

PUBLIC PERCEPTIONS OF ANIMAL THINKING

JEANNINE E. HOLMES

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ABSTRACT

In a systematic replication of a survey by Rasmussen, Rajecki, and Craft (1993), 241 undergraduate psychology students and 148 members of the public were asked to indicate how reasonable it was that a child, dog, cat, bird, or fish had the capacity for each of 12 different cognitive abilities. Consistent with the original study, participants credited both children and animals with simple thinking, but reserved ascriptions of complex thinking to children. However, perceptions of animal cognition appear to have improved since the original study. Specifically, results revealed a general increase in participant ascriptions of complex thinking to animals, converging perceptions related to mammals, and an increase in perceptions of fish cognition. I also assessed the impact of the Internet and social media on public perceptions of animal cognition. While a significant impact was not noted, further examination in this area would be beneficial given the limited scope of my initial investigation and the significant power these mediums provide in information sharing and accessibility.

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INTRODUCTION

Humans have a natural curiosity about animals and a tendency to anthropomorphize their behaviours in order to more readily understand them (Gallup, 1985). There is heated debate over the benefits and drawbacks of anthropomorphism (Bekoff, 2000; Burghardt, 1991, 2007; F. De Waal, 1997; Wynne, 2007), but there is little debate about its widespread use. Researchers in the field of comparative cognition are also inherently curious about animal cognition but take a very different approach, testing their hypotheses through rigorous, objective analyses of cognition and behaviour (Zentall & Wasserman, 2012). Research in comparative cognition has increased tremendously over the past 30 years, greatly improving our understanding of animal cognition (Zentall & Wasserman, 2012). While public perceptions of animal cognition may be influenced by this research, individuals are also influenced by their own experiences with animals. This is particularly true of pet owners, who often attribute human qualities and abilities to their pets (Johnson, Garrity, & Stallones, 1992; Katcher & Fogle, 1981; Voith, 1985). Katcher & Fogle (1981) found that, in a survey of 120 pet owners, 99% of owners reported talking with their pets and nearly all owners indicated they interacted with their pets as if they were human. Almost a third of owners confided in their pets and the same proportion shared the events of their day with their pets. Further, 81% of respondents believed their pets are sensitive to their feelings. Voith (1985) and Johnson, Garrity & Stallones (1992) found that both dog and cat owners were likely to view their pets as family members, talk to their pets, share food with them, and believe that their pets were sensitive to their owners' moods.

In the early 1990s, three comparative psychologists, Rasmussen, Rajecki, and Craft recognized that while the public held clear ideas about animal cognition, we knew very little about public perceptions. Prior to this, only a few studies had explored public perceptions of

animal cognition. Through a survey of undergraduate students and the public, Burghardt (1985) found that participants considered emotional continuity between humans and nonhuman animals more likely than intellectual continuity. Herzog (1992, as cited in Rasmussen et al. 1993) surveyed individuals about the potential of global mental phenomena across 18 different nonhuman animals. Eddy, Gallup, and Povinelli (1993) reported a link between perceived cognitive abilities and phylogenetic order, with perceived cognitive abilities increasing along the putative phylogenetic scale as follows: invertebrates, fish, amphibians, reptiles, birds, and mammals. To fill the gap in the literature, Rasmussen, Rajecki, and Craft (1993) directly investigated public perceptions of animal cognition. Using a structured survey, they asked university students to indicate whether it was reasonable to expect that a companion dog, cat, bird, fish, and school-aged child could accomplish a particular cognitive task or understand a specific aspect of a situation. The 24-question survey covered 12 categories of human cognitive capacities. A factor analysis of the responses indicated two levels of ascribed cognitive capacity: (1) simple thinking (e.g., sensation & perception; emotion; pleasure and displeasure), and (2) complex thinking (e.g., enumeration and sorting; object permanence; memory and foresight). Respondents ascribed simple thinking to the child and all animals but only credited the child with complex thinking.

In a follow-up study in 1995, Rasmussen and Rajecki assessed perceptions of human child mentality and dog mentality across 12 cognitive abilities and 30 items of remorseful feelings for misbehaviour. Respondents awarded higher ratings to the child for complex thinking and “upper level” remorse (e.g., shame, guilt, and embarrassment), but rated the child and dog similarly for simple thinking and “lower level” remorse (e.g. whimpering, feeling anxious, and fear of punishment). Both Hogan (1994) and Mauer (2010) assessed public perceptions of

animal cognition but focused solely on emotions. In 2009, as part of a study on attitudes toward animal use, Knight, Vrij, Bard, and Brandon (2009) assessed the extent to which scientists, animal welfare experts, and laypersons held a belief in animal minds. They assessed both animal cognition and animal sentience across 13 nonhuman species and, similar to the results of Eddy et al. (1993), found that belief in both cognition and sentience increased along the putative phylogenetic scale. While there were differences in the degree to which each category of participants attributed a capacity for cognition and sentience, even the scientists, who had the lowest attribution rates, believed some of the 13 species had at least moderate capacity for cognition and most to have at least a moderate capacity for sentience. While the results of Knight et al. improve our understanding of more current public perceptions of animal thinking, the generalizability of their findings is limited as this was not the focus of their research. Their results were based solely on responses to five statements about animal cognition (capacity to reason, self-awareness, emotions, consciousness, and intelligence). Further, the study did not include a human target comparison group to understand how the public views human versus nonhuman cognition. Maust-Mohl, Fraser, and Morrison (2012) conducted qualitative interviews and a quantitative survey with museum patrons to understand patrons' perceptions of animal thinking and inform the construction of an exhibit on animal minds. Qualitative interviews revealed that patrons recognized cognition related to an animal's survival (e.g. perception), but had doubts about empathy, deception, and awareness. Similar results were found in participants' responses to the on-line survey, which revealed generally neutral responses to the 39 questions and showed no differentiation in responses across the six categories of cognition (learning, memory, communication, problem solving, numerosity, and awareness).

Since the original Rasmussen et al. (1993) study, there has been no equivalent investigation, although an understanding of current public perceptions of animal cognition would be valuable for a number of reasons. First, it would indicate the extent to which research in the field of comparative cognition reaches the public and is accurately understood. Second, an understanding of public perceptions could guide future research and education efforts. Third, knowledge of current and past public perceptions would allow us to understand how public perceptions have changed over time. Finally, debates about animal welfare and public policy decisions often center on a perception—or misperception—of animal cognition. Information on current public perceptions of animal cognition could highlight the perspective of a key stakeholder in these discussions.

The more than 20-year time lapse since the original Rasmussen et al. (1993) study also provides a unique opportunity to assess the impact of the Internet and social media on public perceptions of animal cognition. Not only has our understanding of human and animal cognition changed drastically during the past 20 years, but how the public receives and shares information has also changed tremendously. The Internet and social media have become ingrained in how we communicate, access, and share information (Government of Canada, 2010; Sanou, 2016). Libraries are no longer filled with stacks of books, journals, and access to microfiche, but rather rows of computers with access to the Internet and Google Scholar. Sharing of research is no longer restricted to paper journal subscriptions and presentations at conferences, but includes online journal subscriptions and links to articles through Facebook, personal websites, and LinkedIn. Sharing of animal behaviour knowledge anecdotally is common on social media. YouTube, Facebook and Instagram are filled with pictures and videos of family pets or encounters with wild animals. In fact, the Internet hosts so many photos and videos of cats that it

has been dubbed a “virtual cat park” (Zoe George, 2015). In 2015 it was estimated that there were over 2 million cat videos on YouTube alone (“Why cat clips rule the internet,” 2015) and an estimated 6.5 billion photos of cats on the Internet as a whole (Yang, 2015). News reports of unique animal stories have the potential to go “viral” and reach audience numbers not possible in 1993. An understanding of the influence of the Internet and social media on public perceptions of animal cognition would be valuable in determining how to best deliver research to its intended audience. It may also be helpful in identifying how easily misinformation is spread.

The purpose of this study was to understand how the public perceives animal cognition and how public perceptions have changed since the early 90s. In addition, my goal was to explore the impact of the Internet and social media in influencing public perceptions of animal cognition. Consistent with Rasumussen et al.’s (1993) results, I predicted that participants would attribute simple thinking to both the child and non-human animals but would attribute complex thinking only to the child. I also predicted that perceived levels of cognitive ability would increase relative to 1993 as a result of research published in the intervening years and the impact of the Internet and social media. I expected the Internet and social media to have a significant positive impact on perceptions of animal cognition because of its reach in disseminating information. I also predicted that these mediums may encourage perceptions of animal cognition to exceed capacities supported by research, given the tendency of individuals to anthropomorphize animal behaviour and given that animal-related information is often shared on the Internet without context, allowing for an exaggerated or mis-understanding of the details shared.

I also investigated other related variables of interest, including pet ownership, demographics, and sources of animal cognition knowledge to assess any impact these factors

may have on public perceptions. I expected pet ownership to benefit perceptions of animal cognition, leading to positive correlations between perceived levels of cognitive capacity and pet ownership. I expected mean responses to: (1) be higher for pet owners compared to non-owners, (2) increase with the number of pets owned, and (3) be biased towards the type of pet owned. With respect to demographic factors, we expected to find correlations between perceptions of cognition and age, geography, levels of education, and levels of experience working/volunteering with animals. I did not expect to find a relationship between gender and perceptions of cognition. To assess sources of animal cognition knowledge, participants were asked to rank-order their sources of knowledge from most important to least important across 9 sources of knowledge (see Question #7 in Appendix D). The proportion of each level of a ranking received by each knowledge source was determined and compared across sources of knowledge. In particular, for each source of knowledge we reviewed (1) the proportion of #1 rankings received, (2) the proportion of top 3 rankings received, and (3) the proportion of lowest rankings received. I expected guardianship, education, life experiences, social media, and the Internet to rank among the top ranked sources of knowledge.

METHODS

General

To assess current public perceptions of animal cognition and make comparisons to perceptions held in the early 90s, I systematically replicated the 1993 study by Rasmussen et al., using the same structured questionnaire approach as the original study, but with a between-subjects design, as described below. Additional questions centered on the Internet and social media were added to explore the impact of these mediums on public perceptions of animal

cognition. The survey was made available to participants through Survey Monkey, an online survey platform.

Participants

Consistent with the original study, I recruited students from the undergraduate population, making the survey available through York University's Undergraduate Research Participant Pool (the "URPP"). Two hundred and forty-one students completed the survey, each receiving 0.5 credits toward an optional research participation component of their first year psychology course. In addition, I surveyed the general public outside of the undergraduate population, recruiting 148 individuals via personal social media posts and email distribution by myself and members of my lab at York University.

The researchers in the original study also made their survey available to a small number of professionals in the field of animal behaviour. This comparison group was used to assess differences between perceptions of laypersons and experts. I chose, instead, to use published research in animal cognition as our "expert" benchmark.

Design

The original study used a within subjects design, such that each participant answered the same questions about all five target animals (dog, cat, bird, fish, and child; collectively the "animal groups"). I used a between subjects approach to minimize the potential for participants to make relative judgments across animal groups (and to avoid the tendency for participants to 'rank' species). Each participant answered questions about only one of the five animal groups. URPP participants were assigned to one of the five target animals based on the last digit of their URPP number. Participants from the public were assigned to a target animal based on the last digit of their year of birth.

The survey was comprised of the same 24 questions used in the original study, and can be found in Appendix C. Consistent with the original study, all 24 questions had the same structure and 7-point Likert response scale. The set of 24 questions were consistent across animal groups and participants but question order was randomized for each participant. Each survey began with a short preamble that introduced the target animal and provided context for the question set. The survey preamble was consistent with the preamble used in the original survey and was consistent across the surveys for each animal group. An example preamble is included below:

Situation: The setting is a typical household. In the scene there is a dog. In front of the dog there is a biscuit, a treat. Please answer the following questions about the situation.

The questions were based on 12 categories of cognitive abilities: (a) sensation and perception, (b) gratitude, (c) emotion, (d) pleasure and displeasure, (e) object permanence, (f) morality, (g) schemata, (h) enumeration and sorting, (i) dream, (j) play and imagine, (k) conservation, (l) memory and foresight. The question set included two questions from each category. Each question asked the participant whether it is reasonable to expect that the target animal understands a particular aspect of the situation or can perform a specific cognitive task. The participant was asked to respond to each question on a 7-point Likert scale, with end points of “unreasonable” and “reasonable.” An example question from the fish survey is:

Is it reasonable to expect that, when asleep, the fish might dream about the treat?

I included a list of 11 demographic questions at the end of the survey including questions regarding Internet and social media use. An example survey for the Cat target group is included in Appendix C. A copy of the demographic questions is included in Appendix D.

Data Analysis

General

Prior to conducting statistical analyses, an examination of the Public and Undergraduate data sets was performed to determine whether these data sets could be analysed together. A 2x5x12 (Population Group X Animal Group X Cognition Category) mixed model ANOVA was performed, along with applicable pairwise comparisons to assess any significant differences between the Public and Undergraduate data. In addition, as I ultimately wanted to conduct a factor analysis on the combined data to reduce the number of cognitive categories, separate factor analyses of the Public and Undergraduate data were performed to determine if consistent factor loadings were noted across the data sets.

Preliminary assessments were conducted on the combined data set to ensure sampling adequacy (the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (“KMO”)) and to ensure sufficient dependency among the cognition categories to support the use of factor analysis (Bartlett’s Test of Sphericity).

A factor analysis was then conducted on the combined data set to reduce the twelve categories of cognition to a smaller number of indices. In order to determine the appropriate number of factors to use in the analysis, a principal components analysis of the 12 categories was conducted separately for each animal group, as well as on a combined basis. Two measures were used to assess the appropriate number of factors: (1) a scree plot, and (2) a minimum 0.5 cumulative proportion of variance explained by the principal components.

Eight participants who completed the survey did not complete the demographic questions. These participants were included in the analysis of the main portion of the survey but

excluded from the analysis of the demographic data noted below. All analyses were conducted using R statistical software version 3.3.1 and an alpha level of 0.05.

Current Perceptions of Animal Cognition

A 5 X 2 X 2 (Animal Group X Thinking X Population) mixed model ANOVA was performed on the factored data, along with subsequent pairwise comparisons, as appropriate.

Changes in Perceptions of Animal Cognition

In addition to the above statistical analysis, I contrasted current mean responses across animal groups and cognition categories to 1993 outcomes. Further, I examined which animal group received the highest mean response in each cognitive category, noting differences between the two time periods. Finally, I reviewed each cognitive category, assessing which animal groups received mean responses that exceed the average for that category, noting any differences between 1993 and 2016. Because data from the 1993 study were limited to the charts and details available in the published paper, my analysis was restricted to descriptive statistics.

