23rd Annual International Conference on Comparative Cognition

Sponsored by the Comparative Cognition Society

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Melbourne Beach, Florida

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Wednesday Afternoon

3:30 PM Welcome Reception and Check-In

7:00 PM Opening Remarks (Debbie Kelly)

7:05 PM Memory (Chair: Michael Brown)

7:05 PM **Cognitive decline in aging: Old rats lose the ability to plan for the future**

Jonathon D. Crystal, Matthew J. Pizzo, Spencer Kann (Indiana University), & A. George Wilson (University of Kentucky)

1 People plan to act in the future when an appropriate event occurs, a capacity known as event-based prospective memory. Prospective memory involves forming a representation of a planned future action, subsequently inactivating the representation, and ultimately reactivating it at an appropriate point in the future. Prospective memory in humans is impaired with age. Young rats use prospective memory (Wilson et al. 2013, Current Biology). Here we asked if prospective memory in rats declines with age. Rats completed an ongoing temporal-discrimination task while waiting for a large meal. To promote the use of event-based prospective memory, an event (tone pulses) provided information that the meal could be obtained soon. Event onset and offset and meal onset were unpredictable in time (exponentially distributed delays). Young adult rats (~9 months) showed event-based prospective memory as documented by the decline in ongoing-task performance after the event, with excellent performance on other occasions at the equivalent timepoints. In old rats (~2 years), prospective memory was eliminated. Because prospective memory is documented by a deleterious effect on ongoing performance, the old rats exhibited a relative sparing of performance. Our model provides a framework for exploring factors that protect memory from cognitive decline associated with normal aging.

7:19 PM **Context and memory in the pigeon**

William A. Roberts, Caroline G. Strang, & Krista M. Macpherson (Western University Canada)

2 Pigeons were trained to symbolically match vertical and horizontal striped patterns (comparison stimuli) to working memory (WM) of blue and white sample stimuli. They were then given reference memory (RM) training to discriminate between the vertical and horizontal striped patterns, with choice of one pattern always rewarded. WM retention tests showed little forgetting when the correct comparison stimulus was congruent with RM. When the correct comparison stimulus was incongruent with RM, however, marked forgetting was seen, indicating interference with WM by RM. This interaction of WM and RM was found when the context was the same for WM and RM tests (green or red chamber illumination). When different contexts were associated with WM and RM training, the interaction of memory systems completely disappeared, with memory performance controlled only by the context presented. Context controlled access to independent WM and RM systems.

7:33 PM **Context-dependent effects in intraocular memory in pigeons (*Columba livia*)**

Matthew S. Murphy (University of Massachusetts Lowell), & Robert G. Cook (Tufts University)

3 Birds as laterally-eyed animals have specialized retinal areas for frontal and lateral vision, which have unique perceptual, anatomical, and cognitive properties. The visual fields largely follow different visual pathways in the brain. Previous research showed asymmetrical intraocular transfer, indicating that frontal and lateral information were stored separately in long-term memory. We investigated intraocular transfer in pigeons using an item-specific memory test, and found that pigeons showed faster acquisition and higher performance under conditions benefitting from intraocular transfer. Our research indicated that the lateral and frontal information was stored in a common long-term memory store. However, when we conducted a field-incongruent reversal test, or trained new birds with field-congruent or -incongruent response mappings, the birds showed no impairment in performance, indicating the birds were able to discriminate between frontal and lateral representations of the same stimuli. Our research suggests a single long-term memory store for both visual fields, but the information may be stored with additional field-based contextual information, allowing birds to differentiate lateral and frontal information in memory.

7:47 PM **The primate hippocampus may not do what you remember it does**

Robert Hampton (Emory University Department of Psychology and Yerkes National Primate Research Center)

4 Our laboratory has conducted a large set of experiments comparing the performance of monkeys lacking the hippocampus to a group of experience-matched controls. These experiments were designed to measure cognitive performances ranging from recognition, to recall, to reports of the order of events, to transitive inference, among others. Despite extensive testing in this wide range of tasks, we have not found evidence of the dense amnesia reported in humans like H.M., or any other dramatic deficits, in monkeys lacking the hippocampus. These findings will be briefly compared to those from rats, birds, and humans.

8:01 PM *Break*

8:06 PM Spatial Cognition (Chair: Jennifer Basil)

5 8:06 PM **Comparing performance of pigeons and humans on a sequential object-location learning task**

Julia Schroeder, & Aaron Blaisdell (UCLA)

Humans and pigeons were trained on an object-location learning task in which four different objects appeared in four different locations on a touchscreen repeatedly throughout each session. Participants were partially reinforced for selecting each object when it appeared on the screen. Four groups of subjects were trained in each experiment. In group Object, the objects occurred in a consistent sequence but the locations were randomized. In group Location, the sequence of locations was consistent but object order was randomized. In group Both, the objects and locations occurred in a consistent sequence. In group Neither, both location and object orders were randomized. Group Both showed evidence of object-location binding. During non-reinforced probe trials the sequence order of object, location, or both were randomized. When object-location binding was disrupted, randomizing object and/or location sequences increased response times in some conditions. Results between pigeons and humans will be compared and discussed.

6 8:13 PM **The effects of stimulus-response compatibility on spatial occasion setting**

Josh Wolf, Lauren Cleland, & Kenneth Leising (Texas Christian University)

An occasion setter (e.g., a football stadium) can resolve the ambiguity of whether or not a response (e.g., yelling "Go Frogs") will be followed by reinforcement in the presence of a discriminative stimulus (DS) (e.g., a large group of people). Most occasion setting research has investigated whether an occasion setter controls responding to the DS, but our lab has investigated whether an occasion setter can also control where to respond relative to a spatial DS (e.g., a discrete visual landmark within an array of response locations). The current experiment adds a spatial stimulus-response compatibility manipulation (i.e, a spatial correlate to the Stroop Task) to the spatial occasion setting procedure with humans and pigeons. Generally, human and non-human animals have a tendency to respond towards a stimulus presentation, even if that response is incorrect for the given scenario. We predicted that a S-R incompatible training history (i.e., responding away from the stimulus presentation) would make an occasion setter that signals that response weaker than an occasion setter that signals a S-R compatible response. Results indicate occasion setters from both response histories were effective and transferred well to other landmarks.

7 8:20 PM **Spatial occasion setting following reassignment training in a landmark-based touchscreen task with humans**

Lauren Cleland, Chad Ruprecht, Holly Wright, & Kenneth Leising (Texas Christian University)

We have developed a spatial occasion setting procedure in which the occasion setter signals both whether and where to respond in the presence of a landmark. In the current study with humans, three landmarks were rendered unstable during an initial training session. Establishing an occasion setter as a signal for whether to respond was achieved via trials of a colored background (e.g., X) preceding the onset of a landmark (e.g., XA+) and the opportunity for a reinforced response, but other trials of the landmark alone without the opportunity for reinforcement (e.g., A-). The spatial value of the occasion setter was achieved by reinforcement of a response to the left of landmarks A and B when paired with some occasion setters (+←WA, +←YB) and to the right of these same landmarks when paired with others (XA→+, ZB→+). Additionally, responses to landmark C were reinforced on half of the trials to the right and to the left on the remaining trials (+←C→+). In a subsequent session, two of the previously ambiguous landmarks, A and C, were trained (i.e., reassigned) to signal a reinforced response in a consistent direction (+←C, A→+). We then tested whether the occasion setter W would continue to control spatial behavior to A (+←WA) following reassignment training with A (A→+). The results will be compared to data from pigeons tested in an analogous task.

8 8:27 PM **Detecting the perception of illusory spatial boundaries: evidence from distance judgments**

Bradley R. Sturz, & Kent D. Bodily (Georgia Southern University)

Spatial boundaries demarcate everything from the lanes in our roadways to the borders between our countries. They are fundamental to object perception, spatial navigation, spatial memory, spatial judgments, and the coordination of our actions. Although explicit spatial boundaries formed by physical structures comprise many of the actual boundaries we encounter, implicit and permeable spatial boundaries are pervasive. The prevailing paradigm for detecting implicit spatial boundaries relies on memory-based distance and location judgments. One possibility is that these biases in spatial memory may be attributable to initial biases in spatial perception, but the extent to which implicit spatial boundaries bias spatial perception remains unknown. An approach for detecting the perception of implicit spatial boundaries would be to infer it through known systematic biases in memory-based distance judgments. We harnessed known biases in memory-based distance judgments to infer perception of spatial boundaries by probing the extent to which distances were overestimated across potential spatial boundaries. Results suggest that participants perceived potential spatial boundaries as illusory spatial boundaries leading to biased judgments of distance. A control group eliminated simple two-dimensional distance cues as responsible for this bias. This bias provides a novel method to detect the perception of illusory spatial boundaries.

9

8:41 PM **Reference and working memory in the domestic dog using a spatial memory task**

Krista M. Macpherson, & William A. Roberts (Western University)

Domestic dogs were tested on a spatial memory task using a win-shift procedure. Four identical planks were placed 13.7 m apart, forming a square arena with a plank in each corner. Identical buckets were inverted and placed over these planks to hide potential food rewards. In the study phase of each trial, 2 of 4 locations were baited, and the dogs were allowed to knock over these buckets to obtain the food. In the test phase, all 4 locations had buckets in place, but the only buckets with a hidden food reward were those two that had not been baited in the study phase. Importantly, one corner in the test phase was designated a reference memory (RM) corner because it was always baited in the test phase (and thus never baited in the study phase), while the other baited corner was designated a working memory (WM) corner (and alternated between the three non-RM corners across trials). Dogs demonstrated preference for the RM corner but also improved in their ability to recall the WM corner across trials. Retention intervals were then inserted between the study and test phases in order to determine how RM and WM might be lost over time.

10

8:48 PM **Use of local geometric cues and medial axes for reorientation by the Clark's nutcracker (*Nucifraga columbiana*)**

Teagan A. Bisbing, & Debbie M. Kelly (University of Manitoba)

As animals move about they need to extract information from their surroundings, allowing them to orient. Although many studies have suggested that geometric relationships among surfaces in the environment can be useful sources of such information, little is known about how animals encode geometry. Two theoretical mechanisms have been proposed for encoding geometric properties of the global environment: principal axes and medial axes. Furthermore, localized geometric information may also be crucial for orientation, and may be encoded by processing surface and object metrics in relation to one another or by processing the absolute metrics of surfaces. Here, we attempt to isolate the mechanisms that support the encoding of geometry. Clark's nutcrackers, a food-storing bird with specialized adaptations for spatial memory, were trained to find food consistently positioned in geometrically equivalent corners within a rectangular arena. They were subsequently tested in an L-shaped arena, a transformation that isolated each geometric encoding strategy according to distinct behavioral patterns. Results suggest that the birds used the relative metric properties of local geometric information as a primary strategy for reorientation, and used medial axes secondarily. Comparisons are made between the choice patterns of the nutcrackers and previous findings in domestic chicks, pigeons, and humans.

8:55 PM *Break*

9:05 PM Cognitive Processes I (Chair: Noam Miller)

11

9:05 PM **Inhibitory control in pigeons**

Christina Meier, Stephen Lea, & Ian McLaren (University of Exeter)

The cognitive flexibility to correct behaviour when it suddenly becomes inappropriate is seen as a hallmark of executive-control processes; this implies that only species possessing executive control should be capable of inhibiting behaviour after it has been initiated. Yet many species have to contend with unforeseeable events often requiring response inhibition. Do they all possess executive control? We trained pigeons to peck quickly at one of two keys of different colours to obtain a food reward. On some trials, the rewarded key was replaced (after a varying interval) by a signal of a different colour. Now, in Experiment 1, pecking this signal had no effect, but pecking the usually unrewarded alternative key led to a reward, indicating that the response should be changed (Change-Signal task); in Experiment 2, pecking the alternative key still had no effect, but pecking the signal led to a timeout instead of a reward, indicating that a response should be withheld (Stop-Signal task). Pigeons were able to either change or withhold a response when signalled, but doing so became increasingly difficult with increasing stimulus-signal interval. This suggests that pigeons face difficulties inhibiting an already initiated response, but nevertheless are able to do so.

12

9:12 PM **Investigating the effect of rescue on cognitive bias in neglected equines**

Molly McGuire, Zoe Johnson-Ulrich, Silvia Oriani, & Jennifer Vonk (Oakland University)

Changes in affective state of neglected or abused animals can be difficult to quantify in comparison to physical improvements following rescue. We will assess cognitive bias as a measure of affective state in four groups of equines defined by neglect (present or absent) and length of time at rescue facility (one week, over one year). Stimuli will be presented at two locations; one location that is always rewarded (a bucket with food), and another location that is never rewarded (an identical bucket without food) and the latency to approach the stimuli will be recorded. Once differential responding to the two locations has been established, ambiguous locations (spatially between the reward and non-reward locations) will be presented. Responding to ambiguous locations as if they were reward locations is interpreted as a display of positive cognitive bias (optimism). We predict that horses immediately after neglect will show more pessimism compared to controls, but over time will show more optimism as a result of experiencing a great improvement in welfare.

13

9:19 PM

Asian elephant (*Elephas maximus*) performance on a means-end behavioral task

Jessica Spencer (Busch Gardens Tampa), Lauren Highfill (Eckerd College), Otto Fad, & Ann Marie Arnold (Busch Gardens Tampa)

The current study was a systematic replication of the Irie-Sugimoto et al. (2008) study, testing six Asian elephants (*Elephas maximus*) on a means-end behavioral task of pulling a support to retrieve a distant object. The paradigm was somewhat modified from the original research to accommodate a protected contact setting, reduce the total number of trials, and one condition was excluded. Each elephant was tested on three conditions of increasing difficulty. Specifically, subjects were asked to select from a choice of two trays where one intact tray was baited with a highly-valued produce item and the other was A) empty; B) baited adjacent to the tray; and C) baited on the far side of a break in the tray. Results indicated that the elephants met or exceeded the criteria established for Conditions A and B, but performed at chance levels on Condition C. These data are contrasted with those of the original study where one elephant met criteria for all three conditions, and we will discuss potentially relevant variables affecting performance including differences in visual access to the trays, motivation levels, and the balance of reinforcement necessary to maintain voluntary participation in the study.

14

9:26 PM

The octopus with two brains

Frank W. Grasso (BioMimetic and Cognitive Robotics Lab)

Cephalopods are arguably the most cognitively and neuroanatomically sophisticated of the invertebrates. Their sophisticated behavioral repertoires and markedly non-vertebrate brain architecture afford opportunities for the study of convergent evolution of higher cognitive functioning. Young demonstrated that the neuroanatomical complexity of the central nervous systems of cephalopods ranked comparably in neurons numbers and hierarchical connective organization to mammals. Wells' studies of octopus behavioral and learning capabilities highlighted two complex, interacting, sensory-motor processing systems in the octopus. A chemo-tactile system based on sensory input from the octopuses' eight arms and a visual system based in inputs from the octopuses' a paired eyes. I will review this literature and summarize behavioral results from our laboratory that highlights the challenges of how learning, memory and integrated complex behavior can be accommodated in a nervous system that has 2/5ths of it's neurons in a vertebrate "bilateral" organization and 3/5ths in a distributed, radial organization. The results show that the bilateral and distributed systems support coordinated behaviors and require information sharing between both systems. The octopus studies raise important questions about how we can infer representation from behavior and neuroanatomical evidence and cast a cautionary light on interpretation of convergent brain evolution.

