Where’s the cookie? The ability of monkeys to track object transpositions

Katarzyna Majecka1 · Dariusz Pietraszewski2

Received: 29 January 2018 / Revised: 22 May 2018 / Accepted: 28 May 2018 / Published online: 1 June 2018
© The Author(s) 2018

Abstract
Object permanence is the ability to represent mentally an object and follow its position even when it has disappeared from view. According to Piaget’s 6-stage scale of the sensorimotor period of development, it seems that object permanence appears in Stage 4 and fully develops in Stage 6. In this study, we investigated the ability of some species of monkeys (i.e. pig-tailed macaque, lion-tailed macaque, Celebes crested macaque, barbary macaque, De Brazza’s monkey, L’Hoest’s monkey, Allen’s swamp monkey, black crested mangabeys, collared mangabeys, Geoffroy’s spider monkey) to track the displacement of an object, which consisted of a reward hidden under one of two cups. Our findings showed that the examined subjects possess Stage 6 of object permanence. We then compared our results with data on apes and dogs participating in Rooijakkers et al. (Anim Cogn 12:789–796, 2009) experiment, where the same method was applied. The monkeys examined by us performed significantly better than the dogs but worse than the apes. In our experiment, the monkeys performed above chance level in all variants, but it should be noted that we observed significant differences in the number of correct choices according to the level of a variant’s complexity.

Keywords Object permanence · Transposition · Monkey · Ape · Dog · Piaget · Cognitive abilities

Introduction
Object permanence is defined as the ability to understand that objects continue to exist even when they have disappeared from view. In other words, if an object changes position, the subject is capable of mentally tracking the object’s possible movements. This ability is considered to be the fundamental skill of spatial cognition (Jaakkola 2014).

According to Piaget’s 6-stage scale of sensorimotor development, it is only in Stage 4 that searching for a hidden object starts (8–12 months in human infants). However, if these children see an object in its first location and then this is hidden in another place, then they will seek it in the former location. This response is named an A-not-B or a perseveration error (Piaget 1954). Children between 12 and 18 months are able to find an object when it is hidden in multiple locations within their view (Piagetian Stage 5), but still have difficulties to find an object that is invisibly displaced. The subject who reaches Stage 5 overcomes the perseveration error and takes into consideration successive displacements. The full understanding of object permanence develops in a human infant between the ages of 18 and 24 months (Piagetian Stage 6). Then, a child can solve sequential invisible displacements and reconstruct the movements of an unperceived object (de Blois et al. 1998). It is believed that reaching this stage marks a milestone in children’s development (Piaget 1954). Object permanence and the ability to track a displaced object seem to be very important for many animals because every day they have to remember the location of predators or resources such as food. Piaget’s scale is also used to determine the degree of development of cognitive abilities in non-human species. So far, the solving of displacement tasks has come under scrutiny [reviewed in Jaakkola (2014)] in such animals as cats [reviewed in Shreve and Udell (2015)], dogs (Fiset and LeBlanc 2007; Rooijakkers et al. 2009), dolphins (Jaakkola et al. 2010; Johnson et al. 2015), sea lions (Singer and...
Henderson 2015), dwarf goats (Nawroth et al. 2015), parrots (Pepperberg and Funk 1990), and corvids (Pollok et al. 2000). Likewise, several species of monkey, such as long-tailed macaques (Schoegl et al. 2013), rhesus macaques (Filion et al. 1996) and cotton top tamarins (Neiworth et al. 2003), have become the subject of similar studies. Finally, great and lesser apes have also been examined (e.g. de Blois et al. 1998; Call 2003; Collier-Baker et al. 2006; Rooijakkers et al. 2009; Anderson 2012).

Comparisons of the ability of object tracking have been done in both non-human primates and children. Such comparisons for infants and great apes have been carried out under varying degrees of difficulty (e.g. invisible and visible displacement). Findings have shown that children 19 months, 2 years and 2.5 years old as well as great apes have very similar cognitive skills for dealing with the physical world (Call 2001; Barth and Call 2006; Collier-Baker and Suddendorf 2006; Herrmann et al. 2007).

