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The Ephemeral Reward Task in kea (Nestor notabilis)

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## List of Abbreviations

| | |
|---|---|
| ERT | Ephemeral Reward Task |
| LM | Linear Model |
| GLMM | Generalized Linear Mixed Model |

## Abstract English

This thesis investigates the results of kea (*Nestor notabilis*) in the Ephemeral Reward Task. This test is used to investigate if the kea can solve the paradigm on par with grey parrots (*Psitaccus Erithacus*) and if optimizing the task for the keas ecology improve their results. Thus, improving our understanding of how the specific underlying decision making across different species may work. Within this task, the order in which the tested individual selects the two simultaneously presented rewards, decides if the bird gets access to both or if one is removed out of reach. Adult cleaner fish (*Labroides dimidiatus*) and grey parrots (*Psitaccus erithacus*) have succeeded in this paradigm while capuchin monkeys (*Cebus apella),* chimpanzees *(Pan troglodytes),* orangutans *(Pongo pygmaeus*), pigeons (*Columba livia*) and rats (*Rattus norvegicus*) did not solve the basic task. To expand this line of research, we set out to replicate the test with another parrot species with an expanded experimental set-up.

In a threefold experiment, a total of twelve kea were tested in a baseline condition, a minimal control condition and a social condition – an alteration based on the keas' feeding ecology – in which a partner bird received the second reward in case of a suboptimal choice. Results were analyzed using descriptive statistics and linear models.

Results show that kea could not solve the task. Overall, performance remained near chance across all conditions, and side biases were common, particularly in the minimalist version of the task.

The frequency of side biases suggests simple heuristics rather than flexible decision-making as underlying cognitive processes. In follow-up studies with rats and pigeons it was suggested that impulse control may be a key factor in this task and we found no other factors that affected the results. Findings highlight the importance of task design, ecological validity, and cross-species comparisons in studies of animal cognition.

## Abstact Deutsch

Diese Arbeit untersucht die Ergebnisse von Keas (Nestor notabilis) in der Ephemeral Reward Task. Dieser Test wird verwendet, um zu untersuchen, ob Keas den Test genauso gut lösen können wie Graupapageien (Psitaccus Erithacus) und ob eine Optimierung der Aufgabe für die Ökologie der Keas ihre Ergebnisse verbessert. Dadurch können wir besser verstehen, wie die spezifischen Entscheidungsprozesse verschiedener Arten funktionieren. Bei dieser Aufgabe entscheidet die Reihenfolge, in der das getestete Individuum zwischen zwei gleichzeitig präsentierten Belohnungen wählt, darüber, ob der Vogel Zugang zu beiden erhält oder ob eine davon außer Reichweite entfernt wird. Erwachsene Putzerlippfische (Labroides dimidiatus) und Graupapageien (Psitaccus erithacus) haben dieses Paradigma erfolgreich gemeistert, während Kapuzineräffchen (Cebus apella), Schimpansen (Pan troglodytes), Orang-Utans (Pongo pygmaeus), Tauben (Columba livia) und Ratten (Rattus norvegicus) die grundlegende Aufgabe nicht lösen konnten. Um diese Forschungsrichtung zu erweitern, haben wir uns vorgenommen, den Test mit einer anderen Papageienart und einem erweiterten Versuchsaufbau zu wiederholen. In einem dreiteiligen Experiment wurden insgesamt zwölf Keas unter einer Basisbedingung, einer minimalen Kontrollbedingung und einer sozialen Bedingung getestet – eine Anpassung, basierend auf der Nahrungs-Ökologie der Keas – bei der ein Partnervogel im Falle einer suboptimalen Wahl die zweite Belohnung erhielt. Die Ergebnisse wurden mithilfe deskriptiver Statistiken und linearer Modelle analysiert.

Die Ergebnisse zeigen, dass die Keas die Aufgabe nicht lösen konnten. Insgesamt blieb die Leistung unter allen Bedingungen nahe am Zufall. Seitenpräferenzen waren häufig, insbesondere in der minimalistischen Version der Aufgabe.

Die Häufigkeit von Seitenpräferenzen deutet eher auf einfache Heuristiken als auf flexible Entscheidungsfindung als zugrunde liegende kognitive Prozesse hin. In Folgestudien mit Ratten und Tauben wurde vermutet, dass Impulskontrolle ein Schlüsselfaktor bei dieser Aufgabe sein könnte, und wir fanden keine anderen Faktoren,

die die Ergebnisse beeinflussten. Die Ergebnisse unterstreichen die Bedeutung von Aufgabengestaltung, ökologischer Validität und artenübergreifenden Vergleichen in Studien zur Tierkognition.

# 1 Introduction

When a fish can solve seemingly simple discrimination task while some of the most intensively studied primate species do not, it creates an interesting starting point to investigate the underlying cognition of the species' problem-solving abilities. This occurred in the Ephemeral Reward Task (ERT), first established in cleaner fish (Bshary & Grutter, 2002), where the natural encounter of the two different types of clients that cleaners frequently encounter, were simulated. One being resident clients that will wait until they get cleaned and the ephemeral clients which will swim to another cleaning station before waiting until other clients are being cleaned. The ERT consists of two options that the subject can choose from, with one option (Side A) being ephemeral and the other one (Side B) being present permanently. Choosing side A (ephemeral) results in a food reward and continued access to the other side B (permanent) while choosing the permanent side results in a food reward and the removal of the ephemeral reward out of reach.

Adult cleaner fish (*Labroides dimidiatus*), on which' ecology this task was based on, were found to outperform juvenile wrasse and nonhuman primates, i.e. capuchin monkeys (*Cebus apella),* chimpanzees *(Pan troglodytes)* and orangutans *(Pongo pygmaeus*) (Salwiczek et al., 2012). They were further found to outperform pigeons (*Columba livia*) (Zentall et al., 2017a) and rats (*Rattus norvegicus*) (Zentall et al., 2017b), while on the other hand, grey parrots (*Psitaccus erithacus*) were shown to be able to learn to choose the ephemeral side first and thus increase the number and amount of rewards in the ERT (Pepperberg & Hartsfield, 2014).

Cleaner fish live in coral reefs worldwide, maintaining cleaning stations. They get visited by 'client' fish and feed of their ectoparasites and dead or infected tissue (Bshary & Würth, 2001). The cleaners can get visited dozens to hundreds of times a day, sometimes by multiple fish at once (Grutter, 1995).