15

9:40 PM

Perceptual categorization and analogical transfer in pigeons

Muhammad A. J. Qadri (Tufts University), J. David Smith (University at Buffalo), F. Gregory Ashby (University of California Santa Barbara), & Robert G. Cook (Tufts University)

The investigation of categorization focuses on the similar treatment of distinctive and novel items based on previously learned exemplars. Analogical transfer in categorization has been described as continued categorization despite dramatic changes to salient features of the stimuli. Two studies with human and non-human primates have investigated this type of transfer using multidimensional, continuous, bivariate distributions of stimuli previously used to investigate explicit and implicit perceptual categorization. Those investigations found that both primates showed analogical transfer when explicit categorization was available and poor transfer when implicit categorization was necessary, a pattern which aligns with complex theories of categorization. We extended this comparison by testing pigeons in a similar design. We found that pigeons showed the same pattern of results. Further tests and model simulations, however, suggest these pigeon results can be accounted for within the simple context of implicit categorization.

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9:47 PM

Pilfering may impose limits on food-cachers' memory

Mikel Delgado, Lucia Jacobs (University of California at Berkeley), & Michal Arbilly (Emory University)

Food-storing animals, such as scatter-hoarding squirrel and bird species, rely on caches to survive periods of scarcity. While they must remember the location of their caches to retrieve them, they also face high rates of theft by conspecifics, rendering their memories useless. To examine this antagonistic relationship, we used agent-based simulations, where caching, memory size, and pilfering were allowed to co-evolve. Individuals were faced with periods of food abundance and scarcity, and could either consume found items, store them, retrieve their old caches, or pilfer the caches of others. Our results indicate that caching evolves even when initial likelihood of caching is low, and pilfering readily evolves in the presence of caching. In the absence of pilfering, selection is strongest for the largest memory size; however, as pilfering rates increase, short-term memory is much more adaptive as old caches are likely to have been depleted. Our findings demonstrate how competition with conspecifics may constrain rather than promote the cognitive abilities of food-storing animals.

9:54 PM **Inference by exclusion in two explorative parrot species**

Ludwig Huber (Vetmeduni Vienna), Mark O'Hara, & Alice Auersperg (University of Vienna)

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Reasoning by exclusion – defined as the selection of the correct alternative by logically excluding other potential alternatives – is well established in humans. So far, only a few animal species have convincingly shown this ability. One problem, especially for inquisitive species, is to inhibit exploring a novel solution. Here, we present a novel approach that takes neophilia into account. We employed a novel training and test method to examine the probability of concurrent decision processes underlying choice behaviour when encountering inconsistent or incomplete information. Importantly, to discourage the explorative behaviour of the tested species, two highly explorative and innovative parrots, kea (*Nestor notabilis*) and Goffin cockatoos (*Cacatua goffiniana*), the training included a large amount of novel, unrewarded stimuli. Once habituated to novelty the majority of kea and cockatoos responded to novel stimuli by inferring their contingency via logical exclusion of the alternative more often than this would be expected by chance. However, other strategies, which are not mutually exclusive, such as one-trial learning or avoiding the negative stimulus, also guided the responses of some individuals. These results confirm previous findings showing the enormous innovativeness and flexibility in problem solving, including the invention of tool use, in these birds.

10:08 PM **Super black feathers: structure, perception, and a proposed sensory bias**

Dakota E. McCoy (Harvard University), & Richard O. Prum (Yale University)

18

Many bird species independently evolved super-black, highly absorbent feather patches that reflect less light even than manmade velvet. We describe peculiar microscopic barbule morphology, hypothesize physical mechanisms by which these structures absorb light, and propose that these feathers evolved through sexual selection via sensory bias. Specifically, super black plumage patches always occur next to brilliant color patches. Evidence from humans indicates that deep black patches impede an observer's ability to estimate how much light illuminates a surface, which makes the adjacent color "pop out' or appear to be self-luminous. This perceptual bias can thus be exploited through sexual selection. In this talk, I will also outline proposed research to test (through behavioural assays) the hypothesized perceptual bias described herein. The anti-reflective microstructures described herein are reminiscent of similar structures in butterfly wings, flower petals, and possibly other organisms, and may have applications to solar cell design, optics, and textile manufacture. Further, this paper investigates visual evolution and sensory bias, as well as feather microstructure. As such this paper should be of interest to a broad readership, including those interested in evolutionary theory, sensory bias, avian biology, materials science, and vision research.

Thursday Afternoon

12:00 PM Ron Weisman Outstanding Student Presentation Competition: Paper - Awards Funded by Elsevier (Chair: Chris Sturdy)

19 12:00 PM

Heart rate variability as a physiological index of the exertion of impulse control in dogs

Sarah Beurms, Yannick Boddez (KU Leuven), Stefan Sütterlin (Lillehammer University College Oslo University Hospital - Rikshospitalet), Ellen Van Krunkelsven (Canine Centre of the Belgian Federal Police), & Holly Miller (KU Leuven)

Self-control can be defined as the ability to inhibit impulses in the face of an external demand. Self-control is especially important for working dogs that perform a variety of tasks, such as searching for drugs or missing people, which requires impulse inhibition. We investigated whether heart-rate variability (HRV), a proxy for self-control in humans, was associated with the exertion of self-control by police dogs. We measured the HRV of police dogs during an out-of-sight down-stay exercise for 10 min (Self-Control condition) and for the same duration of time while caged (Control condition). We found that the dogs' HRV was higher when they were exerting self-control than when they were caged. Our result mirrors that reported for humans, and suggests that HRV is associated with the exertion of self-control in dogs.

20 12:07 PM

Adult hippocampal neurogenesis aids pattern separation in Black-capped chickadees

Nicole A. Guitar, & David F. Sherry (The University of Western Ontario)

The function of adult hippocampal neurogenesis is not well understood. It has been proposed to both aid in the formation of memory and to disrupt memory. The present research investigated the effect of decreased hippocampal neurogenesis on spatial working and reference memory in Black-capped chickadees. Two groups were tested in spatial working and reference memory tasks. The treatment group received methylazoxymethanol acetate, a neurotoxin that decreases hippocampal neurogenesis in chickadees. The reference memory task required subjects to remember which six out of twelve locations in trees consistently contained a food reward, and was followed by a reversal. The working memory task required subjects to retrieve one food reward from twelve different locations. The results indicate that a reduction in adult hippocampal neurogenesis had no effect on the performance of either the spatial working memory task or the spatial reference memory task. Significant differences occurred, however, between groups during the reversal phase of the reference memory task. This may indicate that hippocampal neurogenesis contributes to pattern separation: the successful differentiation of similar memories at the time of encoding.

21 12:14 PM

Dissociation of threat level and behaviour: Differences between conspecific and heterospecific signals

Jenna V. Congdon, Allison H. Hahn, Neil McMillan, & Christopher B. Sturdy (University of Alberta)

The namesake chick-a-dee call of North American black-capped chickadees (*Poecile atricapillus*) is produced in a variety of contexts, such as in the presence of predators when it is referred to as a mobbing call. Smaller owls and hawks are of higher threat to chickadees, and chickadees produce more D notes in the presence of high-threat predators than to low-threat ones. Previous research has also found that similar levels of neural activation, measured with immediate early gene expression, occurs following presentation of predator vocalizations and corresponding mobbing calls (i.e., made in the presence of the same predator). In order to investigate behavioural responses, we presented chickadees with playback of high- or low-threat predator and conspecific mobbing vocalizations. Chickadees moved less during the playback of all conspecific calls and more during the playback of all predator vocalizations. We suggest that the latter response is likely due to the initiation of mobbing behaviour, or alternatively results from birds changing positions in an effort to visually locate a potential predator.

22 12:21 PM

Rats remember item in context using episodic memory

Danielle Panoz-Brown, & Jonathon Crystal (Indiana University)

Vivid episodic memories in humans have been characterized as the replay of unique events in sequential order. However, sequential events differ in the age (and hence the relative familiarity) of memories. Therefore, it is difficult to rule out non-episodic (i.e., familiarity based) explanations for the putative episodic memories of sequential events. Here we asked if rats remember the occurrence of multiple unique events and the contexts in which these events occurred (i.e., item in context memory). We used a well-established olfactory memory task in which novel (but not old) odors were rewarded. Our data suggest that rats remember the context in which odors were presented. When the identity of item in context was put in conflict with familiarity cues, rats relied on item in context memory rather than familiarity. We conclude that rats remember multiple unique events and the contexts in which these events occurred using episodic memory.

23

12:28 PM **Individual differences in dolphins while watching video footage**

Kelley Winship (University of Southern Mississippi and Dolphins Plus Oceanside), Holli Eskelinen (Dolphins Plus Oceanside), Secret Holmes (Gulf World Marine Park), & Stan Kuczaj (University of Southern Mississippi)

Video media is a convenient way to test various cognitive abilities in animals. However, it is important to understand how individual differences may influence an animal's interest in and responses toward the videos, as animals' preferences may preclude appropriate interactions with the testing footage and could incite fear or avoidance. In order to examine how individual differences might influence interest in a television, two dolphin species were exposed to five different categories of videos and interest levels (percentage of time watching) and engagement (behavioral rate per minute) were assessed. A subadult male *Tursiops truncatus* and a subadult female *Steno bredanensis* showed the highest mean percentages of time watching the footage, as well as the overall highest mean behavioral rate. The preferences of these animals toward video categories were determined and comparisons between the individuals were made, with significant differences in the types of behaviors observed. The variation in behavioral response toward the television suggests that using video footage to test cognitive abilities in dolphins, as well as its possible implementation as an enrichment device, should be undertaken with caution, as individual differences such as species, age class, and sex, have the potential to cause excessive variability.

12:35 PM Choice (Chair: David Brodbeck)

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12:35 PM **Chimpanzees can point to small amounts of food to accumulate larger amounts: Reversing the reverse-reward contingency error?**

Michael J. Beran, Brielle T. James, William Whitham, & Audrey E. Parrish (Georgia State University)

In the reverse-reward contingency task, two sets of food items are presented. Subjects get whichever set they do not point toward. Nonhuman primates often fail this test. We presented three chimpanzees with a bowl and a single food item. Pointing to the food item led to its transfer to the bowl, and then the presentation of another food item compared to the bowl. This continued until chimpanzees touched the bowl and received its contents, at which point the trial ended. All chimpanzees pointed repeatedly toward the single food item over the larger set in order to accumulate more food. When low preference food items were included with high preference items, the chimpanzees would add a low preference item to the accumulation to keep the trial progressing, and then take the bowl once all high preference items were accumulated. This showed that the chimpanzees monitored which items moved to the accumulation bowl. When presented with the standard reverse-reward task, all chimpanzees failed. Chimpanzees can point to less food to get more food if the contingency for pointing to small food amounts is the continual growth of eventual reward.

25

12:49 PM **The ephemeral choice task: When apparently easy tasks are very difficult**

Jonathon Berry, Jacob Case, & Thomas Zentall (University of Kentucky)

Sometimes the ability to learn a task challenges traditional notions of species-relative intelligence. In the ephemeral choice task, choice of alternative A provides reinforcement and terminates the trial, whereas choice of alternative B also provides reinforcement, yet it additionally allows access to A and its reinforcement. Optimal performance is to always choose B, the so-called ephemeral option, since it results in double the reinforcement. Though this task should be easy to learn, only fish and grey parrots have been found to solve it, consistently selecting B; pigeons and even presumably more intelligent species like monkeys and many apes fail. Exploring this task in other species could prove fruitful in identifying the cognitive mechanisms involved, and to inform their evolutionary history—we have investigated this phenomenon in rats. We tested the rats on an operant version of the task and hypothesized that given their successful performance on similar choice tasks rats might acquire this task. In fact, we found that rats showed little evidence of learning this task. For inexplicable reasons, it appears that several species fail to associate the second reinforcement with their initial choice.

26

12:56 PM **Pigeons do not prefer a near hit alternative in a slot machine like task**

Jacob Case (University of Kentucky), Ines Fortes (University of Minho), & Thomas Zentall (University of Kentucky)

Near hit (sometimes referred to as a near miss) is an outcome that is interpreted as being close to a win, while still being a loss. For example, in a slot machine in which three of a kind is a winner, OOX is a near hit, whereas OXO is a clear loss). Humans have shown preferences for near hit patterns in a variety of gambling contexts (e.g., slot machines, lottery tickets). The current procedure involves the design of a slot machine. Each trial starts with an observing response and choice. Choice of the near-hit option produced a column of three red lights or green lights (a hit); or two reds and a green or two greens and a red (a near hit). Choice of the clear loss produced a hit or a clear loss (red followed by green followed by red or green followed by red followed by green. We found that contrary to humans, the pigeons showed a preference for the clear loss over the near hit outcomes. Differences between humans and pigeons preference will be discussed (in the 15 s that remain).

27

1:03 PM **Revisiting the midsession reversal procedure in humans**

Neil McMillan, & Marcia L. Spetch (University of Alberta)

It has been shown previously that some animals make surprising anticipatory errors on tasks in which contingencies of reinforcement reverse midway through each session; however, humans have been suggested not to display the same error patterns. We trained human undergraduates on several variants of the midsession reversal procedure inspired by recent research. Participants were run for 400 trials, split into 10 blocks of 40 trials each, with one stimulus correct for the first half of each block and the other stimulus correct for the other half. While some participants were presented with simultaneous choices, others were given a go/no-go version of the task; each group was further split by having the first-correct stimulus either fixed or alternating each block. Though humans exhibit better absolute task performance than do pigeons, both species make errors indicative of similar processes: anticipation on a fixed task but a lack of control by time on alternating tasks, and go/no-go performance suggesting that the differences between tasks reflect failures of inhibition.

1:17 PM **Plasticity and flexibility are independent individual traits in a flower bat**

Sabine Wintergerst, Vladislav Nachev, & York Winter (Institute of Biology - Humboldt University – Berlin - Germany)

28

Animals constantly need to update and fine-tune behavioural responses to current conditions. Behavioural plasticity is a longer term ability to fine-tune behaviour to environmental conditions. Flexibility is the short-term ability to shift from one behavioural response to another. We tested the hypothesis that plasticity and flexibility differ in underlying mechanisms by measuring variation between individuals in plasticity and flexibility, and then evaluating correlation between individual traits. We determined plasticity as the change in allocation of foraging time between exploitation and exploration under different food availabilities. We determined flexibility from perseverance behaviour in a "reversal paradigm". 44 male Costa Rican rainforest flower bats *Glossophaga commissarisi* participated in the experiments. 12 bats marked with ID chips participated as a group in an experiment at a time. For a single individual only 2 out of 12 available feeders in a 4x8m outdoor flight cage were active during an experimental session. During the first experiment, bats were exposed to three levels of reward probability in different sessions. During the second experiment, we determined perseverance from continued visiting of a feeder that had become inactive. We found no correlation between our individual measures for plasticity and for flexibility, indicating that they rely on independent mechanisms.