RESULTS

General

Data Aggregation

I focused my analysis of the 2x5x12 ANOVA (Population Group X Target Group X Cognition Category) on the main effect of Population Group and any interaction between Population Group and Cognition Category, as these would affect the reasonableness of conducting a factor analysis on the combined data set. The ANOVA results indicated no main effect of Population Group, $F(1, 379) = 0.39, p = 0.53, \eta = 0$, but an interaction between Population Group and Cognition Category, $F(11, 4169) = 5.76, p < 0.001, \eta = 0.01$. To further

analyse this interaction, I performed pairwise comparisons between the Undergraduate and Public populations across all Cognition Categories. Significant differences were noted in four categories: (1) Sensation & Perception, $p < 0.001$; (2) Pleasure & Displeasure, $p < 0.01$; (3) Play & Imagine, $p < 0.05$; and (4) Conservation, $p < 0.05$. In order to determine whether the differences in these categories would impact a factor analysis of the combined data, factor analyses were performed separately on the Public and Undergraduate data sets, using a 2-factor approach. The use of two factors was determined by a preceding principal components analysis. The four cognition categories in which differences were noted loaded consistently onto the same factors across the data sets with the exception of the Play & Imagine category. In the Public data set the Play & Imagine category loaded similarly across both factors, with a slightly higher loading on the factor opposite to the Undergraduate data set. Given that the mean differences in these four categories did not translate to significant differences in overall factor loadings, the Public and Undergraduate data sets were deemed similar enough to be combined. A table of the mean responses per question for each target animal is provided in Table 1.

Preliminary analyses

Adequate sampling was noted across all targets, with KMO values for each animal group correlation matrix above the suggested minimum of 0.60. I also noted sufficient dependency among the cognition categories across all animal groups to support the use of factor analysis (Bartlett's test, $p < .05$ across all targets).

Factor Analysis

The results of the principal components analysis supported the use of two factors in conducting the factor analysis. The use of two factors is consistent with the original study and our expectations. A subsequent varimax orthogonal factor analysis was conducted for each

animal group and on an overall basis. In the overall factor analysis, the first four cognitive categories listed in Table 2 (sensation & perception; gratitude; emotion; pleasure & displeasure) loaded onto one factor and the remaining categories loaded onto the second factor. All factor loadings were greater than 0.40. The factor analyses for individual animal groups displayed similar factor loadings to the overall analysis revealing consistent loadings across all categories for the Fish target, 11/12 categories for the Dog and Bird targets, and 10/12 categories for the Cat target. Loadings for the Child target were less consistent, with only half of the categories loading in a manner similar to the overall analysis. The three categories of Dream, Play & Imagine, and Schema appear to be viewed by participants as unique categories for children and showed strong loadings on factors separate from the two main factors. Once these three categories were isolated, seven of the remaining nine categories loaded consistently with the overall analysis. As a result of the relative consistency in the loadings across animal groups and with the original study, the 12 cognition categories were reduced to two indices, Simple Thinking (the average of the first four categories in Table 2) and Complex Thinking (the average of the remaining categories in Table 2), collectively referred to as the factor “Thinking.”

Current Perceptions in Animal Cognition

The factored data were first analysed through a 5 X 2 X 2 (Animal Group X Thinking X Population) mixed model ANOVA. The results revealed that participants believed it was most reasonable that children possess the cognitive capacities listed in Table 2, followed by cats, dogs, birds, and fish, $F(4, 379) = 36.16, p < .001, \eta^2 = 0.23$. Participants also reported that it was more reasonable that the animal groups possess simple thinking than complex thinking, $F(1, 379) = 1,118.16, p < 0.001, \eta^2 = 0.38$ and that the capacity for simple and complex thinking varied by animal group, $F(4, 379) = 17.75, p < 0.001, \eta^2 = 0.04$. See Figure 1.

Pairwise comparisons of simple thinking across all animal groups revealed that participants perceived no significant difference in the capacity for simple thinking among children, dogs, and cats, but that significant differences were perceived between fish and birds and between both of these animals and each of children, dogs, and cats (see Table 3). Cats were perceived as most reasonably having simple cognitive capacities, followed by children, dogs, birds, and fish. As seen in Table 4, perceptions of complex thinking were significantly different between all animal groups except between cats and dogs and between birds and fish, with complex cognitive capacities being predominantly ascribed to children, along with ascriptions to dogs and cats in the categories of Object Permanence, Enumeration & Sorting, and Dream (see Figure 2).

The Population Group factor was included in the above ANOVA to better understand any differences in the perceptions of the Undergraduate and Public populations, and to highlight any significant differences that may not have been highlighted in the analyses prior to aggregating the data sets. The results revealed generally consistent results across the two populations, with only minor differences. Undergraduate students and the public reported consistent measures when perceptions of animal cognition are assessed without reference to level of thinking or animal group, $F(1, 379) = 1.57, p = 0.21, \eta^2 = 0.003$. Students and the public perceived the cognitive capacities of the individual animal groups somewhat differently, $F(4, 379) = 4.97, p < 0.001, \eta^2 = 0.04$. As shown in Table 5, public perceptions of cognitive capacities were higher than those of students for all targets except fish (for which the reverse was true). However, these differences are only significant for children, $t(36) = 17.99, p < 0.001, \xi = 0.63$, and fish, $t(25) = 13.21, p < 0.01, \xi = 0.54$; p-values adjusted using the Holm method. In addition, there was a small interaction between population group and levels of thinking $F(1, 379) = 12.87, p < 0.001$,

$\eta^2 = 0.01$, resulting from the public having greater belief in simple cognitive capacities than students, $t(1, 299) = 6.15, p < 0.05$. However, the effect size was small, $\xi = 0.19$. Perceptions of complex thinking were not significantly different across the two populations $t(1, 234) = 0.08, p = 0.78, \xi = 0.03$).

No interaction was noted between target group, level of thinking, and population group, $F(4, 379) = 1.62, p = 0.17, \eta^2 = 0.004$.

Humans, Non-Human Mammals, Non-Mammals

Patterns emerging from the above analysis suggested that public perceptions might be delineated across broader levels of animal categorization: Humans, Non-Human Mammals, and Non-Mammals. To analyse this hypothesis, we performed a 2 X 3 (Thinking X Animal Categories) mixed model ANOVA.

As expected, the results of the initial analysis translated to the new, broader categories. Participants perceived overall cognitive capacity to be most reasonable in human children, followed by non-human mammals, and non-mammals, resulting in a main effect of animal category, $F(2, 386) = 59.60, p < 0.001, \eta^2 = 0.20$ (see Figure 3). Participants also perceived cognitive abilities across the three animal categories to vary at different levels of thinking, $F(2, 386) = 29.53, p < 0.001, \eta^2 = 0.03$. Subsequent analysis of simple main effects revealed participants perceived simple thinking to be equally reasonable in humans and non-human mammals (Tukey HSD, $p = 0.94$) but more reasonable in both humans and non-human mammals than in non-mammals (Tukey HSD, $p < 0.001$ in both cases). Participants perceived complex thinking differently across the three categories, ascribing complex thinking to humans, but not to non-mammals, and only on a limited basis to non-human mammals (in the categories of Object Permanence, Enumeration & Sorting; and Dream).

Changes in Perceptions of Animal Cognition

Mean responses for each cognitive category were compared to 1993 responses, revealing opposing shifts in perceptions of simple and complex thinking. Perceptions of complex thinking appear to have increased over time, while perceptions of simple thinking have remained constant or decreased (see Figure 4). These trends are more pronounced when children are excluded from the analysis (see Figure 5) and are further enhanced when both children and dogs are excluded (see Figure 6).

A comparison of mean responses for each animal group across both time periods also highlighted interesting changes (see Table 6). Decreases were noted in mean responses for children across all categories, except in Memory & Foresight and Enumeration & Sorting. Fish showed the opposite change in perceptions, with increases in mean responses for all categories except Sensation & Perception; Gratitude; and Conservation. Mean dog responses decreased in two-thirds of the categories, while cats and fish showed an equal number of increases and decreases across categories. Overall mean responses revealed a decrease in perceptions of children over 1993 results; no change for dogs or birds; and increases for cats and fish.

A review of the highest mean response for each cognitive category revealed a small but significant change. In 1993 the highest mean response was awarded to children in all categories, while shifts in 2016 perceptions resulted in cats receiving the highest mean response in both the Sensation & Perception and Pleasure & Displeasure categories. Children continued to receive the highest mean responses in the remaining ten cognitive capacities in 2016.

Finally, a review of which animal groups exceeded the category average for each category also highlighted shifts favourable to cats (see Figure 7). Mean perceptions of children exceeded the category average in all 12 categories in 2016, a result consistent with 1993

outcomes. Cats exceeded the category average in one additional category relative to 1993, while dogs exceeded the category average in 1 less category. Mean responses for fish did not exceed the category average in either 1993 or 2016, while birds dropped from exceeding the average in one category in 1993 to no categories in 2016.

Impact of the Internet and Social Media on Perceptions of Animal Cognition

A Welch-adjusted one-way ANOVA was performed comparing overall perceptions of animal cognition across five levels of daily Internet use (less than 1 hour; 1-2 hours; 2-3 hours; 3-4 hours; and more than 4 hours). The same analysis was also performed separately for mean perceptions of simple and complex thinking.

The number of daily hours of Internet use had no impact on overall perceptions of animal cognition, $F(4, 117) = 1.49, p = 0.21, \xi = 0.19$. The same was true in assessments of simple and complex thinking (Simple Thinking: $F(4, 118) = 1.42, p = 0.23, \xi = 0.18$; Complex Thinking: $F(4, 116) = 1.68, p = 0.16, \xi = 0.20$). A visual inspection of Figure 8 illustrates the lack of relationship between Internet use and public perceptions.

Impact of Pet Ownership on Perceptions of Animal Cognition

Pet ownership had minimal, if any, impact on perceptions of animal cognition, as shown in Figure 9. Overall perceptions of animal cognition were consistent across pet owners and non-owners, $t(1, 374) = 0.27, p = 0.61, \xi = 0.04$. While the same was true of perceptions of complex thinking, $t(1, 371) = 0.13, p = 0.72, \xi = 0.02$, pet owners perceived simple thinking to be more reasonable than non-owners, with mean responses of 5.81 and 5.56 respectively, $t(1, 379) = 5.51, p = 0.02$. While significant, the effect size of this difference is small, $\xi = 0.17$.

The number of pets owned did not appear to influence perceptions of animal cognition. Pet owners reported consistent levels of perceived animal cognition whether they owned 1, 2, 3,

4, or 5 or more pets, $F(4, 28) = 0.19$, $p = 0.94$, $\xi = 0.35$. Similarly, no difference was noted in perceptions of either simple or complex thinking across the numbers of pets owned (Simple Thinking: $F(4, 33) = 0.48$, $p = 0.75$, $\xi = 0.35$; Complex Thinking: $F(4, 28) = 0.17$, $p = 0.95$, $\xi = 0.35$).

Finally, the type of pet an individual owned did not bias their perceptions of animal cognition, as shown in Figure 10. Owners reported consistent overall mean perceptions of animal cognition, resulting in no main effect of pet-type on overall perceptions of animal cognition, $F(3, 381) = 0.13$, $p = 0.95$, $\eta^2 = 0.001$. Regardless of the type of pet owned, owners consistently indicated children as most reasonably possessing the indicated cognitive capacities, followed by cats, dogs, birds, and fish. The exception to this indirect “ranking” was noted in fish owners, who ranked fish above birds and cats ahead of children (see Figure 10). An absence of pet bias was further noted in the lack of an interaction between the type of pet owner and perceptions of animal cognition across animal groups, $F(12, 381) = 0.68$, $p = 0.77$, $\eta^2 = 0.02$. A more detailed analysis of simple effects also confirmed no bias among pet owners and non-owners. As shown in Figure 11, we noted no significant differences in the one-way ANOVAs performed to determine whether each animal group was perceived consistently across pet owners, (Dog: $F(3, 26) = 0.50$, $p = 0.68$, $\xi = 0.28$; Cat: $F(3, 26) = 0.67$, $p = 0.58$, $\xi = 0.37$; Bird: $F(3, 9) = 0.47$, $p = 0.72$, $\xi = 0.59$; Fish: $F(3, 24) = 0.48$, $p = 0.70$, $\xi = 0.25$; Child: $F(3, 8) = 0.95$, $p = 0.46$, $\xi = 0.41$). Note that owners of birds and owners of “other” types of pets (pets other than dogs, cats, fish, and birds) were excluded from the analysis due to small sample sizes.

Impact of Demographic Factors on Perceptions of Animal Cognition

Participant Age

A mixed model ANOVA was performed comparing mean perceptions of animal cognition across seven age groups (15-24, 25-34, 35-44, 45-54, 55-64, 65-74) and two levels of thinking. The 0-14 and 85+ age categories were excluded from all analyses due to small sample sizes. The results revealed a main effect of age, $F(6, 372) = 3.43$, $p < 0.005$, $\eta^2 = 0.04$, and an interaction between age and level of thinking, $F(6, 372) = 3.5$, $p < 0.005$, $\eta^2 = 0.01$. An analysis of the simple main effects indicated no relationship between age and simple thinking, $F(6, 24) = 1.74$, $p = 0.15$, $\xi = 0.58$ but a significant result across age categories in perceptions of complex thinking, $F(6, 24) = 2.64$, $p < 0.05$, $\xi = 0.61$ (see Figure 12 for perceptions of complex thinking by age). The large effect size in both analyses prompted the completion of subsequent pairwise comparisons at each level of thinking. The analysis of simple thinking revealed a small number of significant differences but no pattern indicating a relationship between age and simple thinking. A pattern emerged in the analysis of complex thinking. Participants aged 65-74 reported significantly lower mean responses than individuals in all four of the youngest age categories (p -values all less than 0.025) but consistent results compared to the immediately adjacent older age categories. Interestingly, participants aged 55-64 reported the lowest mean responses of all the categories, a value noticeably different from many other categories, yet with only one of these differences noted as significant (the difference relative to the 25-34 category). The high variability in the 55-64 age group data may explain the lack of significant differences noted relative to the other categories. Perhaps larger sample sizes would reveal a clearer split in perceptions between the four lower age categories and the three older categories. See Figure 12.

Participant Gender

Welch-adjusted t-tests were performed comparing overall mean perceptions of animal cognition across gender. The same analysis was performed for perceptions of both simple and complex thinking. No relationships between gender and overall ascriptions of cognition were noted, $t(1, 197) = 2.48$, $p = 0.12$, $\xi = 0.11$. Similarly, no relationship between gender and perceptions of either simple or complex thinking were noted (Simple: $t(1, 189) = 3.81$, $p = 0.05$, $\xi = 0.17$; Complex: $t(1, 198) = 1.43$, $p = 0.23$, $\xi = 0.10$).