According to Jaakkola’s (2014) classification, there are three experimental methodologies to be applied for understanding invisible displacement in non-human animals, namely, a Piagetian task, rotation and transposition. In a standard Piagetian task, the target object is hidden inside the displacement device, which is subsequently placed under one of three opaque containers. Next, the displacement device is removed and the experimenter shows the subject the empty device and then the subject starts to search for the object. In a rotation task, opaque containers are placed on a turntable. The experimenter places the target object under one of the opaque containers and rotates the turntable (90° or 180°). The third type of task, transposition, requires that the target object be placed directly in containers without the intermediate displacement device. Subsequently, one or two containers out of the two or three provided are moved. The way the cups are moved affects the level of difficulty of the task. If the containers cross path or the empty container moves into the initial position of the baited container, then it causes more difficulties for the subject to choose baited containers (Doré et al. 1996; Fiset and Plourde 2013; Jaakkola 2014; Rooijakkers et al. 2009). In all three tasks (i.e. Piagetian, rotation, transposition), the subject possesses a mental representation of the situation and points by logical inference to the correct position of the target object invisibly moved (Jaakkola 2014).

To claim that a species understands invisible displacement, three factors must be controlled for or ruled out: sensory cues, social cues and associative learning. If these factors are not controlled for, then they could affect the results of experiments. Thanks to them, the animal could complete the task successfully without conceptual understanding of invisible displacement (Jaakkola 2014). Sensory cues could be, e.g., smell in case of dogs or the ability to echolocate (cf. dolphins, bats). Social cues include unintentional body language or gaze of the experimenter. Associative learning might cause the animal to pass the test because they have learned simple associative rules such as ‘pick the location that the experimenter indicated’. Although the Piagetian framework may have some limitations, it is still very useful in examining and comparing cognitive abilities of human and non-human animals (Pepperberg 2002).

According to Amici et al. (2010), there is no overall clear-cut distinction in cognitive skills between apes and monkeys, and existing differences have often been overestimated (Tomasello and Call 1997). However, due to miscellaneous procedures applied in different experiments, it is hard to make comparisons between species. For this reason, we decided to apply the methods used by Rooijakkers et al. (2009), who compared dogs and great apes in experiments on their ability to track visually object transposition.

The purpose of this study was to investigate the ability of some species of monkeys to track the displacement of an object and to compare the results from the literature on apes and dogs, to which the same method was applied using the transposition task (Rooijakkers et al. 2009). In this study, we were also interested in evaluating how the subjects solve problems depending on the level of a variant’s complexity.

Methods

Ethical note

The experiment was non-invasive, the subjects participated in it voluntarily and they were neither food nor water deprived for the testing. The study received the approval of The Local Ethics Committee for Animal Experimentation (permit number 3/ŁB11/2016 of 18th January 2016) and acted in accordance with the law from 15th January 2015 on the protection of animals used for scientific purposes.

Subjects

19 monkeys (7 females and 12 males), born in captivity, participated in the experiment (Table 1). The monkeys were housed at zoos across Poland: in Łódź (six individuals), Warszawa (one individual), Wrocław (nine individuals) and Poznań (three individuals). All individuals lived in indoor and outdoor enclosures, were fed their species-typical diet (vegetables, fruit, insects) and water was available at all times. For all subjects, the experiment involved rewards hidden inside cups and transposition tasks were a new experience.
Warm-up

The monkeys were tested in the indoor or outdoor enclosures in which they lived. Enclosure selection depended on factors such as good visibility of the platform by the subject, not finding any trace of the subject’s anxiety, and weather conditions. A wooden platform (60 × 30 cm) was attached outside of a mesh panel. There were four small dots on the platform at a distance of 15 cm from each other indicating the location of the cups. Two identical opaque grey cardboard cups (diameter 8 cm, 9 cm high) were used in the experiment. During the experiment, fruit and insects (species-typical diet) were provided as a reward.

All subjects underwent a warm-up phase prior to the experiment with the aim to familiarise them with the procedure of disappearance of food under cups and receiving it after touching the cup. The warm-up phase took place at the same location where the experiment was later carried out using the same platform and cups. The platform was fixed to the net and left for 1 h to give the subjects time to get used to it. The warm-up phase was conducted by the experimenter (E1). During this phase, the cups were randomly distributed over the whole surface of the platform, but never in the locations where they were to be presented during the experiment. E1 showed the empty cups to the subject and then covered the reward with one of the cups. The individual received the reward after choosing the correct cup. In the situation when the subject pointed to the un-baited cup, E1 showed an empty cup and where the reward is, but subject did not get it. The warm-up phase was completed when the subjects touched one of the two cups (baited or un-baited) five times. At this stage, the experimenter did not manipulate the cups in the same way as during the actual part of the experiment.