1:31 PM *Break*

1:36 PM Biopsychology (Chair: Olga Lazareva)

1:36 PM **Impaired short-term and long-term spatial memory and disrupted hippocampal connectivity in wild sea lions naturally exposed to algal toxin domoic acid**

Peter Cook (Emory University), Colleen Reichmuth (University of California Santa Cruz), Gregory Berns (Emory University), Andrew Rouse (University of California Santa Cruz), Laura Libby (University of California Davis), Sophie Dennison (Animal Scan Advanced Veterinary Imaging), Owen Carmichael (Pennington Biomedical Research Center), Kris Kruse-Elliott, Josh Bloom (Animal Scan Advanced Veterinary Imaging), Baljeet Signh (University of California Davis), Vanessa Fravel, Lorraine Barbosa (The Marine Mammal Center), Jim Stuppino (Animal Scan Advanced Veterinary Imaging), William Van Bonn (Shedd Aquarium), Frances Gulland (The Marine Mammal Center), & Charan Ranganath (University of California Davis)

29

Domoic acid is a naturally occurring neurotoxin produced by increasingly frequent and widespread algal blooms. The most visible victims are California sea lions (*Zalophus californianus*), with hundreds stranding in distress each year. Affected sea lions reliably develop gross hippocampal lesions, but no prior work has examined behavior in these animals. We obtained measures of hippocampal damage from structural MRI, and behavioral measures of spatial memory in 30 sea lions undergoing rehabilitation. Extent of right hippocampal damage predicted number of errors in a delayed alternation task and once-daily spatial foraging task, and extent of right dorsal hippocampal damage predicted a slower learning rate for the location of a food cache across days. Using in vivo functional brain imaging in 11 additional sea lions, and post-mortem diffusion white matter mapping in 8 brains, we showed disrupted connectivity between the hippocampus and thalamus and fornix pathology in animals with domoic acid poisoning. In humans, the hippocampal-thalamic pathway is essential for event-related or episodic memory. Together, these findings indicate pervasive memory deficits in sea lions with domoic acid poisoning. Sea lions are flexible central place foragers, and spatial memory impairment likely interferes with foraging and navigation, driving stranding and mortality.

1:50 PM **A re-examination of ZENK expression following hetero- and conspecific playback in the zebra finch auditory forebrain**

Erin N. Scully (University of Alberta), Allison H. Hahn (University of Wisconsin), Kimberley A. Campbell, Neil McMillan, Jenna V. Congdon, & Christopher B. Sturdy (University of Alberta)

30

Zebra finches (*Taeniopygia guttata*) are sexually dimorphic songbirds, not only in appearance, but also in vocal production. While the males produce both calls and songs, the females only produce calls. One particular vocalization, their distance call, differs between the sexes; however, the call of both males and females typically consists of one or two harmonic notes. Avey et al. (2014) presented hetero- and conspecific calls, including zebra finch calls, to adult male black-capped chickadee (*Poecile atricapillus*). ZENK expression, an immediate early gene, was measured in two auditory forebrain areas (caudomedial mesopallium, CMM, and caudomedial nidopallium, NCM). In black-capped chickadees, there was no significant difference in expression for calls produced by other species that were phylogenetically distant from black-capped chickadees. Here, we replicated that study with adult male and female zebra finches. We found no difference in ZENK expression in either male or female zebra finches regardless of the playback; however, there was a trend for more expression, in both males and females, in response to female zebra finch distance calls. Our results suggest that, similar to black-capped chickadees, zebra finch expression in the CMM and NCM is related to acoustic similarity and not phylogenetic distance.

1:57 PM

31

Song control or vocal control? The role of HVC in black-capped chickadee call production

Shannon K. Mischler, & Scott A. MacDougall-Shackleton (University of Western Ontario and Advanced Facility of Avian Research)

Songbirds are one of the few animal clades to have developed the capacity for vocal learning. During development (the sensory phase) birds must be exposed to adult birdsong in order to learn their song. The song-control system, including the brain region HVC, in the songbird brain is crucial for the learning, production and maintenance of song. In contrast to birdsong, bird calls are typically thought to be innate and are used in a variety of contexts: in aggressive encounters, to maintain contact or to indicate mild alarm. In some cases calls are plastic, and may therefore have a learned component. Black-capped chickadees produce a variety of complex calls in addition to their song. This study aimed to determine the behavioural role of HVC in the production of the chick-a-dee, gargle and tseet calls in black-capped chickadees. Immediate-early gene expression is high in HVC during production of gargle calls as well as song, suggesting that HVC is important for the production of learned calls. In the current study chickadees' calls were recorded, and a baseline of each call type was acquired. The birds then underwent an HVC lesion surgery, and calling behaviour was examined post-surgery. Results will be discussed.

2:04 PM

32

Yawn duration predicts brain size and complexity in mammals

Andrew Gallup, & Allyson Church (State University of New York at Oneonta)

Previous research suggests that yawning functions to promote cortical arousal through enhanced circulation and brain cooling. Although yawns or yawn-like mandibular gaping patterns have been identified across vertebrate classes, comparative investigations into the variation of this behavior are lacking. Here we propose that differences in the motor pattern may be tied to corresponding neurological variation between species, whereby longer yawns are needed for animals with larger and more complex brains. To test this we gathered video clips of yawns for over 20 mammalian species in which there was available brain size and complexity data to draw to from (i.e., brain weight, encephalization quotient, and number of cortical neurons). Results indicate that interspecies yawn duration is a significant positive predictor of brain size and complexity. These findings have the potential to drastically alter our understanding of why animals yawn.

2:11 PM

33

Prefrontal neurons encode actions and outcomes in conjunction with spatial location

Brett Gibson, Kristen Onos, Miranda Francoeur, Benjamin Wormwood, Rikki Miller, & Robert Mair (University of New Hampshire)

To respond adaptively to change organisms must utilize information about recent events and environmental context to select actions that are likely to produce favorable outcomes. We developed a dynamic delayed nonmatching to position task to study the influence of spatial context on event-related activity of medial prefrontal cortex neurons during reinforcement-guided decision making. We found neurons with responses related to preparation, movement, lever press responses, reinforcement, and memory delays. Combined event-related and videotracking analyses revealed variability in spatial tuning of neurons with similar event-related activity. While all neurons exhibited spatial tuning broadly consistent with correlated behaviors, for instance reinforcement-related activity concentrated in locations where reinforcement was delivered, some had elevated activity in more specific locations, for instance reinforcement-related activity in one of several locations where reinforcement was delivered. A similar distinction was observed for neurons that did not exhibit criterion event-related activity: some fired throughout all areas visited during training sessions and others at specific locations. Our results suggest that reinforcement-guided decision making emerges from discrete populations of medial prefrontal neurons that encode planned or ongoing movements and actions and anticipated or actual action-outcomes in conjunction with information about spatial context.

2:25 PM

34

The role of food quality on food intake and energy consumption, body weight, exercise, and motivation in rats.

Aaron P. Blaisdell, Eric Sosa, Ava Abuchaei, Neveen Youssef, Andrew Thompson, & Alicia Izquierdo (UCLA)

We previously found that compared to rats that consumed a healthy control (CON) diet, rats that consumed a refined, purified (REF) diet showed deficits in motivation and attention. In this talk, I will describe the effect of 6 weeks of diet quality (REF vs CON) on changes in food intake and energy consumption, and in changes in body weight. I will report interesting interactions between diet quality, on the one hand, and body weight and food consumption, on the other, in response to discontinuation of behavioral testing and while remaining on their respective diets. Next, I will discuss the effects of either switching from REF to CON or remaining on REF on the amount of time spent running when given voluntary access to a running wheel. Finally, using a progressive-ratio (PR) schedule of sucrose-solution reinforced lever pressing, I will show how switching from REF to CON for 5 weeks resulted in a rescue of the motivational deficits induced by chronic consumption of the REF diet. Together, the results suggest that highly processed diets dysregulate energy homeostasis, and that switching from REF to CON results in selective recovery of motivation that does not include the motivation to exercise or its benefits.

2:39 PM *Snack Break*

3:10 PM Communication (Chair: John Magnotti)

3:10 PM

Biological salience influences song discrimination: Evidence from chickadees and neural networks

Christopher B. Sturdy (University of Alberta), Allison H. Hahn (University of Wisconsin), John Hoang, Neil McMillan, Kimberley A. Campbell, & Jenna V. Congdon (University of Alberta)

35

In temperate songbirds, male song has been relatively well-studied, while it was thought that females did not produce song. However, there is now evidence from numerous species that females also produce song. We recently described male and female song production by black-capped chickadees, including acoustic differences in the song's first note (fee note). To examine if chickadees perceive sex differences in songs, we trained birds on an operant discrimination task. Results from the discrimination task demonstrated that birds perceive sex-based differences in songs; however, results did not reveal use of any one specific acoustic mechanism. In order to examine the discrimination of songs in the absence of biological factors, we trained artificial neural networks (ANNs) on an analogous task. Similar to chickadees, the discrimination abilities of ANNs generalized to novel song exemplars. However, unlike the responding by birds, ANNs responded to manipulated songs in a manner consistent with our predictions based on bioacoustic analyses. Specifically, ANN results revealed that features in the fee note are a primary acoustic mechanism that could be used to discriminate male and female songs. Taken together, these results suggest that biological salience associated with the songs may influence the discrimination abilities of chickadees.

3:24 PM

Endocannabinoid expression and reward associated with affiliative singing in male European starlings

Allison H Hahn, Devin P Merullo, Jeremy A Spool, Caroline S Angyal, Sharon A Stevenson, & Lauren V Riters (University of Wisconsin-Madison)

36

For many species, communication signals, such as vocalizations, are essential for social interactions. Male songbirds produce high rates of sexually-motivated or agonistically-motivated song to attract mates or repel rivals during the breeding season, but some songbirds continue to sing year-round. For example, European starlings produce high rates of nonsexually-motivated song in the nonbreeding season while in large affiliative flocks, and different reward mechanisms regulate communication under different social contexts. Song produced in an affiliative context may be intrinsically rewarding and mediated by opioids. Endocannabinoids modulate the opioid system and are involved in regulating reward and singing behavior, but the contributions of endocannabinoids to song-associated reward in an affiliative context are unknown. In the current study, we examined the role of endocannabinoids in song-associated reward in a nonbreeding context. Using a modified conditioned place preference paradigm to measure song-associated reward, we found that song production positively correlates with conditioned preference strength, demonstrating a link between producing song and reward. Preliminary data reveal that song production relates to endocannabinoid expression in the ventral tegmental area, a brain region implicated in reward and motivation. These results suggest a role for endocannabinoid signaling in reward mechanisms associated with communication outside of a sexually-motivated context.

3:38 PM

Overt intentionality in an object choice task in bonobos and dogs

Heidi Lyn (University of Southern Mississippi), Stephanie Jett (University of South Alabama), Megan Broadway, Mystera Samuelson, Jennie Christopher, & Bea Chenkin (University of Southern Mississippi)

37

One consistent argument surrounding the difference between human and nonhuman communication systems is that nonhuman animals rely entirely on associative learning to follow communicative acts, like pointing, while humans rely on cognitive representations of the intentions of the communicator (e.g. Tomasello, Scott-Phillips). In this scenario, in an object choice task (point following) humans would require obvious cues to the communicative nature of a point (overtly communicative cues) while nonhumans should perform at the same level whether those cues are present or not. To evaluate this theory, we tested 3 bonobos (*Pan paniscus*) on the object choice task both with and without overtly intentional cues (e.g. gaze alteration). When these cues were removed, the apes' performance fell from almost perfect to chance levels, indicating that intentional cues are vital for the performance of bonobos in this task ($p<.01$, binomial tests). A similar study is underway with domestic dogs (*Canis familiaris*). Data collection from this first stage will be completed by the date of the conference. These findings suggest strongly that nonhuman animals utilize overtly intentional cues to recognize gestural communication from humans, suggesting that comprehension of overt intentionality is not the key distinction between the communicative systems of animals and humans.

3:52 PM Canine Cognition (Chair: Reggie Gazes)

38

Canine functional imaging and the dog-human bond

3:52 PM *Andie Thompkins, Sinan Zhao, Bhavitha Ramaiahgari, Lucia Lazarowski, Paul Waggoner, Ronald Beyers (Auburn University), Lizzie Benecke (iK9 LLC.), Thomas Denney, Gopi Deshpande, & Jeffrey Katz (Auburn University)*

Dogs provide a unique means of investigating shared human and canine psychological phenomena, and their trainability allows for neuroimaging to be carried out non-invasively in a conscious and unrestrained state. The experiments discussed here aimed to develop a reliable and valid stimulus set of emotion expression in human faces, identify longitudinal changes in activation patterns specific to familiarity and emotion recognition in the domestic dog, and identify brain-behavior relationships relevant to the dog-human bond. To investigate the neural mechanisms of dogs' sensitivity to faces and emotions, we targeted differential activation patterns mediated by familiarity and emotional valence of stimuli. We observed activation patterns analogous to those found in humans and non-human primates, notably in the amygdala and hippocampus. Using an unsolvable task, we sought to identify behavioral tendencies to demonstrate attachment to a familiar person during stressful situations. Familiarity bias scores obtained in the unsolvable task were correlated with neural activations on an individual dog basis, and neuroimaging data for each dog were compared across longitudinal timepoints. These findings add to the understanding of canine cognition, identification of neural correlates of behavior, and can validate early-life selection measures for dogs in working roles.

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3:59 PM **Qualitative differences in behavioral flexibility between dogs (*Canis familiaris*) and pigeons (*Columba livia*)**

Kristina Pattison, Jennifer Laude, Rebecca Rayburn-Reeves, Daniel Michler, & Thomas Zentall (University of Kentucky)

Pigeons given a simultaneous spatial discrimination reversal, in which a single reversal occurs at the midpoint of each session, consistently show anticipation prior to the reversal as well as perseveration after the reversal, suggesting that they use a less effective cue (time) than what would be optimal to maximize reinforcement (local feedback). In contrast, rats (Rattus norvegicus) and humans show near-optimal reversal learning on this task. To determine whether this is a general characteristic of mammals, in the present research, pigeons (*Columba livia*) and dogs (*Canis familiaris*) were tested with a simultaneous spatial discrimination mid-session reversal. Overall, dogs performed the task more poorly than pigeons. Interestingly, both pigeons and dogs employed what resembled a timing strategy. However, dogs showed greater perseverative errors, suggesting that they may have relatively poorer working memory and inhibitory control with this task.

40

Dogs preferentially give to friends

4:06 PM *Mylène Quervel-Chaumette (University of Vienna), Rachel Dale, Sarah Marshall-Pescini (University of Vienna and Wolf Science Center), & Friederike Range (Wolf Science Center of Austria)*

Pro-sociality or other-regarding preferences are defined as voluntary actions that benefit others. Such behaviors routinely occur in humans and can be directed towards complete strangers. However most occurrences of pro-social behaviors tend to be directed towards kin, social partners and in-group members. Similarly, pro-social tendencies in non-human primates have been found to be strongest towards familiar and bonded partners such as group members. In the current study, using a bar pulling paradigm, we sought to determine whether pet dogs would exhibit pro-social behaviors in terms of delivering food to a conspecific (while obtaining none themselves) and whether they would do so more for a familiar social partner than for a stranger. Importantly, it is the first study using this paradigm, which included controls to look at potential social facilitation effects. Results showed that dogs exhibit pro-social behaviors towards a familiar but not towards a stranger conspecific. These results support the idea that pro-sociality may not be related to phylogenetic closeness to humans but rather to a species sociality and reliance on cooperation.

