions to complete each task for Muscovy Ducks (n=10)
This table lists the number of sessions it took each bird to complete the task.

Turkey Number	Task 1 (arc)	Task 2 (object disappearance)	Task 3 (partial hiding)	Task 4 (complete hiding)	Task 5 (two sites, visible)
Duck 1 (old)	3	1	2	7	N/A
Duck 2 (old)	3	1	4	6	N/A
Duck 3 (old)	3	1	3	8	N/A
Duck 4 (young, oldest)	1	2	2	8	N/A
Duck 5 (young, oldest)	1	3	2	9	N/A

Duck 6 (young, oldest)	1	2	3	9	N/A
Duck 7 (young, middle)	1	4	5	7	N/A
Duck 8 (young, middle)	1	4	6	7	N/A
Duck 9 (young, youngest)	3	5	6	7	N/A
Duck 10 (young, youngest)	3	5	6	7	N/A
Mean (Standard Deviation)	2 (+/- 1.05)	2.8 (+/- 1.62)	3.9 (+/- 1.73)	7.5 (+/- 0.97)	N/A

Group Comparison

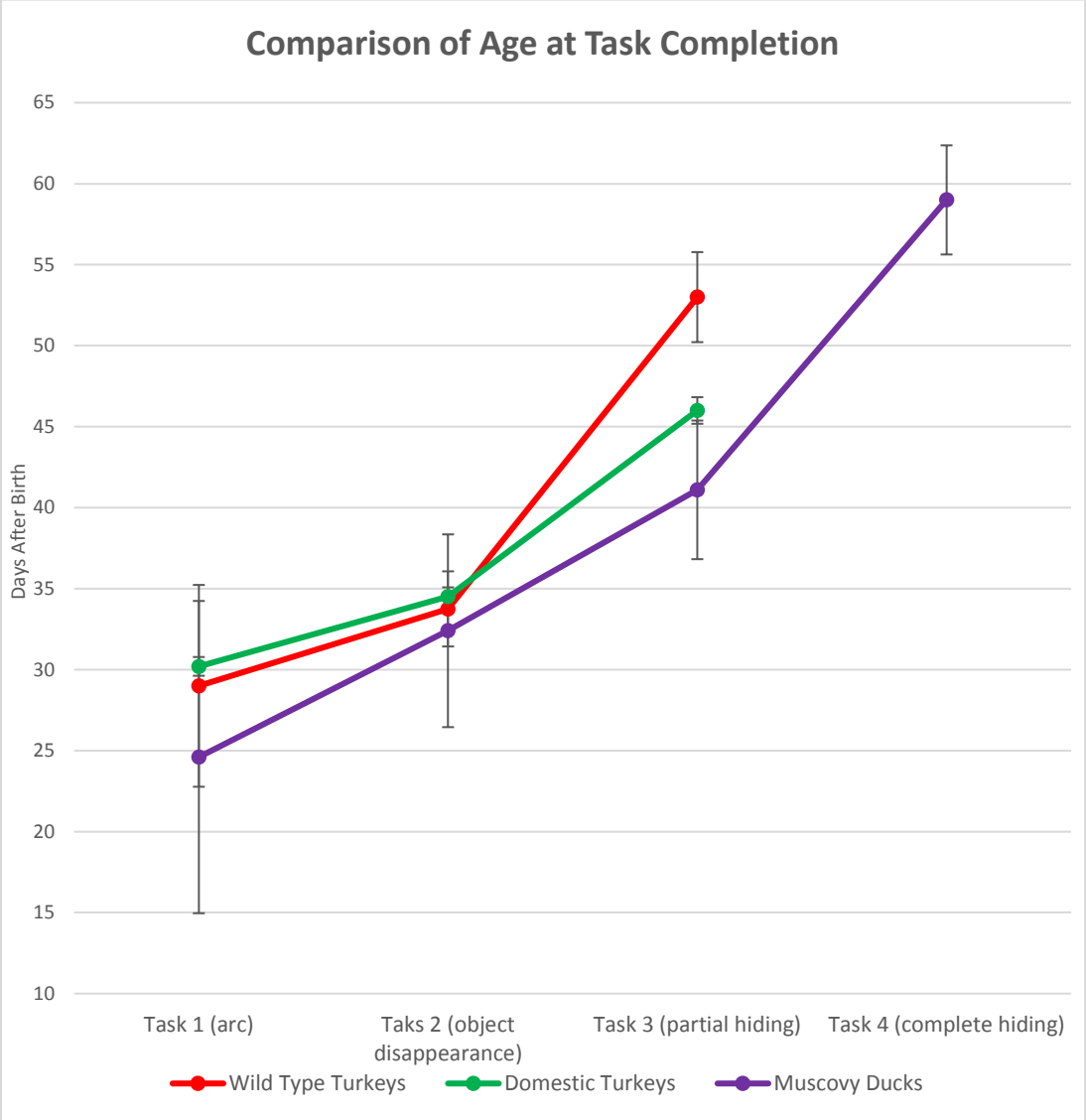

Figure 3 | A comparison of ages and standard deviations at task completion
This graph compares the average age and the standard deviations that each of the three studied species completed tasks 1-4.

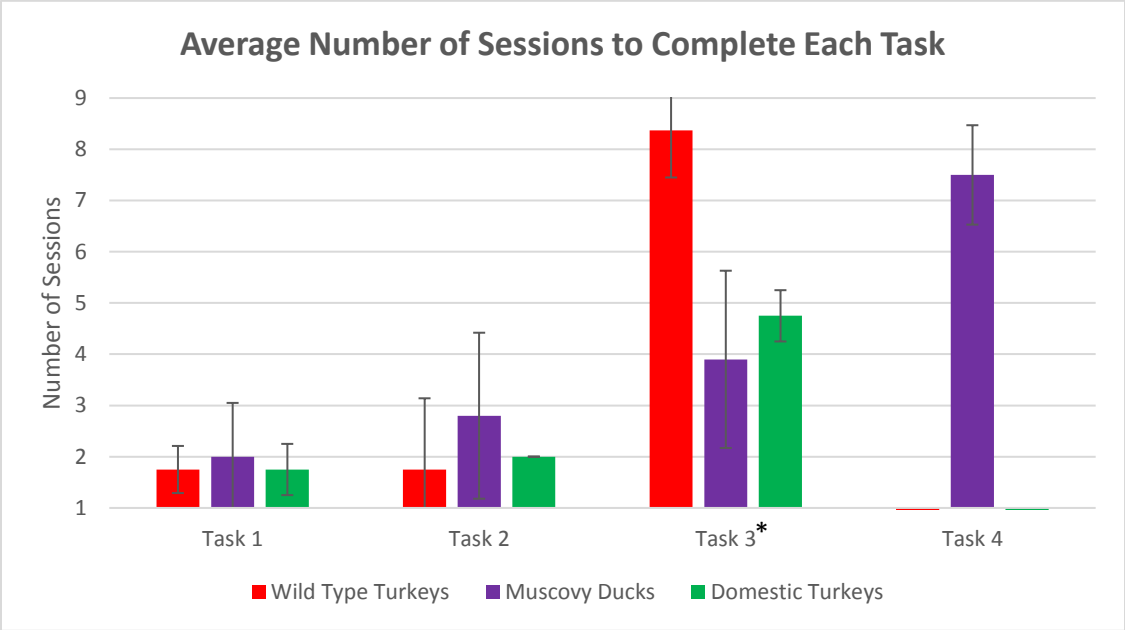

Figure 4 | Average number of sessions to complete each task
This graph compares the average amount of sessions and the standard deviations it took each of the three studied species to complete tasks 1-4.
Notes: *p<0.009

As alluded to in the previous section, there were several similarities and differences between the species, as well as between the two types of turkeys. When comparing the wild type turkeys and domestic turkeys, we can see that their progress for Task 1 and Task 2 all but mirror each other. The divergence occurs when completing Task 3, as the domestic turkeys successfully completed it approximately 12 days before the wild type turkeys. This means that they reached Stage 3 object permanence significantly faster at a full week and a half earlier than the wild type turkeys.

The domestic turkeys and Muscovy ducks are almost the opposite in terms of developmental similarities and differences. The Muscovy ducks successfully completed Task 1 approximately 1 week earlier than the domestic turkeys. This separation in

completion time decreases for Task 2, with the Muscovy ducks completing it approximately two days before the domestic turkeys. The gap then continues to widen, with the Muscovy ducks completing Task 3 at an average of five days before the domestic turkeys. The Muscovy ducks achieved Stage 4 object permanence by completing Task 4 at an average of 59 days old while the domestic turkeys only achieved Stage 3.