Those clients with small territories have little choice in the cleaning stations while those with larger territories can be more selective for optimal service (Bshary & Schäffer, 2002; Bshary & Würth, 2001). Beyond the clients physically punishing the cleaners for eating mucus, healthy tissue, etc. (cheating), this dissimilar service is displayed by selectively cleaning ephemeral clients first, over resident ones (Bshary & Schäffer, 2002). The dynamics of the interactions of cleaners and clients is explained by market theory, which models the risks and benefits of an action. For the cleaners it is beneficial in the short term to feed of the clients' mucus or healthy tissue with the cost of its own reputation and future visits of the client. Contrary to that is the short-term drawback of restricting to feed of parasites and dead tissue with the benefit of a good reputation and more frequent visits of the client (Bshary, 2010).

Cleaner fish not only respond to immediate interactions but also keep track of individual client reputations and adjust their service accordingly. This requires memory, discrimination, and flexible decision-making. Whether such behaviors are purely instinctive adaptations or reflect more general cognitive abilities is unclear (Bshary & Grutter, 2002).

To investigate this specific discrimination in detail, Bshary & Grutter (2002) tested twelve adult cleaner fish in an experimental version of a simultaneous visit of an ephemeral and a resident client. Two identical rewards were fixed to differently coloured levers which can ben pulled out of the water by the experimenter. During the experiment, the fish developed a significant preference to choose the ephemeral choice first. This, however, still offered little insight into the internal decision making of the cleaners. The ability to make these optimal decisions can either be a specific ecological adaptation or general cognition, meaning that the fish use widespread learning rules that allow them to solve such tasks spontaneously.

To provide more insight into which strategy the fish follow, another test was performed with new individuals and a version for different primate species was designed and performed. The results of the fish were compared to the results of well-established

species in cognitive tasks like capuchin monkeys, chimpanzees and orangutans (Salwiczek et al., 2012). All six adult cleaner fish were able to solve the task, while only one out of seven juvenile cleaners (14 %), one out of four chimpanzees (25 %) and none of the four orangutans or eight capuchin monkeys solved the task. One hypothesis to explain this result is that cleaners see the removal of the ephemeral choice both as a social and foraging punishment which acts as intense negative reinforcement, potentially increasing their performance (Pepperberg & Hartsfield, 2014).

Following this perplexing outcome, Pepperberg & Hartsfield (2014) tested three adult grey parrots on the paradigm, arguing the ecological similarities to the primates over the fish. Contrary to the expectations argued on this basis, all three tested grey parrots solved the task successfully.

An explanation for this similarity between cleaner fish and grey parrots could be in the perception of the task. While both fish and parrots grab the reward with their mouth or beak sequentially, the primates grab their reward with either the left or right hand, also possibly simultaneously and might therefore perceive both sides rather as a unity compared to parrots and fish (Pepperberg & Hartsfield, 2014).

As a result of the grey parrot's success in the ERT, the scientific focus shifted away from deciding if possible ecological adaptations of the fish or general cognition aided them in the tasks toward the question: What do these fish and birds have in common that allow them to succeed where the primates did not.

To build on the findings with grey parrots of Pepperberg & Hartsfield (2014) and further investigate the performance of parrots in this area, we designed a version of the Ephemeral Reward Task that focusses on the ecological specificities in another parrot species, the kea (*Nestor notabilis*).

Kea are omnivorous alpine mountain parrots that are endemic to the high mountains of the South Island of New Zealand. They are ecological generalists and live on a wide variety of, mainly vegetarian, food resources with over a hundred food items reported

(Brejaart, 1988). They live in a fission fusion dynamic where undefined subgroups frequently split off and later rejoin, while different groups are not clearly separated from each other. This way, kea have no clear individual hierarchy which can lead to Kea also gathering at bigger food sources like fruiting bushes or carcasses where feeding becomes a social exercise (Diamond & Bond, 1999; Schwing, 2010). Kea were also reported to actively hunt small mammals if the opportunity arises (Beggs & Mankelow, 2002).

During their ontogeny kea have many interactions with conspecifics of all ages and it is likely that they learn from them regarding foraging techniques (Diamond & Bond, 1991). Young birds are fed by other members of the group and follow them around for this opportunity. They also learn from elder birds about the location and retrieval techniques (Huber et al., 2001) so there is a large social aspect in the feeding ecology of kea. Furthermore, the kea is experiencing seasonal scarcity of food in winter when most plants are dormant and seasons of abundance in summer. This makes them opportunistic and constantly on the search for food. Since they are opportunistic feeders, they aggregate at abundant food sources like a carcass. These occasions give the young extensive opportunity for social interaction. A link between an opportunistic lifestyle and cognition was described by Huber et al. (2001). In addition, kea reach sexual maturity only at the age of three to five years, which gives them plenty of opportunities and time to learn.

## 1.1 Research Question and Hypotheses

The present test consists of three individual tests, the baseline test which recreates the conditions of the grey parrots and what the following tests will be compared to, the control test which simplifies the setup drastically to control for any effects of the apparatus itself and lastly the social condition which repeats the baseline test with new birds and adds social pressure by a peer bird receiving the second rewards in case of choosing the permanent side first.

Like the grey parrots and capuchins, the kea have the necessity to cover broad ranges to forage in groups, which makes them a suitable comparison for the baseline test and potential social influences in foraging decisions.

The aim of this study is to compare the keas results of the baseline test of the ERT to the results of the grey parrots and, if the addition of a partner bird will change the results – thereby including a social condition reflecting their social behaviour from an ecology where food can be scarce and feeding can become a social exercise (Schwing, 2010).

In the present study, a threefold experiment was designed, comprised of a baseline test, a control test and a social test. The baseline recreated the ERT for kea and follows the principles of the test of the grey parrots. Since the apparatus became much more complicated than the version of the grey parrots, both to eliminate the experimenters influence as much as possible and to allow for a following social condition we added a control version being a wooden board on the floor and manual removal of the rewards. This represents the grey parrots' version much more closely and helps to distinguish between influences from the species and from the apparatus. Lastly, we performed a social condition, the baseline test with new birds in which a partner bird received the removed rewards, in contrast to the food just disappearing. Within this social condition, the Social Punishment Hypothesis, stated by Salwiczek et al. (2012), is investigated. The idea behind this hypothesis is that cleaner fish perceive the departing of an ephemeral

fish not only as a loss of food but also as a negative social interaction, reinforcing the choice of the ephemeral choice first. This social punishment is imitated by the partner bird eating the reward in full view but out of reach in case of a suboptimal choice (choosing the permanent side first).