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4:13 PM **Neurobehavioral evidence for individual differences in canine cognitive control: An awake fMRI study**

Gregory Berns, Peter Cook, & Mark Spivak (Emory University)

Based on behavioral evidence, the domestic dog has emerged as a promising comparative model of human self-control. However, while research on human inhibition has probed heterogeneity and neuropathology through an integration of neural and behavioral evidence, there are no parallel data exploring the brain mechanisms involved in canine inhibition. Here, using a combination of cognitive testing and awake neuroimaging in domestic dogs, we provide the first evidence localizing frontal brain regions underpinning response inhibition in this species, and demonstrate the dynamic relationship between these regions and behavioral measures of control. Thirteen dogs took part in an in-scanner go/no-go task and an out-of-scanner A-not-B test. A frontal brain region was identified showing elevated neural activity for all subjects during successful inhibition in the scanner. Moreover, the level of activation was correlated with both false alarm rate and the dogs' liberalism/conservatism (Grier's beta). Conservative performance in the go/no-go task was also correlated with fewer errors in the out-of-scanner A-not-B test, suggesting that dogs show consistent neurobehavioral individual differences in cognitive control, as is seen in humans. These findings help establish parity between human and canine mechanisms of self-control and pave the way for future comparative studies examining their function and dysfunction.

4:27 PM **Dogs' intuitions about gravity and solidity revisited: The tubes task and the shelf task**

Emma Tecwyn, & Daphna Buchsbaum (University of Toronto)

42

In comparison to the wealth of research on dog social cognition, dogs' physical cognition skills are relatively understudied. We tested domestic dogs on versions of two classic physical reasoning tasks: the tubes task and the shelf task, to investigate their intuitions about gravity and solidity. In the tubes task dogs had to search for a treat dropped down a diagonal opaque tube which was connected to one of three possible cups. In the shelf task a treat was dropped behind a screen and dogs had to search in one of two possible locations: top (treat landed here if the shelf was present); or bottom (treat landed here if the shelf was absent). We found no evidence for a gravity bias in either task: there was no significant preference for the gravity cup in the tubes task, or for the bottom location in the shelf task. There was also no evidence that dogs searched on the basis of the solidity principle, because they did not perform better than expected by chance in either task, though performance improved across trials. Results are discussed in the context of previous findings with dogs, non-human primates and children in similar tasks.

4:41 PM *Break*

4:51 PM Cognitive Processes II (Chair: Andrew Gallup)

4:51 PM **Search strategies during change detection by pigeons (*Columba livia*)**

Walter T Herbranson (Whitman College)

43

Pigeons can detect several kinds of changes, including changes in form, brightness, and color. Previous research has suggested that in change detection tasks, pigeons engage in a serial search, moving from location to location until a change is detected. If so, then pigeons might adjust their search process to make use of information about the most likely location of an upcoming change. Pigeons learned a change detection task in which they viewed alternating displays consisting of lines projected onto three response keys. Features on one key changed between displays, whereas the other two remained constant, and pecks to the changing key were reinforced. In each of three conditions, one key had a higher probability of displaying a change. Pigeons increased the likelihood of successful detection by beginning their search in the location that was most likely to change. This location varied across conditions, and pigeons' preferences matched it in each. Thus, pigeons were able to learn the base rates, and exploit them to produce more efficient change detection. These results contribute to a more complete understanding of change detection, and may also provide some insight into phenomena such as change blindness.

5:05 PM **Rats' knowledge that an outcome is a continuous variable increases their use of an additive causal-invariance function in a blocking procedure**

Mary E. Flaim, Julia Schroeder, Jeffrey K. Bye, Laura Bedoyan, Rui He, Pimlada Tantiwuttipong, Patricia W. Cheng, & Aaron P. Blaisdell (University of California Los Angeles)

44

Recent studies have shown that both human adults and children assume causal invariance when evaluating candidate causes. We test the generality of this analytic reasoning process in rats. Half of the rats were pre-exposed to visually signaled foot shocks at various intensity levels. Then all rats received blocking training with auditory CSs using training parameters not sufficient to induce a blocking effect. In Phase 1, CS1 was paired with a foot shock and in Phase 2, CS1 and CS2 were paired with a foot shock. The foot shocks in both phases were always at the maximum level experienced by rats in the pre-exposure group. Strong blocking of CS2 was found in rats that had been pre-exposed to a variable shock, but not in rats that had not been pre-exposed. This indicates that the pre-exposure disambiguated that shock is a continuous variable and hence that the CSs should have additive causal capacities: if click were a cause of shock, then shock would have been more intense in Phase 2 than in Phase 1. The disambiguation led the pre-exposed rats to show strong blocking. Thus, similar to humans, rats appear to use rational causal-invariance functions appropriate for an outcome variable type.

5:12 PM **Rats employ both association and chunking strategies to produce an interleaved pattern II**

Karen E. Doyle (Marygrove College), & Stephen B. Fountain (Kent State University)

45

This study examined alternate learning strategies in a serial multiple choice paradigm to determine the extent to which rats are dependent on associative information when solving a cognitively taxing task. Rats in an operant water chamber were presented with a target "run" response subpattern (123456) and an interleaved alternation response subpattern (787878) forming the interleaved pattern 172837485768. Manipulations to the interleaved alternation subpattern occurred between groups. Manipulations included presence of a "cued" forced choice or "uncued" free choice trials, a rule-based alternation pattern structure or random elements, and presence of rule violations (787878 vs. 788778). A transfer presented rats with an unchanged interleaved pattern in a novel context. Performance on both subpatterns was examined. The "run" subpattern was affected by cuing and structure of the alternation subpattern. Violations had no effect. Following transfer to a novel context, disruption to performance was dependent on cue availability within the pattern. The results indicate that rats may be combining several strategies including ordinal position, conditional discrimination learning, rule abstraction and chunking in order to complete this difficult task.

5:26 PM **Within-session sequence learning by pigeons**

Rebecca M. Rayburn-Reeves, Muhammad A. J. Qadri, Dan I. Brooks, Ashlynn M. Keller, & Robert G. Cook (Tufts University)

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The ability for animals to use time as a discriminative cue for adaptive behavior was examined. Using a within-session sequence learning paradigm, four pigeons were presented a 4-alternative simultaneous discrimination consisting of randomly positioned horizontally-aligned colors (ABCD). Each color was reinforced for 24 consecutive trials over the course of a 96-trial session (Trials 1-24, A; 25-48, B; 49-72, C; 73-96, D). After extensive training, pigeons learned to select the correct order of the stimuli across a session. They showed both order-based anticipatory and perseverative errors among the stimuli near each transition point. Probe sessions confirmed that time controlled the transitions across the list items. Further tests extending sessions to 786 trials assessed responding in untrained portions of the temporal landscape. Our findings indicate that pigeons use temporal information to sequentially order complex behavior. Implications for how such temporal sequences are represented in memory are considered.

5:40 PM **Automated cognitive testing in free-ranging wild birds**

Emily Kathryn Brown, & Robert R. Hampton (Emory University)

47

Because cognitive processes are shaped by both long- and short-term environmental pressures, cognition is best understood in context. Though laboratory experiments allow for meticulous control of experimental variables, they divorce cognition from the natural context that may be necessary for its expression. A long-standing problem in the field of comparative psychology is how best to integrate well-documented natural behaviors with an experimentally testable theoretical framework. Yet, few examples exist of automated cognitive testing in wild populations. Here we describe an automated cognitive testing system for wild birds, and preliminary data that we have collected using it. Wild birds were tested in an S+/S- discrimination on an outdoor touchscreen computer apparatus. Correct responses were reinforced with food access below the screen, which terminated after subjects had the opportunity to eat. After the birds learned to respond correctly, the correct stimulus reversed. To continue to receive food rewards, birds learned to suppress responses to the previously reinforced stimulus, and to instead select the previously unreinforced stimulus. Birds successfully completed reversals, demonstrating that we can engage wild birds in sustained cognitive testing over many days using our setup. We will discuss future directions and potential applications of our testing system.

8:30 PM Poster Session I (8:30 - 11:00)

See Poster Abstracts Starting on Page 25

Poster Presenters: Please set up your posters between 8:00 and 8:30

12:00 PM Associative Processes (Chair: Jonathon Crystal)

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12:00 PM **Investigations into the properties of spatial cues and occasion setters using a spatial-search task**

Kenneth Leising, Chad Ruprecht, Joshua Wolf, & Lauren Cleland (Texas Christian University)

There are primarily four orthogonal properties of a spatial cue that determine its utility. How noticeable the cue is (salience), the probability of finding the goal in the presence of the cue vs. in its absence (contingency), the degree to which the cue varies in its position relative to the goal (stability), and the degree to which the cue is temporally or spatially contiguous to the goal (proximity). I will review several experiments using a spatial occasion setting task to study situations in which the properties of separate spatial cues interact to determine spatial behavior. Undergraduate students and pigeons were trained to respond at a target location (+) signaled by a landmark (e.g., LM A), only if the landmark was preceded by a colored display (e.g., X→A+). The direction of the target relative to the landmark (A) was signaled by the colored display (X or Y) which preceded it (+←YA, XA→+). In each experiment, transfer tests with novel configurations of background colors and landmarks were conducted. The results of these experiments will be discussed in terms of spatial learning and occasion setting separately, as well as using spatial learning to study occasion setting and vice versa.

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12:25 PM **If you let me choose, I'd rather mate as a male first**

Beatriz Alvarez (Universidad de Oviedo), Joris Koene (Vrije Universiteit), Karen Hollis (Mount Holyoke College), & Ignacio Loy (Universidad de Oviedo)

Sexual conflict is present in every mating situation because female and male interests are different given the different allocation of their reproductive resources. From an evolutionary perspective, individuals should try to maximize their reproductive fitness and to minimize sexual conflicts. A clear demonstration of this problem arises in simultaneous hermaphroditic species that mate unilaterally (i.e., one individual acts as a male and the other as a female). In this case the first sexual conflict to be overcome is which individual is going to perform which role. Thus they provide a great model to examine what is the best reproductive strategy to take in terms of costs and benefits. One source of information that can contribute to optimize mating encounters is associative learning. In this experiment, we have assessed whether signalling the presence of a conspecific can affect the sexual role of the snail *Lymnaea stagnalis*. Subjects belonging to the experimental group showed an increased male mating performance compared to the control group, for which the cue and the presence of a conspecific were not contingent. The results obtained showed that when subjects were able to predict a mating encounter the preferred reproductive strategy was that of the male role.

50

12:32 PM **Acquisition of temporal duration**

Russell M. Church (Brown University), & Kathryn L. Kalafut (Antioch College)

The purpose of this research was to describe the learning curve of rats with extensive training in different temporal intervals. Twelve Sprague-Dawley rats were trained in a standard Med Associates operant chambers to obtain 45-mg pellets by pressing the lever at the appropriate times. Five days each week, the rats had three 2-hour sessions, with a 30-minute break between sessions in which the lever was retracted and no stimuli were presented. The rats were trained on 75 days (225 hours). The task had randomized 80% fixed-intervals and 20% peak-intervals. The two variables were the length of the intervals (from 16 seconds to 96 seconds), and the length of the number of days of a particular interval (from 17 days to 1 day). The learning curves can be fit by many functions and many models, but different functions are needed to account for the learning curves of individual rats and to account for the learning curves of the mean of the rats.

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12:46 PM **Adaptive significance of negative incentive contrast effects in foraging bees: evidence from the influence of colony state**

Fred Dyer, Allison Young, & Kassie Miner (Michigan State University)

Animals that experience a decline from high to low reward may temporarily depress their feeding compared with control animals that have only experienced the lower reward. This "negative incentive contrast effect" involves both disruption of feeding and search for novel options, suggesting that it is an adaption promoting search given evidence that better options are available. If so, then the propensity to search should be affected by its costs and benefits and the uncertainty of the options. We tested this idea in social bees by manipulating colony food stores. When food stores are empty, foragers should benefit by exploiting known (but downshifted) resources rather than exploring unknown locations. Supporting this prediction, both honey bee and bumble bee foragers were slower to reaccept a downshifted resource, and spent more time in unrewarded search, when the larder was full than when it was empty. Thus, contrast effects show adaptive plasticity mediated by social information. We also compared the species when colony state was matched. Bumble bees, which are generally more reliant than honey bees on individual search, were slower to reaccept a downshifted reward, and searched more extensively. Thus, contrast effects are coadapted to the foraging ecology of a species.

1:00 PM **Reinforcement and the control of behavioral variability: A past and possible future**

W. David Stahlman (University of Mary Washington)

52

Researchers have studied behavioral variability and its causes throughout the bulk of the history of psychological science. A review of this extensive literature reveals a remarkably consistent narrative, one in which organismal response variability is a negative function of reinforcement. This relationship is observed across a wide swath of different experimental manipulations, in both response-relevant (i.e., operant) and response-irrelevant (i.e., Pavlovian) situations, and with a number of species. Here, I present a survey of my research from the last decade on the reinforcement factors that control behavioral variability in animals. This work corroborates and extends the literature on the control of behavioral variability. I argue that these results (amongst others) have vast implications for our science. I suggest that investigators consider adopting a perspective on the appropriate content of psychological science, one in which organismal behavior production is an analogue for the process of biological evolution.

1:25 PM *Break*

1:30 PM Concept Learning (Chair: Bradley Sturz)

1:30 PM **Pigeons (Columba livia) as trainable observers of pathology and radiology breast cancer images**

Edward Wasserman, Victor Navarro (University of Iowa), Elizabeth Krupinski (Emory University), & Richard Levenson (University of California Davis)

53

Pathologists and radiologists spend many years acquiring their medically essential visual skills, making it important to understand how this process unfolds and what image features support accurate diagnostic performance. Insights into human behavioral tasks can often be obtained by deploying animal models. We report that pigeons can serve as promising surrogate observers of medical images. The birds proved to have a keen ability to distinguish benign from malignant human breast histopathology after training with differential food reinforcement; more importantly, the pigeons could generalize their classification behavior to novel image sets. The birds' histological accuracy was modestly affected by the presence or absence of color as well as by degrees of image compression, but these impacts could be ameliorated with further training. Turning to radiology, the birds were similarly capable of detecting cancer-relevant microcalcifications on mammogram images. However, when tasked to classify suspicious mammographic masses, the pigeons were capable only of image memorization and were unable to generalize when shown novel examples. These successes and difficulties suggest that pigeons are well-suited to help us better understand human medical image perception; they may also prove useful in performance assessment and development of medical imaging hardware, image processing, and image analysis tools.