Finally, the wild type turkeys and Muscovy ducks show virtually no similarities in the development of object permanence. For Tasks 1 and 2, the difference in age between the two is similar to the difference between the domestic turkeys and Muscovy ducks. The Muscovy ducks completed these tasks just over half a week earlier than the wild type turkeys. For Task 3, we see this difference continue with the Muscovy ducks completing Task 3 significantly faster at an average of about a week and a half earlier than the wild type turkeys. The Muscovy ducks also surpass the wild type turkeys by completing Task 4, showing Stage 4 completion.

Table 5 | Comparison of Average Age of Task Completion with Standard Deviations
This table compares the average number of days after birth and the standard deviations for each species to complete the task.

Task Number (and name)	**Wild Type Turkeys (n=8)**	**Domestic Turkeys (n=4)**	**Muscovy Ducks (n=10)**
Task 1 (arc)	**29 (+/- 6.23)**	**30.5 (+/- 0.58)**	**24.6 (+/- 9.64)**
Task 2 (object disappearance)	**33.75 (+/- 2.32)**	**34.5 (+/- 0.58)**	**32.4 (+/- 5.95)**
Task 3 (partial hiding)	**53 (+/- 2.78)**	**46 (+/- 0.82)**	**41.1 (+/- 4.28)**
Task 4 (complete hiding)	**N/A**	**N/A**	**59 (+/- 3.37)**

Statistical Comparison

Levene's test for equality of variance was conducted and found that there were no significant differences among the three groups. For the statistical comparison, the decision to use the Kruskal-Wallis H-test and Mann-Whitney *post-hoc* test was due to the assumption of equal variance and the relatively low sample sizes.

A Kruskal-Wallis H-test was performed to determine if there were any significant differences among the groups with regard to the average number of days required to complete Tasks 1, 2, and 3. Results showed that there were no significant differences among the three species in the number of days to complete Task 1 [$H(2) = 1.77$, $p = 0.41$]. For Task 2, results also showed no significant differences among the three species in the number of days to completion [$H(2) = 1.43$, $p = 0.49$].

Results showed a significant difference among the three species in the number of days to complete Task 3 [$H(2) = 16$, $p = 0.0003$]. A Mann-Whitney *post-hoc* test revealed that the significant differences were between the wild type turkeys ($M = 53$, $SD = 2.78$) and domestic turkeys ($M= 46$, $SD= 0.82$) ($U = 0$, $p = 0.0022$) and the wild type turkeys and Muscovy ducks ($U = 79$, $p = 0.0003$). The domestic turkeys and Muscovy ducks ($M = 41.1$, $SD = 4.28$) ($U = 40.5$, $p = 0.03$) were not significant under the Bonferroni correction, but were significant under a standard $p<0.05$ critical value.

Table 6 | Kruskal-Wallis H-test Results
This table shows the statistical information for each individual task with Task 3 being the only task the shows significant differences between the groups.
Notes: *p<0.05, **p<0.009

Task Number	Statistical Information
Task 1	H(2) = 1.77, p = 0.41
Task 2	H(2) = 1.43, p = 0.49
Task 3	H(2) = 16, p = 0.0003**

Table 7 | Mann-Whitney post-hoc test Results for Task 3
This table shows the statistical information for each pair with the all three pair comparisons showing significant differences.
Notes: *p<0.05, **p<0.009

Comparison Group	Statistical Information
Wild Type vs. Domestic	U = 0, p = 0.0022**
Wild Type vs. Muscovy	U = 79, p = 0.0003**
Domestic vs. Muscovy	U = 40.5, p = 0.03*

DISCUSSION

When considering the results, it is important to remember that the main focus of this study was to determine the developmental timelines and end points of object permanence in these previously unstudied subject groups. Scale 1 tasks were used for their ability to accurately determine which stage an animal is currently in at a given time, as well as compare the results to other avian species previously tested using this scale. Within this study, the results showed that only the Muscovy ducks achieved Stage 4 object permanence but could go no further. The two turkey types were only able to obtain Stage 3 object permanence, with out-of-sight objects being out of mind as well.