Participant Geography

I analysed participants' current geography as well as their predominant continent of residence as they related to assessments of animal cognition. Welch-adjusted one-way ANOVAs were performed comparing overall mean perceptions of animal cognition across continents (for each of current and predominant geography). The same analysis was performed regarding perceptions of both simple and complex thinking. Note that for analyses of predominant geography, Australasia was removed from the analysis due to a low sample size ($n=1$).

No relationships were noted between current geography and ascriptions of cognition. This was true for overall perceptions, $F(4, 6) = 0.55$, $p = 0.71$, $\xi = 0.53$; as well as for perceptions of simple and complex thinking (Simple: $F(4, 7) = 1.91$, $p = 0.22$, $\xi = 0.58$; Complex: $F(4, 6) = 0.29$, $p = 0.87$, $\xi = 0.45$). Similarly, there was no relationship found when assessing predominant geography (Overall: $F(3, 22) = 1.36$, $p = 0.28$, $\xi = 0.29$; Simple: $F(3, 21) = .93$, $p = 0.45$, $\xi = 0.23$; Complex: $F(3, 21) = 1.15$, $p = 0.35$, $\xi = 0.30$).

Education

Welch-adjusted one-way ANOVAs were performed comparing overall mean perceptions of animal cognition across levels of education. The same analysis was performed regarding perceptions of both simple and complex thinking.

No relationships were noted between level of education and ascriptions of cognition. This was true for overall perceptions, $F(7, 36) = 0.23$, $p = 0.98$, $\xi = 0.33$, as well as for perceptions of simple and complex thinking (Simple: $F(7, 37) = 0.55$, $p = 0.79$, $\xi = 0.34$; Complex: $F(7, 36) = 0.31$, $p = 0.95$, $\xi = 0.36$).

Occupation/Volunteer Experience

Participants from the public survey were asked to indicate the extent to which their occupation or volunteer activities involved animals. Participants responded using a 4-point Likert scale with end-points of “not at all” and “to a great extent.” A Welch-adjusted one-way ANOVA was conducted to determine if the level of involvement with animals in an occupation or volunteer capacity had any impact on overall perceptions of cognition. The same analysis was performed for perceptions of simple and complex thinking. Participants who answered the child survey were excluded from the analysis in order to focus on non-human animal cognition and animal-related occupational/volunteer experience.

Participants perceived overall animal cognition consistently regardless of the level of involvement with animals in an occupation or volunteer capacity, $F(3, 41) = 0.34$, $p = 0.79$, $\xi = 0.17$. Simple and complex thinking were similarly viewed consistently across the different levels of involvement (Simple: $F(3, 41) = 0.98$, $p = 0.41$, $\xi = 0.26$; Complex: $F(3, 41) = 0.18$, $p = 0.91$, $\xi = 0.15$).

Sources of Knowledge

Guardianship of a pet or a child, life experiences and education were most often reported as key sources of animal cognition knowledge. As shown in Table 7, guardianship received the highest proportion of #1 rankings of knowledge sources (0.31), followed by life experiences (0.23), and education (0.14), together representing 0.68 of all #1 rankings. The same three categories received the highest proportions of top three rankings. Life experiences received the highest proportion of top 3 rankings (0.22), followed by guardianship (0.18), and education (0.13), representing 0.53 of all top 3 rankings. Social media, print media, education, and guardianship were most often reported as the least important sources of animal cognition knowledge, receiving the highest proportions of the lowest ranking (social media = 0.27, education = 0.13, print media = 0.15, guardianship = 0.14). Television, books, movies and the Internet occupied the middle rankings, in descending order of importance.

A Welch-adjusted one-way ANOVA was performed to analyse whether the type of knowledge source had any impact on perceptions of animal cognition. Data for each knowledge source consisted of average perceptions of participants who gave a #1 ranking to that particular category. In spite of the fact that individuals clearly obtained their knowledge of animal behaviour from different sources, participants perceived animal cognition consistently across all sources of knowledge, $F(8, 78) = 0.63$, $p = 0.75$, $\xi = 0.28$.

DISCUSSION

Current views of animal cognition and changes in perceptions relative to the original study were generally consistent with my predictions. Of particular interest was a shift in perceptions acknowledging greater levels of complex cognition in animals. Contrary to my predictions, I found no evidence to support the impact of the Internet or social media on public

perceptions. Similarly, I found little evidence to link any demographic factors to differences in public perceptions. My expectations of key sources of animal cognition knowledge were consistent with my results, with the exception of the Internet and social media, which were generally deemed an irrelevant source of knowledge by participants.

Factor Analysis

The loadings across targets were lower and less consistent than in the original study. I suspect this to be the result of two factors: (1) the within subjects design of the original study would likely have resulted in more consistency across targets; and (2) the larger sample size for each animal group in the original study of $n = 294$ would likely have resulted in higher loadings compared to an average sample size of $n = 78$ in the current study. The split of the categories between the two factors is very similar to the original study with Factor 1 comprising simple categories and Factor 2 comprising complex categories (see Table 2). The only category that loaded differently relative to the original study is Play & Imagine, which loaded onto the complex thinking factor in the current analysis but loaded onto the simple thinking factor in the original study. This is not surprising as the original study noted that, while on an overall basis the Play & Imagine category loaded onto simple thinking, when the data was split into children and pets, the Play & Imagine category continued to load onto simple thinking for the pets but loaded onto complex thinking for children. Thus, while we've seen a shift in overall loadings, some of the underlying animal groups already exhibited that shift in 1993.

Current & Changing Perceptions of Animal Cognition

Consistent views of animal cognition were noted between the current and original study with some notable differences. Overall, the public continues to view children as most reasonably possessing the cognitive capacities captured in the survey. Further, simple thinking continues to

be ascribed to all animal groups and is still seen as more likely than complex thinking, which is generally reserved only for children. However, perceptions of cognition across mammal groups have narrowed, with consistent views of simple thinking reported across children, cats, and dogs; and smaller inter-group differences noted in perceptions of complex thinking. Most interestingly, the public appears more willing to ascribe complex thinking to animals relative to ascriptions in 1993. Finally, there have been significant shifts in public perceptions of individual animal groups since 1993. In particular, cognitive perceptions of cats have shown some notable increases, with cats receiving consistent “rankings” as children in some cases. Fish, while still receiving the lowest mean responses, have garnered increased mean perceptions in both simple and complex thinking. Conversely, children have seen decreases in perceptions of both simple and complex thinking.

A Narrowing of Perceptions Across Mammal Groups

A narrowing of perceptions of cognition across the target mammal groups was noted in a number of measures of the study. Group means of overall cognition and simple thinking have shifted across animal groups, resulting in cats receiving the highest mean response for simple thinking, and with mean perceptions of cats falling second only to children in overall cognition. In comparison, mean responses for both overall cognition and simple thinking in 1993 saw the highest mean response awarded to children followed, in order, by dogs, cats, birds, and fish. Not only is the shift in indirect “rank ordering” of animal groups a notable difference, but the absence of a significant difference in perceptions of simple thinking between children, dogs, and cats, is also a departure from the original study in which children were perceived as more reasonably possessing simple thinking than both dogs and cats.

The narrowing of perceptions among target mammals was also seen in complex thinking, albeit to a lesser extent. Ascriptions of complex thinking continued to be mainly reserved for children, but dogs and cats were also credited with complex thinking in three categories (Object Permanence; Enumeration & Sorting; and Dream), an increase over the original study in which dogs and cats were only ascribed the capacity for object permanence.

When broader categories of animal groups were analysed (Humans; Non-Human Mammals, and Non-Mammals), the consistency in ascriptions of simple thinking across mammals was also apparent. Simple thinking was differentiated across broader categories of mammals and non-mammals, while ascriptions of complex thinking required a further level of differentiation between categories of mammals to properly capture public perceptions.

There are a number of factors that may underlie the narrowing of perceptions across mammal targets. I believe the main driver relates to the significant increase in animal cognition research that has been published since the original study. This research continues to report previously unsuspected or previously unsupported cognitive abilities in animals that I believe has increased the perceptions of cognition in non-human animals and encouraged the perception that simple cognitive abilities across children, dogs, and cats are similar.

A second factor to consider is the difference in the design of each study; the between-subjects design used in the current study relative to the within-subjects design used in the original study. It is possible that in the original study relative judgements created a bias to differentiate responses between each animal group. This bias should have been minimized by a counterbalancing of the order in which participants were surveyed about each animal group. Regardless, relative judgements cannot be the entire explanation as perceptions of children, dogs, and cats narrowed while perceptions for birds and fish did not follow suit.

The difference in factoring of cognitive categories into simple and complex thinking could also have resulted in the narrowing of perceptions. While the four categories included in simple thinking in the current study were factored similarly in the original study, the Play & Imagine category was allocated differently across the two studies with its inclusion in *complex* thinking in the current study and in *simple* thinking in the original study. An analysis of the current data using the same factoring as the original study revealed the same narrowing of perceptions across the mammal groups. In fact, mean perceptions in the mammal groups were even closer when factoring from the original study was applied. In addition, comparisons of means across the animal groups continued to show the same significant differences (or lack thereof). The only minor change was a lack of significant difference between the dog and bird groups in current perceptions of simple thinking, a result that contradicts the suggested impact of the above factoring hypothesis. Thus, while the change in factoring had the potential to cause a narrowing of perceptions relative to the original study, the analysis does not support this hypothesis.

The decrease in mean responses for children also played a significant role in the narrowing of perceptions across mammal groups. While this may reflect a true shift in public perceptions, the decrease in mean responses for children may have also resulted from the change in the study design to a between-subjects approach, as noted above.

The survey questions themselves represent a final factor to consider in explaining the narrowing of perceptions. The survey questions may not have highlighted the complexities of each simple thinking category, which would otherwise have revealed differences between humans and non-human mammals. While this may be valid criticism of the survey questions and

is something to consider for future study, it does not explain the change in perceptions relative to 1993.

Perception Changes in Complex Thinking and Individual Animal Groups

Shifts in perceptions of complex thinking, as well as significant shifts in perceptions of cats, fish, and children were noted in comparisons of mean responses between the current and original study. My review of simple and complex thinking categories revealed small decreases or negligible changes in perceptions of simple thinking, while perceptions of complex thinking appear to have increased over time. A similar trend was found in overall mean responses of simple and complex thinking across animal groups; mean responses of simple thinking decreased in three of the five animal groups, while four of the five animal groups reported increases in mean responses of complex thinking. The upward trend in perceptions of complex thinking was somewhat limited, however, as the public continues to reserve ascriptions of complex thinking to humans. Further, while cats and dogs were credited with complex thinking in three complex categories (an increase of two categories over the original study), they were not credited with complex thinking overall. The above trend is interesting as it suggests that the results of animal cognition research may be encouraging individuals to consider complex thinking in animals other than humans. As with other measures in this study, however, this trend may also be the result of a switch to a between subjects approach in the current study and the resulting use of absolute judgements compared to relative judgements (which may have encouraged ranking across animal groups in the original study). While this is a potential explanation, I would expect a consistent shift in changes between animal groups across all categories if the change in perceptions was strictly due to a shift between relative and absolute judgements. This shift is not evident in the results shown in Table 6.

A review of changes in individual animal groups also highlighted some interesting changes in perceptions. Perceptions of cognition in cats have increased over time, with cats receiving the highest average response in two cognitive categories (a measure solely held by children in 1993), the highest overall mean response for simple thinking, and an increase in the number of categories for which mean responses for cats exceeded the category average (an increase from 6 categories to 7). Consistent with supporting research, we expected perceptions of cats to align with perceptions of dogs. However, increases in perceptions of cat cognition resulted in outcomes consistent with those for children. I expect this is a result of absolute judgements being made without a reference point. Further, the 7-point response scale only allows for a certain amount of differentiation between levels of perceived cognition, which could have also indirectly led to similar perceptions of cats and children.

Perceptions of fish cognitive abilities also increased significantly, with increases in almost all cognition categories. While I expect relative judgements versus absolute judgements may have played a role in this shift in perceptions, I also expect that perceptions were influenced by animal cognition research published since the original study. Evidence of fish cognition and related research interest has increased significantly over the past three decades (e.g., Sloman, Wilson, & Balshine, 2006). We would have expected similar research to have influenced perceptions of bird cognition. However, increases in public interest in declining world fisheries and sustainable fishing over the past two decades may have drawn more attention towards fish-related research. Pop culture phenomenon such as the “Finding Nemo” movie may also have increased the public’s interest in fish.

Finally, perceptions of children have decreased significantly since 1993, with reductions noted across almost all cognition categories, although, as mentioned above, it is possible that

these decreases are the result of absolute perceptions versus relative perceptions due to a change in the study design to a between-subjects protocol.

Impact of the Internet and Social Media on Perceptions of Animal Cognition

A review of daily hours of Internet activity was found to have no relationship with perceptions of cognition in different species. Further, when asked to rank sources of animal cognition knowledge, participants ranked social media as one of the least relevant resources and ranked the Internet in the bottom three resources. These results are somewhat surprising, but may reflect the fact that daily hours of Internet use is not a good gauge of the influence of the Internet or social media. In particular, this measure does not address what material or content is being viewed. Social media feed content is based on the contacts and organizations the user “follows” and Internet searches are user-directed, thus content viewed would often depend on what the user is looking for or what has been posted by the user’s network of connections. Further, the many headlines, viral posts, and social content of family and friends make competition for visibility on the Internet extremely high. Animal cognition content would either have to be sought out directly, be posted by someone in a viewer’s network, or make headlines in order for that content to be viewed by an individual. While this may make it difficult for animal cognition research to reach mass audiences animal cognition research has gone viral in the past. Research revealing a New Caledonian crow could solve a complex cognitive puzzle that most children aged 4 to 5 years failed to solve, was featured in a number of online journals and newspapers and garnered 19 thousand “likes” and 3.7 thousand “shares” on National Geographic’s Facebook page in 2014 (Cheke, Loissel, & Clayton, 2012; Langin, 2014; Logan, Jelbert, Breen, Gray, & Taylor, 2014). A similar reaction occurred for evidence of American crows gathering around dead conspecifics to learn about danger (behaviour the media dubbed

“crow funerals”) (Swift & Marzluff, 2015) and for evidence of European wild boars washing their food (Sommer, Lowe, & Dietrich, 2016). Further, there is no shortage of general animal related content that is widely circulated on the Internet and social media. Currently there are more than 45 million animal-related videos on YouTube alone, more than 112 million posts on Instagram tagged with the word “dog” and 98 million tagged with “cat.” I would be surprised if this material has not had some impact on perceptions of animal cognition. More finely tuned questions may help to identify and understand the impact of this material

Impact of Pet Ownership on Perceptions of Animal Cognition

I was surprised to find that pet ownership did not have a significant impact on perceptions of animal cognition, particularly since participants ranked “guardianship” as the most important source of animal cognition knowledge. While pet owners exceeded non-owners in ascriptions of simple thinking, the effect size was small and no difference was noted for complex thinking. Pet ownership may not provide additional information that is relevant to the questions posed in this survey beyond what a non-owner could garner outside of personal pet ownership (including experiences with others’ pets). The lack of difference in complex thinking may involve an additional factor, as these behaviours can be harder to identify or make conclusions about even for individuals familiar with an animal. The survey questions themselves may also have played a role in our results. Participants who responded “No” to having a pet in their household may have owned pets in the past, skewing non-owners’ responses closer to owners’ responses. More specific questions or additional questions might have revealed a difference in perceptions.

