Animal Behavior and Cognition
ABC 2025, 12(2):288-299
DOI: https://doi.org/10.26451/abc.12.02.07.2025

Probabilistic Pups, Hapless Humans, and Monkeys in the Middle: What Gamblers could learn from Dogs (*Canis lupus familiaris*)

Steven Baker[1] **and Heidi Lyn**[2]*

[1]Department of Psychology, University of South Alabama, USA
[2]Department of Psychology and Stokes School of Marine and Environmental Sciences, University of South Alabama, USA

*Corresponding author (Email: hlyn@southalabama.edu)

Citation – Baker, S., & Lyn, H. (2025). Probabilistic pups, hapless humans, and monkeys in the middle: What gamblers could learn from dogs (*Canis lupus familiaris*). *Animal Behavior and Cognition, 12*(2), 288-299. https://doi.org/10.26451/abc.12.02.07.2025

Abstract – The idea of luck has been around for thousands of years in many cultures. One concept closely related to luck is that of probability — the odds of a certain outcome happening. While people may generally believe they have a good understanding of probabilities, research has shown that they often have difficulty with intuitive probability estimation. This misunderstanding stems from a common behavior in humans known as "pattern seeking behavior." Apophenia, an extreme version of pattern seeking behavior, can have significant consequences influencing behaviors such as gambling addictions, healthcare biases, and poor financial decision-making behavior. It has been noted that some animals, such as rats, perform better than humans in tasks that require choosing options in random probabilistic sequences. Researchers hypothesize that these differences are because humans over-think the problem and try to find patterns where there are none, and non-human animals make simpler, logical connections. To test the hypothesis, we tested dogs (*Canis lupus familiaris*) and capuchin monkeys (*Sapajus apella*) against humans in a task where the correct answer was randomly assigned according to a strict probability relation. Our findings show that dogs, like rats, seem to outperform humans in tasks associated with picking correct answers in randomness, while monkeys perform at a level between dogs and humans. Therefore, dogs, while probably not able to grasp advanced concepts of probability such as types of distributions (poisson, gamma, beta, exponential, etc.), may have a better intuitive understanding of probabilities than humans, and capuchin monkeys may have some affinity toward human-like pattern-seeking behavior.

Keywords – Probability, Apophenia, Dogs, Humans, Monkeys, Random, Gambling

---

If you gave a human, a monkey, and a dog $100 each and set them loose in a casino, who would come back with more money? While it sounds like a setup to a mediocre joke, the answer can be complicated because probabilities, especially those based on randomness, are complicated.

Mathematicians have worked for thousands of years to formalize many concepts of randomness using rules of probability. While people may like to believe they have a good understanding of probability and randomness, in reality humans have unorthodox methods of thinking and analyzing the logic of random events and encounters. The tendency for illogical thinking sometimes leads to difficulties, such as healthcare biases (Buetow, 2019) and poor financial decision-making, such as investing performance (Jain & Kesari, 2020). One example of such illogical thinking is the "gambler's fallacy" (Tune, 1964), which is when people fail to recognize independence in chance events, leading to a false belief that one can predict future independent outcomes based upon previous independent outcomes. A common example of the gambler's fallacy is flipping a coin and getting heads five times in a row. Many people intuitively assume that the next flip will be tails because the odds of getting heads six times in a row (P(6H)) follows a binomial distribution (Bernoulli, 1713) and is incredibly rare, with its probability being about 0.012.

$$P(6H) = P(H)^6 = .5^6 \approx .012 = 1.2\%$$

This means that, on average, six heads in a row only happens roughly 12 times every 1000 attempts (one attempt being equivalent to a series of 6 coin flips). However, because each flip of the coin is independent — each trial has no effect on any other trial — the odds of getting six heads in a row are the exact same as those of getting five heads, then one tail ($P(5H1T)$) in order. The logic here holds true despite the probability of coin flipping not being completely random (Bartoš et al., 2023).