1:44 PM **Powering-up tests for same/different abstract-concept learning**

John Magnotti (Baylor College of Medicine), Anthony Wright (UT Medical School at Houston), Jeffrey Katz (Auburn University), & Debbie Kelly (University of Manitoba)

54

The gold standard for demonstrating abstract-concept learning is the application of a learned rule to novel stimuli. Operationally, this standard often means statistically indistinguishable performance in accuracy on trained and novel stimuli. Many laboratories have used this standard to show abstract-concept learning across a plethora of species. However, accuracy is only one measurement of abstract-concept learning. If subjects are treating novel stimuli identically to trained stimuli, then we should see: 1) equivalent accuracy, 2) equivalent choice response time patterns, and 3) equivalent behaviors during the fixed-response (FR) requirement. We built a simple statistical model of abstract-concept learning to understand how each of these variables changes across training set size and thus co-varies with abstract-concept learning. We analyzed these measures across successive transfer tests in two species: Clark's nutcrackers (n=7) and magpies (n=10). Our results show that response time and FR variables for novel stimuli change across set size expansion. In particular, variables related to the FR, which occurs when only the sample stimulus is on screen, can distinguish between trained and untrained stimuli early in training. Using convergent measures of abstract-concept learning provides a noticeable increase in statistical power, opening the door to detailed analyses of individual-level conceptual behavior.

1:58 PM **Location as an element in pigeons' recognition of visual objects**

Stephen Lea (University of Exeter)

55

A number of different phenomena in pigeon visual cognition suggest that pigeons do not immediately recognize two identical objects in different locations as being "the same". Two experiments were carried out to examine this question directly. Pigeons were trained in absolute go/no-go discriminations between arbitrary selections from sets of 16 images; in Experiment 1, the images were all human faces, in Experiment 2 they were paintings by Claude Monet (these were more easily discriminated than the face images). Of the 8 positive stimuli, 4 always appeared in the same location, while the other 4 appeared equally often in each of 2 locations; and the same was true of the negative stimuli. In both experiments, there was a consistent tendency for the stimuli that appeared in a single position to be better discriminated than those that appeared in two positions. The effects were relatively small, comparable in size to idiosyncratic differences of learning rates to particular stimuli. These results suggest that, for a pigeon, an image's location is one of the bundle of features that define it, and that pigeons need to learn to abstract from that feature rather than doing so automatically.

2:12 PM *Break*

2:17 PM Social Learning (Chair: Debbie Kelly)

2:17 PM **Mechanisms of social influence on rat spatial choice**

Marie E. Saxon, Kelsey A. Heslin, & Michael F. Brown (Villanova University)

56 Rats were tested in a spatial choice task in which information about the location of hidden food was available from the outcome of the rat's previous choices. Information about the hedonic value of food in baited locations was available only from social cues provided by a second (Model) rat. Both kinds of information affected the spatial choices made by the rats. Two lines of evidence indicate that the social influence was driven primarily by a social affiliation tendency rather than by the contingency between locations chosen by the model rat and the hedonic value of the food. [Presented by M.F. Brown]

2:31 PM **Overimitation in the domestic dog: the effect of demonstrator intentionality and causal plausibility**

Daphna Buchsbaum (University of Toronto), Amanda Seed (University of St. Andrews), & Emma C. Tecwyn (University of Toronto)

57 In classic 'overimitation' studies, children blindly copy all actions including ones that are clearly unnecessary, whereas non-human primates only copy necessary actions. In contrast, our recent research has demonstrated that the extent to which children and capuchin monkeys overimitate depends on both the social context and their prior physical knowledge. In the current study, we used the same paradigm to investigate overimitation in the domestic dog. Dogs provide an interesting comparison to primates when considering how social and physical factors influence copying behaviour, given that they appear better able to leverage many human social cues, but may have more limited physical reasoning skills. Dogs observed a human demonstrator perform a 2-action sequence (AB) on a puzzle-box, which then dispensed a reward. We manipulated how necessary the first action (A) seemed across two dimensions: Intentionality (Unknowing, Intentional or Pedagogical demonstration); and Causal plausibility (actions A and B were performed on the Same box, or action A was performed on a Separate box). We recorded the extent to which dogs performed (1) AB sequences; and (2) action A, regardless of whether it formed part of a sequence. Dogs' performance is discussed in relation to our previous findings with children and capuchins.

2:45 PM **Information is information: how pigeons combine personal and 'social-like' cues**

Noam Miller (Wilfrid Laurier University)

58 Animals that live in groups have two sources of information about their environment: personal information, based on their past experiences, and social information, based on the choices made by conspecifics. Animals must combine these sometimes conflicting data and most models assume that they do so by treating each type of information differently. But what if all information enters into learning in the same way, regardless of its source? I show how social cues can be simply incorporated into existing associative models and that this model recreates many empirical collective behavior results. To test this approach, I trained pigeons in operant boxes to solve a discrimination based on two sets of cues: one 'personal' and one 'social-like'. Pigeons combined the cues (under some conditions only) in a way that is consistent with the predictions of the model, suggesting that there may be just one learning mechanism for both types of information.

2:59 PM **Dynamic duos: Prosocial behavior in bats**

Eric Hoffmaster, Jennifer Vonk (Oakland University), & Nadia Siekert (Organization for bat conservation)

59 Once thought to be uniquely human, prosocial behavior has been examined in a number of species, such as vampire bats, which engage in food-sharing at extreme personal cost. Because the chiropteran order, however, is extremely diverse, it has yet to be determined if other bat species also exhibit prosocial behavior. Jamaican fruit bats (*Artibeus jamaicensis*) are a social species that have been observed to engage in such behaviors as cooperative mate guarding, and hence are ideal to study to determine if they also display prosocial behavior. Thus, we assessed whether Jamaican fruit bats would assist a conspecific in an escape paradigm in which a donor could opt to release a recipient from an enclosure. The apparatus contained two compartments - one of which was equipped with a sensor that, once triggered, released the trap door of the adjacent compartment. 66 exhaustive pairs of 12 bats will be tested both when recipient is present and absent to determine cessation rates of releasing the trap door over 44 trials. Bats within a pair will exchange roles on consecutive trials. If donors behave prosocially they should continue to release the door on recipient present, but not recipient absent trials, over time.

3:06 PM **Neonatal imitation and early social experience predict gaze following abilities in infant macaque monkeys (*Macaca mulatta*)**

Elizabeth A. Simpson (University of Miami), Grace Maloney (University of Virginia), Pier F. Ferrari (University of Parma), Stephen J. Suomi, & Annika Paukner (National Institutes of Health)

60 Individuals vary in their social skills and motivation, the causes of which remain largely unknown. Here we investigated whether an individual's propensity to interact with others within days after birth, and differences in infants' early social environment, may predict a later social skill. Specifically, we tested whether neonatal imitation—newborns' capacity to match modeled actions—and social experience in the first months of life predict gaze following (directing attention to locations where others look), in infant macaques (*Macaca mulatta*; n = 119). Facial gesture imitation in the first week of life predicted gaze following at 7 months of age. Imitators were better at gaze following than non-imitators, suggesting neonatal imitation may be an early marker, predicting socio-cognitive functioning. In addition, infants with rich social environments outperformed infants with less socialization, suggesting early social experiences also support the development of infants' gaze following competence. The present study offers compelling evidence that an individual difference present from birth predicts a functional social cognitive skill in later infancy. In addition, this foundational skill—gaze following—is plastic, and can be improved through social interactions in the first months of life, providing infants with a strong foundation for later social interaction and learning.

3:20 PM *Snack Break*

4:00 PM In Honor of the Contributions of Karen Hollis (Chair: Lauren Guillette)

4:00 PM **Video demonstrations to test the effect of social interaction on social information use**

Lauren Guillette, & Susan D. Healy (University of St. Andrews)

61 Zebra finches, a social songbird, use social information when faced with uncertainty: females copy males foraging on novel foods and males copy the nest-material choices of familiar, but not unfamiliar, males. Here we used a one-demonstrator paradigm to test social learning, but, in place of live demonstrators, we used video demonstration. Video demonstration allowed us to examine whether social interaction between the knowledgeable demonstrator and a naive observer was necessary for the transfer of social information. Using a between-subjects design we found that social interaction is not necessary (video playback with no sound) for information transfer to and use by the naive observer. Live streaming video demonstration, where demonstrators and observer could vocally interact, was similarly effective to the no interaction condition, yielding the same results as live demonstrators. When video demonstration with sound (vocalizations but no interaction) was played back, however, the naive observers did not consistently use social information in their novel foraging decisions. Taken together these results suggest that social interaction is not necessary for social learning, and in some cases 'poor' interactions may inhibit transfer and/or use of social information.

4:15 PM **Learning for brood parasites**

David Sherry (Western University)

62 The central theme of Karen Hollis's research has been the adaptive value of learning: how learning equips animals to anticipate and prepare for biologically important events. We have examined how Brown-headed cowbirds' brood parasitic mode of reproduction influences what they learn and remember and how the cowbird hippocampus has been modified to support learning and memory. Female cowbirds learn the locations of potential host nests and re-visit nests to track the number of host eggs and the stage of host clutch completion. Male Brown-headed cowbirds do not search for host nests. We have found sex differences favouring females on tests of spatial memory that resemble search for host nests and sex differences favouring females in adult hippocampal neurogenesis. Females also perform slightly better than males on tests of numerical ability. But on other spatial memory tasks, males perform better than females and some neuroanatomical results show no sex differences in the hippocampus. The adaptive value of learning about host nests differs for female and male cowbirds. Natural selection for successful brood parasitism has acted differentially on females and males, selectively modifying specific learning abilities and the neural structures that support them.

4:30 PM **Rescue behavior or aggression: A dilemma for altruistic ants**

Elise Nowbahari, Vanessa Martinez, Jean-Luc Durand (Université Paris 13 - Sorbonne Paris Cité - France), & Karen L. Hollis (Mount Holyoke College)

63 Previously we have shown that ants, *Cataglyphis cursor*, are able to recognize both nestmates and intruders in various situations and adapt their behavior accordingly: aggression toward strangers and rescue behavior toward entrapped nestmates. In the present study we explored whether the same individual that reacts aggressively toward a stranger would help its entrapped nestmate or whether ants specialize in these two behaviors. In this study, the groups of 5 ants encountered a victim in each of two counterbalanced conditions, namely an entrapped nestmate and an entrapped heterospecific (stranger); following these two tests, ants next were given a preference test in which they encountered both an entrapped nestmate and a heterospecific. The results showed a high positive correlation between the duration of rescue behavior in the nestmate condition and the duration of rescue behavior in the preference test, as well as, in different individuals, a high positive correlation between the duration of aggressive behavior in the heterospecific test and the duration of aggressive behavior in the preference test. These and other results are the first to document individual specializations in rescue and aggressive behavior -- a kind of "personality" -- in ants.

4:45 PM **Coordinating associative and ecological accounts of learning: Conditioning as choice behavior**

Ignacio Loy, Beatriz Alvarez (Universidad de Oviedo), & Eneida Strempler-Rubio (Universidad Nacional Autónoma de México)

64 Pavlovian conditioning of tentacle lowering in the snail, *Helix aspersa*, as an instance of appetitive conditioning has proven effective to show evidence of paradigmatic associative learning phenomena (e.g., blocking) that are explained by current theoretical models. However, the biological function that this kind of learning could have in feeding-related behavioral repertoires such as food finding is unclear. This is especially important given that ecological learning theories claim that the explanation of a particular learning ability must be based on the adaptation to environmental demands. In this talk we review previous literature where no effects of conditioning on food odor preferences or food finding have been obtained, and their potential limitations. In a series of experiments, we show that when these ecological variables were controlled, an effect of learning on food odor preference and food finding was observed. Finally, we discuss the need of a more integrative view of learning, necessary for a better understanding of animal cognition. Associative and ecological accounts of learning can be unified under optimization models in which learning is understood as a decision that the animal needs to make.

5:00 PM **Search image versus search rate: a long-term impact**

Susan D. Healy (University of St. Andrews)

65 In the late 1980's, I was an observer to a debate over whether search image or search rate better explained the prey selection of predators hunting for cryptic prey. During that debate I met Karen Hollis for the first time. It was not a debate that attracted then, or indeed since, much attention. With hindsight, however, I realise that that debate crystallised what has become for me an ever-fascinating pursuit: attempting to find psychological explanations for the behaviour of animals in an ecological context. Furthermore, this debate showed me that testing hypotheses experimentally was one thing but that designing experiments that would usefully pit one hypothesis against another could be a rewarding intellectual challenge. It was also my first, first-hand experience of scientific debate and it seemed exciting and fun. Here I will present some recent work from my own search for the psychological ecology of animals.

5:15 PM **From animal laboratory to the local health clinic**

J. Bruce Overmier (University of Minnesota)

66 Recently, colleagues have lamented the dearth of graduate students entering comparative psychology. And this has as a consequence fewer new PhD researchers as well. Attracting students to the field of comparative psychology depends on our telling true stories about past and ongoing researches in our field—stories about exciting unexpected findings that have importance for the whole field of psychology. Not doing so results in starving the field of popular support, government support, and resources for attracting and supporting new students. If we do not tell these stories, nobody else will. People are fascinated by animals and how "smart" they are, so comparative cognition may well be how we save the discipline.

5:55 PM Introduction - Lauren Guillette

6:00 PM Master Lecture - The role of learning in coevolution: An insect model - Karen Hollis

7:30 PM Banquet

Saturday Afternoon

12:00 PM Business Meeting of the Comparative Cognition Society

1:10 PM Group Photo Shoot

1:30 PM Symposium: Evolution of Music (Chair: Marisa Hoeschele)

Pitch perception in birds and humans

1:30 PM *Marisa Hoeschele (University of Vienna), Lauren M. Guillette (University of St Andrews), Allison H. Hahn (University of Wisconsin-Madison), Robert G. Cook (Tufts University), Bernhard Wagner (University of Vienna), Daniel I. Brooks (Brown University), & Christopher B. Sturdy (University of Alberta)*

67 Although music as we encounter it today in our society has grown through culture, the core aspects of music are present cross-culturally and are biological in origin. Comparative studies can help us understand what distinguishes music from what other animals do, and what traits might predict music-like perception and production. My focus in this talk is on pitch: the perceived highness or lowness of notes. The perception of pitch in an acoustic signal is not as simple as one might imagine. There are many ways to perceive pitch and they sometimes contradict each other. The absolute pitch of a signal is usually its fundamental frequency, but humans also attend to relative pitch (the logarithmic difference in frequency between notes) and chroma (sometimes referred to as the pitch quality which repeats each time frequency is doubled). Sets of notes can also be heard as consonant/dissonant ("pleasing"/"displeasing") depending on the simplicity/complexity of relative pitch ratios. Here I will discuss work comparing humans to avian species in terms of their pitch abilities. In summary, birds have absolute and relative pitch abilities, and there is some evidence that they attend to consonance/dissonance, but no evidence to date that they attend to chroma.

1:44 PM **Do songbirds recognize melody on the basis of absolute pitch? Challenges to a prevailing view.**

Aniruddh D. Patel (Tufts University), Micah R. Bregman, & Timothy Q. Gentner (UC San Diego)

68 Humans easily recognize 'transposed' musical melodies shifted up or down in log frequency. Surprisingly, songbirds seem to lack this capacity, although they can learn to recognize human melodies and use complex acoustic sequences for communication. Two decades of research have led to the widespread belief that songbirds, unlike humans, are strongly biased to use absolute pitch (AP) in melody recognition. This work relies almost exclusive on acoustically simple stimuli that may belie sensitivities to more complex spectral features. Here, we investigate melody recognition in a species of songbird, the European Starling (*Sturnus vulgaris*), using tone sequences that vary in both pitch and timbre. We find that small manipulations altering either pitch or timbre independently can drive melody recognition to chance, suggesting that both percepts are poor descriptors of the perceptual cues used by birds for this task. Instead we show that melody recognition can generalize even in the absence of pitch, as long as the spectral shapes of the constituent tones are preserved. These results challenge conventional views regarding the use of pitch cues in non-human auditory sequence recognition.