The following hypotheses were outlined:

- H1: Kea will learn to choose the ephemeral reward first in the baseline test within 10 sessions of 10 trials each.
    - H1a: The number of sessions required to learn choosing the ephemeral reward first in the control condition will decrease compared to the baseline test.
    - H2: The number of sessions required to learn choosing the ephemeral reward first in the social condition will decrease compared to the baseline test.
- The results of this study will be compared to the results of the previous tests with other species, especially from the grey parrots to see if 1) the similar ecology enables kea to solve the ERT as well, and 2) whether losing the ephemeral reward to a peer will reinforce their problem-solving ability, which would indicate an involvement of Social Punishment Hypothesis.

# 2 Material & Methods

During this experiment, twelve kea (*Nestor notabilis*) were tested within three different experimental set-ups in solving the ERT, using a custom-built apparatus. The general procedure and presentation of the rewards stayed close to the procedure which was used to test the grey parrots but was adapted to minimize the experimenters influence and allowed the later presentation of a partner bird in the social condition. For details, see 2.1.1. In each test 6 birds were tested for 10 sessions with ten trials per session resulting in 100 trials per bird. As the control test was focusing on the apparatus and not on the birds, the same birds of the baseline test participated. For a detailed breakdown of the birds and which tests they participated, see Table 1. The data was then analyzed using descriptive statistics and measures of central tendency and dispersion, as well as linear models to compare the results between the baseline and the control condition (Test 1 and 2) and baseline and the social condition (Test 1 and 3). For both the model included the influence of the test condition, the individual birds and session number.

## 2.1 Experimental Setup

Three experimental conditions were designed to test the kea's ability to solve the Ephemeral Reward Task (ERT): A baseline condition with a minimal condition as a control and a social condition.

The baseline condition was in principle based on the setup of Pepperberg & Hartsfield (2014) where a single parrot was presented with two simultaneous choices, the permanent and ephemeral reward. Whether the reward was permanent or ephemeral was signaled by its presentation on a black or white background. Which background presented which was semi randomly assigned to each bird so that both groups had an equal split of black or white being the ephemeral choice. If the ephemeral reward was chosen first, the other reward stayed for the bird to access the peanut while choosing the permanent option first led to the removal of the second reward.

For the present study we adapted the presentation of the rewards, in that, first, the presentation was as independent of the experimenter as possible and second, the same setup allowed for a follow-up test where a partner bird got the reward in case of suboptimal choices. The apparatus allowed the experimenter to move the rewards using wires below the setup, out of sight of the kea. In the baseline condition, this ERT apparatus (described in sub-chapters 2.1.1 and 2.1.2) was used with only the tested bird. This test provided a baseline comparison with previous studies on cleaner fish, grey parrots, primates, pigeons, and rats.

The minimalist condition (Test 2) simplified the task in order to control for possible perceptual or mechanical distractions. The minimalistic apparatus is also described in sub-chapters 2.1.1 and 2.1.2). This condition increased the visibility of rewards and backgrounds and reduced potential complexity introduced by moving parts.

The social condition (Test 3) repeated the baseline design but added a social component. A partner bird, positioned on the experimenter's side of the apparatus, received the ephemeral reward whenever the test bird made a suboptimal choice. This manipulation simulated a more natural ecological situation in which competitors benefit from poor decision-making. Two males, one high-ranking and one low-ranking, were chosen as partners and paired randomly with each three of the six focal birds.

### *2.1.1 Experimental Procedure*

The apparatus (visualized in Figure 1, Figure 2 and Figure 3) used in the baseline and social conditions was a custom-built wooden construction (described in detail in sub-chapter 2.1.2) that spanned two adjacent compartments, enabling the bird and the experimenter to face each other directly, as is visualized in Figure 1. The control setup was a painted wooden board on the floor with the experimenter sitting behind it (see Figure 4).

The reward was placed in one of two sliding boxes with insertable black or white bottom plates within the apparatus. The upper section of the apparatus was covered by a

transparent plastic panel with two narrow slits, which allowed the kea to reach the rewards but prevented tampering with the mechanism. The sliding mechanism was concealed within a lower wooden box, so that the experimenter could move the rewards without the bird observing the action. This was done to avoid association with the experimenter giving or denying treats. The placement of the rewards in the sliding boxes was furthermore concealed by a foldable wooden barrier to abstract the keas gaze from the loading of the boxes and thereby eliminate visual cues.

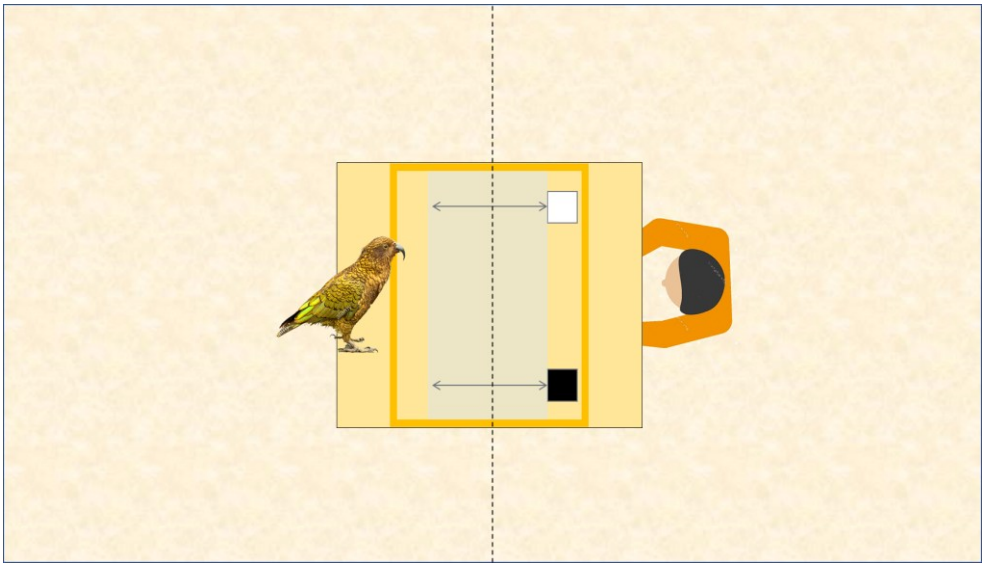


***Figure 1:*** *Schematic top view of the experimental compartments with the test setup (not to scale). The dotted line represents wire-mesh between the compartments; the beige rectangle depicts the apparatus with the upper frame in yellow and the grey plastic cover.*

The design of the apparatus ensured symmetry, minimized experimenter interference, and reduced the possibility of birds associating movements with human actions. Additionally, the experimenter maintained a neutral posture and gaze, focusing on a central point between the two choices, in order to avoid giving unintentional cues.