$$P(5H1T) = (P(H)^5)(P(T)) = (.5^5)(.5) \approx .012 \approx 1.2\%$$

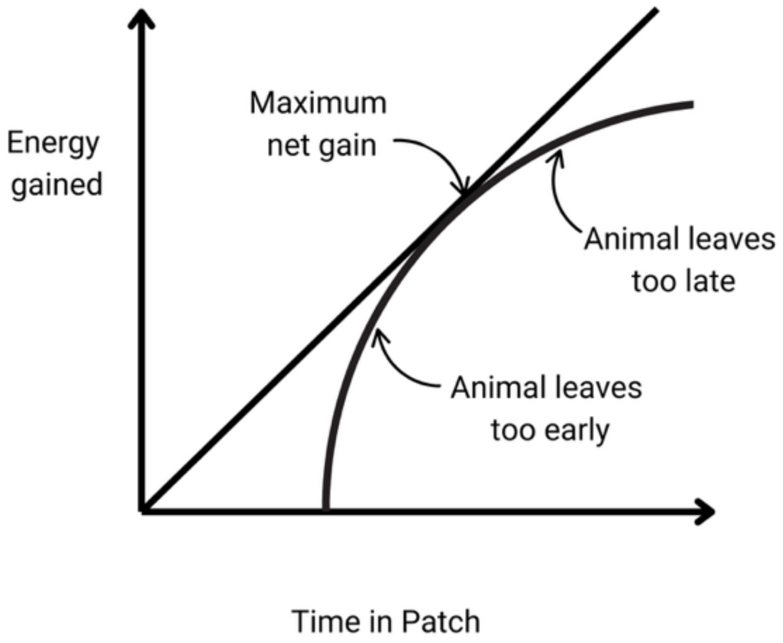
Apophenia — this tendency to seek patterns where they do not exist (Conrad, 1958, as cited in Bell et al., 2007), evolved because seeing patterns can be advantageous to both survival and reproduction. In humans, the creativity that can stem from pattern seeking behaviors has resulted in the development of tools and better methods of problem solving (Goel, 2014; Orban & Caruana, 2014; Zaidel, 2014). Due to these advantages, humans often favor apophenia over the more logic- or probabilistic-based approaches to situations. For example, the aforementioned gambler's fallacy was given its name because it is heavily associated with gambling and gambling addiction. Even if the individual using the apophenia-based pattern consistently loses — they usually return, thinking they may win *this time*, because they have a misrepresentation of how probabilities work on a case-by-case basis. The apophenia-based pattern is compounded by the fact that pathological gamblers also have a poorer understanding of random events (Turner et al., 2006).

Although humans often display signs of apophenia, what about other species? One could argue that the foraging and predatory behaviors of some animals are akin to forms of pattern recognition. For example, optimal foraging theory states that animals optimize their feeding habits by finding the highest net energy gain by either decreasing the energy they use to find food or finding food that will give them more energy (Stephens & Krebs, 1986), which is a probabilistic pattern. Figure 1 shows graphical depictions of optimal foraging theory (MacArthur and Pianka, 1966), highlighting how an animal would not receive the optimal net energy intake if it stopped foraging for a specific prey too early or too late Optimal foraging theory explains why animals will eat suboptimal prey when better resources are harder to find (Langerhans et al., 2021). While optimal foraging theory involves probabilities, it primarily focuses on recognizing consistencies in the behaviors of other species or the environment, rather than looking for patterns in random events. To determine whether animals inherently seek out patterns (and potentially see patterns where they do not exist) or if they passively notice patterns in the real world without actively seeking them out, more studies need to be conducted with randomized options.

Fam, Westbrook, and Arabzadeh (2016) tested possible differences in pattern seeking behavior in rats versus humans by using randomized choice options. In their study, participants had to pick between two independent options. One option had a "better" chance of being correct and the other had a "worse" chance of being correct, but each trial was randomized within a pre-chosen probability matrix. Correct answers were rewarded, and incorrect answers were not rewarded. The logical behavior, which best aligns with statistical reasoning, was to choose the option with the better chance to maximize rewards. In this study, rats outperformed humans, consistently picking the more probabilistic option. Humans also picked the "correct" option a majority of the time, however, they were much more likely to choose the "incorrect" answer and overall did worse, likely due to the randomness in the options, and the tendency for humans to seek out patterns, even where they do not exist (Fam et al., 2016).

Figure 1

Graphical Representation of Optimal Foraging Behavior



So, rats perform better than humans on tests associated with probabilistic reasoning, what about other mammals? Is pattern seeking behavior a uniquely human trait? Or could animals who are closely related or closely associated with humans also display this behavior? Two potential hypotheses are 1) that pattern seeking behavior is learned and animals who spend considerable time interacting with humans would show human-like choice patterns and 2) that pattern-seeking behavior evolved gradually within the primate line, in which case nonhuman primates should show more similar choice behavior to humans. To test these competing hypotheses, we tested capuchin monkeys (*Sapajus apella*) (as a representative of the nonhuman primates) and domestic dogs (*Canis lupus familiaris*) due to their close association with humans and their careful selection for communication and cooperation with humans (Benz-Schwarzburg et al., 2020).

Dogs have been an increasingly popular choice for comparative tests of cognition and communication over the past few decades (e.g., Broadway et al., 2017; Clark & Leavens, 2019; Collier-Baker et al., 2004; Lyn et al., 2021; ManyDogs Project et al., 2023). Arguments have been made that humans bred dogs specifically for better communication with humans (Hare et al., 2002), but recent findings have suggested that dogs are not always as successful at communication with humans as had been previously reported (Clark & Leavens, 2019; Lyn et al., 2021; ManyDogs Project et al., 2023) and several studies suggest that dogs are much more likely to find associative methods to try to solve cognitive tasks (Collier-Baker et al., 2004; Lyn et al., 2021). Dogs' tendency for apophenia, therefore may help clarify dogs' differences in cognitive processing.