Procedure

The experiment always started in the same way. The forward-facing experimenter (E1), invariably the same person, sat in front of the subject, separated by the mesh panel and the platform, and obtained its attention by showing the reward. Once the subject focused on the task, E1 put the food reward on the platform (location 2 or 4; Fig. 1) and next showed two empty cups and then covered the reward with one of them. The initial position of the cups in all variants was always the same (location 2 and 4). After hiding the reward, the experimenter instantly proceeded to manipulate the cups. E1 simultaneously moved the cups from initial to final positions in the following way: the right-hand side cup with his right-hand and the left-hand side cup with his left hand. After the cups were put in their final positions (Fig. 1), the subject could touch either of them. It was only when the subject had made the

| Subject (name) | Species | Sex | Age (years) | ZOO |
|---------------|---------|-----|-------------|-----|
| Grześ | Pig-tailed macaque *Macaca nemestrina* (Linnaeus, 1766) | Male | 23 | ZOO Łódź |
| Naomi | Lion-tailed macaque *Macaca silenus* (Linnaeus, 1758) | Female | 11 | ZOO Łódź |
| Rani | Lion-tailed macaque *Macaca silenus* (Linnaeus, 1758) | Female | 21 | ZOO Łódź |
| Woolfie | Lion-tailed macaque *Macaca silenus* (Linnaeus, 1758) | Male | 26 | ZOO Łódź |
| Punio | Lion-tailed macaque *Macaca silenus* (Linnaeus, 1758) | Male | 13 | ZOO Łódź |
| Taro | Celebes crested macaque *Macaca nigra* (Desmarest, 1822) | Male | 17 | ZOO Wrocław |
| Tyson | Barbary macaque *Macaca sylvanus* (Linnaeus, 1758) | Male | 11 | ZOO Wrocław |
| Lisbeth | Barbary macaque *Macaca sylvanus* (Linnaeus, 1758) | Female | 2 | ZOO Wrocław |
| Ries | Barbary macaque *Macaca sylvanus* (Linnaeus, 1758) | Male | 11 | ZOO Wrocław |
| Canail | Barbary macaque *Macaca sylvanus* (Linnaeus, 1758) | Male | 9 | ZOO Wrocław |
| Hiszpan | De Brazza’s monkey *Cercocebus neglectus* Schlegel, 1876 | Male | 16 | ZOO Łódź |
| Holly | L’Hoest’s monkey *Cercocebus lhoesti* Schlegel, 1899 | Female | 8 | ZOO Wrocław |
| Pyza | Allen’s swamp monkey *Allenopithecus nigroviridis* (Pocock, 1907) | Female | 19 | ZOO Warszawa |
| Corso | Black crested mangabey *Lophocebus aterrimus* (Oudemans, 1890) | Male | 19 | ZOO Wrocław |
| Alf | Collared mangabey *Cercocebus torquatus* (Kerr, 1792) | Male | 16 | ZOO Wrocław |
| Olaf | Collared mangabey *Cercocebus torquatus* (Kerr, 1792) | Male | 5 | ZOO Wrocław |

**Table 1** Monkeys included in the experiment
right choice that it received the hidden reward. The second experimenter (E2), facing downwards, was present during all trials, read out the subsequent numbers of the variants and noted whether the selection made by the subject was correct or not. All the subjects underwent the experiment in the presence of five variants, each of them applied four times, summing up to 20 trials total. Determined by drawing lots at the outset of the experiment, the order of performing the random sequence of variants remained the same for each subject. The conditions of drawing lots stipulated that in each of the five task variants the food should be hidden twice under the right-hand side cup and twice under the left-hand side one. What is more, during one session, none of the variants could be repeated more than twice in a row. The variants were implemented as follows:

**Variant 1** E1 grabbed the right cup with the right hand and the left cup with the left hand, then with one continuous movement he moved the cups so that the cup from location 2 would be placed on location 1, and the cup from location 4 on location 3.