Among pet owners, perceptions of pet owners were unaffected by the number of pets owned and owners did not appear to be biased toward the type of pet owned. The lack of

relationship between perceptions and the number of pets is not surprising as owning one pet may be sufficiently informative relative to two or more pets for purposes of answering the survey questions. The lack of bias among pet owners is somewhat surprising, but may simply suggest that pet owners are interested in all animals and balance their pet experiences with their knowledge of other animals.

Impact of Demographic Factors on Perceptions of Animal Cognition

Demographic factors appear to have a very minimal impact on perceptions of animal cognition. While the lack of relationship between gender and perceptions was consistent with my predictions, I suspect the lack of impact of geography is due to small sample sizes for continents outside of North America. Similarly, larger sample sizes across all age groups may have revealed a split in perceptions between young and old participants that my results hinted at but did not fully support. Of course, the split in perceptions between some young and old participants could simply be the result of a large sample that is heavily weighted towards the age category of undergraduate students (in spite of accounting for unbalanced sample sizes in the analysis). Unbalanced sample sizes may have also impacted the results related to education as my sample was heavily weighted toward higher levels of education. While education appeared to have no impact on perceptions, it received the third highest proportion of #1 rankings as a source of animal cognition knowledge. A fairly homogenous sample of highly educated individuals may explain this discrepancy. Finally, the lack of impact of occupation and volunteer experience was surprising, especially given that life experience and education were two of the top three ranked sources of animal cognition knowledge. Effect sizes between the different levels of experience were generally small, indicating it is unlikely an issue of sample size. It is possible that the 4-point Likert response scale was not definitive enough to reveal

differences across levels of experience. However, differences between the extremes of the scale would still be expected.

Sources of Knowledge

Formal education, guardianship, and life experiences were reported to be the most important sources of animal cognition knowledge. While these results are consistent with my expectations, the lack of importance ascribed to the Internet and social media was surprising. Individuals are either: (1) unaware of the influence of the Internet and social media, (2) are unwilling to admit any influence, or (3) do not come in contact with animal cognition information through either of these mediums (and do not consider general animal-related postings to influence their perceptions).

Also of interest was the split of rankings for guardianship and education. These categories received some of the highest proportions of both #1 rankings and the *lowest* rankings. The split in education rankings is likely due to differing fields of study across participants. The split in guardianship rankings may partly be related to pet ownership. The split of the *top three* rankings of guardianship between pet owners and non-owners is, respectfully, 60:40, whereas the same split for the bottom ranking is 40:60. While it seems paradoxical that *non*-owners would rank guardianship highly, I expect these individuals were likely pet owners in the past (an aspect not captured in the survey questions).

Public Perceptions versus Expert Research

Available research was reviewed to assess how closely public perceptions aligned with scientific evidence.

Sensation and Perception

Participants were asked whether it was reasonable to expect that the target animal could (1) see the treat, and (2) taste the treat? Participants attributed both vision and taste to all targets, which is consistent with available research. In humans, taste buds first appear in the seventh or eighth week of gestation and are mature structurally by the 13th to 15th week of gestation (Bradley & Stern, 1967). Taste in dogs and cats is reported to be essentially similar but with some noted differences regarding responses to bitterness (only cats) and responses to sugars (cats are limited to lactose) (Bradshaw, 1991). Kare (1970) notes that taste receptors in birds are structurally similar to other vertebrates but their sense of taste differs from humans. Birds tend not to respond to sweet but are more tolerant of sour than humans. Birds are indifferent to certain bitter items but reject others. Finally, Hara (1994) notes that fish not only have taste receptors in their mouths but, in some cases, also have them all over their bodies.

All of the five targets in the survey have perceptual vision but with notable differences. Birds not only see colours but also ultraviolet spectrum (Olsson, 2016). A dog only has two cone cells (compared to three in humans and four in birds), meaning they are red-green colour blind, however, dogs have a much wider peripheral vision than humans (Miller & Murphy, 1995). Cats have poorer colour discrimination and have a wider peripheral vision than humans (Ghose, 2013; Loop, Bruce, & Petuchowski, 1979). While cats have better night vision, they have lower overall visual acuity (Jacobson, Franklin, & McDonald, 1976). Fish eyes are similar to terrestrial vertebrates but have a more spherical lens (Jagger, 1992). Most species can see colour, and some can see ultraviolet light (Hawryshyn, 1992).

Gratitude

Participants were asked whether it was reasonable to expect that the target animal might know that its parent/owner (1) provided the treat, and (2) could withhold the treat? Participants attributed an understanding of who provided the treat to all targets except fish and attributed an understanding of the parent/owner's ability to withhold the treat to all targets except the bird and fish. Participant perceptions more closely align with assumptions and observations that individuals have about gratitude in animals than related research.

A review of the research on gratitude in children by Froh et al. (2011) revealed that there is very limited research on the topic and little consensus as to when children develop gratitude. The authors indicate that while some believe development of gratitude is possible in infancy, others believe that gratitude cannot develop in children until they are less egocentric and can understand the perspectives of others, an ability that seems to develop by age 10.

There is no direct research on gratitude in animals but there is research on the abilities required to engage in gratitude (as set out by Bonnie and de Waal (2004)) including the ability to (a) recognize individuals, (b) detect cheaters, and (c) mentally keep score of acts given and received. While there is evidence of reciprocity in the grooming behaviour of impalas (Hart & Hart, 1992) and food-sharing in vampire bats (Wilkinson, 1984), it has been suggested by Bonnie and De Wall (2004) that these are examples of "symmetry-based reciprocity" that stems from relatedness or proximity of individuals rather than repayment in gratitude. Interestingly, in vampire bats, food-sharing via blood regurgitation is typically only seen between pairs of bats that are familiar with each other, and a bat is more likely to share food with an individual who has previously shared food with them (also suggesting the ability to recognize individuals and keep score) (Wilkinson, 1984). de Waal (1989) proposed that behaviours that approximate

gratitude can be seen in chimpanzees. In feeding trials of chimpanzees, chimps were more likely to share food with individuals who had groomed them earlier that day even after accounting for effects of dominance and proximity. Similarly, research with vervet monkeys revealed that individuals were more willing to aid unrelated individuals who had recently groomed them. Recent grooming between related individuals seems to have no impact on an individual's willingness to provide aid (Seyfarth & Cheney, 1984).

Emotion

Participants were asked whether it was reasonable to expect that the target animal might be (1) happy if it obtained the treat and (2) unhappy if it did not obtain the treat? Participants attributed both emotions to all targets, with the exception of attributions of unhappiness to fish, to which participants provided a neutral response.

Because of our limited ability to communicate with animals, any evidence of emotions in animals is subject to interpretation by humans. Further, similar to human research, animal research appears to suffer a bias toward negative emotions, and thus less research has been undertaken regarding happiness (Boissy et al., 2007). However, one avenue to better understand emotional capabilities in animals is to test their ability to recognize different emotions in others. Chimpanzees were able to match emotions of unfamiliar conspecifics in a video to still photographs of other unfamiliar conspecifics expressing the same emotions (Parr, 2001). Research by Albuquerque et al. (2016) suggests dogs are able to integrate visual and audio information to correctly match positive or negative facial expressions to related positive or negative acoustic stimuli. Further, this result was true for both human and dog stimuli. While many believe we are able to behaviourally observe happiness in other animals (Boissy et al.,

2007), the above research is some of the only research that suggests animals can discriminate emotions.

Pleasure and Displeasure

Participants were asked whether it was reasonable to expect that the target animal might (1) like, or (2) dislike certain treats as food? Participants attributed both cognitive capacities to all targets. Pleasure and displeasure are also difficult emotions to quantify without human interpretation. However, similar facial expressions of pleasure and displeasure have been demonstrated across humans, primates and rats (Cabanac, 2005, as cited in Balcombe, 2009; Steiner, Glaser, Hawilo, & Berridge, 2001). Further, positive affective responses have been linked to similar brain activity across humans and rats (Norgren, Hajnal, & Mungarndee, 2006; Peciña, Smith, & Berridge, 2006). However, evidence of pleasure and displeasure in dogs, cats, birds, and fish remains anecdotal or speculative.

Object Permanence

Participants were asked whether it was reasonable to expect that the target animal could understand that the treat still existed even if it was (1) placed behind a solid barrier, and (2) moved to another room? Participants attributed both cognitive capacities to children, dogs, and cats, but not to birds or fish. These overall perceptions are generally inline with current research, with the exception of birds. It is generally accepted that Corvids (e.g., crows and blue jays) and Psittacine (e.g., parrots) birds are capable of solving invisible displacement problems (Hoffmann, Rüttler, & Nieder, 2011; Pepperberg & Funk, 1990; Zucca, Milos, & Vallortigara, 2007) (the 6th and highest stage in the Piagetian object permanence framework (1954)). Some, however, have criticized the testing procedure used in these studies, arguing that it allows for local rules to be developed and casts doubt about whether a participant's success in invisible displacement

problems is due to conceptual understanding (Gagnon & Doré, 1992). While dogs & cats were initially thought to display stage 6 object permanence capabilities (Dumas, 1992; Gagnon & Doré, 1992), more recent research has challenged this belief (Collier-Baker, Davis, & Suddendorf, 2004; Doré, 1990). However, both dogs and cats have been shown to be capable of the level of object permanence described in the survey questions (i.e., stage 4 - occluded recovery) (Dumas, 1992; Gagnon & Doré, 1992). There is no published research providing evidence of object permanence in fish. Children are generally able to successfully retrieve hidden objects at 8 months (Piaget, 1954), although some suggest that younger infants have the capacity for this level of object permanence even if they do not always display it by reaching for occluded objects (Aguiar & Baillargeon, 2002; Munakata, McClelland, Johnson, & Siegler, 1997).

Morality

Participants were asked whether it was reasonable to expect that the target animal might think it wrong (improper) (1) if someone else ate its treat, and (2) to eat the treat because it belonged to someone else? Participants indicated that children, dogs, and cats would object to someone else eating their treat, but were more neutral on this aspect of morality in birds and fish. Understanding the moral issue of eating someone else's treat was only attributed to children.

There is some disagreement as to whether children have the cognitive capacity for moral understanding at age 2, but most agree that school-aged children have an understanding of right and wrong (Kagan, 1990). While morality as we define it for humans has not been shown in non-human animals, researchers such as Frans de Waal believe that morality exists to a certain degree in some animals. de Wall (2006, as cited in F. De Waal, 2009) suggested that empathy and reciprocity are "prerequisites" of morality and that these prerequisite behaviours can be seen

in some animals. He proposes that, in primates, reciprocity can be seen through food sharing (chimpanzees, F. B. De Waal, 1989, as cited in Flack & De Waal, 2000; orangutans, Edwards & Snowdon, 1980; capuchin monkeys, Rose, 1997), and that empathy is observed in the consoling behaviour offered towards distressed group members (F. B. De Waal & van Roosmalen, 1979). While certain of these prerequisites have been shown in other animals, e.g., food sharing in vampire bats (Wilkinson, 1984), strong evidence towards morality has not been suggested in species other than primates.

Schema

Participants were asked whether it was reasonable to expect that the target animal might (1) have its own name for the treat, and (2) know why treats and carrots are different?

Participants did not attribute these cognitive capacities to any of the targets except the ability to know why treats and carrots are different, which was attributed to children.

Children use various schemas to differentiate items in their environment and to better understand the world around them (Piaget, 1945/1959, 1923/2013). While there is debate over the age at which schemas are developed, there is general agreement that school-aged children are able to categorize objects, create mental representations of objects, and use verbal labels for objects (Müller, Sokol, & Overton, 1998). Evidence of schemas used by non-human animals is suggested in their ability to recognize individuals. While much of this research relates to primates, birds have been shown to be able to recognize familiar versus unfamiliar individuals (Falls, 1982; Beer, 1971, as cited in Kondo, Izawa, & Watanabe, 2012) as well as cross-modally recognize specific familiar individuals (Kondo et al., 2012). Dogs have been shown to cross-modally recognize body size in other dogs (Taylor, Reby, & McComb, 2011) as well as recall their owner's face in a photo after hearing their owner's voice (Adachi, Kuwahata, & Fujita,

2007). While there is no current evidence of cross-modal recognition in fish or cats, archer fish have been shown to be able to discriminate between human faces (Newport, Wallis, Reshitnyk, & Siebeck, 2016) and cats can distinguish between human vocal calls (Saito & Shinozuka, 2013).

Animal use of naming conventions is less clear. Animals can learn to associate words and symbols with objects and even quantities (Biro & Matsuzawa, 2001; Kaminski, Call, & Fischer, 2004; Matsuzawa, 1985; Pilley & Reid, 2011). However, evidence of spontaneous use of names or symbols in animals outside of primates is limited to research by Berg, Delgado, Cortopassi, Beissinger, and Bradbury (2012) who suggest that parrots name their offspring.

Enumeration and Sorting

Participants were asked whether it was reasonable to expect that the target animal could (1) count up to three treats, and (2) tell the difference between small, medium, and large treats? Participants attributed counting only to children, but attributed the ability to discriminate treat size to all animals (although the attribution to fish was weaker than to other species). Available research is somewhat consistent with public perceptions.