Monkeys are similarly a popular choice in comparative studies of cognition and communication (Anderson et al., 1995; Bovet et al., 2005; Brosnan & de Waal, 2003; Klein et al., 2013). Monkeys are a group of primates more evolutionarily conserved in comparison to great apes and humans. Most species are considered to have evolved more than 40 million years ago, although the most recent divergence within Capuchin monkeys is hypothesized to be only 6-8 million years ago (Lynch Alfaro et al., 2012). Studies suggest that capuchin monkeys have a sense of "fairness" (Brosnan & de Waal, 2003) and macaques respond similarly to humans in a probabilistic task (Klein et al., 2013); however, at least two studies show mixed results for abstract thinking with baboons performing well on an abstract task (relational matching:

Bovet et al., 2005) and capuchins doing poorly on a separate, similarly abstract task (abstraction across containers: Felsche et al., 2024). Monkeys, therefore, may provide an opportunity to explore the evolutionary development of apophenia, as another abstract process, within the primate line. Here we compared dogs, humans, and monkeys on a probabilistic choice task to see if human contact or evolutionary hypotheses best explain apophenia-like pattern seeking behavior in nonhumans.

Methods

Ethics Statement

The research protocol for the dogs was approved by both the Institutional Animal Care and Use Committee (IACUC) (Approval #2010111) and IRB (#2033353) at the University of South Alabama. Consent for each dog subject was obtained by the owner. The monkeys were housed at Georgia State University, which is accredited by the Association for Assessment and Accreditation of Laboratory Animal Care, International, and all procedures in this experiment were approved by the IACUC (#A22031) of Georgia State University.

Participants

Twenty-nine dogs (*Canis lupus familiaris*) and 28 community members (*Homo sapiens*) at the University of South Alabama, U.S.A., were sampled as well as 10 Brown capuchin monkeys (*Sapajus apella*) at the Language Research Center, Georgia State University, U.S.A.

Dogs were pets brought in by their owners through local recruitment efforts (e.g., word-of-mouth, flyers, online research systems like SONA, etc.). Animal use agreements were signed by each owner and several demographic details were collected. Examples of breeds used include: Miniature Pinscher, Dachshund, Beagle, Labrador Retriever, Staffordshire Terrier, Golden Doodle, Chihuahua, French Bulldog, Boston Terrier, Pitbull, and Australian Shepard. Dogs' ages ranged from 2 months to 14 years; 12 dogs were female and 17 were male. There were no exclusion criteria for the dogs — every dog that was brought was at least able to attempt to complete the study. To assess dogs' wellbeing during the study, experimenters examined how anxious they seemed while participating. Anxious behaviors considered included ceasing to participate, attempting to hide, excessive scratching at the door, excessive whining or barking, or aggressive behavior. If these anxious behaviors occurred, a short break was taken (approximately 5 minutes). If multiple breaks occurred with no signs of progress, then the experiment was ended. For example, one dog was unable to complete the experiment as it stayed near the door, scratching and pawing at it, resulting in a suspension of trials.

Human subjects were recruited through the same techniques mentioned above from within the community of the University of South Alabama. Informed consent was obtained. The human participants' ages ranged from 18 to 34; 18 females and 10 males participated in the study.

Ten adult capuchin monkeys (2 males and 8 females) were tested at the Language Research Center. Their ages ranged from 11-36 years. All monkeys were socially housed had extensive testing experience on a variety of cognitive and communicative tasks. Capuchin monkeys were tested in the morning, during periods in which monkeys voluntarily chose to separate into individual test chambers that attached to their home enclosures. They had continuous visual and auditory access to their social group throughout these test sessions. During other times, they had indoor and outdoor access with their social group. All monkeys were fed a veterinarian approved diet that included calculating caloric intake from the rewards of this task to calibrate daily intake. All monkeys had continuous access to water, as food and water restriction was never used.

Procedure

All subjects were given similar procedures. All methods included a single test session with 35 trials where participants were required to pick between two probabilistic options: one had an 80% chance of being correct while the other had a 20% chance of being correct. Correct options were rewarded, and incorrect options were not.