**Variant 2** E1 grabbed the right cup with the right hand and the left cup with the left hand, then with one continuous movement he moved the cups so that the cup from location 2 would be found on location 1, and the cup from location 4 on location 2.

**Variant 3** E1 grabbed the right cup with the right hand and the left cup with the left hand. Then with one continuous motion, so that the arms would cross over the platform, moved the cup from location 2 to location 3, and the cup from location 4 to location 1.

**Variant 4** E1 grabbed the right cup with the right hand and the left cup with the left hand. Then with one continuous motion, so that the arms would cross over the platform, moved the cup from location 2 to location 3, and the cup from location 4 to location 2.

**Variant 5** E1 grabbed the right cup with the right hand and the left cup with the left hand. Then with one continuous motion, so that the arms would cross over the platform, moved the cup from location 2 to location 4, and the cup from location 4 to location 2 (Fig. 1).

After completion of the experiments, a control test was performed in which the experimenter (E1) covered the cups while placing the food to prevent the subject from knowing where it was hidden. The control procedure resembled the experiment, but the monkey received the reward regardless of the cup choice. The control test aimed at the exclusion of such factors as the use of scent or unconscious hints given by E1.

The subjects entered the experiment voluntarily and could stop the experiment at any moment, departing from the place where it was carried out. Some subjects completed the experiment during one session, whereas some subjects lost interest in working with the experimenter. The experiment was continued when the subject again approached the place of the experiment.

**Data scoring and analysis**

Differences between variants were analysed by the ANOVA Friedman test. In case of significant effects, a post hoc test (Conover-Iman) was conducted. Second, the Wilcoxon test was used to determine whether the results of the experiment in each variant were above chance. Third, differences (calculated separately for each variant) were investigated between
the results of the experiment and the control test using a non-parametric exact two-tailed statistic (Wilcoxon test). Finally, the findings obtained from the studied monkeys were compared with the raw scores of dogs and apes as available from the literature (Rooijakkers et al. 2009). To determine differences between dogs \((N = 20)\) and monkeys \((N = 19)\), and between apes \((N = 8)\) and monkeys, the Mann–Whitney \(U\) test was performed separately for each variant.

**Results**

The individual results of the subjects tested in each variant are shown in Table 2.

**Differences between variants**

A significant effect of variant was observed (ANOVA Friedman test \(\chi^2 = 13.40, \, n = 19, \, df = 4, \, P < 0.01\)). Post hoc Conover-Iman test showed that monkeys performed better in Variant 1, where both cups were moved to new locations without crossing each other’s path, compared to Variants 3, 4 and 5, where cups crossed each other’s path. The subjects also achieved better results in Variant 2, where one cup moved to a new location and then substituted the initial location of the first without crossing each other’s path, compared to Variant 4 (Table 3). Overall, the examined monkeys performed above chance in all variants (Wilcoxon test \(z > 2.65, \, P < 0.01\) in all variants) (Fig. 2). When treated as a group, the subjects showed significant differences between the performance of the experiment to the result of the control test in each variant, which excludes other external factors affecting selection of the cup during the test (Table 4).

**Comparison of results with dogs and apes**

The monkeys subjected to the experiment achieved significantly better results than dogs (as reported in Rooijakkers et al. 2009) in all five variants \((Z > -4.83, \, P \leq 0.001\) in all cases Table 5; Fig. 2). However, the monkeys scored worse than apes (Rooijakkers et al. 2009) in Variant 2, 3, 4 and