Children generally learn to verbally count to three between the ages of 2 and 3 years, although infants have been shown to have the capacity for numerical discrimination and simple arithmetic with small numbers at 5 - 6 months (Lipton & Spelke, 2003; Starkey, Spelke, & Gelman, 1990; Wynn, 1992; Xu & Spelke, 2000). While numerosity research in non-human animals has focused mainly on primates, there is evidence of numerical discrimination, or an approximate number system (“ANS”, (Merritt, DeWind, & Brannon, 2012)) for all target animals in the survey. In a preferential looking task, dogs spent more time looking when the number of treats revealed from behind a screen didn’t match the number placed behind that same

screen (West & Young, 2002). Dogs have also been shown to be able to discriminate larger quantities from smaller quantities, although with somewhat mixed results (Macpherson & Roberts, 2013; Ward & Smuts, 2007). American coots have been shown to defend against brood parasitism by counting their eggs (Lyon, 2003). Baby chickens tracked the movement of a small number of imprinted objects as they moved between two occluded screens and were reliably able to choose the screen with the larger number of objects (Rugani, Regolin, & Vallortigara, 2008). Pigeons have been shown to be able to discriminate proportions when presented with two equally sized shapes that each contained a different proportion of the target colour (Emmerton, 2001). An African grey parrot named Alex was also shown to understand the word “none” to mean the absence of something (Pepperberg & Gordon, 2005), although this ability did not translate to all scenarios (Pepperberg, 2006). Mosquito fish choose to swim in larger schools to avoid predation (Agrillo, Dadda, Serena, & Bisazza, 2008) but have also been shown to discriminate numbers without the benefit of non-numerical external cues (Agrillo, Dadda, Serena, & Bisazza, 2009). Evidence also suggests that angelfish are capable of quantity discrimination that is subject to a ratio limit consistent with Weber’s Law and with other higher order vertebrates (Gómez-Laplaza & Gerlai, 2011). Evidence of numerosity in cats is very limited. Research by McComb, Packer, and Pusey (1994) revealed that female lions were less likely to approach (or were more cautious about approaching) a playback of three intruders versus one. Domestic cats have been shown to be capable of discriminating between quantities, although they do not necessarily do so spontaneously and appear to use visual cues that co-vary with the quantities to solve the problem (Pisa & Agrillo, 2009).

Dream

Participants were asked whether it was reasonable to expect that the target animal (1) when asleep might dream about the treat, and (2) when awake might daydream about the treat? Participants attributed dreaming to children, dogs, and cats but daydreaming only to children and dogs. Available research suggests that the electroencephalographic (EEG) patterns of REM sleep associated with dreams in humans (Dement & Kleitman, 1957) can also be seen in other mammals, including dogs and cats (Siegel, 2008; Zepelin & Rechtschaffen, 1974), and have also been shown in birds (Low, Shank, Sejnowski, & Margoliash, 2008; Rattenborg, Martinez-Gonzalez, & Lesku, 2009). Evidence linking brain activity during REM sleep to evidence of dreaming in animals comes from research with rats. In rats, brain activity and patterns during REM sleep have been matched to similar brain activity and patterns recorded during running exercises in a maze earlier in the day (Louie & Wilson, 2001). There is no available research regarding REM sleep in fish, although recent research demonstrating REM sleep in the Australian dragon *Pogona vitticeps* suggests that the related EEG patterns could date back to a common ancestor of reptiles and birds (Shein-Idelson, Ondracek, Liaw, Reiter, & Laurent, 2016).

The development of the resting state network that is associated with daydreaming in adult humans has been shown to develop in the last 10 weeks of pregnancy and, at birth, appears similar to an adult network (Doria et al., 2010). Research related to the resting state network in animals is limited to the rat and has only recently begun to be mapped using fMRI images (Pawela et al., 2008; Zhang et al., 2010).

Play and Imagine

Participants were asked whether it was reasonable to expect that the target animal could (1) pretend that the treat was something to play with, and (2) could make up some other uses for the treat besides something to eat? Participants attributed both cognitive capacities to children and also attributed the ability to pretend to cats.

While there is disagreement among researchers regarding the specific developmental timeline of object play in children, most suggest advanced object play emerges between 2 and 3 years of age (Vig, 2007). Object play is observed in domestic cats as early as 4 weeks (Barrett & Bateson, 1978) and has been observed in wild cheetah cubs (Caro, 1995). Dogs also engage in object play (Biben, 1982). In birds, object play has also been observed in some species in the form of “play caching” (Marzluff & Balda, 2010), tossing stones (Sauer, 1956 as cited in Diamond & Bond, 2003), or jumping on food (Smith, 1977). Evidence of object play in fish is much more controversial but recent research suggests that observed activities of Cichlid fish meet the definition of object play (Burghardt, Dinets, & Murphy, 2015).

Conservation

Participants were asked whether it was reasonable to expect that the target animal could understand that (1) if the treat was broken in half, there still would be just one treat, not two, and (2) a narrow, thick treat would contain as much material as a wide, flat treat? Participants did not attribute either cognitive capacity to any of the targets, except attributing question #1 to children. These perceptions are consistent with available research, with the exception that children typically do not begin to pass quantity conservation tests until 7 years of age (Piaget & Inhelder, 1966). While quantity conservation has been shown in non-human animals, research

has focused solely on primates (Beran, 2007, 2008, 2010; Cacchione, Hrubesch, & Call, 2013; Call & Rochat, 1996; Suda & Call, 2004; Woodruff, Premack, & Kennel, 1978).

Memory and Foresight

Memory plays an obvious role in the daily lives of animals. Honey bees need to remember the location of a food source in order to convey its location to other bees through their waggle dance (Von Frisch, 2014). Male mantis shrimp (*Gonodactylus bredini*) appear to remember females they have recently mated with and are less aggressive toward them during the period when the female is guarding their brood (Caldwell, 1992). Male fish (*Astatotilapia burtoni*) remember the winners and losers of observed fights between conspecifics and use this information to preferentially spend more time with losers over winners (as losing fights harms their reproductive attractiveness) (Grosenick, Clement, & Fernald, 2007). However, while there is clear evidence of certain forms of memory in non-human animals, there has been significant debate over evidence of episodic memory in non-human animals, the type of memory queried in my survey (Griffiths, Dickinson, & Clayton, 1999; Roberts, 2002, 2012; Suddendorf & Corballis, 1997; Tulving, 1983, 1985). Tulving (1972) defined episodic memories as autobiographical events that are connected to a specific time and place. Most agree that episodic-like memory has been demonstrated in food-caching birds, including scrub jays, magpies, and black-capped chickadees (Clayton & Dickinson, 1998, 1999; Clayton, Yu, & Dickinson, 2001; Feeney, Roberts, & Sherry, 2009; Zinkivskay, Nazir, & Smulders, 2009), as well as in rats (Babb & Crystal, 2005). Scrub jays have been shown to preferentially retrieve more perishable cached food ahead of less perishable cached food, suggesting they are able to remember what food they have cached, where they cached it and some measure of time from when they cached it (Clayton & Dickinson, 1998, 1999; Clayton et al., 2001). Rats not only

demonstrated they could remember where to find their favoured chocolate treats in an 8-arm radial maze, but also the interval of time necessary before the chocolate treat would be provided. Chocolate treats were replenished after a 4-hour interval but not after a 30-minute interval. Rats learned this discriminative cue and showed a preference for searching for the chocolate after a 4-hour interval but not after a 30-minute interval (Babb & Crystal, 2005). Skeptics note, however, that evidence of episodic-like memory in non-human animals is limited to memory within a single day and not over longer periods of time (Roberts, 2012).

With respect to the animals considered in our survey, researchers have proposed that episodic memory may be ecologically relevant in animals that cache or hoard food (Clayton, Bussey, & Dickinson, 2003) and, as result, related research has mainly focused on animals demonstrating these behaviours. Very recent research by Fugazzi et al. (2016), proposes evidence of episodic memory in dogs. However, as suggested by Alexandra Horowitz and Clive Wynne (Brulliar, 2016), the methodologies of Fugazzi et al. leave room for interpretations of the results as evidence of semantic memory. Similarly, Hamilton et al. (2016) propose evidence of episodic-like memory in zebrafish, although the remembering of the zebrafish could be explained as familiarity rather than true episodic memory. The absence of research suggesting episodic memory in cats, dogs, and fish is not evidence that these animals are not capable of such memory. Contrary to remarks by Tulvin (1983), Clayton et al. (2001), have suggested that episodic memory is unlikely to be unique to humans or even unique to caching birds given that there are other instances in which episodic memory could be important for survival. Evidence of episodic memory in children is much clearer, suggesting that episodic memory is not fully developed until 4 years of age (Hayne & Imuta, 2011). Perceptions of survey participants appeared to be somewhat in-line with available research but underestimated the capacity of birds.

Participants indicated that episodic memory was most reasonable in children, was somewhat reasonable in cats and dogs, but was not reasonable in birds and fish.

The second survey question in this category asked participants whether it was reasonable to suggest that the target animal could plan to eat the treat tomorrow? Research on planning in animals is still in its infancy. The Bischof-Kohler hypothesis suggests that planning requires the ability to dissociate from current motivation in order to act towards the future, a quality critics suggest animals do not possess (Suddendorf & Corballis, 1997). However, Okuda et al. (2003), suggest that the mental time travel required for both episodic memory and future planning depends on similar areas of the human brain and this has encouraged researchers to consider planning abilities in corvids, in which episodic memory had already been demonstrated. Raby et al. (2007) were able to demonstrate planning for a future motivational state in scrub-jays. Scrub jays were trained to learn which type of food was made available in which compartments at breakfast daily. When given the opportunity to cache the same types of food at night, scrub jays preferentially cached food in a compartment that had been shown to be unavailable in that compartment at breakfast. McKenzie, Cherman, Bird, Naqshbandi, and Roberts (2004) similarly showed that squirrel monkeys could anticipate the future consequences of their choices. Squirrel monkeys did not display a temporal myopia effect, consistently choosing the larger of two quantities of food, regardless of their size. Further, once researchers began to pilfer the larger quantity such that it was more advantageous in the end for the squirrel monkey to initially choose the smaller quantity of food, the squirrel monkeys changed tactics and began selecting the smaller food quantity over the larger quantity. Additional work by Naqshbandi and Roberts (2006) demonstrated that squirrel monkeys would reverse their baseline preference for a larger quantity of food over a smaller quantity when the quantity of food chosen affected the monkey's

future access to water. Water was removed from the monkeys' enclosure and was returned 30 minutes later if 1 food item was chosen, but was returned 4 hours later if 4 food items were chosen. As the food items induced thirst, the monkeys learned to plan for future thirst and switched their preference to 1 food item over 4 food items. Planning has also been demonstrated in apes who have been shown to choose tools based on anticipated future use (Osvath & Osvath, 2008). While most agree that the above evidence suggests a capacity to plan for a future need, critics have proposed that the actions of scrub jays and apes may be based in semantic memory and that further work needs to be done (Clayton, 2015; Roberts & Feeney, 2009). Participants in the current study indicated planning was somewhat reasonable in children but somewhat unreasonable in animals. Participants' perceptions of planning in animals is not surprising given that the above evidence is relatively recent and is limited to a handful of species, none of which are captured in our study. Participants' assessments of planning in children appeared to match available research which suggests that planning develops between four to six years of age (Atance, Louw, & Clayton, 2015; Atance et al., 2015; Clayton, 2015).

General Discussion

Taken as a whole these results suggest that perceptions of animal cognition have improved over time. The increase in perceptions of fish cognition, the converging of perceptions between mammals, and the general increase in ascriptions of complex thinking all indicate that individuals are acknowledging greater levels of cognitive abilities in animals. While I believe this is, in large part, due to the influence of animal cognition research, it is also important to recognize that my results are a function of the methodologies used. As noted by the original authors, the questionnaire is an indirect measure of public perceptions and different responses may have been reported if participants were directly asked about animal cognition. For example,

the questions could have directly asked if “fish have a sense of gratitude?” or if “cats have a sense of morality?” Further, responses were limited to the questions asked in each category and limited to the categories included in the questionnaire. Thus, while I was able to make comparisons across species, some similarities and differences may not have been captured. In addition, perceptions noted for a particular category may not reflect the complexities of that category, nor would the perceptions of a particular species necessarily reflect its full cognitive capacity.

The assumption underlying this study was that the cognitive capacity of animals can be adequately measured and compared from a human-centric standpoint. It is possible that an animal has the capacity for a particular cognitive skill but does not exhibit that skill because it is not important for their survival. Similarly, an animal may exhibit a particular cognitive capacity but it goes unnoticed because we cannot measure it or because we don’t recognize the behaviour for what it is. Of course, this is a common issue in comparative cognition research and explicit theories of animal cognition. Further, given the goal of the original study was to understand the public’s *implicit* theory of animal thinking, human cognitive ability is a natural reference point.

An improved understanding of animal cognition may also explain why factor loadings were lower and less consistent than in the original study. While I suspect that the change in factor loadings is partly related to aspects of our methodology, it may also suggest that as the public gains a deeper understanding of animal cognition it becomes less practical and less relevant to distil their perceptions into only two levels of thinking.

CONCLUSIONS

Understanding public perceptions allows us to evaluate the extent to which our research reaches the public and is properly understood. While public views of animal cognition have

increased over time, perceptions have not necessarily kept pace with related research. Public perceptions were generally inline with available research but deviations tended to underestimate animal cognitive capabilities, particularly with respect to birds and fish.

While I did not note any influence of social media or the Internet on public perceptions, further examination in this area would be beneficial given the limited scope of my initial investigation and the significant power these mediums provide in information sharing. Both these mediums are currently undervalued as a knowledge resource in animal cognition, providing a significant opportunity for increased utilization.

My results have also led me to consider additional questions not captured in this study. How would perceptions of wild animals compare to the animal groups currently investigated? In particular, where would perceptions of a chimpanzee fall in the indirect “ranking” of animal groups? How does the public perceive “large brained” animals such as dolphins; racoons that are branded as “urban masterminds;” or the clever fox? Understanding public perceptions is inherently interesting to comparative psychologists, but it is also important in the larger context of global education and conservation efforts. It is harder to ignore the plight of a species when you know it can dream.