The difference between the final point of object permanence development for turkeys and ducks may be close enough to be considered a fluke, but the environmental pressures surrounding the separate evolution of both is a more plausible explanation. The Muscovy ducks, whose natural environment includes a nest hidden inside a tree trunk and searching for food under water, would do well to develop Stage 4 object permanence (Cornell Lab of Ornithology, 2017). Being able to remember the location of a meal that is underwater when going up to take a breath or when the food is obscured by changing underwater conditions would be an evolutionary advantage. After developing Stage 4 object permanence due to the pressures associated with locating food in a mutable, water-based environment, other behaviors that helped to ensure that lineages' survival, such as

building nests in hollowed tree trunks, might have been passed down and solidified this development as a necessity for the ducks.

Turkeys, on the other hand, have no real reason to need anything past Stage 3 development. The environmental pressures for the Muscovy ducks are nonexistent in the turkeys' world, with the seeds and insects eaten during the warm months plentiful and easy to keep track of, as well as easy to find a replacement meal if the original has "disappeared" from the line of sight. The ease of finding food continues during the cold months when fruits such as acorns mature, as well as different seeds such as white ash and cherry. Snow fall does not stop this ease as vegetation such as ferns and buds from hemlocks are visible and in ample amounts for the turkeys to survive. During the different seasons, turkeys' resting places at night continue to be easy to locate, with roosting locations usually being in the trees surrounding their current feeding area and their nests built on the ground (Pack, 2003). Their results are practically identical to those of chickens, from which they are separated by 15 million years compared to the 54 million years separating turkeys from the Muscovy ducks. The only difference between the two is that the chicken has been found to exhibit Stage 4 ability when the hidden object is a social partner (Regolin, Vallortigara, & Zandorlin, 1994).

Interestingly enough, there does appear to be a difference in the development of object permanence between the wild type and domestic turkeys. As mentioned before, figure 3 shows that the two turkey types have a similar developmental trajectory for Tasks 1 and 2 but diverge in the time it takes to meet the success criteria for Task 3. Initially, it was hypothesized that the wild type turkeys would develop object permanence

faster due to the necessity of living in a hostile environment, but it appears to be the opposite. The domestic turkeys completed Task 3 one week earlier, but why this is remains a mystery. We theorize that this faster development is due to the overall nature of a standard domestic turkey's environment. Most domestic turkeys are found on farms with food production as the intent. Controlled hatching at these farms often causes the poults to be raised without a mother to serve as a model for foraging. In addition, food on these farms is spread out in a variety of locations, which can be blocked from the line of sight due to multiple variables. Since the domestic turkey poults have no mother to rely on for food, it is possible that Stage 3 object permanence develops faster out of a necessity.

When looking at previous avian object permanence studies, the most influential are those that use the Scale 1 tasks as the experimental paradigm. Figure 5 shows comparison of Task 1-5 age completion using the two turkey types, Muscovy ducks, magpies (Pollok, Prior, & Gunturkun, 2000), and Eurasian jays (Zucca, Milos, & Vallortigara, 2007).

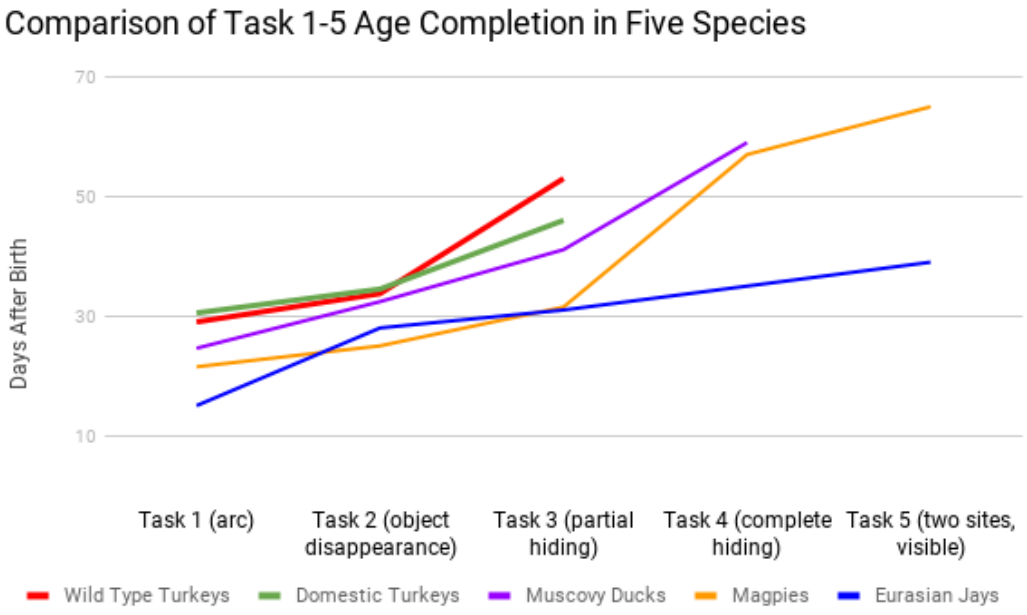

Figure 5 | A comparison of age for task completion in five species
This graph compares the average age of six species that completed tasks 1-5 (Pollok, Prior, & Gunturkun, 2000), (Zucca, Milos, & Vallortigara, 2007).