For dogs, each test required two researchers. Lab members of the Comparative Cognition and Communication Lab at the University of South Alabama assisted in experimentation. Researcher 1 (R1) was designated to hold the treats, while Researcher 2 (R2) was designated to hold the dog using a leash. A pre-test phase was conducted to familiarize the dog with the indication process, and the ability to gain rewards. For this phase, R1 would hold out one hand at a time containing a treat, training the dog to touch the hand for a potential reward. Pre-testing lasted between 4-10 trials, with the offered hand randomized for each dog to avoid any side biases, this ranged from 4-10 trials because it generally took 4-10 trials for each dog to understand the task, touching a hand, and receiving a treat, some dogs were able to pick up on this quickly while others took a several to tens of trials longer.

During the test trials, R1 remained in a kneeling position with the treats in a container or a fanny pack behind their back. R2 guided the dog about .9-1.5 m in front of R1 and held an iPad that had the schedule of the trials. This schedule had two options, either "R" or "L", indicating R1's Right or Left hands. The schedule was predetermined where one option had an 80% chance of being correct and the other had a 20% chance of being correct. This was counterbalanced so that 14 dogs had R as the 80% option and 14 had L as the 80% option. Both hands were offered to the dog and a choice was recorded when one hand was touched. After R2 positioned the dog correctly, R2 read what the schedule said for the trial and R1 placed both hands in the treat container behind their back and grabbed a treat with the hand R2 indicated. Both hands were put in the container to mask any olfactory cues used by the dog and prevent any possible cues from R1's body language. R1 then indicated they were ready and R2 counted down "3… 2… 1…" After 1, R1 raised both hands, fists closed so the dog could not see which hand held the treat, and R2 released the dog to choose between the hands while also starting a timer. When the dog indicated a hand — usually by touching the chosen hand — R1 opened the hand revealing either a treat if the dog was correct or nothing if the dog was incorrect. If correct, the dog was allowed to eat the treat. R2 stopped the timer if the dog did not choose within 30 seconds; the trial was reset and not counted. This sequence was repeated a total of 35 times per dog. While olfactory cues were not actively controlled in this study, both hands of the researcher were used to handle treats. Should the dogs rely on olfactory cues, we would expect their percentage correct to be high, while their logical choices percentage would suffer.

For human participants, a computerized test was designed to mimic the dog test, with only one researcher required. The researcher explained the test beforehand to the participant and administer the test. Participants were simply told that two options would be presented, and they should try to maximize their points. In this test, participants were also given two options per trial, "R" and "L", with one having an 80% chance of being correct and the other having a 20% chance of being correct. These options were counterbalanced across participants to avoid side bias. The participants simply clicked on the option to choose it. Each correct option was rewarded with a game point and incorrect options were not rewarded. No physical rewards were used, although those recruited through the University may have been offered extra credit, a standard methodology with humans (Galizio & Buskist, 1988; althouh see Kollins et al., 1997 for some discussion).

The monkeys were tested in their home housing, with visual contact to the experimenter area. During each trial, the monkeys were presented with opaque tumbler cups that were placed on a tray on top of a sliding cart that could be moved into and out of touch range of the monkeys while still allowing them to see it. At the beginning of the trial, the tray was baited with preferred food items out of reach and then slid toward the monkey, and the monkey could then pick up their chosen cup or touch one of the cups. Food items underneath that cup were handed to the monkey. One researcher baited and presented the options and recorded the data from these trials.

Data Analysis

Data were analyzed in three ways: by comparing the number of correct and incorrect answers that the dogs, monkeys, and humans got in their trials (*Number Correct*); comparing the number of times the right and left options were chosen (*Number of Logical Choices*); and comparing the average number of trials it took to recognize that the more likely option should be consistently chosen (*Trials Until Logical Consistency*). This last variable was calculated based on the percentage of remaining trials once the most likely option was chosen 85% of the time. For example, if after five trials (out of 35), the participant chose the most likely option in 85% of the remaining trials, then "5" was used. If there was never a point where the participant chose the more likely option over 85% of the time, then "35" was used.