At the beginning of each trial, two rewards (one-quarter of a peanut each) were placed on black and white backgrounds. The kea's choice was defined by the bird touching the reward. While it was without exception the beak that touched the reward first, touching it with the foot would have sufficed either. Touching the reward with feathers would

have been counted as accidental or reviewed in a case-to-case basis. If the choice was optimal, being the ephemeral box, the permanent box stayed in place for the bird to consume its rewards; if suboptimal, being the permanent box, the ephemeral reward was either removed from reach (Tests 1 and 2) or given to the partner bird (Test 3).

The performance criterion was defined as reaching at least one of the following thresholds: For three consecutive sessions seven out of ten correct choices must be made, for two consecutive sessions eight out of ten correct choices must be made, or nine out of ten correct choices must be made in a single session. Once a bird met criterion, it was not tested further in that condition.

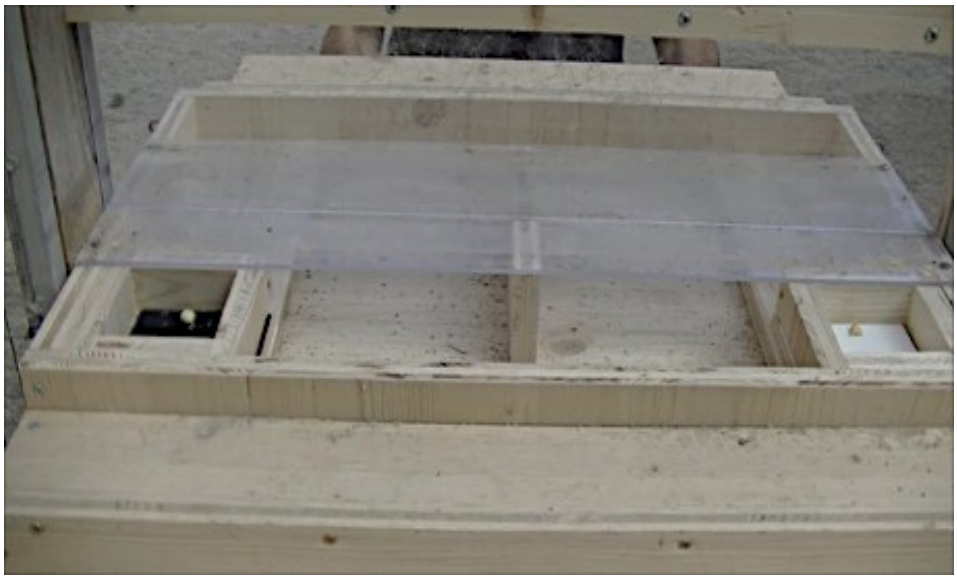


***Figure 2:*** *ERT apparatus from the tested bird's perspective. On the left is the reward offered on a black background, on the right on a white background. The backgrounds can be switched. In the back is the experimenter operating the cables below the apparatus.*

To control for a possible bias, the position of the ephemeral and permanent options was pseudo-randomized, ensuring no more than two consecutive presentations of the same reward type on the same side. If a bird developed a strong side bias (operationally defined as five consecutive choices for the same side within a session), the ephemeral reward was switched to the opposite side by presenting the sub-optimal permanent

reward on the side of the side bias until the bird chose on the other side again or the session ended.

Each trial was separated by a 45-second inter-trial interval. During one testing session, ten trails were executed. During the inter-trial period, the view to the experimenters' side of the apparatus was covered with a wooden shield (see Figure 5), preventing the birds from observing the experimenter's handling of the rewards.



**Figure 3:** Social condition of the ERT. *The social partner in the front and the tested bird in the back. In the bottom right is the opening to the lower section of the apparatus with the steel cables that are operated by the experimenter.*



***Figure 4:*** *Experimenter sits behind the wooden board with painted spots in black and white. The reward peanut is visible on the black spot. The tested kea is standing on top of the board.*



***Figure 5:*** *The foldable barrier is up to block the tested birds' gaze. Both the barrier and the partner bird are on the experimenter's side of the apparatus.*

### *2.1.2 Test apparatus*

The apparatus used in this experiment consisted of two adjoining test compartments with openings on both sides, as is visualized in Figure 1, Figure 2 and Figure 3. It was comprised of an upper structure, where the rewards were presented and a lower structure in which the cables ran to move the boxes. To move the boxes, the experimenter only moves the lower arms which are obscured under the table. By this the movement of the boxes is as separate from the actions of the experimenter as possible.

The upper part of the apparatus was a shallow wooden frame (60 cm x 40 cm x 10 cm, W x L x H) in which two rails ran along the length equidistant from the edges. In these rails ran two steel wires that controlled two sliding boxes (10 cm x 10 cm). These boxes moved along the rails back and forth if the wire was pulled in either direction. Each box had an insertable bottom plate, either black or white. A transparent plastic panel was placed on top of the chamber and only left two narrow slits open on both sides to give a clear access point to the boxes. A step was in front of the frame for the kea to stand on and give a clear view inside.

The wire then ran down in the second part of the apparatus which was a wooden box with the same width as the upper frame, which extended 20 cm in each direction lengthwise, to give the kea a place to stand. In the box, the wire looped back to the other side and was connected to its other end and formed a loop. The experimenter could pull on the wire in either direction below the table with a move from the hands and outside of the bird's view. This way the sliding box could easily be pulled in either direction without a visible connection to the experimenter.

The apparatus for the minimal condition (Test 2) consisted of a flat wooden board (50 × 20 × 2 cm) bearing two circles (10 cm radius), one black and one white. Each circle contained a reward, and to control for visual contrast, the opposite color was outlined around each circle. In this setup, the experimenter removed the non-chosen reward directly by hand.

## 2.2 Data Collection

The data collection was executed in summer and autumn 2017 and spring 2018. The baseline test was conducted between the 31.08.2017 and the 19.09.2017, the control test was conducted between the 11.11.2017 and the 29.11.2017 and the social condition was tested between the 13.05.2018. and the 03.06.2018. Each bird was tested every 2-3 days, depending on its motivation and participation in other experiments. All experiments were conducted in the Kea Lab at the Haidlhof Research Center of the Messerli Institute in Bad Vöslau, Lower Austria.

Each bird completed up to ten sessions, per testing day only one session which each lasted approximately 30 minutes, with ten trials to complete in each of these sessions. This accounted for a total of 100 trials per condition per bird. The 100 trials are the presented number in the original test setup for the primates (Salwiczek et al., 2012) and were further used by Pepperberg & Hartsfield (2014).