By using the comparisons shown in figure 5, we can see something of a pattern form. The mainly food storing species, the magpies and Eurasian jays, both have the fastest rates of development. This fast rate of development is consistent amongst birds of similar lifespans which includes ravens (Ujfalussy, Miklósi, & Bugnyar, 2013), while avian species, such as the grey parrot, have longer life spans and develop at a slower rate by comparison (Pepperberg, Willner, & Gravitz, 1997). When looking at the steepness of incline, we can see that the Muscovy ducks develop object permanence at a similar speed to the magpies for Tasks 1 to 2 and Tasks 2 to 3. This changes when the Muscovy ducks are found to develop faster than the magpies from Task 3 to Task 4. When compared to the Eurasian jay, the Muscovy duck develops faster from Task 1 to Task 2 but then

slower for Tasks 2 to 4. This grouping continues with the foragers, the two turkey types and Muscovy ducks, who all complete each task within 10 days of one another. While we can argue that the type of food acquisition strategy affects the speed at which object permanence develops, Figure 5 can also be used as the basis for a future study reviewing the effects of lifespan on object permanence development. As it seems now, Table 8 helps illustrate the possibility that a shorter life span causes object permanence to develop faster, a trend that is reversed for those species with longer life spans. On the other hand, those avian species with longer life spans do exhibit high levels of object permanence development with the wild type turkeys, who have a lifespan of 3 to 4 years only mastering up to Stage 3, while the Eurasian jays, who have a lifespan of 15 to 17 years, mastering all stages of object permanence. This may be similar to the recent findings showing a positive correlation with avian longevity and relative brain size (Minias & Podlaszczuk, 2017).

This idea is illustrated within magpies with the development of object permanence occurring faster than other developmental mile markers. The average completion of Stage 2 was at approximately 3 weeks, which occurred just after the age that magpies begin to become mobile. Stage 3 was completed at 4 weeks of age, in between the appearance of fledging, when a bird begins to fly, and food-storing. Next, stage 4 ended a full week after food retrieval begins to occur, and stage 5 was completed one week before full independence is normally achieved (Pollok, Prior, & Gunturkun, 2000).

Table 8 | The relative lifespan of the six compared species
This table briefly lists the relative lifespan for each species compared in figure 4.

Species Name	Relative Lifespan (Years)	Final Stage Achieved
Wild Type Turkeys	3 to 4 Years	Complete Stage 3
Domestic Turkeys	2 to 3 Years	Complete Stage 3
Muscovy Ducks	7 to 8 Years	Complete Stage 4
Magpies	15 to 20 Years	Complete Stage 6a, not Stage 6b
Eurasian Jays	15 to 17 Years	Complete Full Stage 6

After completing this study, there are a few paths that could be taken by future researchers. The first of these is to repeat the study by starting both types of turkey subjects at a younger age. While we have sufficient subjects for the descriptive and statistical results, testing them at a younger age would allow for more concrete developmental times for Stage 2. The next path would be to test an avian species with a lineage similar to that of the Muscovy duck. This could be approached in a variety of ways. The most appropriate for a comparison with the current study would be to find a relative that is separated by approximately 15 million years of evolution and lives in a similar environment and test to determine if their object permanence development is similar to that of the turkeys and chickens. An alternate view would be to test a species closer in separation who lives in a different environment altogether to determine if object permanence development is species or order based. This would help to corroborate the

evolutionary theory proposed for why the Muscovy ducks reached Stage 4 completion. Finally, future research could help to test the explanations put forward by testing chickens with the Scale 1 tasks and the turkeys with a social partner based Stage 4 task. This would hopefully confirm that chickens and turkeys have a similar timeline and end for object permanence development using this time-proven paradigm. In addition, it would also open a new door into a possible relationship between social evolution and object permanence.

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BIOGRAPHY

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