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APPENDIX A: TABLES

Table 1 – Mean Responses By Question and Animal Group

	<u>Child</u>	<u>Dog</u>	<u>Cat</u>	<u>Bird</u>	<u>Fish</u>	<u>Mean</u>
Q1 - Sensation & Perception	6.36	6.42	6.49	6.21	5.69	6.23
Q2 - Sensation & Perception	5.9	6.01	6.16	5.69	5.25	5.8
Q3 - Gratitude	5.83	5.77	6.01	5.36	4.06	5.41
Q4 - Gratitude	5.83	5.46	5.51	4.63	3.45	4.98
Q5 - Emotion	6.47	6.22	6.48	5.95	5.18	6.06
Q6 - Emotion	6.09	5.91	6	5.23	4.55	5.56
Q7 - Pleasure & Displeasure	6	6.05	6.51	5.59	5.18	5.87
Q8 - Pleasure & Displeasure	5.65	5.68	6.28	5.33	5.14	5.62
Q9 - Object Permanence	5.26	4.96	5.3	3.9	3.52	4.59
Q10 - Object Permanence	5.52	4.97	5.14	3.55	3.21	4.48
Q11 - Morality	6.04	5.44	5.22	4.67	4.1	5.09
Q12 - Morality	4.79	3.37	3.11	2.64	2.43	3.27
Q13 - Schema	4.49	3.88	3.7	3.23	3.23	3.71
Q14 - Schema	5.74	4.33	4.18	4.31	3.91	4.49
Q15 - Enumeration & Sorting	5.92	4.12	4.13	3.99	3.26	4.28
Q16 - Enumeration & Sorting	6.26	5.22	5.39	4.87	4.69	5.29
Q17 - Dream	5.09	5.21	4.92	3.96	3.57	4.55
Q18 - Dream	5.1	4.82	4.48	3.63	3.58	4.32
Q19 - Play & Imagine	4.88	4.4	4.91	4.23	3.82	4.45
Q20 - Play & Imagine	4.83	3.92	4.44	4.04	3.22	4.09
Q21 - Conservation	5.18	3.37	3.18	2.99	2.79	3.5
Q22 - Conservation	3.83	2.88	2.85	2.96	2.57	3.02
Q23 - Memory & Foresight	5.66	4.81	4.81	4.26	3.6	4.63
Q24 - Memory & Foresight	4.88	3.53	3.3	3.76	3.29	3.75
Mean Response	5.48	4.86	4.94	4.37	3.89	4.71

Table 2 - Mean Responses by Category and Animal Group

Category	Factor	Animal Group					Category Mean
		Child	Dog	Cat	Bird	Fish	
Sensation & Perception	1	6.13	6.22	6.33	5.95	5.47	6.02
Gratitude	1	5.83	5.62	5.76	4.99	3.76	5.19
Emotion	1	6.28	6.06	6.24	5.59	4.86	5.81
Pleasure & Displeasure	1	5.82	5.87	6.39	5.46	5.16	5.74
Object Permanence	2	5.39	4.97	5.22	3.72	3.36	4.53
Morality	2	5.42	4.4	4.16	3.65	3.27	4.18
Schema	2	5.12	4.11	3.94	3.77	3.57	4.1
Enumeration & Sorting	2	6.09	4.67	4.76	4.43	3.97	4.78
Dream	2	5.1	5.01	4.7	3.79	3.58	4.44
Play & Imagine	2	4.86	4.16	4.68	4.13	3.52	4.27
Conservation	2	4.51	3.13	3.01	2.97	2.68	3.26
Memory & Foresight	2	5.27	4.17	4.06	4.01	3.44	4.19
<i>Group Mean</i>		5.49	4.87	4.94	4.37	3.89	4.71

Table 3 - Simple Thinking Pairwise Comparisons of Target Groups

Group	Mean Difference	Confidence Interval		Adjusted p-value
		Lower	Upper	
Cat-Bird	0.68	0.27	1.09	0.00
Child-Bird	0.52	0.10	0.93	0.01
Dog-Bird	0.44	0.03	0.86	0.03
Fish-Bird	-0.69	-1.10	-0.27	0.00
Child-Cat	-0.16	-0.58	0.25	0.81
Dog-Cat	-0.24	-0.65	0.17	0.50
Fish-Cat	-1.37	-1.78	-0.95	0.00
Dog-Child	-0.08	-0.49	0.34	0.99
Fish-Child	-1.20	-1.62	-0.79	0.00
Fish-Dog	-1.13	-1.54	-0.71	0.00

Table 4 - Complex Thinking Pairwise Comparison of Target Groups

Group	Mean Difference	Confidence Interval		Adjusted p-value
		Lower	Upper	
Cat-Bird	0.51	0.07	0.94	0.01
Child-Bird	1.41	0.97	1.85	0.00
Dog-Bird	0.52	0.08	0.96	0.01
Fish-Bird	-0.39	-0.83	0.05	0.12
Child-Cat	0.90	0.46	1.34	0.00
Dog-Cat	0.01	-0.43	0.45	1.00
Fish-Cat	-0.89	-1.33	-0.45	0.00
Dog-Child	-0.89	-1.33	-0.45	0.00
Fish-Child	-1.79	-2.24	-1.35	0.00
Fish-Dog	-0.90	-1.34	-0.46	0.00

Table 5 - Undergraduate & Public Mean Responses

Factor	<i>Animal Group</i>				
	Child	Dog	Cat	Bird	Fish
Undergraduate Sample (N = 241)					
Simple	5.76	5.79	6.13	5.34	4.91
Complex	4.98	4.25	4.34	3.84	3.78
	5.24	4.76	4.94	4.34	4.15
Public Sample (N = 148)					
Simple	6.42	6.16	6.27	5.80	4.66
Complex	5.59	4.44	4.27	3.75	2.87
	5.86	5.01	4.94	4.43	3.47

Table 6 - Differences in Mean Responses: 2016 versus 1993

	Difference (2016 - 1993)					<i>Category Mean</i>
	Child	Dog	Cat	Bird	Fish	
Sensation & Perception	-0.55	-0.33	-0.16	-0.23	-0.35	-0.20
Gratitude	-0.59	-0.55	-0.35	-0.66	-1.33	-0.70
Emotion	-0.36	-0.15	0.24	-0.02	0.24	-0.01
Pleasure & Displeasure	-0.58	-0.23	0.65	-0.04	1.75	0.31
Object Permanence	-0.27	-0.29	-0.31	-0.83	0.28	-0.29
Morality	-0.61	-0.74	-0.32	0.11	0.80	-0.15
Schema	-0.92	-0.52	-0.24	0.02	0.62	-0.21
Enumeration & Sorting	0.00	0.45	0.81	0.80	0.93	0.59
Dream	-1.28	0.90	0.92	0.11	0.64	0.26
Play & Imagine	-1.17	0.33	1.06	0.46	0.23	0.18
Conservation	-1.14	-0.73	-0.58	-0.31	-0.12	-0.56
Memory & Foresight	0.51	1.31	1.43	1.32	1.22	1.16
<i>Mean Response</i>	-0.58	-0.05	0.26	0.06	0.41	

Table 7 - Proportion of Rankings Received Across Knowledge Sources

Rank	Education	Life Experiences	Guardianship	TV	Movies	Books	Print Media	Internet	Social Media
1	0.14	0.22	0.31	0.05	0.04	0.03	0.07	0.05	0.07
2	0.10	0.31	0.12	0.11	0.09	0.09	0.04	0.09	0.04
3	0.13	0.11	0.10	0.18	0.10	0.13	0.08	0.09	0.08
4	0.11	0.05	0.05	0.14	0.14	0.18	0.11	0.13	0.09
5	0.08	0.06	0.04	0.17	0.14	0.15	0.12	0.13	0.11
6	0.06	0.07	0.04	0.16	0.14	0.16	0.14	0.12	0.11
7	0.07	0.06	0.04	0.09	0.14	0.10	0.18	0.20	0.12
8	0.08	0.09	0.08	0.06	0.15	0.10	0.14	0.14	0.16
9	0.19	0.04	0.14	0.06	0.07	0.04	0.15	0.04	0.27
NA	0.16	0.06	0.16	0.08	0.10	0.11	0.11	0.10	0.12