For data collection a table was created in excel containing ten sessions with ten trials and the semi randomly decided side of the ephemeral reward each per test and bird. For each testing session, the table was transcribed manually in a notebook so that only the first choice of the bird per trial was noted in the moment. The result was later entered into the excel table. Additionally, video recordings of the sessions were made. These served on the one hand as secondary data recording as backup and furthermore, about 20 % of the data recordings were double checked, meaning that 20 % of the manual recorded sessions were compared with the video recordings for quality control. If any discrepancies were found for the testing day it was corrected in the excel file and notebook. Also, the entire time slot morning/ afternoon of the day was controlled. Each testing day consisted of two timeslots in which the birds were tested, one from 10:00 to 12:00 a.m. and the other from 13:00 to 15:00 p.m. During each, between 3 or four birds could be tested. The rest of the day was free from testing for the birds to socialize, feed

and rest. Participating in the tests was voluntary for the birds, indicated by the bird by coming into the test compartment on their own and/or the refusal to leave again. Usually, around 5-10 birds were found waiting in front of the compartment and keeping them out was more challenging than motivating a bird to enter. In terms of the time of day, the testing sessions always took place Each bird took part in the experiment either in the first or the second time slot, never both slots in one day. The order in which the kea were tested was semi-randomly determined prior to the experiments: The days of participation were chosen in a way that each bird was tested two times a week without having periods longer than four days in between two tests.

The birds were given access to the testing compartment but were not forced. If the bird did not participate or refused to enter the compartment, it was tested another day. Due to the extraordinary curiosity and playfulness of the birds, the motivation to participate in this task was given naturally and was only enhanced by food rewards. They were at no time, including testing sessions, deprived of food and water.

## 2.3 Study subjects

The group of 28 kea lived in a 2080 $m^3$ (52m x 10m x 4m) outdoor aviary. Feeding took place three times a day with a mix of fruits, vegetables, seeds and different sources of protein, with an ad libitum water access.

For both the baseline and social condition, six birds were selected to roughly represent a homogenous representation of age, sex and hierarchical position. In addition to these twelve birds, two birds were selected as partner bird whose sole purpose lay in eating the reward in case of a suboptimal choice. For details see Table 1.

Three experimental conditions (described in chapter 2.1) were designed to test the kea's ability to solve the Ephemeral Reward Task: Test 1 being the baseline condition, Test 2 (which served as a control for Test 1) and Test 3, the social condition. The six

birds which participated in Tests 1 and 2 were assigned to group A. The other six birds, which participated in Test 3 were assigned to group B. Two further birds were not tested, but only served as partners of the participating birds in group B.

The overall age ranged from two years up to 18 years. Looking at the two groups A and B, the age range was three to 18 years in group A and two to 17 years in group B. Both groups contained two males and four females. Table 1 provides a sample description in terms of name, sex, age and if the bird was raised by hand or by a parent, as well as the assignment of individuals to the different groups and experiments.

**Table 1: Demographic information on test subjects**

*Description of the 14 individuals used for the experiments in terms of name, sex, age and breeding type, as well as specification of the experiments the individuals were involved in, or whether they participated as a partner bird in the social condition (Test 3).*

**Demographic information on test subjects**

| Name | Sex | Age [years] | Raised | Group | Test |
|---|---|---|---|---|---|
| **John** | M | 18 | parent | A | 1, 2 |
| **Pick** | M | 13 | hand | A | 1, 2 |
| **Liho** | F | 3 | parent | A | 1, 2 |
| **Lilly** | F | 10 | hand | A | 1, 2 |
| **Sunny** | F | 10 | hand | A | 1, 2 |
| **Mali** | F | 3 | parent | A | 1, 2 |
| **Coco** | F | 10 | hand | B | 3 |
| **Willy** | F | 10 | hand | B | 3 |
| **Jean-Luc** | M | 2 | hand | B | 3 |
| **Elvira** | F | 17 | parent | B | 3 |
| **Kiri** | F | 2 | parent | B | 3 |
| **Roku** | M | 9 | parent | B | 3 |
| **Kermit** | M | 13 | hand | - | Partner |
| **Anu** | M | 10 | hand | - | Partner |

## 2.4 Data Analysis

The manually recorded data was transferred to an Excel file and further processed and analyzed using R (*version 4.4.3*) and RStudio (*version 2024.12.1+563*). In programming, the pipe function from the *magrittr* (*v.2.0.3*) package was used for convenience to string functions together. The data calculation was done using the *dplyr* (*v1.1.4*) package and the plotting was done using the ggplot2 (*v3.5.1*) package.

### *2.4.1 Descriptive Statistics*

To gain a better understanding of the results of the different tests, they were first summarized using descriptive statistics. Since first hypothesis is the number of birds reaching a fixed criterion and the corresponding deviation from 50% success rate which is regarded as the choice is random from the reward type. To do this, for each session the mean correct choice was calculated. The descriptive statistics contain summarizing the number of birds which passed each experiment and the required number of sessions. Measures of central tendency, i.e. mean and median, as well as measures of dispersion, i.e. range - minimum value (min), maximum value (max) - and standard deviation (SD) were determined and presented in tables.

### *2.4.2 Linear Models*

To tests for differences in between the results of the baseline condition and the control condition as well as differences in the results of the baseline condition and the social condition. The data used for the analysis within each test was normally distributed both in the raw data itself. The residuals were furthermore linearly spread With these assumptions controlled for, a Linear Model (LM) from the *stats* package was suitable to check the influence of predictor variables on the response variable. In parallel to the LM, a generalized linear mixed model (GLMM) with the random effects of side and sex were built per comparison (baseline/control and baseline/social) to analyze the data using the binary raw data of optimal or suboptimal choice. Since this model did not find

noticeably different results than the substantially simpler LM, the simpler model was used.

The response variable in the analysis was the mean correct choice for each session per test, and the linear model was used to look for influences of the individual birds and the session number in between the tests. For significance, $\alpha = 0.05$ was used. The calculated model was summarized using an Anova type II.

# 3 Results

Three experiments were conducted in this study to examine the kea's ability to solve the Ephemeral Reward Task: A baseline condition (Test 1), a minimal condition (Test 2) serving as a control for possible perceptual or mechanical distractions and a social condition (Test 3), involving a partner bird. Results for these experiments are described both using measures of central tendency and measures of dispersion (see sub-chapter 3.2) and using linear models to compare different testing conditions, regarding H2.

### *3.1 Graphs*

In addition to tables, results were displayed in histograms (to display the spread of values across the dataset), in scatterplots (where potential changes in dependance of another variable were looked at) and line plots (with error bars (+- SD) for categorical predictor variables).