---

**Table 2** Sum of correct choices of each subject per variant (with four trials in each variant)

| Subjects | Species | Variant 1 | Variant 2 | Variant 3 | Variant 4 | Variant 5 |
|----------|---------|-----------|-----------|-----------|-----------|-----------|
| Grześ    | Pig-tailed macaque | 3 | 3 | 3 | 2 | 4 |
| Naomi    | Lion-tailed macaque | 4 | 4 | 4 | 4 | 4 |
| Rani     | Lion-tailed macaque | 4 | 3 | 2 | 2 | 3 |
| Woolfie  | Lion-tailed macaque | 3 | 3 | 3 | 4 | 3 |
| Punio    | Lion-tailed macaque | 4 | 3 | 3 | 2 | 1 |
| Taro     | Celebes crested macaque | 3 | 3 | 3 | 3 | 4 |
| Tyson    | Barbary macaque | 3 | 4 | 3 | 4 | 3 |
| Canail   | Barbary macaque | 4 | 4 | 4 | 4 | 3 |
| Ries     | Barbary macaque | 4 | 3 | 4 | 4 | 4 |
| Lisbeth  | Barbary macaque | 4 | 3 | 2 | 2 | 3 |
| Hiszpan  | De Brazza’s monkey | 4 | 4 | 4 | 1 | 3 |
| Holly    | L’Hoest’s monkey | 4 | 4 | 4 | 2 | 2 |
| Pyza     | Allen’s swamp monkey | 4 | 3 | 2 | 2 | 2 |
| Corso    | Black crested mangabey | 4 | 3 | 4 | 4 | 3 |
| Alf      | Collared mangabey | 4 | 4 | 4 | 3 | 3 |
| Olaf     | Collared mangabey | 4 | 4 | 3 | 4 | 4 |
| Zosia    | Geoffroy’s spider monkey | 4 | 4 | 3 | 2 | 2 |
| Zuza     | Geoffroy’s spider monkey | 4 | 4 | 3 | 2 | 3 |
| Colombo  | Geoffroy’s spider monkey | 3 | 3 | 3 | 2 | 3 |
5. It was only in Variant 1 that no statistically significant differences were noted (Table 5; Fig. 2).

Discussion

In the present study using the transposition task, monkeys were successful in all variants, both in the case of a simple displacement of the two cups and in displacements with reverse swapping. However, there were differences in the number of correct choices according to the level of a variant’s complexity. Generally, it was easier for the subjects to track the position and find the hidden reward if the cups did not cross each other’s path during movements. In fact, the monkeys obtained worse results if the paths of the two cups were crossed and the two containers exchanged locations with one another. Although monkeys performed above chance level in all variants, they scored significantly worse than the apes examined by Rooijakkers et al. (2009), except for Variant 1. In the latter experiment, which employed exactly the same procedure of this study, chimpanzees, bonobos, orangutans and gorillas succeeded in all variants, and the level of difficulty did not affect the results of the apes (Rooijakkers et al. 2009), except for Variant 1. In another experiment using a Piagetian task, which involved object transposition in the presence of the above-mentioned ape species, all subjects selected the correct cup above chance level and there were no significant differences amongst single and double (the reward changed the position twice) displacement tasks (Barth and Call 2006). Call (2001) observed that orangutans, chimpanzees and 26-month-old children performed above chance level on visible and invisible displacement tasks, except for nonadjacent

Table 4 Wilcoxon test results comparing the performance of the subjects to the result of the control test

| Variant | T  | z  | P   |
|---------|----|----|-----|
| Variant 1 | 0 | 3.62 | <0.001 |
| Variant 2 | 0 | 3.62 | <0.001 |
| Variant 3 | 9 | 3.05 | 0.01  |
| Variant 4 | 5 | 2.67 | 0.01  |
| Variant 5 | 15 | 2.13 | 0.03  |

Table 5 Comparison of the results of the examined monkeys and dogs and the results of monkeys and apes [data on dogs and apes from Rooijakkers et al. (2009)] (Mann–Whitney U test)

| Comparison | Monkeys | Apes | Dogs | Monkeys/dogs | Monkeys/apes |
|------------|---------|------|------|--------------|--------------|
|            | Mean (± SD) | Mean (± SD) | Mean (± SD) | Z | P | Z | P |
| Variant 1  | 3.74 (± 0.45) | 4.00 (± 0.00) | 2.85 (± 0.88) | −3.23 | 0.001 | 1.54 | 0.12 |
| Variant 2  | 3.47 (± 0.51) | 4.00 (± 0.00) | 2.30 (± 1.08) | −3.57 | <0.001 | 2.51 | 0.01 |
| Variant 3  | 3.21 (± 0.71) | 3.88 (± 0.35) | 1.85 (± 0.59) | −4.59 | <0.001 | 2.33 | 0.02 |
| Variant 4  | 2.84 (± 1.07) | 3.75 (± 0.46) | 1.65 (± 0.81) | −3.21 | 0.001 | 2.02 | 0.04 |
| Variant 5  | 3.00 (± 0.82) | 3.63 (± 1.06) | 1.00 (± 0.92) | −4.83 | <0.001 | 2.26 | 0.02 |
invisible displacements (i.e. the reward was moved to a nonadjacent container). In another of Call’s (2003) experiments, several tasks were presented to chimpanzees and orangutans. In the no-landmark transposition (food is presented directly to the subject), apes performed better than in the landmark (the subject had to infer the position of the reward using a landmark) transposition test, whereas in the latter subjects obtained significantly better results in the no-swap transposition compared to the reverse swap.