Rhythm and regularity perception in birds

1:58 PM *Carel ten Cate, Michelle Spierings, Jeroen Hubert (IBL Leiden University), & Henkjan Honing (ILLC University of Amsterdam)*

69 While humans can easily entrain their behaviour with the beat in music, this ability is rare among animals. Comparative studies may provide insight in how and why this ability evolved. It has been suggested that beat perception and entrainment are linked to the ability for vocal learning. For birds, there is limited evidence for beat and regularity perception, except for some large parrot species, and the link to vocal learning is unclear. Some species show a limited ability to distinguish regular from irregular stimuli over tempo transformations, but most evidence suggests that birds attend primarily to absolute and not relative timing of patterns and to local features of stimuli. In our experiments, we trained zebra finches and budgerigars (both vocal learners) to distinguish a regular from an irregular pattern of beats and then tested them on various tempo transformations of these stimuli. Both species reduced the discrimination after tempo transformations. They attended mainly to local temporal features of the stimuli, although some individuals showed an additional sensitivity to the more global pattern if some local features were left unchanged. Our study indicates that birds attend to a mixture of local and global rhythmic features.

2:12 PM **Exploring the processing advantages of consonance in humans and other animals**

Juan M. Toro, & Paola Crespo-Bojorque (ICREA - Universitat Pompeu Fabra)

70

In the present study we explore the extent to which non-human animals have a processing advantage for musical consonance. Consonance is a salient perceptual feature in harmonic music associated with pleasantness. Research suggests both human infants and adults process more easily consonant intervals than dissonant intervals. We ran experiments on rule learning over consonant and dissonant intervals with rats (a species that, under controlled lab conditions, does not have extensive experience with harmonic stimuli) and human participants. Results show differences across species regarding the extent to which they benefit from differences in consonance. Animals learn abstract rules with the same ease independently of whether they are implemented over consonant intervals, dissonant intervals, or over a combination of them. Humans, on the contrary, learn an abstract rule better when it is implemented over consonant than over dissonant intervals. Results suggest that for humans, consonance might be used as a perceptual anchor by other cognitive processes as to facilitate the detection of abstract patterns. Lacking extensive experience with harmonic stimuli, non-human animals tested here do not seem to benefit from a processing advantage for consonant intervals.

2:26 PM **Beauty and the Beast: Components of music processing in pigeons**

Robert G. Cook (Tufts University)

71

Music is a virtually defining feature of our species. The universal production and perception of music is foundational across human culture and has powerful effects on our thoughts and emotions. Nevertheless, the melodic, harmonic and rhythmic processes that underlie music perception did not evolve fully-formed in our hominid ancestors. There must have been cognitive precursors in non-human animals. This talk will review recent experiments conducted in our lab examining how pigeons process different musically-related features. Evidence on their processing of harmonic, melodic and rhythmic information in different auditory discrimination tasks is presented. The results suggest overall that while pigeons are under-appreciated auditory beasts they are not rock 'n' roll animals. Speculations about the origins of music as related to birds will be considered.

2:40 PM *Break*

2:45 PM Tool Use and Problem Solving (Chair: David Stahlman)

2:45 PM **Behavioral flexibility and problem solving in captive bears**

Zoe Johnson-Ulrich (Oakland University), Lily Johnson-Ulrich (Michigan State University), Tamra Cater (University of Colorado), & Jennifer Vonk (Oakland University)

72

Behavioral flexibility is the ability to alter behavior in order to solve novel problems and is thought to be a key component involved in the evolution of complex cognition. Bears have been generally neglected in studies of cognition despite the fact that they show high manual dexterity, there is anecdotal evidence of tool-use, and they have relatively large brains within *Carnivora*. In order to assess behavioral flexibility in bears, we presented captive bear representatives (grizzly bears, Asiatic black bears, Andean spectacled bears, giant pandas, and sun bears) with a multi-access box (MAB) designed for use with carnivores. This MAB has four solutions that allow subjects to access food within the box, each requiring a different manipulation to open. When first presented with the box, all four solutions were accessible; when one solution was learned, it was blocked and subjects had to learn a new solution until all solutions were learned. Multiple measures were taken to evaluate subjects' behavioral flexibility, such as total number of solutions learned (innovation), the number of trials to abandon a blocked solution and try a new one (inhibition), and the number of different behaviors directed to the box (behavioral diversity).

2:52 PM **Individual variation in problem-solving strategy with the multi-access box paradigm in spotted hyenas**

Lily Johnson-Ulrich (Michigan State University), Zoe Johnson-Ulrich (Oakland University), & Kay Holekamp (Michigan State University)

73

Behavioral flexibility is a general cognitive ability of animals to adaptively modify behavior in order to solve novel problems. Its execution can involve many specific cognitive abilities such as innovation, social learning, and inhibitory control. However, successful problem-solving involves a complex interaction among cognition and other behavioral traits such as temperament and motivational state. Here, we developed a problem-solving task suited for mammalian carnivores using the multi-access box paradigm (MAB). The MAB has 4 solutions that each requires a different motor pattern to solve. We measured behavioral flexibility as the number of different solutions learned. In addition, we also extracted traits thought to affect behavioral flexibility: inhibition, persistence, neophobia, exploration, and arousal. Spotted hyenas have been well established as an excellent model organism for studying the evolution of intelligence, as they show a high degree of behavioral flexibility in adapting to a diverse array of habitats across sub-Saharan Africa. Here we tested 10 captive hyenas of varying sexes and ages. We aimed to identify consistent behavior patterns within individuals based on measured traits, and of those that were consistent, determine whether or not they correlated with number of MAB solutions learned, i.e. behavioral flexibility.

2:59 PM **Problem solving in an American and fish crow for public demonstration**

Preston Foerder, Victoria Perret (The University of Tennessee at Chattanooga), & Sara E. Carlson (The Tennessee Aquarium)

74 Corvids are known for their problem solving abilities. However, little research has been conducted on problem solving in two species of crows endemic to North America, the American crow (*Corvus brachyrhynchos*) and the fish crow (*Corvus ossifragus*). To ascertain the range of cognitive ability in these species, three problem solving tasks previously tested on other corvids were replicated on one member of each species held at the Tennessee Aquarium in Chattanooga. The specific problem solving tasks included: string pulling to acquire hanging food; the Aesop's fable task, dropping stones into a water-filled tube to raise the level to acquire the food; and stick tool use to obtain food placed otherwise out of reach. This research extends our knowledge of cognition in corvids to local species. Because the aquarium uses these birds as demonstration animals, this work will also inform and educate the general public about the science of comparative cognition.

3:06 PM **Mechanisms of learning in flower handling by bumblebees (Bombus impatiens)**

Caroline G. Strang, & David F. Sherry (Western University)

75 In order to extract nectar from flowers, foraging bumblebees often have to engage in flower handling: lifting and moving petals, and changing their body position within flowers. Although it has long been acknowledged that learning plays a role in flower handling - enabling bees to extract nectar more quickly with repeated visits to flowers - the mechanisms underlying that learning remains unclear. We developed a model of flower handling in which bees encountered a barrier on their way to a nectar reward. Bees were required to lift the barrier, akin to lifting a petal, in order to reach the nectar. Bees were given repeated trials in order to quantify the latency to success and the use of different behavioural strategies (e.g. biting the barrier, digging in the area of the barrier). Results show that all bees initially used the same behavioural strategies, but with experience increased their use of successful strategies. The change in strategy use shortened the latency to success on the task. Our results show that improvement in flower handling consists of learning to select innate behavioural strategies.

3:13 PM *Snack Break*

3:43 PM Memory and Perception (Chair: Stephen Lea)

3:43 PM **A method for studying recall memory in dolphins**

Heidi E. Harley (New College of Florida), Wendi Fellner, Leslie Larsen, & Lisa Green (Disney's Epcot's The Seas)

76 Working memory is central to many cognitive tasks. Recall memory has been difficult to study in non-human species. Here we present a paradigm in which a dolphin saw a stimulus and vocally reported its identity to a remote person naïve to the identity of the stimulus. The dolphin was successful at accurately reporting three different stimuli using vocally-unique labels after a short delay. This method may be useful for studying recall in dolphins.

3:57 PM **Are there sex differences in individual notes of black-capped chickadee chick-a-dee calls?**

Kimberley A. Campbell, Allison H. Hahn, Jenna V. Congdon, & Christopher B. Sturdy (University of Alberta)

77 The black-capped chickadee (*Poecile atricapillus*), a common North American songbird, produces a chick-a-dee call that contains information regarding individual identity, geographic origins, flock membership, and species of the caller. This call is composed of four main note types (A, B, C, and D) that occur in a relatively fixed order. Sex differences have been identified in other black-capped chickadee vocalizations (tseet calls, fee-bee songs) and in chick-a-dee calls of Carolina chickadees (*P. carolinensis*). Here we set out to identify sex differences in acoustic features (e.g., frequency, duration, and amplitude) in the notes of black-capped chickadee chick-a-dee calls. Permuted discriminant function analyses were conducted using these acoustic measures in an attempt to determine which feature, or combination of features, could contribute to the classification of the sex of a caller. Our findings indicate that the start frequency of A notes resulted in the most accurate discrimination between male and female calls, meaning that there is a way for chickadees to tell males and females apart from call alone. Future projects will investigate the possibility of whole-call composition differing between the sexes as well as operant conditioning experiments aimed at testing black-capped chickadees' perception of sex differences within chick-a-dee calls.

4:04 PM **Long-term memory for a simple discrimination task in two California sea lions (Zalophus californianus)**

Kristy Lindemann-Biolsi (St. Francis College and The Center for the Study of Pinniped Ecology and Cognition), Candyce Paparo (Long Island Aquarium and Exhibition Center), & Afia Azaah (St. Francis College and The Center for the Study of Pinniped Ecology and Cognition)

78 Long-term memory has been studied in a variety of species and contexts. Studies have demonstrated that nonhuman animals have the ability to retain information for varying time limits, but most of these are on the level of hours, days, or weeks. We argue that due to the behavioral ecology of pinnipeds, and of sea lions in particular, the retention of information from year to year is a critical cognitive ability. Our current research has therefore focused on long-term memory in two California sea lion subjects, Bunker and Java. These subjects learned a simple discrimination task to a 95% criterion. After an approximately 16 month interval with no exposure to the stimuli or the task/apparatus, they performed at 100% correct response levels. This was then replicated with the same two sea lions after an 18 month interval without exposure to the stimuli or task without decrement. This evidence supports the limited data available on the long-term memory capabilities of marine mammals and of sea lions in particular.

4:18 PM **Spatial integration across the pigeon visual field**

79

Ashlynn M. Keller, & Robert G. Cook (Tufts University)

Birds possess large visual fields with complex features, but how they use and integrate information from different points across this visual space has not been well investigated. Using a go/no-go task, we trained four pigeons (*Columba livia*) to distinguish displays containing one or two dots (circles). Directed pecking to a target dot was rewarded with food when the dot was presented alone, while pecks to a dot were not reinforced when a second dot was also present. Multiple sizes of dots were tested, and their locations on the display and relative to each other were varied. Heat maps capture the area in which the two separated dots were successfully detected, and they revealed the extent and shape of the pigeons' integration mechanisms within the frontal visual field. A follow up experiment attempted to control for head position during display scanning. Comparisons revealed that this fixation reduced the maximum extent for spatial integration. Implications for the processing of different types of visual displays will be discussed.

4:25 PM **Trimming the postcranial vibrissae of Florida manatees (*Trichechus manatus latirostris*) raises vibrotactile detection thresholds**

80

Gordon B. Bauer (New College of Florida), Christin T. Murphy (Woods Hole Oceanographic Institute), David A. Mann (Loggerhead Instruments), Katharine Boerner, Laura Denum (Mote Marine Laboratory), & Roger L. Reep (University of Florida)

A 50 cm patch of postcranial sensory hairs (vibrissae) of two Florida manatees was trimmed to the skin surface. This raised the particle displacement detection thresholds in this area from 0.001 μm with hairs to 0.004 μm without hairs in one manatee and from 0.002 μm to 0.006 μm in the other, suggesting that the postcranial vibrissae play an important role in mechanoreception. Vibrissae that were trimmed from one subject during psychophysical testing were collected for analysis of vibrissal structure. Photometric measurements were conducted on fifteen postcranial vibrissae using ImageJ software. Mean length of the vibrissae sampled was 2.2 cm (sd=0.61). In addition, photometric analysis was used to measure the spacing of the array and create a coordinate map of the arrangement of the vibrissae. A subsample of the vibrissae was further investigated using imaging techniques. Computed tomography (CT) scanning and scanning electron microscopy (SEM) were used to image the hairs and compare their features to the vibrissae of other terrestrial and marine mammals. The manatee postcranial hairs have a smooth vibrissal surface and circular cross-sectional profile, which are features shared with terrestrial mammals but not with pinnipeds.

4:32 PM **Towards describing scenes: Pigeons' discrimination of depth in images**

81

Suzanne L. Gray, Muhammad A. Qadri, Daniel I. Brooks, & Robert G. Cook (Tufts University)

The perception of the scene requires many complex visual mechanisms, such as figure-ground extraction and object identification. Depth perception is a critical process that underlies these higher level image-processing mechanisms. We presented pigeons with scenes containing multiple 3D rendered objects that contained small, visible response areas. The pigeons were trained to select the response area on the closest object. The pigeons learned this depth discrimination, and they were sensitive to monocular depth cues and scene properties such as object occlusion and relative size. The use of this technique to determine how pigeons perceive images will be considered.

4:39 PM **Short-term and long-term memory in zebrafish (*Danio rerio*)**

82

Robert Gerlai, Andreea Talpos, Jason Jia, & Yohaan Fernandes (University of Toronto Mississauga)

About fifteen thousand gene products are suspected to be involved in vertebrate neuronal plasticity, only a fraction of which have been identified and functionally characterized. The zebrafish is an excellent tool with which learning and memory genes may be discovered using mutation screens. However, although the zebrafish has been in the forefront of genetics and developmental biology, its cognitive and mnemonic characteristics are largely unknown, and behavioural tests for these phenomena have been rare. Here, we will review the most recent methods developed in and findings from our laboratory. In a shuttle box paradigm, we analyzed memory of prior presence of rewarding social stimuli using computerized stimulus delivery and automated response quantification. Our results suggested significant memory of spatial information (location of rewarding stimuli) as well as anticipatory responses, i.e. short-term (seconds to minutes) temporal encoding. The automated nature of the task will make it useful for high throughput mutation screening. In a different associative learning task, we found significant long-term (days) memory in zebrafish. Although a simple vertebrate, we argue that the zebrafish will be invaluable for the analysis of the most ancient and evolutionarily conserved fundamental features of learning and memory common to vertebrates.