## 3.2 Descriptive Statistics

Across the three experiments, overall performance of the kea remained close to chance level, with only one bird successfully reaching criterion. When pooled across individuals and sessions, the mean proportion of correct choices was 0.52 (range = 0.20-1.00, SD = 0.14). Descriptive statistics for each test are summarized in Table 2.

**Table 2: Summary of results**

*The results for all three testing conditions, as well as the overall (total) performance in all three conditions taken together are presented in terms of mean, median, range (minimal and maximal value) and standard deviation (SD).*

| Test | Mean | Median | Min | Max | SD |
|---|---|---|---|---|---|
| Total | 0,52 | 0,5 | 0,2 | 1 | 0,14 |
| Baseline | 0,54 | 0,5 | 0,2 | 0,8 | 0,14 |
| Baseline control | 0,48 | 0,5 | 0,2 | 0,8 | 0,11 |
| Social | 0,56 | 0,6 | 0,2 | 1 | 0,15 |

For the analysis a side preference was defined differently than during the experiments. While during the test the side preference was a measure when counter measurement were taken, in the analysis it describes the sessions where the birds choose predominantly on one side. A side preference in the analysis was defined with one side chosen by the bird eight times or more in one session. In the baseline condition (Test 1), five of the six birds developed side biases, defined as choosing the same side in nine or more out of ten trials within a session. The results of this condition yielded a mean of 0.54 correct choices (range = 0.20-0.80, SD = 0.14). Side bias occurred in 25 % of sessions, divided even between left-leaning (N = 8; 53 %) and right-leaning (N = 7; 47 %) biases, as is presented in Table 3.

In the baseline control condition (Test 2), all six birds developed side biases. The mean correct performance dropped slightly to 0.48 (range = 0.20–0.80, SD = 0.11). Side biases were particularly strong in this condition, occurring in 47 % of sessions (N = 28). When there was a side bias, right-side preferences dominated with 75 % (N = 21), while left-side preferences were less frequent with 25 % of cases (N = 7). Despite the simplified setup, no bird reached criterion and overall performance did not differ from chance, as is presented in Table 3. The frequency of mean correct choices per session were plotted and visually analyzed for normal distribution for each test individually (see Figure 6).

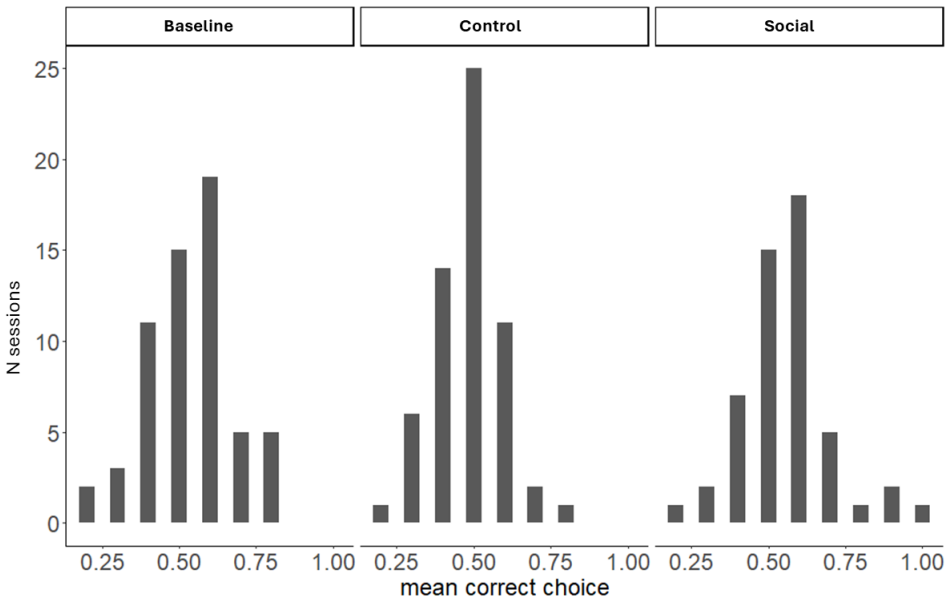



***Figure 6:*** *Histogram of the mean correct choice distribution for all three tests.*

***Table 3: Overview of side biases***

*The number and percentage share of birds showing a side bias is presented, as is the overall number of sessions per test, the number of biased sessions in total, as well as the sessions with right- and left-bias.*

| | **Test 1** | **Test 2** | **Test 3** |
|---|---|---|---|
| **Biased birds** (N[%]) | 5 [83.33] | 6 [100] | 4 [66.67] |
| **Sessions** (N) | 60 | 60 | 51 |
| **Biased sessions in total** (N[%]) | 15 [25.00] | 28 [47.00] | 11 [22.00] |
| **Sessions with right-bias** (N[%]) | 7 [47.00] | 21 [75.00] | 7 [64.00] |
| **Sessions with left-bias** (N[%]) | 8 [53.00] | 7 [25.00] | 4 [36.00] |

In the social condition (Test 3), performance was somewhat more variable. One bird from the social condition achieved criterion in the first session, representing the only case of task success in the study. Across all birds, the mean correct performance was 0.56 (range = 0.20-1.00, SD = 0.15). Side biases again emerged, but were less frequent than in other conditions, occurring in 22 % of sessions (N = 11). When a bias occurred,

right-side preferences were more common with 64 % of cases (N = 7) than left-side preferences, which made up 36 % of cases (N = 4).

Performance across sessions for each condition is visualized in Figure 7, which plots mean correct choices by session of the different tests. Results indicate no consistent improvement across sessions, with group averages remaining near the chance level of 50 %.