Overall, the results obtained by monkeys vary among experiments using a Piagetian task. For instance, long-tailed macaques performed above chance level in single and double transpositions (Amici et al. 2010), spider monkeys only in a single transposition, but neither coped with a reverse transposition, that is, when the baited cup and empty cup switched location twice and returned to their original position. Experiments on cotton top tamarins revealed that their performance was above chance level in both visible and invisible displacement tasks and only in one (i.e. double invisible displacement with the second cup manipulated by the experimenter) did results dropped to chance level (Neiworth et al. 2003). Even though the procedures adopted in the aforementioned experiments differed, it is certain that a transposition which comprises crossing paths poses difficulty to many species of primates. It is solely apes that tackled such tasks successfully regardless of difficulty level.

The monkeys used in the present experiment scored significantly better in all tasks than the dogs examined by Rooijakkers et al. (2009), which performed above chance only in Condition 1 (i.e. both containers moved to a new location and not crossing each other’s path). If the containers changed their position in such a way that they crossed each other’s path, then the dogs could not follow the transition of the reward. This seems to indicate that monkeys exhibit more flexibility in mental representation compared to dogs. Rooijakkers et al. (2009) assumed that great apes use their mental representation more flexibly than dogs. Undoubtedly, one must also concur with Rooijakkers et al. (2009), who noted that dog inferential abilities are better expressed in the olfactory than in the visual modality. Moreover, differences in cognitive abilities between dogs and primates are well illustrated by Bräuer et al. ’s (2006) research. Their experiments showed that dogs perform better at finding hidden food using communicative cues given by the human experimenter, whereas apes do better when the reward causes a noticeable change in the physical world (e.g. by generating a noise). Generally, the cup manipulated by the experimenter was preferred by the examined dogs and they achieved almost 50% better results than the apes in understanding communicative cues (Bräuer et al. 2006). The latter experiment provided arguments for apes’ developed ability to make inferences about the working of the physical and social world. In nature, apes are forced to gain food from hidden locations (e.g. underground nests), which requires causal understanding, and sometimes they need to use a tool. Probably because of this, they have evolved to develop skills in reading causal cues (Bräuer et al. 2006).

Dogs are considered to have an ability to read human behaviour and use triadic communication, i.e. one individual informs another about the location of various things, including food resources, for example, by pointing or other gestures. Their skills in understanding cooperative signs have developed over thousands of years of domestication (Coppinger and Coppinger 2002; Hare and Tomasello 2005; Bräuer et al. 2006). On the other hand, as a result of domestication, dogs could have lost some skills necessary for causal understanding due to lack of subsistence problems thanks to humans (Bräuer et al. 2006; Rooijakkers et al. 2009; Wynne 2016). Furthermore, ontogenetic development of interspecies cooperative skills in a dog may well result from the relationship established with a human in the first weeks of its life, which is usually not the case with primates subjected to experiments (Miklósí et al. 2003; Wynne et al. 2008).