4:53 PM *Break*

4:58 PM Numerosity (Chair: Victoria Templer)

83

4:58 PM **The influence of species differences and methodological factors on quantity discrimination in apes and new world monkeys**

Regina Paxton Gazes (Bucknell University), Vanessa Schmitt (Zoo Heidelberg and Zoo Atlanta), Alison Billas (German Primate Center), Julia Fischer, & Tara Stoinski (Dian Fossey Gorilla Fund International and Zoo Atlanta)

Performance on quantity discrimination tasks is highly variable both within and between non-human primate species. Differences in performance may result from species specific cognitive differences, or from methodological factors such as discrepancies in representational format of the stimuli presented. Using methods employed with Old World primates by Schmitt & Fischer (2012), we presented apes (gorillas and orangutans) and new world monkeys (brown capuchin and squirrel monkeys) with choices between quantities of items presented in either Edible (quantities of food) or Inedible (quantities of pebbles that stood in for quantities of food) formats. Orangutans and old world primates showed poor performance with Edible stimuli, while gorillas and new world primates showed poor performance with Inedible stimuli, suggesting possible species differences in cognitive abilities underlying processing stimuli in these formats. A series of follow up experiments elucidating the influence of methodological factors such as delay and motivation revealed that major species differences washed out when animals were highly motivated to perform by increasing the quality of the food reward. This suggests that despite initial findings, there may be few underlying cognitive differences between these species in the effect of representational format on quantitative abilities.

84

5:05 PM **Response competition in monkey magnitude judgments: Size judgments are affected by reward values of stimuli**

Audrey E. Parrish, & Michael J. Beran (Georgia State University)

Nonhuman primates are proficient in discriminating sets on the basis of size, quantity, and reward value, demonstrating many of the same hallmark characteristics as humans for encoding and representing magnitudes. We were interested in whether competing quantitative information about a stimulus (size versus reward value) would create interference in monkey magnitude judgments. Rhesus and capuchin monkeys first learned to sequence a series of four colored squares of identical size on the basis of associated food-pellet quantities, creating high- and low-valued colors. Next, monkeys learned to classify black squares of varying size as 'small' or 'large' in an absolute classification task. Monkeys then were presented with interleaved sequencing and classification trials, and the classification task included baseline trials (black squares) and test trials (colored squares) of varying size. Monkeys were highly proficient in size classification for baseline trials; however, test trials presenting colored squares created response competition for square size and value. Monkeys sometimes classified high-valued colored squares as 'large' when they were truly small in size and low-valued colored squares as 'small' when they were truly large in size. Thus, response competition exists in monkey magnitude judgments in which the associated reward value of a stimulus interferes with size perception.

85

5:12 PM **Representation of prey number and competitor number by a spider**

Fiona Cross, & Robert Jackson (University of Canterbury)

Portia africana is a spider-eating salticid spider known to execute pre-planned detours for reaching its prey. Moreover, there is evidence from earlier experiments of *P. africana* representing the number of prey spiders in a scene. In these experiments, *P. africana* first viewed prey in a scene that could only be reached by taking a detour. The scene went out of view while *P. africana* took the detour but it came back into view at the end of the detouring path. When the number of prey items viewed at the end of the detour differed from the number viewed at the beginning, *P. africana* appeared to experience expectancy violation, with this evidence coming from the spider hesitating and sometimes failing to cross a ramp to reach the prey. Using similar methods, we investigate here whether *P. africana* also attends to the number of other *P. africana* individuals in a scene (i.e., competitors). When *P. africana* individuals could see competitors as well as prey, there was evidence of expectancy violation when the number of competitors changed during a trial. Evidently, *P. africana*'s capacity to represent exact numbers is applicable to at least two categories: prey and competitors.

86

5:26 PM **All SNARC tasks are not created equal: A between-task analysis of individual differences in spatial-numerical association of response codes**

Olga Lazareva, Cody Dressler, Bailey Mack (Drake University), & Regina Gazes (Bucknell University)

The SNARC effect describes a tendency to respond to Arabic numerals representing smaller quantities (e.g., 1 or 2) faster if the response is located on the left than if it is located on the right, and vice versa for larger quantities. The SNARC effect has been interpreted as an evidence of automatic spatial organization of numeric information, and has recently been reported for many other dimensions (e.g., brightness, length, etc.). It is not yet clear whether these findings imply that non-numerical orderable information is also automatically organized spatially, just like numbers are. In several experiments, we explored whether the same participants exhibit similar pattern of SNARC effect in different tasks. Using principal component analysis, we found that the SNARC tasks utilizing numerical information (e.g., parity, magnitude) consistently loaded on a single factor whereas the SNARC tasks relying on object properties (e.g., brightness, line length) loaded on a separate, second factor. Overall, our results suggest that the SNARC effect exhibited in number-related tasks is largely independent from the SNARC effect in tasks using physical attributes of the objects. The lack of internal consistency across different SNARC tasks should also be taken into account in comparative research with non-human animals.

5:40 PM Closing Remarks (Debbie Kelly)

8:30 PM Poster Session II (8:30 - 11:00)
See Poster Abstracts Starting on Page 32
Poster Presenters: Please set up your posters between 8:00 and 8:30

Posters

Poster Session I - Thursday Evening

Ron Weisman Outstanding Student Presentation Competition: Poster
Posters P1-P3

Awards Funded by Elsevier

P1

Effects of failure, shaping step size, and reinforcement rate on subsequent responses in the bottlenose dolphin (*Tursiops truncatus*)

Lisa K. Lauderdale, Mystera M. Samuelson (The University of Southern Mississippi), Mark J. Xitco Jr. (United States Navy Marine Mammal Program), Evan H. Dart, & Stan A. Kuczaj II (The University of Southern Mississippi)

Operant conditioning techniques, such as positive reinforcement training, are used to train dolphins in captivity to voluntarily perform behaviors. However, the shaping procedures implemented by trainers can vary widely and are generally qualitative in nature. The current study examines the effects of two types of failure (i.e., attempts and no-attempts), step size, and reinforcement rate during operant-conditioning based training sessions involving six bottlenose dolphins (*Tursiops truncatus*) at the U.S. Navy Marine Mammal Program in San Diego, CA. The effects of these three factors on learning a trained beaching behavior were systematically investigated over a three-month period. Failure types were categorized as (1) trials in which the dolphin attempted the behavior or (2) trials in which the dolphin did not attempt the behavior. The results showed that subjects learned from both types of failure. The rate at which attempt trials were reinforced was not correlated with rate of failure. Larger mean step sizes were weakly correlated with higher failure rates, indicating that smaller step sizes may be more effective during acquisition.

P2

Use of a two-way communication keyboard by two bottlenose dolphins (*Tursiops truncatus*) at Disney's The Seas

Ali Taylor, Pepper Hanna (University of Southern Mississippi), John Gory (Disney's The Seas), Mark Xitco (U.S. Navy Marine Mammal Program), & Stan Kuczaj (University of Southern Mississippi)

Savage Rumbaugh et al. (1986) demonstrated the use of a two-way communication system, using a lexigram keyboard, between humans and bonobos (*Pan paniscus*), and humans and chimpanzees (Pan troglodytes). Previous research has established dolphins can learn to comprehend symbolic communication systems (Herman et al., 1984). The present study examined two bottlenose dolphins' (*Tursiops truncatus*) ability to learn a two-way communication system using an underwater keyboard. Humans modeled use of the keyboard in daily activities that might be of interest to the dolphins, but no explicit training occurred. Throughout the study, from 1992 to 2000, each dolphin used 61 unique keys, while humans used 65 unique keys. Although modeled by humans, the dolphins displayed a different pattern of key use, preferences developing for food and location keys despite the fact that humans more often used action and location keys. Dolphins were more likely to use specific location keys when certain foods were present at the locations. Additionally, dolphins were more likely to repeat a key press than were humans, but these self repeats declined over time. The differences between human and dolphin use of the keyboard suggest different motivations in cross-species communication.

P3

Are large dogs smarter than small dogs? Investigating within species differences in large and small dogs: Spatial memory

Megan Broadway, Mystera Samuelson, Jennie Christopher, Stephanie Jett, & Heidi Lyn (University of Southern Mississippi)

The study of canine cognition can be useful in understanding the ontology and selective pressures that affect the development of cognitive abilities. Dogs have undergone intensive artificial selection yielding distinctive breeds, which differ both phenotypically and behaviorally. Breed-based cognitive differences have not been found, but some studies suggest that there may be differences in broader categories such as working disposition and sex. The influence of size on canine cognition has not been thoroughly addressed, despite the fact that large dogs are often perceived to be 'smarter' than small dogs. This preconception has only recently been addressed and supported in one study comparing large and small dogs in a social cognition task, where large dogs outperformed small dogs in a pointing choice task. Here, the cognitive differences of large and small dogs were assessed using a series of spatial cognition tasks. As predicted, there were no differences between large and small dogs. Therefore, it is unlikely that disparities found in social cognition tasks are due to genetic or physiological differences related to size. Instead, it is probable that differences in cognitive performance are based on other factors such as prior training experience or past experience with humans in general.

Rhesus monkeys selectively shift attention within working memory to prioritize relevant information

Ryan Brady, & Robert Hampton (Emory University)

P4 Attentional mechanisms evolved to allow animals to focus limited processing capacity on information relevant to on-going behavior. In addition to focusing attention within the external environment, humans can shift attention within contents of working memory to prioritize relevant information. While evidence exists that monkeys exhibit some cognitive control over memory, little is known in nonhumans about how attention can be shifted between representations in working memory. Using a post-sample cueing paradigm, we tested the extent to which monkeys can control attention within working memory to prioritize relevant information. Monkeys saw an array of multiple images. Shortly after its disappearance, they were visually cued to a location that predicted which item would be tested in a subsequent recognition test. If monkeys use the cue to shift attention to the cued item within working memory, then they will show better memory for cued items compared to non-cued items. The results of two experiments indicate that monkeys prioritize the cued item with a memory load of two items, but not three. Our results suggest that monkeys selectively shift attention within working memory to prioritize relevant information. Future work will be aimed at understanding the conditions under which monkeys shift attention within working memory.

You or the Food? Canine Preferences and Violation of Expected Outcomes

Ashley Prichard, Peter Cook, Mark Spivak, & Gregory Berns (Emory University)

P5 In Experiment 1, 15 dogs were pre-trained to associate 3 objects with 3 outcomes: food, owner praise, or nothing. Awake fMRI in response to the cues revealed significant caudate activation to objects associated with food or praise relative to nothing. Following scanning, dogs were given a behavioral preference test in which they chose between food or their owner in a Y-maze. Using a Hidden Markov Model (HMM), individual preferences were measured by the sequential transition probability between food and praise. The relative transition probability was correlated with the differential caudate activation to cues signifying food or praise. In Experiment 2, we examined the change in caudate activation following the non-occurrence of expected praise following the associated cue. Dogs who showed greater behavioral preference for their human, also showed the greatest depression in caudate activity following non-receipt of expected praise. Our results demonstrate the capability of awake-fMRI to further elucidate the cognitive processes underlying choice in dogs. Consistent with known reward functions of the caudate, we find a striking consistency between brain activity and behavior despite the dramatically different contexts inside and outside of the MRI.

Persistence and gazing at humans during an unsolvable task depends on the age, sex and experience of pet dogs

Rachel Rem, Kristy Gould (Luther College), & Jennifer Templeton (Knox College)

P6 Previous research investigated how dogs respond to an unsolvable task, both in terms of task persistence and the amount of time they look to humans for help or information. We tested 26 pet dogs on an unsolvable version (lid screwed shut) of a previously learned task that consisted of opening a wooden box's lid to retrieve food after demonstrations by a stranger, and in the presence of their owner. Time spent away from the box was used as a measure of persistence. We found that dogs with little to no formal training spent more time away from the box than dogs that had formal training. Male dogs spent more time away from the box than female dogs. Older dogs (5 years or older) spent more time away from the box than younger dogs (1-4 years old). The more demonstrations on how to open the box that were needed during training, the less overall contact was made with the box. Finally, dogs that were obtained as pets from a shelter/rescue gazed less at their owners than dogs obtained as pets from breeders, with a trend indicating that the age obtained (puppy vs. adult) may contribute to those results.

Spatial memory for multiple food locations: Dogs remember where the food is but the quantity does not matter

Sylvain Fiset, & Jostin Frenette (Université de Moncton in Edmundston)

P7 We examined if the use of a win-stay or win-shift search strategy in domestic dogs is dependent upon food quantity when dogs revisit multiple food locations. In 3 experiments, dogs were led to 3 or 4 open, baited containers and allowed to eat one piece of food from 1 or 2 of them. Then, dogs were brought back to their starting position, the remaining pieces of food were removed from the containers and dogs were released for free exploration. The results revealed that dogs avoided the containers they had depleted of food and revisited the containers from which they had not eaten (Experiment 1). However, if the containers in which they had eaten still contained food, dogs revisited these containers as frequently as the containers from which they had not eaten, and that, even if the amounts of food available in the baited containers differed (Experiments 2 and 3). In conclusion, dogs use a win-shift search strategy to avoid revisiting empty food locations. However, they do not use any particular search strategy to remember multiples locations that contain different food quantities.

Tiger Salamanders' (*Ambystoma tigrinum*) Response Learning and Usage of Visual Cues

Shannon M. A. Kundey, Roberto Millar, Justin McPherson, Maya Gonzalez, Aleyna Fitz, & Chadbourne Allen (Hood College)

P8 We explored tiger salamanders' (*Ambystoma tigrinum*) learning to execute a response within a maze as proximal visual cue conditions varied. In Experiment 1, salamanders learned to turn consistently in a T-maze for reinforcement before the maze was rotated. All learned the initial task and executed the trained turn during test, suggesting they learned to demonstrate the reinforced response during training and continued to perform it during test. In a second experiment utilizing a similar procedure, two visual cues were placed consistently at the maze junction. Salamanders were reinforced for turning towards one cue. Cue placement was reversed during test. All learned the initial task, but executed the trained turn rather than turning towards the visual cue during test. In Experiment 3, we investigated whether a compound visual cue could control salamanders' behavior when it was the only cue predictive of reinforcement in a cross-maze by varying start position and cue placement. All learned to turn in the direction indicated by the compound visual cue. Following training, testing revealed they attended to stimuli foreground over background features. These results suggest that salamanders learn to execute responses over learning to use visual cues but can use visual cues if required.

Chrysippus' Pigeon: Inference by Exclusion in an Avian Model

Marisol Lauffer, Leyre Castro, & Ed Wasserman (University of Iowa)

P9 Inference by exclusion can be exhibited by deductively responding to new stimuli when presented in the context of old stimuli. We investigated this effect in a two-alternative, forced-choice discrimination task in pigeons. In Phase 1, two stimuli (A and B) were assigned to Response 1, and two stimuli (C and D) were assigned to Response 2. In Phase 2, Stimuli A and B were now assigned to Response 2; based on birds' prior training, choice accuracy should now be below chance. Also, in Phase 2, Stimuli E and F, new stimuli replacing Stimuli C and D, were concurrently presented and assigned to Response 1. With no prior training, pigeons' responding should be at chance. However, if the pigeons were to apply an exclusion rule (Stimuli E and F are not Stimuli A and B), then they might choose Response 2 for new Stimuli E and F because they are concurrently choosing Response 1 for old Stimuli A and B; so, choice accuracy for Stimuli E and F should also be below chance. Indeed, our pigeons responded at below chance levels to Stimuli E and F, consistent with their exhibiting inference by exclusion. Control subjects failed to show this effect.