APPENDIX B: FIGURES

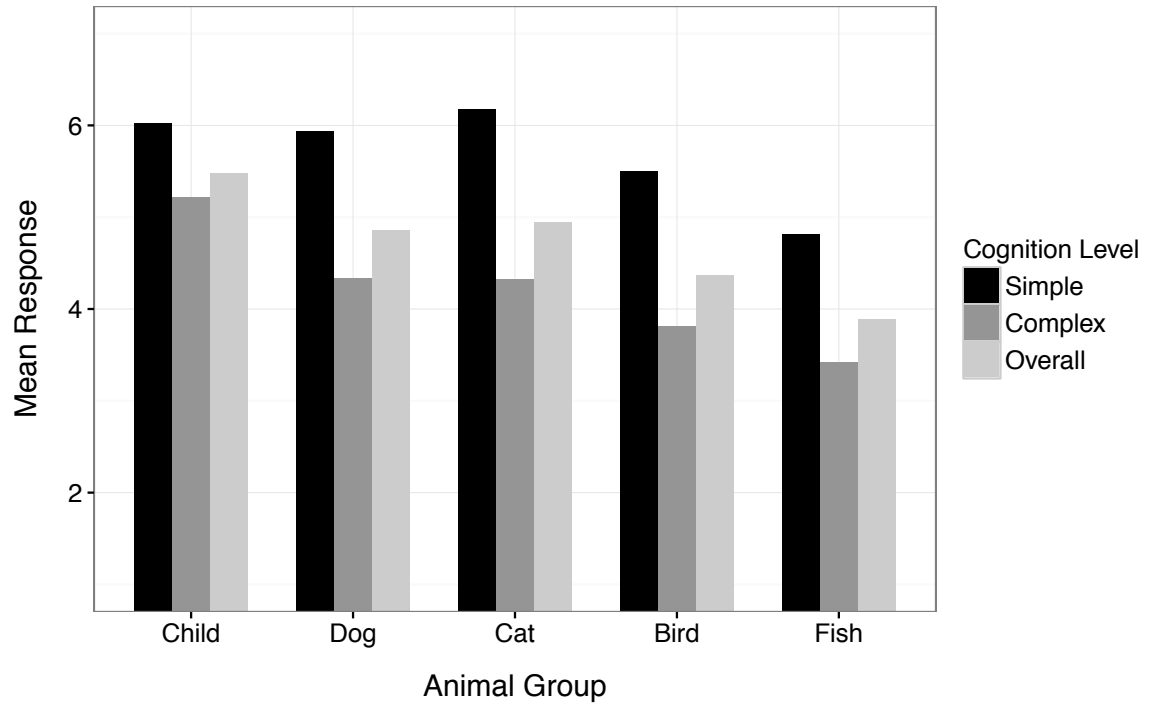


Figure 1 - Mean Perceptions of Cognition by Animal Group

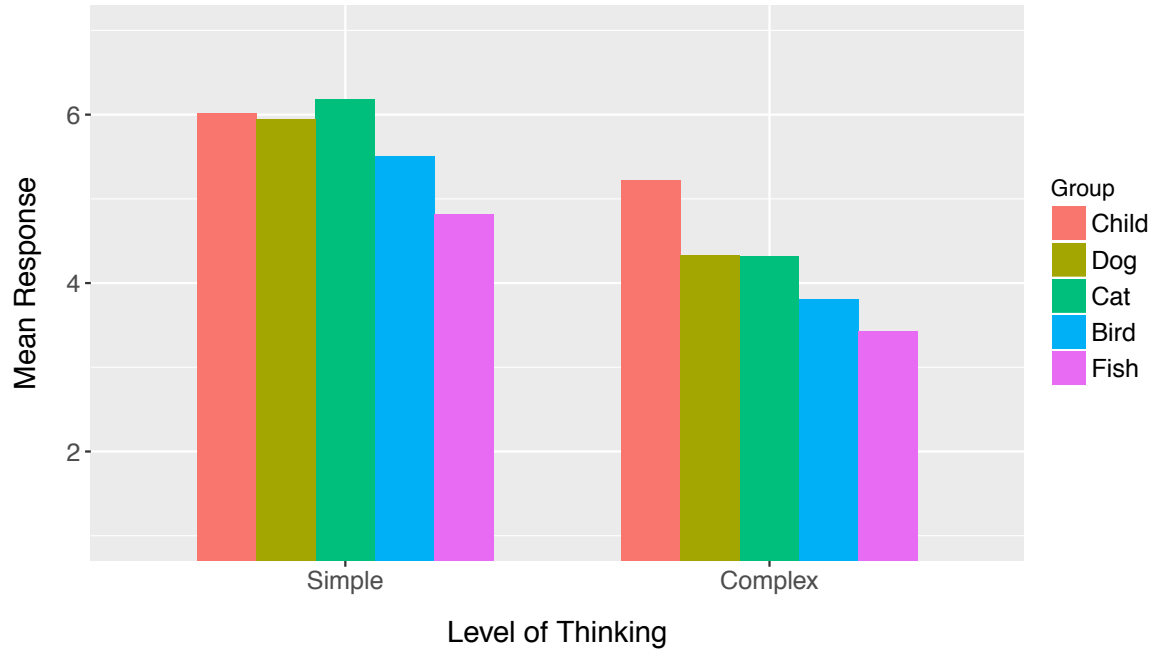


Figure 2 - Mean Responses by Level of Thinking and Animal Group

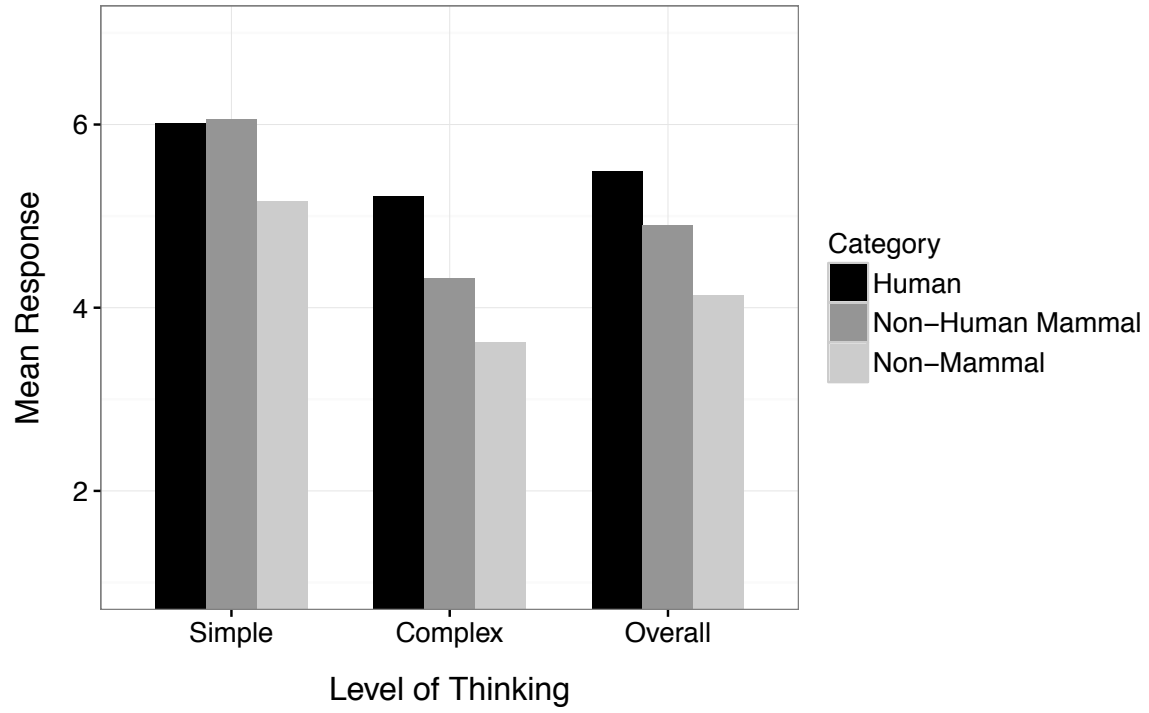


Figure 3 - Mean Response by Level of Thinking and Animal Category

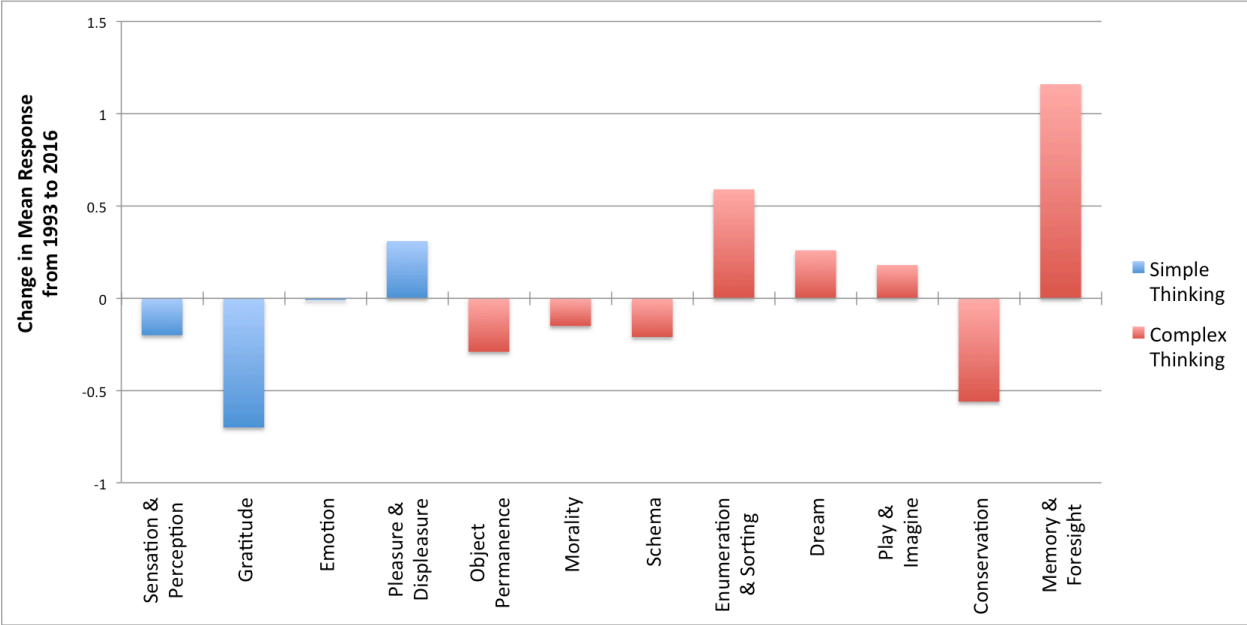


Figure 4 - Change in Mean Response by Category (All Targets)

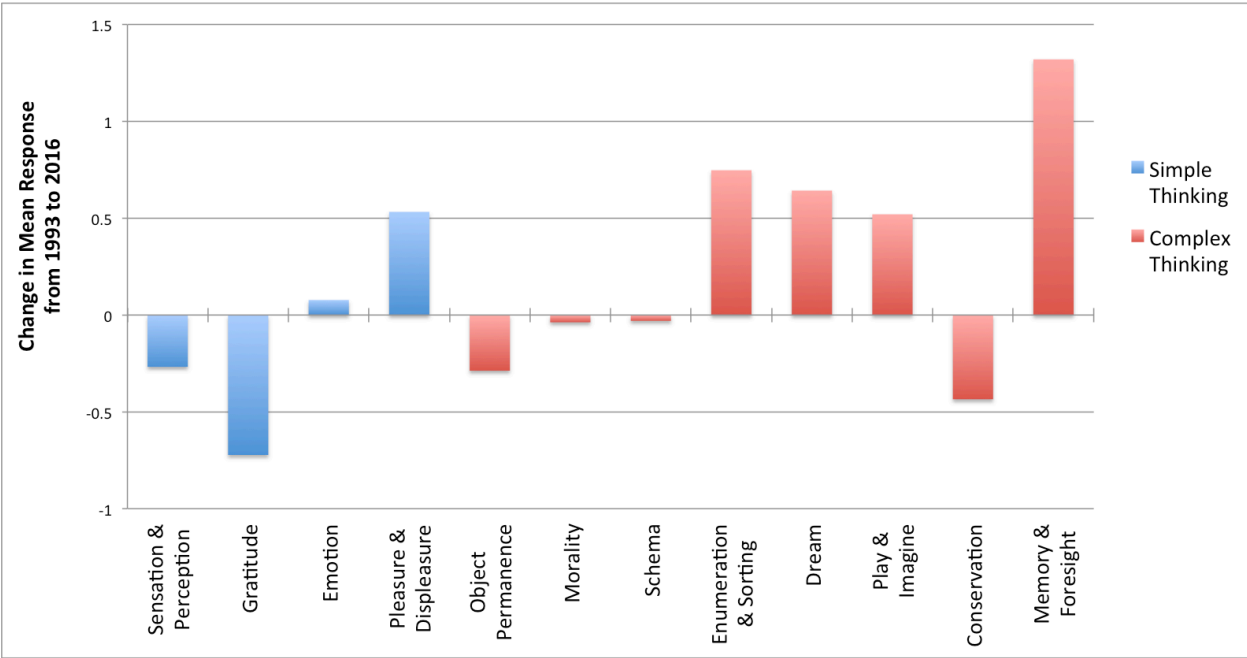


Figure 5 - Change in Mean Response by Category (Excludes Children)

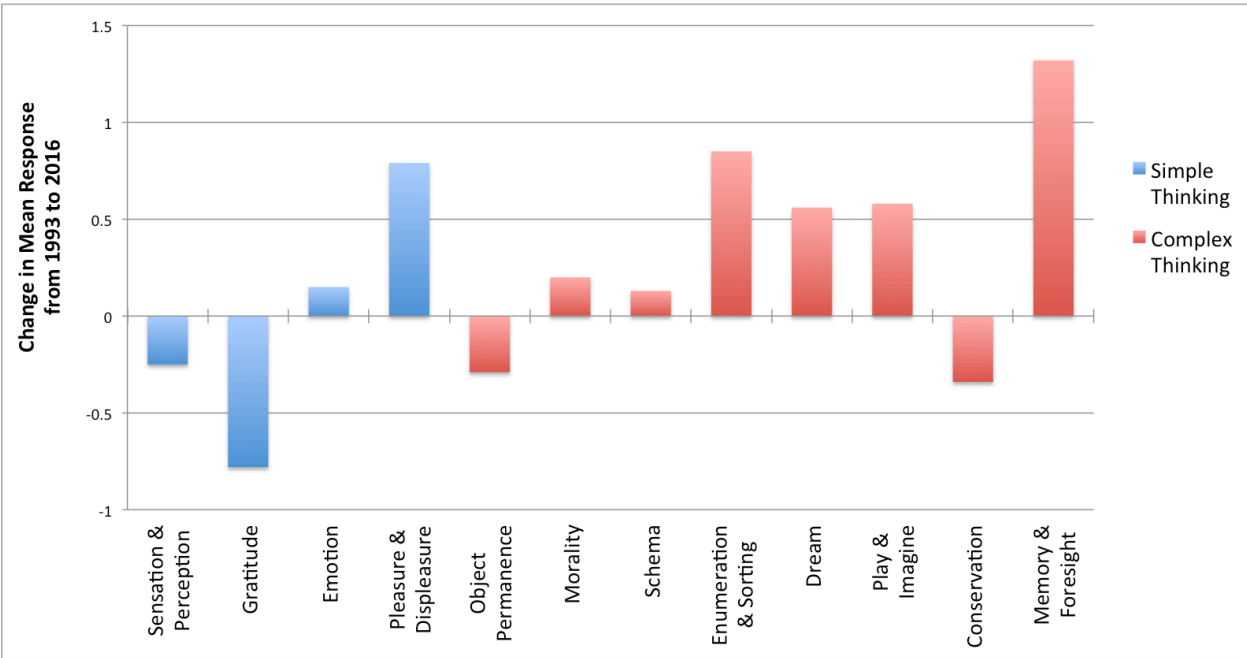


Figure 6 - Change in Mean Response by Category (Excludes Children & Dogs)

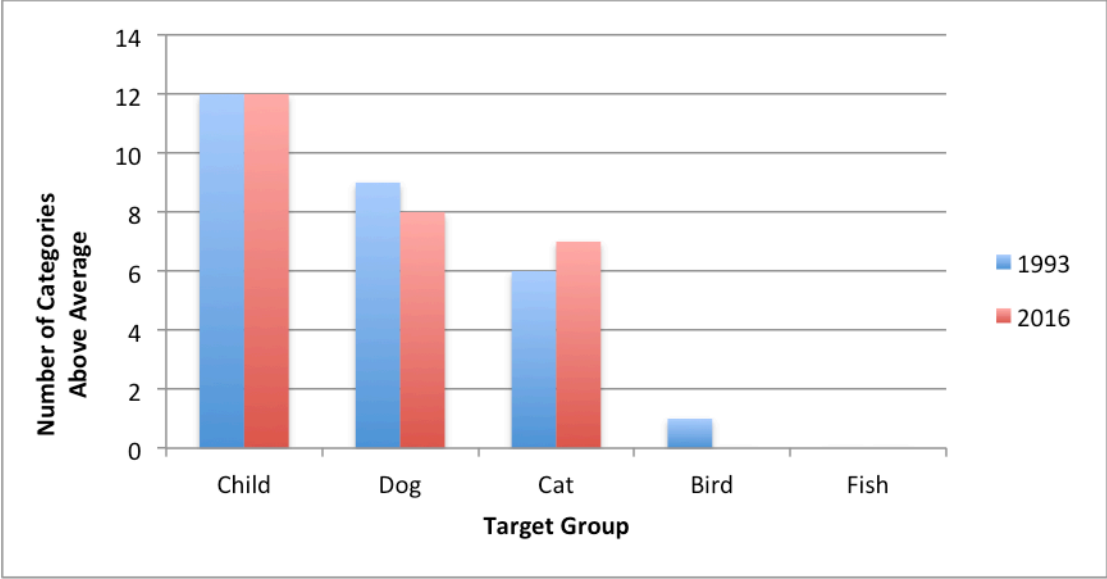


Figure 7 - Number of Categories in which the Target Group Exceeded the Category Average