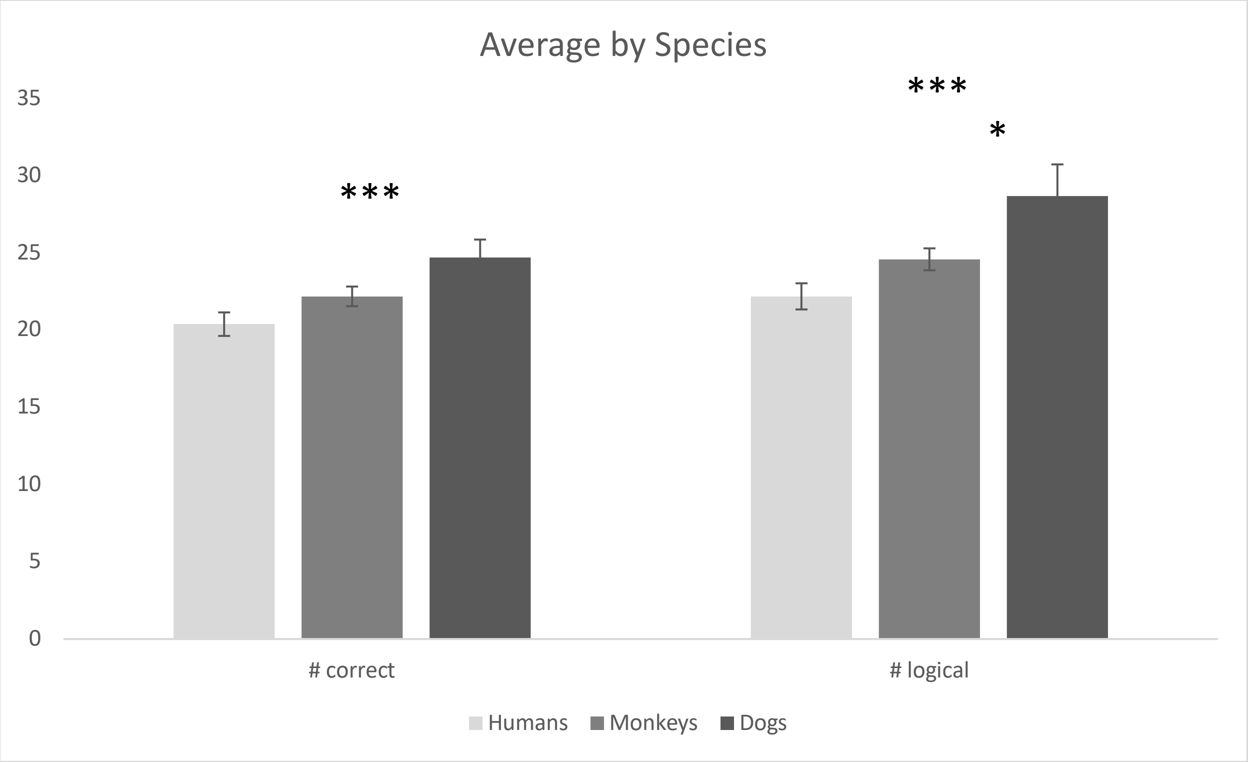
All analyses were performed in Jamovi (Fox & Weisberg, 2020; R Core Team, 2021; The Jamovi Project, 2021). One monkey made fewer logical choices, which fell outside the standard 2 standard deviations from the mean. Analyses excluding this outlier, however, did not result in a different outcome, therefore the following analyses includes all participants with the exception of a single dog that did not complete the trials.

Results

Overall, dogs performed the best on this task, with humans performing worst, and monkeys in the middle (Figure 2). The 28 dogs had an average "Number Correct" score of 24.68/35 (70.51%), whereas humans had a mean score of 20.39/35 (58.26%), and monkeys had an average of 22.2/35 (63.43%) ($F(2,63)=9.34$, $p < .001$, Fischer's test; assumptions of homogeneity of variance and normality were not violated). The only significant differences, however, were between humans and dogs (Tukey's post hoc mean difference = 4.29, $p < .001$). Similarly, the dogs' mean "Number of Logical Choices" was 28.71/35 (80.03%), whereas humans' was 22.18/35 (63.37%), and the monkeys' was 24.6/35 (70.29%) (F(2,63)=14.61, $p < .001$, Fischer's test; assumptions of homogeneity of variance and normality were not violated). In this case, the dogs were significantly more logical than both the humans and the monkeys, with no difference between the humans and the monkeys, although the difference between the dogs and the humans was much greater (Tukey's post hoc humans/dogs = -6.54, $p < .001$, dogs/monkeys = 4.11, $p < .05$). These responses suggest the dogs were relying on side probabilities, and not on other choice mechanisms, such as olfaction.