According to the hypothesis of Natale et al. (1986), monkeys’ progress is limited to Stage 5 on the Piagetian scale of sensorimotor development of object permanence. The authors of that study presumed that only apes, hence not monkeys, could solve a task with the use of mental representation. However, the results of the present experiments as well as those of other researchers have given evidence for the reaching of Stage 6 by the examined monkeys. The species of monkeys that demonstrated good cognitive abilities is the cotton top tamarin, and results have shown that they possess Stage 6 object permanence (Neiworth et al. 2003). On the other hand, another monkey species, namely, the squirrel monkey, did not possess this stage (de Blois et al. 1998). Amongst primates, it was only lemurs that demonstrated Stage 5 of object permanence, as they failed in invisible displacement tasks—a result explained by Deppe et al. (2009) to be of ecological relevance. According to their hypothesis, lemurs’ ability to obtain stationary fruit or leaves and to avoid predators such as raptors, snakes and viverrids does not have to go beyond solving a visible displacement task. Lemurs are attacked by fossas, a large cat-like carnivore in Madagascar, only during sleep. Snakes hunt them using sit-and-wait tactics, whereas raptors observed through foliage can appear in and disappear from the field of view (Goodman 2003). On the other hand, in animals which are at risk of attack by terrestrial stalking predators such as felines, possessing Stage 6 object permanence is very important (Deppe et al. 2009).

In the case of non-primate animals, some species of birds can achieve a high level of cognitive abilities. Four species of parrots (i.e. an African Grey parrot, an Illiger macaw, a cockatiel, and a parakeet) showed Stage
credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

References

Amici F, Aureli F, Call J (2010) Monkeys and apes: are their cognitive skills really so different? Am J Phys Anthropol 143:188–197

Anderson MR (2012) Comprehension of object permanence and single transposition in gibbons. Behaviour 149:441–459. https://doi.org/10.1163/156853912X639769

Barth J, Call J (2006) Tracking the displacement of objects: a series of tasks with great apes (Pan troglodytes, Pan paniscus, Gorilla gorilla, and Pongo pygmaeus) and young children (Homo sapiens). J Exp Psychol Anim Behav Process 32(3):239–252

Bräuer J, Kamiński J, Riedel J, Call J, Tomasello M (2006) Making inferences about the location of hidden food: social dog, causal ape. J Comp Psychol 120(1):38–47

Call J (2001) Object Permanence in Orangutans (Pongo pygmaeus), Chimpanzees (Pan troglodytes), and Children (Homo sapiens). J Comp Psychol 115(2):159–171

Call J (2003) Spatial rotations and transpositions in orangutans (Pongo pygmaeus) and chimpanzees (Pan troglodytes). Primates 44:347–357

Clayton NS, Dickinson A (1998) Episodic-like memory during cache recovery by scrub jays. Nature 395:272–278

Collier-Baker E, Suddendorf T (2006) Do Chimpanzees (Pan troglodytes) and 2-year-old children (Homo sapiens) understand double invisible displacement? J Comp Psychol 120(2):89–97

Collier-Baker E, Davis JM, Nielsen M, Suddendorf T (2006) Do chimpanzees (Pan troglodytes) understand single invisible displacement? Anim Cogn 9:55–61

Copping R, Copping L (2002) Dogs: a new understanding of canine origin, behaviour and evolution. Chicago University Press, Chicago

de Blois ST, Novak MA, Bond M (1998) Object permanence in Orangutans (Pongo pygmaeus) and Squirrel Monkeys (Saimiri sciureus). J Comp Psychol 112(2):137–152

Deppe AM, Patricia C, Wright PC, Szelistowski WA (2009) Object permanence in lemurs. Anim Cogn 12:381–388

Doré FY, Fiset S, Goulet S, Dumas MC, Gagnon S (1996) Search behavior in cats and dogs: interspecific differences in working memory and spatial cognition. Anim Learn Behav 24:142–149. https://doi.org/10.3758/BF03198962

Duchaine B, Cosmides L, Tooby J (2001) Evolutionary psychology and the brain. Curr Opin Neurobiol 11:225–230

Filion CM, Washburn DA, Gullelde JP (1996) Can monkeys (Macaca mulatta) represent invisible displacement? J Comp Psychol 110(4):386–395

Fiset S, LeBlanc V (2007) Invisible displacement understanding in domestic dogs (Canis familiaris); the role of visual cues in search behaviour. Anim Cogn 10:211–224

Fiset S, Plourde V (2013) Object permanence in domestic dogs (Canis lupus familiaris) and gray wolves (Canis lupus). J Comp Psychol 127:115–127. https://doi.org/10.1037/a0030595

Goodman SM (2003) Predation on lemurs. In: Goodman SM, Benstead JP (eds) The natural history of Madagascar. University of Chicago Press, Chicago, pp 1221–1228