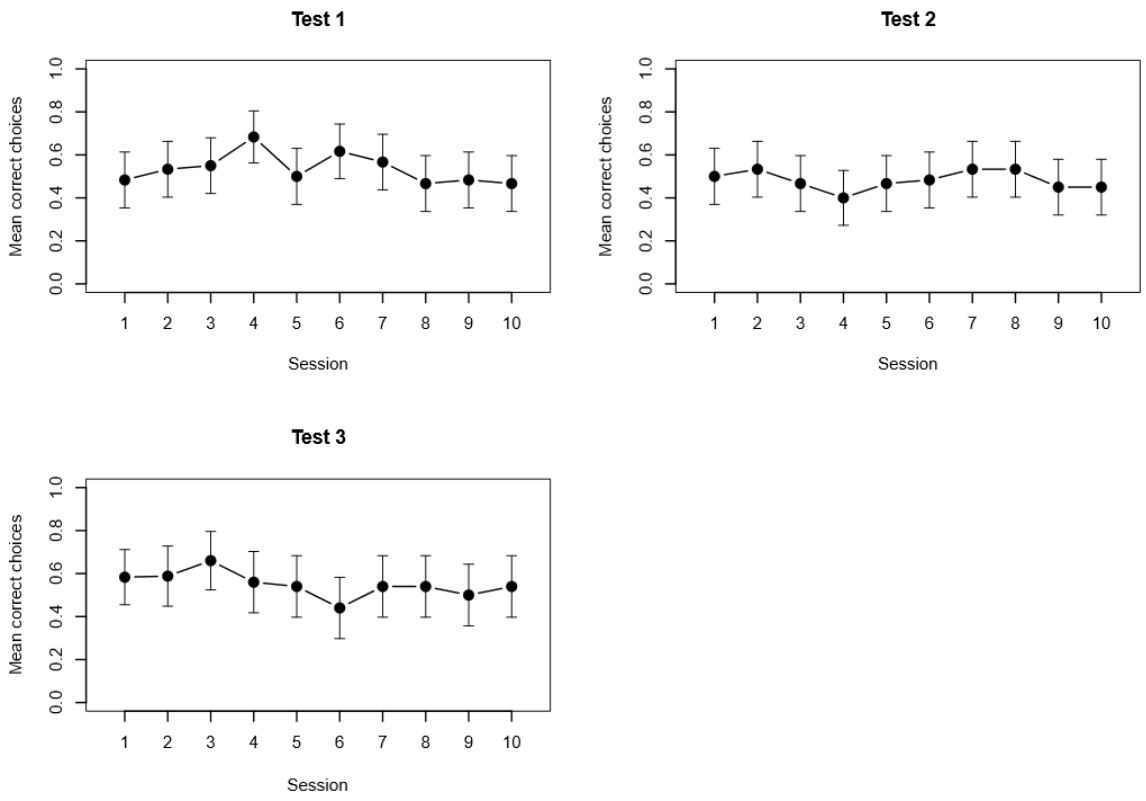



***Figure 7: Mean correct choices across sessions per testing condition (Test 1-3)***

## 3.3 Linear Models

Linear models were applied to compare the baseline test against the control (Test 1 and 2) and the social condition (Test 1 and 3) to assess potential influences of session number, individual bird, sex, age, or side of the ephemeral reward. Comparison of Test 1 and Test 2 showed no influence of the individuals ($F(5,112) = 0.93$, $p = 0.46$) or session

(F(1,112) = 1.15, p = 0.28), but a significant effect of test condition was found (F(1,112) = 5.27, p = 0.02), with Test 2 producing lower performance than Test 1 (see table 4).

***Table 4: Anova table Type II of the linear model – Comparison between Test 1 and Test 2***

**Linear Model – Test 1 vs. Test 2**

| | Sum Sq | Df | F value | p value | |
|---|---|---|---|---|---|
| **Test** | 0.08533 | 1 | 5.2745 | 0.0235 | * |
| **bird** | 0.07567 | 5 | 0.9354 | 0.4610 | |
| **session** | 0.01868 | 1 | 1.1544 | 0.2849 | |
| **Residuals** | 1.81199 | 112 | | | |
| **Signif. codes: '***' < 0.001 '**' < 0.01 '*' < 0.05 '.' < 0.1** | | | | | |

Comparison of Test 1 and Test 3 showed a significant influence of the individuals (F(10,99) = 2.836, p = 0.004) but none for the session (F(1,99) = 2,50, p = 0,12). The lm returned no statistics on the Test variable and returned the warning that no difference to the results from the bird variable was found so "0" was displayed in the Sum Sq column while the others stayed empty. For details, see table 5.

***Table 5: Anova table Type II of the linear model – Comparison between Test 1 and Test 3***

**Anova table Type II of the Linear Model – Test 1 vs. Test 3**

| | Sum Sq | Df | F value | p value | |
|---|---|---|---|---|---|
| **Test** | 0 | | | | |
| **bird** | 0.48755 | 10 | 2.8360 | 0.003857 | ** |
| **session** | 0.04302 | 1 | 2.5024 | 0.116863 | |
| **Residuals** | 1.70198 | 99 | | | |
| **Signif. codes: '***' < 0.001 '**' < 0.01 '*' < 0.05 '.' < 0.1** | | | | | |

The bird that reached criterion in the first session of the social condition was removed as an outlier since there was no proper control. Since there was no further follow-up for the bird after the session and it was a strong outlier, it was decided to exclude the bird. When this bird was excluded, no significant effect of the birds were present ($F(9,98) = 1.40$, $p = 0.19$) and the session number had no significant effect either ($F(1,98) = 2.52$, $p = 0.11$). The lm returned no statistics on the Test variable and returned the warning that no difference to the results from the bird variable was found so "0" was displayed in the Sum Sq column while the others stayed empty. For details, see table 6.

***Table 6: Anova table Type II of the linear model – Comparison between Test 1 and Test 3 without outliers***

**Anova table Type II of the Linear Model – Test 1 vs. Test 3, removed outlier**

| | Sum Sq | Df | F value | p value |
|---|---|---|---|---|
| **Test** | 0 | | | |
| **bird** | 0.21830 | 9 | 1.4013 | 0.1980 |
| **session** | 0.04374 | 1 | 2.5268 | 0.1151 |
| **Residuals** | 1.69626 | 98 | | |
| **Signif. codes: '***' < 0.001 '**' < 0.01 '*' < 0.05 '.' < 0.1** | | | | |

In summary, only one kea succeeded in solving the Ephemeral Reward Task under the social condition. Overall, performance remained near chance across all conditions, and side biases were common, particularly in the minimalist version of the task.

# 4 Discussion

The present study examined the performance of kea (*Nestor notabilis*) in the Ephemeral Reward Task (ERT) across three different experimental conditions. The central finding was that kea, unlike adult cleaner fish (*Labroides dimidiatus*) and grey parrots (*Psittacus erithacus*), did not spontaneously solve the task. Kea did not show evidence of learning the optimal strategy across the 100 trials allowed per condition. Thus, Hypothesis 1, stating that kea will learn to choose optimally in the baseline test within 100 trials, was not confirmed. Only one bird reached criterion but was excluded for lack of further testing.

Furthermore, side biases were common and often persistent, particularly in the minimalist version of the task. This frequent emergence of side biases suggests that many birds adopted heuristic strategies rather than attending to the task contingencies. This is consistent with previous findings in pigeons and rats (Zentall et al., 2016), which also developed strong side preferences or preferences for the suboptimal choice in the Ephemeral Reward Task (Zentall et al., 2016, 2017b)(Zentall et al., 2016, 2017b).