Figure 2

Average Correct Number of Trials and Logical Responses for each Species

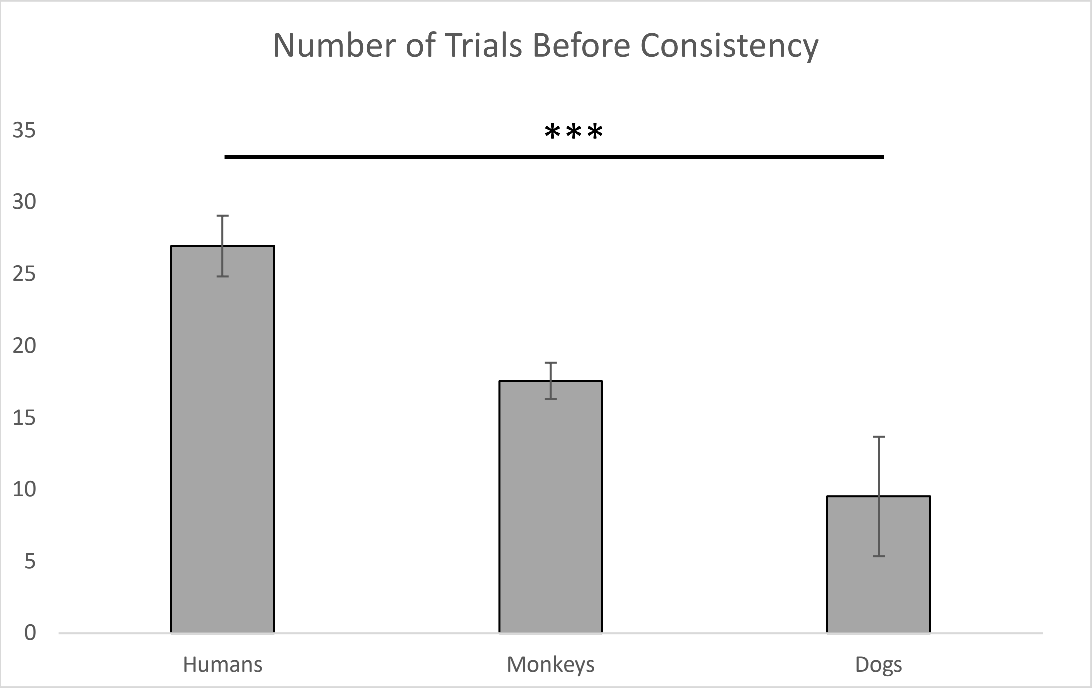


Note. Out of 35 trials. Error bars represent standard errors of the mean. *** = $p < .001$, * = $p < .05$ through Tukey post-hoc tests.

In the case of the mean number of "*Trials Until Logical Consistency*", the assumptions of both homogeneity of variance and normality were violated (Figure 3); therefore, Welch's tests were used. The dogs took an average of 9.54 trials (out of 35) to reach logical consistency, whereas humans took an average of 22.18 (out of 35), and monkeys had an average of 17.6 (out of 35) ($F(2, 21.9) = 24.5$, $p < .001$). The median number of trials before logical consistency for dogs was 5.5, and for monkeys 14.5. whereas human's median number of trials before logical consistency was 35, meaning more than half of the humans never reached logical consistency. Here again, the only significant difference was between the humans and the dogs (Games-Howell post-hoc test = 17.5, $p < .001$). See Supplementary Materials for individual data. Overall, dogs did not show any signs of apophenic behavior in this experiment.

Figure 3

Average Number of Trials before Reaching Consistency by Species



Note. Error bars represent standard errors of the mean. *** = $p < .001$ through Games-Howell post-hoc tests.

Discussion

Our findings show a clear difference among the three tested species in pattern seeking behavior. Humans consistently behaved illogically, searching for patterns, dogs performed logically, and monkeys' performance was somewhere in the middle. These findings all together suggest that apophenia is likely an evolutionary trait within the primate line, although that assertion requires much more research to corroborate our findings. It would be especially useful to test apophenia behaviors in the great apes. We would expect apes to fall between the monkeys and the humans on these pattern-seeking behaviors, a finding that would strengthen our current evolutionary hypothesis.

It is important to note that the dogs and monkeys had extensive experience with humans, and in the case of the monkeys, extensive testing experience on cognitive tasks. Although none of the participants had experience with this specific task before, experience with testing in general and extensive human interaction have been shown to increase success in cognitive tasks in great apes and likely other species (Russell et al., 2011). Therefore, it is possible that monkeys without that experience may perform differently than how we report here; however, it is unclear how inexperienced monkeys might respond to this task. Humans respond by looking for patterns, which ultimately leads to lower levels of rewards. One might assume that inexperienced monkeys would perform less like humans and more like dogs, but one could just as easily argue that monkeys would use their experience to learn how to maximize their rewards, which would suggest that inexperienced monkeys may respond more like humans. More research is needed to separate learned responses from evolutionary adaptation.

It is interesting to note, that within learning tasks, all three species react similarly to varying probabilities of reward as measured by schedules of reinforcement (Ferster & Skinner, 1957). Fixed schedules result in increased activity as the animal comes closer to the expected reward while variable schedules result in consistently high performance of behaviors — which is why variable schedules are used in gambling machines. These universal behavioral responses suggest humans, monkeys, and dogs process probabilities similarly at some level; however, given our choice task, the species diverge. Potentially the ephemeral nature of the computer points that served as the task reinforcer for humans affected their performance, at least in part (Kollins et al., 1997). However, both dogs and monkeys received food as a primary reinforcer, leaving little doubt that within this choice task, species differences remain. Still, the effects of differential reinforcers may be a fruitful avenue for future research.