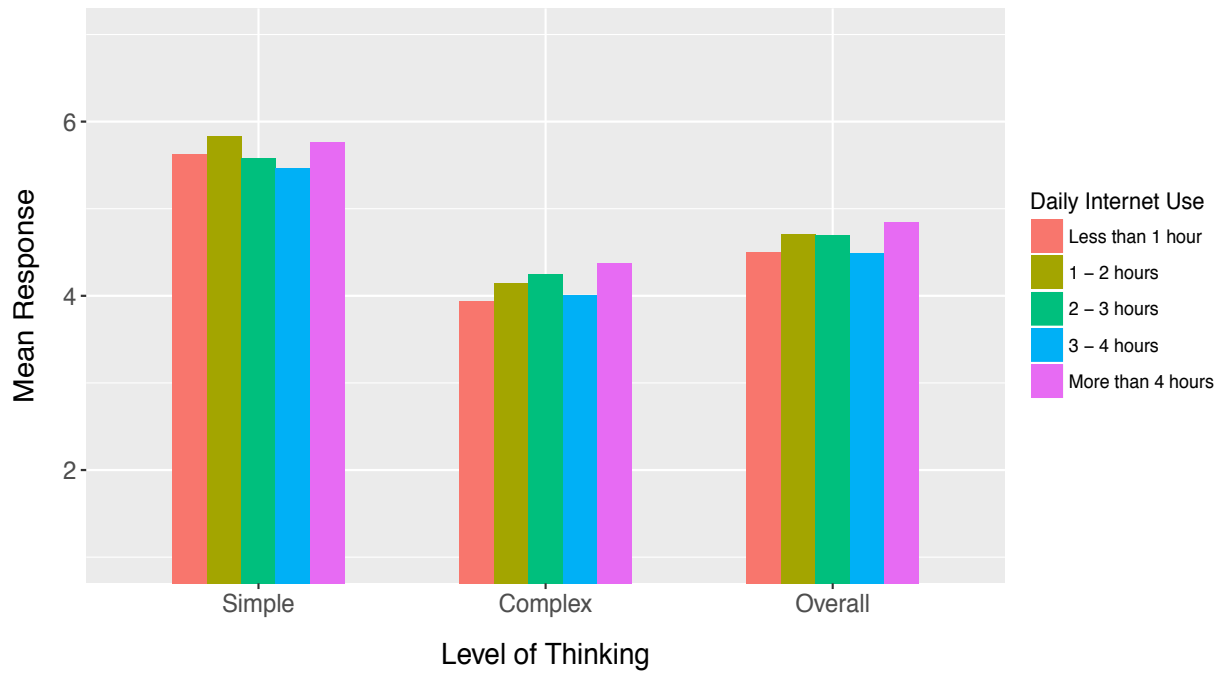


Figure 8 - Mean Response by Daily Internet Use

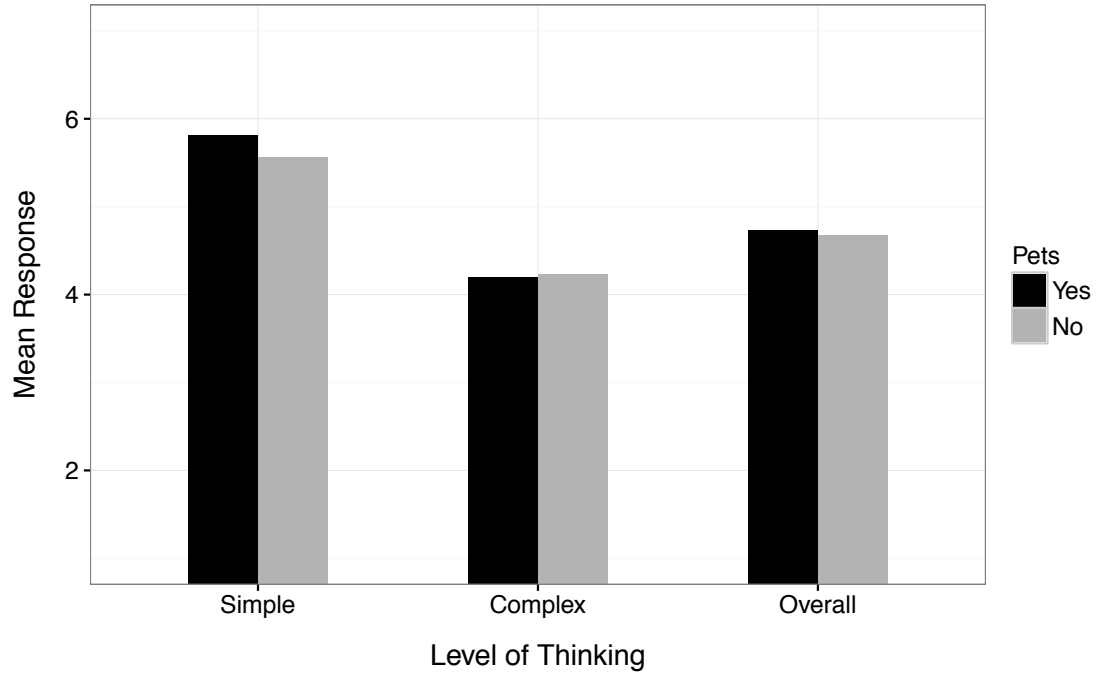


Figure 9 - Mean Response by Pet Ownership

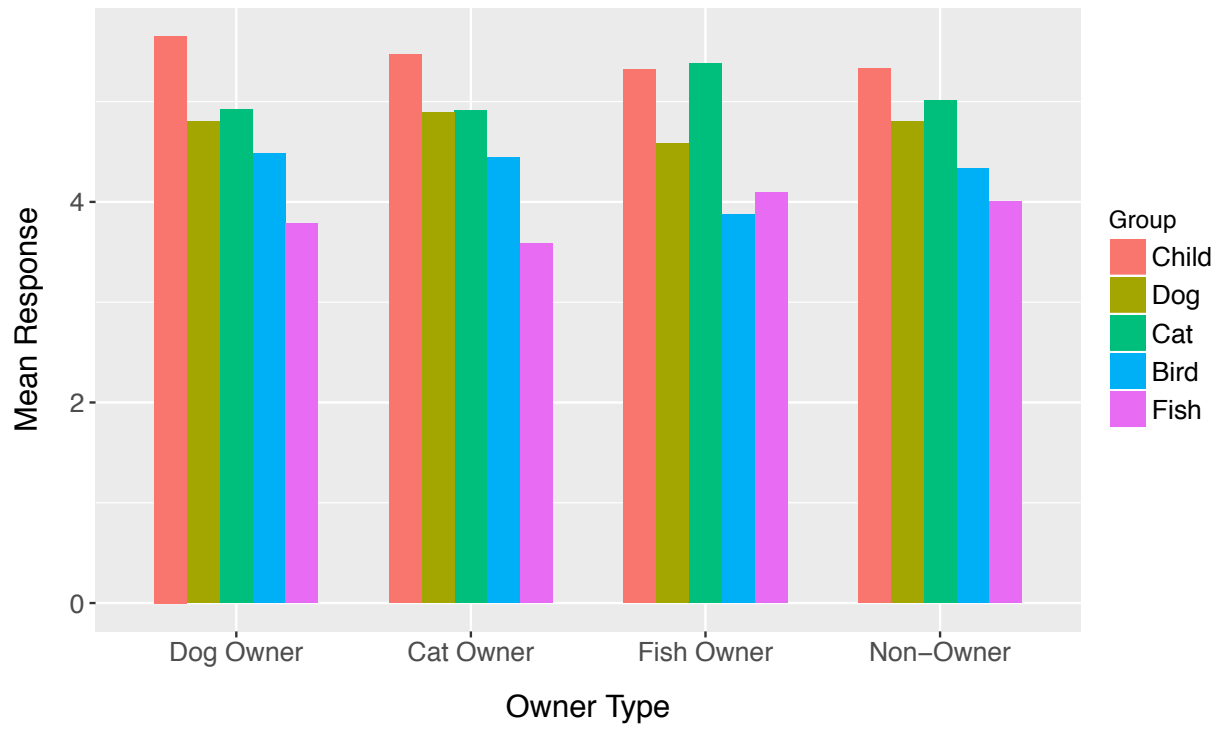


Figure 10 - Perceptions of Animal Groups by Owner Type

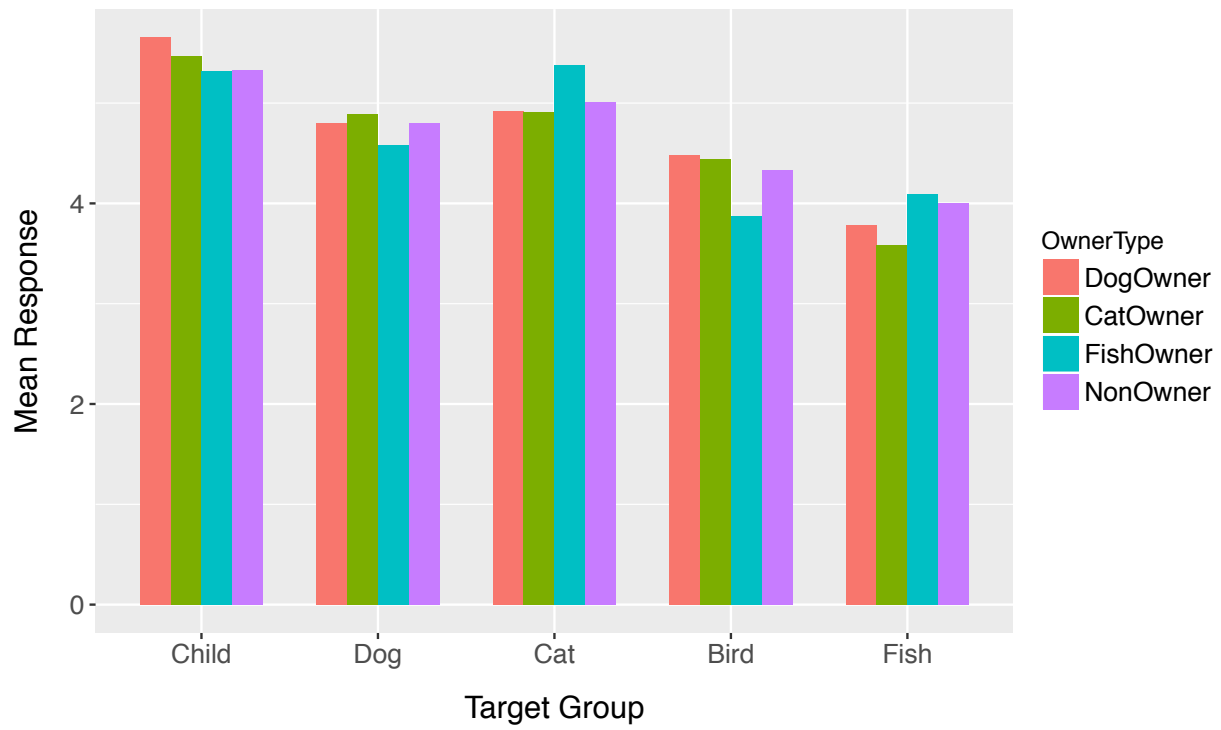


Figure 11 - Perception Bias of Owner Type

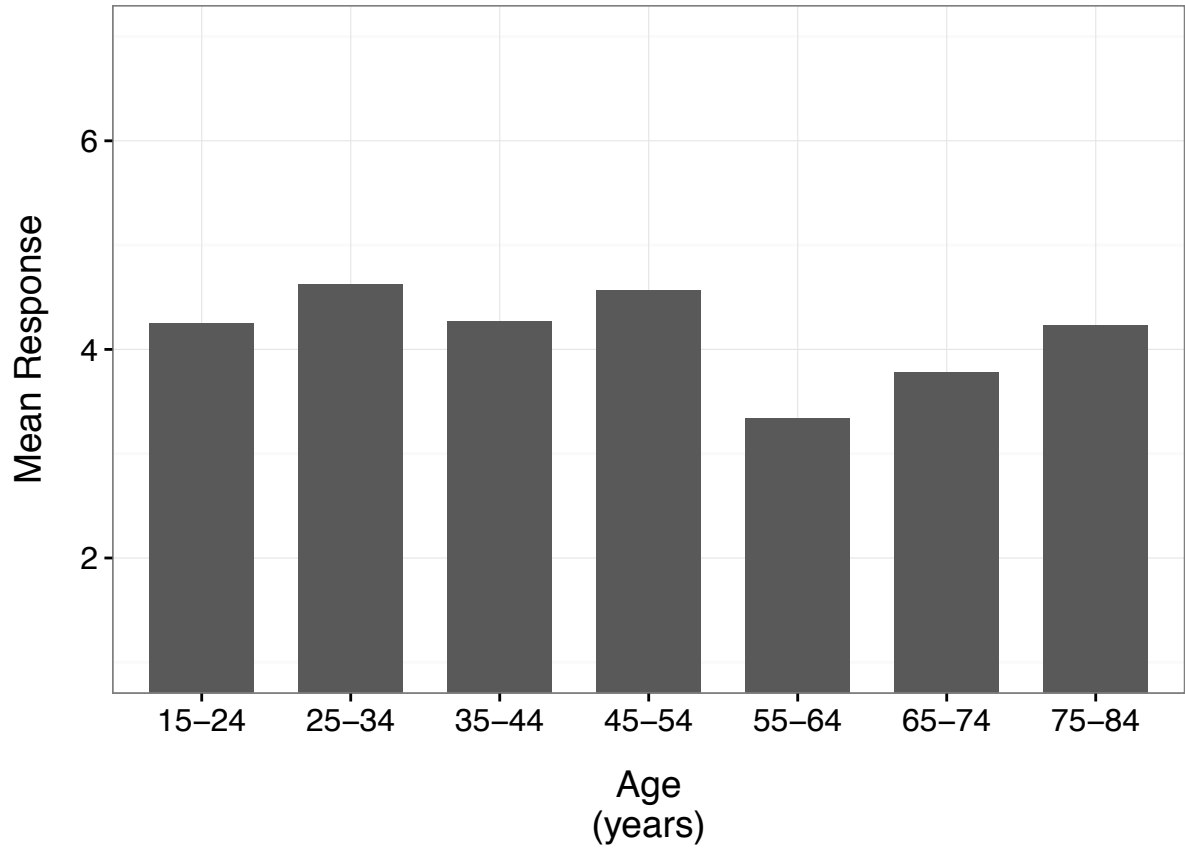


Figure 12 – Perceptions of Complex Thinking by Age

APPENDIX C: SURVEY QUESTIONS

Survey Questions - Version C

SITUATION: The setting is a typical household. In the scene there is a cat. In front of the cat is a cat treat.

Please answer the following questions about the situation.

1. Is it reasonable to say that the cat could see the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. Is it reasonable to say that the cat could taste the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Is it reasonable to say that the cat might know that its owner provided the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Is it reasonable to say that the cat might know that its owner could withhold the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. Is it reasonable to say that the cat might be happy if it obtained the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. Is it reasonable to say that the cat might be unhappy if it did not obtain the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Is it reasonable to say that the cat might approve of (like) certain treats as food?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. Is it reasonable to say that the cat might disapprove of (dislike) certain treats as food?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. Is it reasonable to say that the cat could understand that the treat still existed even if it was placed behind a solid barrier?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. Is it reasonable to say that the cat could understand that the treat still existed even if it was moved to another room?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. Is it reasonable to say that the cat might think it wrong (improper) if some other cat ate its treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

12. Is it reasonable to say that the cat might think it wrong (improper) to eat the treat because it belonged to some other cat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. Is it reasonable to say that the cat might have its own name for the treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. Is it reasonable to say that the cat might know why treats and canned cat food are different?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

15. Is it reasonable to say that the cat could count up to three treats?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

16. Is it reasonable to say that the cat could tell the difference between small, medium, and large treats?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

17. Is it reasonable to say that the cat, when asleep, might dream about the treat?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

18. Is it reasonable to say that the cat, when awake, might daydream about the treat?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

19. Is it reasonable to say that the cat could pretend that the treat was something to play with?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

20. Is it reasonable to say that the cat could make up some other uses for the treat besides something to eat?

(1 = Unreasonable; 7 = Reasonable)

1. 2. 3. 4. 5. 6. 7.

21. Is it reasonable to say that the cat could understand that, if the treat was broken in half, there still would be just one treat, not two?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22. Is it reasonable to say that the cat could understand that a narrow, thick treat would contain as much material as a wide, flat treat?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

23. Is it reasonable to say that the cat could remember eating a treat yesterday?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

24. Is it reasonable to say that the cat could plan to eat the treat tomorrow?

(1 = Unreasonable; 7 = Reasonable)

1.	2.	3.	4.	5.	6.	7.
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

APPENDIX D: DEMOGRAPHIC QUESTIONS

Please tell us a bit about yourself.
(Surveys B through E)

1. What is your age?

- 0 - 14 years old
- 15 - 24 years old
- 25 - 34 years old
- 35 - 44 years old
- 45 - 54 years old
- 55 - 64 years old
- 65 - 74 years old
- 75 - 84 years old
- 85+ years old

2. What gender do you most closely identify with?

- Male
- Female
- Prefer not to respond

3. In which continent do you currently reside?

- North America
- South America
- Europe
- Africa
- Asia
- Australasia
- Prefer not to respond

4. In which continent have you lived for the majority of your life?

- North America
- South America
- Europe
- Africa
- Asia
- Australasia
- Prefer not to respond

5. What is the highest degree or level of education you have received?

- No schooling completed
- Elementary school - 8th grade
- Some high school, no diploma
- High school graduate, diploma, or the equivalent
- Some college credit, no degree
- Trade/technical/vocational training
- Associate degree
- Bachelor's degree
- Master's degree
- Doctorate degree
- Prefer not to respond

6. To what extent does your occupation or volunteer activities (past or present) involve animals.

Not at all	Very little	Somewhat	To a great extent
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Which of the following sources have contributed to your understanding of how an animal thinks?
(Please RANK ORDER all that apply from greatest impact = 1, to least impact = 9).

(Note: Each option must receive a unique ranking, i.e. a ranking value can only be used once. Assign N/A for any options not applicable.)

<input type="text"/>	Formal Education	<input type="checkbox"/> N/A
<input type="text"/>	Life Experiences	<input type="checkbox"/> N/A
<input type="text"/>	Pet ownership	<input type="checkbox"/> N/A
<input type="text"/>	Television	<input type="checkbox"/> N/A
<input type="text"/>	Movies	<input type="checkbox"/> N/A
<input type="text"/>	Books	<input type="checkbox"/> N/A
<input type="text"/>	Newspapers & Magazines	<input type="checkbox"/> N/A
<input type="text"/>	Internet Searches	<input type="checkbox"/> N/A
<input type="text"/>	Social Media (including Facebook, Twitter, Youtube, etc.)	<input type="checkbox"/> N/A

8. On average, how many hours per day do you spend on the internet?

- Less than 1 hour
- 1 - 2 hours
- 2 - 3 hours
- 3 - 4 hours
- More than 4 hours

9. Do you have a pet(s) in your household?

- Yes
- No

Please tell us a bit about yourself.
(Surveys B through E - continued)

1. How many pets are in your household?

- 1
- 2
- 3
- 4
- 5+
- Not applicable.

2. What type of pet(s) do you have in your household? (Choose all that apply)

- Dog
- Cat
- Bird
- Fish
- Not applicable
- Other (please specify)