Similar to the baseline condition, also across the other conditions, group performance remained close to chance level. The control condition of the baseline test had the same birds performing the task under mechanically much simpler conditions, being a painted board on the floor and the experimenter. The results did not improve over the ERT apparatus but decreased significantly while the development of side biases increased. As the apparatus was built with the reduction of the experimenter's influence in mind and its control showed a decrease in performance It can be speculated that the more direct interaction with the experimenter has some sort of effect. A new group of birds tested soly with the control setup as well as increasing their trial maximum to 200 or further could shed more light on the underlying mechanisms that drive the bird's decision making. Regarding just the present results it suggests that it was not any influencing or distracting factor from the apparatus hindering the birds from solving the task. Hypothesis 1a was therefore rejected.

The social condition that copied the procedure from the baseline condition with a different group of birds and a partner bird eating the removed reward did not show significant improvement over the baseline condition. Thus, Hypothesis 2 was not confirmed. While one outlier did solve the task, its influence was too strong to keep it in the analysis in good faith, so it was removed.

The results of the kea contrast sharply with those of adult cleaner fish (Grutter, 1995), which performed at high levels in the ERT and with those of grey parrots, being the only species to successfully learn the basic version of the task (Zentall & Case, 2018). The results of kea presented in this study align more closely with outcomes from juvenile wrasse, non-human primates (chimpanzees, orangutans, capuchins, age range 5-20, median of 10), pigeons (age range 5-8), and rats, all of which struggled with or failed to solve the ERT.

Cleaner fish are frequently presented with the choice between different clients where the choice which client to prefer has direct consequences on overall food availability. Access to alternative cleaning stations is a strong motivator to be cleaned first, while the cleaners can provide better quality service to motivate the clients to stay. Higher quality is defined by preferred cleaning, no cheating, e.g. the feeding of mucus of healthy tissue, or tactile stimulation (Bshary & Schäffer, 2002).

In cleaner fish, service quality is further modulated by client ecology. Predatory clients, which could eat cleaners, are cheated on less often (Bshary & Schäffer, 2002). Cleaners also engage in tactile stimulation, gently touching clients with their pelvic fins, which is interpreted as a cooperative signal(Bshary & Würth, 2001). These dynamics illustrate how cleaner fish adjust their strategies flexibly to the social and ecological context and raise the possibility that they adapted specifically for this ecological niche.

Cleaner fish may interpret the removal of the ephemeral option as a form of both foraging and social punishment (Pepperberg & Hartsfield, 2014), while grey parrots may benefit from their sequential foraging behavior, using their beak to grasp and consume food in steps, an action more analogous to the sequential structure of this

specific task than the simultaneous grasping and eating which is available in this task for primates (Pepperberg & Hartsfield, 2014).

In contrast, primates struggled to choose optimally in the Ephemeral Reward Task, unless the task is substantially modified (Zentall & Case, 2018). For example, when capuchin monkeys were tested with computerized joysticks that forced sequential decision-making. As they can only move and use the cursor on the screen during the decision making phase and not while being rewarded, the possibility to use the arms while eating which is removed. In accordance with this hypothesis their performance improved (Prétôt et al., 2016a). Likewise, tasks that obscured or delayed access to rewards sometimes yielded better results (Prétôt et al., 2016b). These findings have been taken to suggest that perceptual or motor constraints, rather than general intelligence, may explain species differences in the ERT. The different findings as well as the concluded hypothesis, that it is delayed gratification, is summarized and presented by Zentall & Case (2018).

The slight improvement of the keas' performance observed in the social condition, where a competitor bird received the ephemeral reward, may indicate that social context can enhance task relevance. However, because only a single individual reached criterion, this evidence remains weak. Still, the difference between baseline and social condition suggests that kea may, under certain contexts, perceive the task in ways that align with their ecological tendencies toward competition and opportunism.

Several methodological considerations may have influenced performance. First, the number of sessions was limited to ten per bird per condition, following the protocol of Pepperberg and Hartsfield (2014). By contrast, pigeons and rats succeeded in modified versions (increased trial count and varying time between presentation and their choice) of the task only after 30-35 sessions (Zentall & Case, 2018). Weak evidence against this is the decreasing success rate of the kea in the second test, where the same birds were tested in a different procedure but for the same underlying problem. Second, in all conditions the rewards were visible at the time of choice. Prior research with primates

(Prétôt et al., 2016b) has shown that visible rewards increase impulsive, suboptimal choices, whereas concealing rewards under cups improved performance.

In conclusion, the suggestion of decreasing impulsive choice seems most promising to explain the keas' poor results as well as to extend the number of sessions to at least 30 to mimic the improved results of rats and pigeons (Zentall & Case, 2018).

## 4.1 Limitations

As described in sub-chapter 2.2, both group A and B contained two males and four females. As there were not enough birds in all age and sex combinations, it was decided in one case to use a juvenile female instead of a male to include the age category rather than adhering strictly to the 50/50 split of the sexes. Unintentionally though, another bird was mistaken for a male when still being juvenile. The beak morphology in juvenile kea can be used to assume the sex of the bird. But only when reaching maturity around 3 years, male upper beaks grow more prominent and, in most cases, allow for a visual distinction between male and female birds. In this case for males relatively small upper beak which resembles strongly a female one led us to the conclusion that it was a female. However, since none of the juvenile birds reached criterion, it does not change the conclusion of the experiments.

Only one bird reached the pre-defined criterion of 9/10 correct trials within one session and was not further tested. Additional sessions as well as reversal learning of the reward types both could have been strong methods to confirm the keas understanding of task. This not being done stands as a flaw in the methodology. As it presents a strong outlier and did not receive the full set of 10 sessions or reversal sessions it was decided to exclude the bird.

## 4.2 Conclusion

In summary, the results demonstrate that kea do not spontaneously solve the standard Ephemeral Reward Task, placing them closer to primates, pigeons, and rats than to cleaner fish or grey parrots. They also do not improve their performance with the influence of a peer eating the rewards they lose access to for suboptimal choices. The suggested influence of delayed gratification still is plausible for kea and represents a potential follow-up to the test. The plastic panel of the apparatus provides a built-in possibility to present the rewards without giving access. The prevalence of side biases suggests reliance on simple heuristics rather than flexible decision-making. While the addition of a social component may provide some ecological relevance, it was insufficient to produce widespread success. These findings highlight the importance of task design, ecological validity, and cross-species comparisons in studies of animal cognition.

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