It is possible that the logical performance of the dogs underlies their success at many cognitive tasks. For example, considerable scientific effort has been expended to describe and delineate the abilities of dogs to follow human points (e.g., Hare & Tomasello, 1999; ManyDogs Project et al., 2023; Udell et al., 2013). Recent studies, however, have suggested that dogs do not always successfully follow points, especially cross-body (contralateral) points (Lyn et al., 2021; ManyDogs Project et al., 2023). These findings echo earlier suggestions that dogs primarily use associative, logical mechanisms to solve problems. For example, dogs could solve invisible displacement tasks, but only if the object used in the displacement had a final position near the correct choice (Collier-Baker et al., 2004). Similarly, ipsilateral (same side) points have the movement begin and end on the same side as the correct choice, and dogs solve that task easily. Contralateral points, on the (literal) other hand begin on the opposite side from the correct choice, potentially running afoul of the dogs' logical choice mechanism.

Monkeys, in contrast, have been shown to rely on more complex cognitive processes in some tasks. In the same pointing task as the dogs (the Object Choice Task) rhesus macaques initially performed quite poorly following ipsilateral points, until the experimenter was hidden behind a curtain (Schmitt et al., 2014), suggesting the monkeys were attending to less logical cues when the experimenter was present. Capuchin moneys have also shown similar responses to humans in a probabilistic paradigm (Monty Hall Problem, Klein et al., 2013). In contrast, at least one study suggests that humans and apes can form abstract reasoning mechanisms in choice paradigms, but capuchin monkeys do not (Felsche et al., 2024) — another argument for further phylogenetic exploration of apophenia along the primate line. Further studies describing apophenia as related to primate phylogenies could clarify evolutionary branch points for pattern-seeking behavior.

The search for potential mechanisms to explain the increase in pattern-seeking behavior in the primate line could potentially be informed by analogous findings in humans, in specific circumstances. For example, "split-brain" individuals — those with severed nerve connections between brain hemispheres to alleviate symptoms of epilepsy — exhibited behavior similar to the patterns observed here in dogs and previously in rats, consistently favoring the "logical" choice (Wolford et al., 2004). A plausible interpretation can be based on earlier findings that “magical thinking” and apophenia is associated with a right hemisphere processing bias (Bell et al., 2007). Therefore, the split-brain population may be able to rely on more rational brain regions in the left hemisphere with reduced interference from the "less logical" regions in the right. By comparing these split-brain findings with our current study, it can be inferred that much of the dissimilarity in pattern seeking behavior among our species may potentially be attributed to increased inter-hemispheric communication or an increase in the development of the “illogical” (creative, pattern-seeking) regions of the brain in the primate line. Further investigation into this neuropsychological communication dynamic holds promise for shedding light on pattern-seeking behaviors and their associated outcomes.

In contrast, Fyfe et al. (2008) found that participants who scored high on schizotypal personality traits (STA-scale) and delusional thinking styles (PDI-21) also scored high on apophenia. Fyfe et al. (2008) then argued that these findings might not be a result of humans misunderstanding causation, but rather an exaggeration of humans' tendency to attribute mental states. Potentially, then, the mechanism underlying apophenia is the same that allows for enhanced Theory of Mind and delusional psychopathologies may be the result of an extreme expression of this evolutionary adaptation (Fyfe et al., 2008).

These results also support the findings that the idea of probability is something that is widely misunderstood among the human population. From more objective methods of schizophrenia screenings and fairer healthcare practices to gambling rehabilitation and smarter stock market picks, apophenia is a prime candidate for future research to assist our understanding of real-world problems. Insights provided by better understanding pattern-seeking behavior across species could prove valuable for better understanding of similarities and differences in cognition and the evolution of those processes in humans and nonhumans alike.

Acknowledgements

We would like to thank all participants that took part in this study, as well as the members of the Comparative Cognition and Communication Lab at the University of South Alabama that assisted in running the trials. At the Language Research Center, we would like to thank Dr. Michael Beran for assisting with the monkey methodology and gathering the monkey data.

Author Contributions: Stephen Baker: Conceptualization, Methodology, Investigation, Data Analysis, Writing; **Heidi Lyn:** Methodology, Data Analysis, Writing, Supervision

Funding: Heidi Lyn holds the Joan M. Sinnott Chair, which is funded by the USA Foundation.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data is available upon request.