Hare B, Tomasello M (2005) Human-like social skills in dogs? Trends Cogn Sci 9:439–444

Herrmann E, Call J, Hernández-Lloreda MV, Hare B, Tomasello M (2007) Humans have evolved specialized skills of social
cognition: the cultural intelligence hypothesis. Science 317:1360–1366
Horik JO, Clayton NS, Emery NJ (2012) Convergent evolution of cognition in corvids, apes and other animals. In Shackelford TK, Vonk J (eds), The Oxford handbook of comparative evolutionary psychology. The Oxford University Press, Oxford
Jaakkola K (2014) Do animals understand invisible displacement? A critical review. J Comp Psychol 128(3):225–239
Jaakkola K, Guarino E, Rodriguez M, Erb L, Trone M (2010) What do dolphins (Tursiops truncatus) understand about hidden objects? Anim Cogn 13:103–120
Johnson CM, Sullivan J, Buck CL, Trexel J, Scarpuzzi M (2015) Visible and invisible displacement with dynamic visual occlusion in bottlenose dolphins (Tursiops spp). Anim Cogn 18:179–193
Miklósi A, Kubinyi E, Topál J, Gácsi M, Virányi Z, Csányi V (2003) A simple reason for a big difference: wolves do not look back at humans, but dogs do. Curr Biol 13:763–766
Natale F, Antinucci F, Spinozzi G, Poti P (1986) Stage 6 object concept in nonhuman primate cognition: a comparison between Gorilla (Gorilla gorilla gorilla) and Japanese Macaque (Macaca fuscata). J Comp Psychol 100(4):335–339
Nawroth C, von Borell E, Langbein J (2015) Object permanence in the dwarf goat (Capra aegagrus hircus): perseveration errors and the tracking of complex movements of hidden objects. Appl Anim Behav Sci 167:20–26
Neiworth JJ, Steinmark E, Basile BM, Wonders R, Steely F, DeHart C (2003) A test of object permanence in a new-world monkey species, cotton top tamarins (Saguinus oedipus). Anim Cogn 6:27–37
Pepperberg IM (2002) The value of the Piagetian framework for comparative cognitive studies. Anim Cogn 5:177–182
Pepperberg IM, Funk MS (1990) Object permanence in four species of psittacine birds: an African Grey parrot (Psittacus erithacus), an Illiger mini macaw (Ara maracana), a parakeet (Melopsittacus undulatus), and a cockatiel (Nymphicus hollandicus). Anim Learn Behav 18(1):97–108
Piaget J (1954) The construction of reality in the child. Basic Books, New York
Pollok B, Prior H, Güntürkün O (2000) Development of object permanence in food-storing magpies (Pica pica). J Comp Psychol 114(2):148–157
Reader SM, Hager Y, Laland KN (2011) The evolution of primate general and cultural intelligence. Philos Trans R Soc B 366:1017–1027
Rooijakkers EF, Kaminski J, Call J (2009) Comparing dogs and great apes in their ability to visually track object transpositions. Anim Cogn 12:789–796
Schloegl C, Waldmann MR, Fischer J (2013) Understanding of and reasoning about object–object relationships in long-tailed macaques? Anim Cogn 16:493–507
Sell AN (2012) Evolved cognitive adaptations. In: Shackelford TK, Vonk J (eds) The Oxford handbook of comparative evolutionary psychology. The Oxford University Press, Oxford
Shreve KRV, Udel MAR (2015) What’s inside your cat’s head? A review of cat (Felis silvestris catus) cognition research past, present and future. Anim Cogn 18:1195–1206
Singer R, Henderson E (2015) Object permanence in marine mammals using the violation of expectation procedure. Behav Proc 112:108–113
Tomasello M, Call J (1997) Primate cognition. Oxford University Press, New York
Wynne CDL (2016) What is special about dog cognition? Curr Dir Psychol Sci 25(5):345–351
Wynne CDL, Udell MAR, Lord KA (2008) Ontogeny’s impacts on human-dog communication. Anim Behav 76:e1–e4. https://doi.org/10.1016/j.anbehav.2008.03.010
Zucca P, Milos N, Vallortigara G (2007) Piagetian object permanence and its development in Eurasian jays (Garrulus glandarius). Anim Cogn 10:243–258