References

Bartoš, F., Sarafoglou, A., Godmann, H. R., Sahrani, A., Leunk, D. K., Gui, P. Y., Voss, D., Ullah, K., Zoubek, M. J., Nippold, F., Aust, F., Vieira, F. F., Islam, C.-G., Zoubek, A. J., Shabani, S., Petter, J., Roos, I. B., Finnemann, A., Lob, A. B., … Wagenmakers, E.-J. (2023). Fair coins tend to land on the same side they started: Evidence from 350,757 flips (arXiv:2310.04153). arXiv. http://arxiv.org/abs/2310.04153

Benz-Schwarzburg, J., Monsó, S., & Huber, L. (2020). How dogs perceive humans and how humans should treat their pet dogs: Linking cognition with ethics. *Frontiers in Psychology*, *11*, 584037. https://doi.org/10.3389/fpsyg.2020.584037

Bernoulli, J. (1713). *Ars conjectandi*. Impensis Thurnisiorum, fratrum.

Buetow, S. (2019). Apophenia, unconscious bias and reflexivity in nursing qualitative research. *International Journal of Nursing Studies*, *89*, 8–13. https://doi.org/10.1016/j.ijnurstu.2018.09.013

Fam, J., Westbrook, F., & Arabzadeh, E. (2016). Temporal dynamics of choice behavior in rats and humans: An examination of pre- and post-choice latencies. *Scientific Reports*, *6*(1), 20583. https://doi.org/10.1038/srep20583

Fox, J., & Weisberg, S. (2020). *car: Companion to Applied Regression* [Computer software]. https://cran.r-project.org/package=car.

Fyfe, S., Williams, C., Mason, O., & Pickup, G. (2008). Apophenia, theory of mind and schizotypy: Perceiving meaning and intentionality in randomness. *Cortex*, *44*(10), 1316–1325. https://doi.org/10.1016/j.cortex.2007.07.009

Goel, V. (2014). Creative brains: Designing in the real world. *Frontiers in Human Neuroscience*, *8*. 241. https://doi.org/10.3389/fnhum.2014.00241

Jain, N., & Kesari, B. (2020). *The impact of behavioral biases on financial risk tolerance of investors and their decision making*. Unpublished Dissertation. Retrieved from: https://www.researchgate.net/publication/366836734

Langerhans, R. B., Goins, T. R., Stemp, K. M., Riesch, R., Araújo, M. S., & Layman, C. A. (2021). Consuming costly prey: Optimal foraging and the role of compensatory growth. *Frontiers in Ecology and Evolution*, *8*, 603387. https://doi.org/10.3389/fevo.2020.603387

MacArthur, R. H., & Pianka, E. R. (1966). On optimal use of a patchy environment. *The American Naturalist*, *100*(916), 603-609.

Orban, G. A., & Caruana, F. (2014). The neural basis of human tool use. *Frontiers in Psychology*, *5*. 310. https://doi.org/10.3389/fpsyg.2014.00310

R Core Team. (2021). *R: A Language and environment for statistical computing* (4.0) [Computer software]. https://cran.r-project.org.

Russell, J. L., Lyn, H., Schaeffer, J. A., & Hopkins, W. D. (2011). The role of socio-communicative rearing environments on the development of social and physical cognition in apes. *Developmental Science*, *14*(6), 1459–1470. https://doi.org/10.1111/j.1467-7687.2011.01090.x

Stephens, D. W., & Krebs, J. R. (1986). *Foraging Theory* (Vol. 6). Princeton University Press.

The Jamovi Project. (2021). *Jamovi* (2.2) [Computer software]. https://www.jamovi.org

Tune, G. (1964). Response preferences: A review of some relevant literature. *Psychological Bulletin*, *61*(4), 286.

- Turner, N. E., Zangeneh, M., & Littman-Sharp, N. (2006). The experience of gambling and its role in problem gambling. *International Gambling Studies*, *6*(2), 237–266. ttps://doi.org/10.1080/14459790600928793

Wolford, G., Newman, S. E., Miller, M. B., & Wig, G. S. (2004). Searching for Patterns in Random Sequences. *Canadian Journal of Experimental Psychology / Revue Canadienne de Psychologie Expérimentale*, *58*(4), 221–228. https://doi.org/10.1037/h0087446

Zaidel, D. W. (2014). Creativity, brain, and art: Biological and neurological considerations. *Frontiers in Human Neuroscience*, *8*. https://doi.org/10.3389/fnhum.2014.00389.

Supplementary Materials

Table S1

Dog Summary Data

Dog #	Scores	Logical	# of trials before most likely option was consistent
1	24	30	5
2	26	28	27
3	25	32	5
4	25	28	12
5	26	33	5
6	29	34	5
7	31	31	5
8	24	24	26
9	24	30	6
10	24	30	5
11	20	26	21
12	25	27	20
13	28	26	7
14	24	34	5
15	23	26	12
16	20	21	16
17	30	34	5
18	27	33	5
19	23	25	12
20	23	23	10
21	26	27	7
22	28	33	5
23	29	33	5
24	18	23	14
25	Incomplete	Incomplete	Incomplete
26	26	31	5
27	17	26	7
28	24	28	5
29	22	28	5
Mean	24.68	28.71	9.54