Within-Session Reversal Learning in Rhesus Macaques (*Macaca mulatta*)

Brielle T. James, Michael J. Beran (Georgia State University), & Rebecca M. Rayburn-Reeves (Tufts University)

P10 During a simultaneous visual or spatial discrimination midsession reversal task, pigeons have been shown to display both anticipatory and perseverative errors surrounding the point of reversal. Rats, however, show no anticipation and only short-term perseveration on spatial discriminations, even on tests with a variable point of reversal and multiple points of reversal. This difference in efficacy has been hypothesized to result from pigeons using the less optimal cue of time, and rats using the more optimal cue provided by feedback from recent trials. We presented rhesus macaques (*Macaca mulatta*) with a mid-session reversal task using a simultaneous visual discrimination to further investigate these species differences in behavioral flexibility. When a single reversal point occurred midsession rhesus macaques showed no anticipation of the reversal and a similar level of perseveration to rats. These same results also were seen when the monkeys were given tasks with a variable reversal point and multiple reversals within sessions. These results indicate that rhesus macaques do not use time as a cue for reversing within the session, and the results support qualitative species differences in reversal learning between some mammals and some avian species.

Using an iPad-Equipped Touchscreen Apparatus to Evaluate Operant Associations: A Study Conducted by Undergraduates in Learning Laboratory Course.

Elyssa Johnson, Taryn Quinn, Katie Thoma, Josh Wolf, & Kenneth Leising (Texas Christian University)

P11 Touchscreen-equipped operant chambers enable flexible stimulus display and response recording. We used an iPad-equipped operant task to evaluate what kinds of associations may support operant responding. Past research has tested for the presence of stimulus-response (S-R), stimulus-outcome (S-O), and response-outcome (R-O) associations using a variety of devaluation procedures. In the current experiment, rats were trained on separate trials to paw-press two visual discriminative stimuli (a star or clouds) presented on the iPad. Paw presses to each stimulus were reinforced with a different outcome (sucrose or pellets). Prior to testing with both stimuli, all rats were sated on the pellet outcome. Based on previous literature, we expected to see a decrease only in the number of paw-presses made to the stimulus associated with the devalued outcome (evidence for R-O association). Devaluing the pellet outcome caused a decrease in responses to both stimuli. This result is inconsistent with an R-O association, but is consistent with a two-process account (S-R and S-O). These results inform researchers as to the type of associations that may develop during touchscreen procedures and highlight the flexibility of a touchscreen-equipped operant chamber. Furthermore, this experiment was carried out with undergraduates in a Learning Laboratory course.

Binding of Consistent and Variable Mapped Stimuli in a Mid-session Reversal Task

Martha R Forloines (Auburn University), Thomas A Daniel (College of William Mary), Robert G Cook (Tufts University), & Jeffrey S Katz (Auburn University)

P12 In mid-session reversal tasks that switch contingencies from matching to nonmatching, pigeon behavior is controlled by temporal factors showing a modulation of task switching over a session. Specifically, discrimination shifts gradually with time from matching to nonmatching. This shift occurs because pigeons learn item-specific rules that are bound to the session's time-course (Daniel, Cook, & Katz, 2015). To test the cognitive flexibility of the pigeons, we examined the effect of stimulus mapping whereby stimuli were variably mapped to both portions of a session (MTS and NMTS) or consistently mapped to one portion of the session. We hypothesized that if specific stimuli bind to the sessions' time course, then the variably mapped stimuli would show modulation of task switching whereas the consistently mapped stimuli would not. Indeed, by the end of training (40 sessions) pigeon did show such cognitively flexibility.

Manipulation of Filled and Unfilled Shapes and Shape Words Confirms Saliency Manipulation in a Delayed Match-to-Sample Task

Z. Kade Bell, Joshua E. Edwards, Ty W. Boyer, & Bradley R. Sturz (Georgia Southern University)

P13 The extent to which geometric processing is isolated from other processes remains a long-standing question. Sturz, Edwards, and Boyer (2014) developed a delayed match-to-sample task that presented a sample of a shape, shape word, or bi-dimensional stimulus (shape and shape word). Post delay, participants identified the sample shape or the sample word by selecting between two shapes or two shape words. An asymmetrical pattern of interference emerged with increased reaction times and errors occurring in matching shape targets but not word targets. This was interpreted as shape words activating a semantic and spatial representation of shapes, but shapes only activating a spatial representation; however, such a pattern of results could have resulted from the shape word being more salient than the shape. The present experiments replicated and extended these results by manipulating figure-ground relations to contrast the original condition with an alternative to address an explanation based upon sample shape saliency (Experiment 1) and by confirming the effectiveness of the saliency manipulation (Experiment 2). Experiment 1 replicated the asymmetrical pattern of results for both conditions, and Experiment 2 confirmed the saliency manipulation. Collectively, these results undermine a pure saliency explanation and have comparative implications for the isolation of geometric processing.

Do Dogs Use Their Noses? Investigating Olfactory Perception in the Domestic Dog

Sally J. Wilson, & Anna M. Yocom (The Ohio State University)

P14

The nasal tissue lining the domestic dog's nasal cavity may contain over 200 million sensory receptor sites dedicated to receiving smell molecules. But how dedicated are dogs to their extraordinary olfactory abilities? It has generally been assumed that dogs depend more on olfaction than vision to investigate and perceive the world. However recent research has shown evidence that contradicts this assumption (Horowitz 2013), making it unclear under what conditions dogs actually utilize olfaction. The goal of the present research was to further investigate the question of how much and when dogs utilize olfaction. It was assessed whether shelter dogs would investigate and choose greater over smaller quantities of food through olfaction alone, if provided with a short investigation period to smell two closed containers with differing amounts of food (1:5). The preliminary results of the present research indicate that even though dogs spent more time investigating the larger quantity container (Wilcoxon Signed Rank, p=0.000), they were not successful in choosing greater over smaller quantities of food through olfaction alone, choosing the container with more food at only chance levels (binomial test, $p > 0.05$). Explanations and future research directions on canines are discussed.

An Exploration of Visual Object Constancy in Goldfish (*Carassius auratus*)

Irene Fobe, Taylor O'Leary, & Caroline DeLong (Rochester Institute of Technology)

P15

Object constancy, the ability to recognize objects despite changes in orientation, has recently been examined in fish. Fish live in a three-dimensional environment in which it would be advantageous to recognize prey, predators, and other objects from different angles. Malawi cichlids trained to visually discriminate between 3D objects such as small plastic models of turtles and frogs successfully maintained their discrimination when objects were rotated 45, 90, or 180 degrees to the side or to the back (Schluessel et al., 2014). The current study examines visual object constancy in goldfish using 2D stimuli. Two goldfish were trained to discriminate between a half circle and an upwards-facing arrow (black stimuli on a white background) in a two-alternative forced choice task. Both fish successfully discriminated between the training stimuli at a level significantly above chance (M = 70%) over the final 30 sessions. In test sessions, they were presented with the same objects 45, 90, 135, 180, 225, 270, and 315 degrees away from the training orientation. Preliminary results show that the fish are significantly above chance on some aspect angles but not others. This study will help clarify the mixed evidence to date on visual object constancy in fish.

Effect of static and dynamic visual depth cues on size perception in pigeons: or do they perceive a dynamic corridor illusion?

Yuya Hataji, & Kazuo Fujita (Kyoto University)

P16

Visual depth perception is important for species that depend on vision. However, it is still unclear how they use multiple depth cues and to what extent such usage is shared among various species. We studied how pigeons use pictorial and motion parallax depth cues using a dynamic version of the "corridor illusion." Pigeons learned to classify the size of a white target circle on the corridor background made of grids. There were two conditions; static and dynamic. The static condition was the same as the classical corridor illusion. In the dynamic condition, the target and the corridor moved from side to side. The moving amplitude was larger for "nearer" objects. In the test that followed, we inserted probe test trials in which target position and amplitude changed independently to examine (1) whether pigeons show a corridor illusion in static and dynamic conditions, and (2) which depth cues, pictorial or motion, is dominant for them. We conducted the same tests in humans to clarify (3) how different is the use of depth cue between humans and pigeons.

Can Mongoose Lemurs Recognize Individual Humans?

Robin Rowland, & Lauren Highfill (Eckerd College)

P17

The present study examines if mongoose lemurs have the ability to recognize and distinguish between individual humans. Although numerous studies have examined the abilities of wild birds, livestock, and even insect species to recognize and distinguish between humans, non-human primates have been largely understudied in this area. Prior to this study, no research has been conducted to examine if lemurs, or any Strepsirrhini primates, are capable of distinguishing and recognizing humans. The human recognition abilities of 11 captive mongoose lemurs were examined by comparing behavioral responses to the presence of an unfamiliar and habituated experimenter. Responses to both experimenters were recorded before and after familiarization of the habituated experimenter to control for the presence of humans. Three variables were used to measure lemur reactions to experimenters: number of vocalizations, proximity to the experimenter, and latency to approach experimenters. Lemur subjects were not found to exhibit statistically significant differences in behavioral responses to either experimenter. In light of the findings of previous studies, which indicated the presence of human recognition abilities in other primate species, further research is recommended to better understand the extent of human recognition abilities in the Strepsirrhini primate group.

Testing for the presence of metamemory in a prospective Delayed-Match-to-Sample task in rats

Aidan J. Preston, Samuel M. Miller, Keith Lee, Kristin M. Palframan, & Victoria L. Templer (Providence College)

P18

Metamemory is the ability to cognitively assess the strength of one's memories. It has been operationally defined as improved performance on choice-trials in which there is an option to decline trials as compared to forced-trials in which there is no such option. We tested the ability of Long-Evans rats to distinguish between remembering and forgetting by presenting a decline option that allowed four-choice delayed match to sample (DMTS) tests to be by-passed. Animals that have metamemory should choose to take tests in which they remember, as this choice leads to a preferred reward. Correspondingly, they should decline tests when they forget as it leads to a guaranteed, but less preferred, reward. First, retention intervals were titrated until the rate of successful DMTS trials fell in the range of 40%-70% ensuring subjects had experience with both remembering and forgetting. Rats with a success rate >70% at delays greater than 20 minutes were excluded from further testing. Four rats with lesser delays entered the metacognitive testing phase where they experienced sessions that were comprised of 25% forced-trials and 75% choice-trials. There was no significant difference between success rates in forced versus choice-trials, suggesting lack of adaptive use of the decline response.

Sex Differences in Alternation Learning in CF1 and C3H Mice.

James D. Rowan, Amanda Schroeder, Shihui Liang, Feven Abraha, Joy Johnson, & Holly Boettger-Tong (Wesleyan College)

P19 This set of 2 experiments examines whether two strains, CF1 and C3H mice, would show sex/strain differences in acquisition of simple single (SA) and double alternation (DA) patterns. For eighteen days, the mice were placed into the chamber and ran ten repetitions of the SA patterns. The mice were then transferred to a DA pattern for an additional 18 days. Both strains and sexes learned the SA patterns equally well and to the same levels as other strains of mice examined in our lab (less than 10% errors by Day 18). However, for the CF1 strain both male and female mice had a significant deficit in the rate of learning the DA patterns. By Day 18 of the experiment, neither group performed above chance levels (50% errors). Examining the error types found that both sexes made perseveration errors on the first trial of the chunks indicating that the CF1 mice seem to not extinguish the SA rule learned in SA portion of the experiment. For the C3H group, males learned the DA patterns faster than the females but both groups were committing less than 10% errors by Day 18.

Sex Differences in Massed vs. Spaced Serial Pattern Acquisition In Adult Rats

Jessica L. Sharp, Samantha M. Renaud, Megan E. Miller, & Stephen B. Fountain (Kent State University)

P20 Spacing in human learning tasks often improves performance. To examine spacing effects in rats' serial pattern learning, male and female rats learned a pattern, 123-234-345-456-678-781-818, where digits represent spatial locations within an octagonal chamber, by making nose-poke responses until they achieved high levels of performance. For males, too much spacing (5 patterns/day) of serial pattern learning over longer periods of time slowed acquisition compared to massed training (20 patterns/ day), with males receiving spaced training (5 patterns/day) displaying significantly slower learning on all elements of the pattern. This result is not consistent with the idea that spacing might improve acquisition of a serial pattern. To test whether females would replicate the effect observed in males, female rats were assigned to complete 5, 10, or 20 patterns/day until they reached a total of 700 patterns. For females, results indicated no significant differences in acquisition were observed for any element type when compared across 5, 10, and 20 pattern conditions. Males were affected by spacing of patterns whereas females were not. The results indicate that males are more sensitive to spacing than females in rat serial pattern learning.

Rat Sequential Learning for Impoverished Serial Patterns Favors Multiple-Item Learning

Megan E. Miller, Jessica L. Sharp, & Stephen B. Fountain (Kent State University)

P21 When rats learn highly-organized serial patterns they formulate rules based on pattern structure that aid in correctly making different responses for different structural element types. For this experiment, we explored how simplifying pattern structure might allow for further investigation of the learning mechanisms involved in chunk-boundary element stimulus-response learning and violation element multiple-item learning. Four 10-element serial patterns were designed to assess acquisition for these element types separately with special attention to learning chunk-boundary versus violation element types. Adult rats were trained on one of four serial patterns: two patterns had one chunk-boundary in cued or uncued form, and two patterns had one violation element in cued or uncued form. After acquisition, rats received a drug challenge by i.p. injection of the anticholinergic drug scopolamine. Results indicated that all pattern element types were learned at the same rate despite containing different element types presented cued and uncued. Scopolamine caused high error rates for all higher-order elements as observed in previous results with violation element retention under scopolamine. Thus, chunk-boundary elements and violation elements were both encoded similarly as violation elements. These similarities in encoding might be due to the impoverished pattern structure that favored multiple-item learning over chunking.

Assessing Dominance Hierarchies throughout Development in Socially-Housed Rats

Lindsey Ciolfi, Brittany M. Hemmer, Alexandra Fischbach, Samuel M. Miller, Melissa Grasso, & Victoria L. Templer (Providence College)

P22 Social hierarchies in ten group-housed Long-Evans rats were assessed throughout five stages of development: juvenility, early adolescence, late adolescence, early adulthood, and late adulthood. Late adulthood was further examined over an additional ten-week period to assess the long-term stability of possible hierarchies formed during development. To determine if a dominance hierarchy exists social behavior was analyzed through two measures. First social observations of naturally occurring dominant-submissive interactions were observed in the home cage using focal sampling, and the outcome of aggressive and submissive behaviors were recorded. Second, a dominance based skill task, known as the tunnel task was implemented on every two-animal pair. The tunnel task requires the more dominant rat to push his opponent out of the tunnel, in order to receive a food reward. For both the naturally-occurring homecage behaviors and the tunnel task, social hierarchy orders were determined using Elo-ratings to reproduce a representative number which dynamically decreases or increases based upon the outcome of interactions. The extent to which dominance hierarchies are stable or shifting throughout development and in late adulthood will be discussed and the relationship between dominance hierarchies and overall levels of sociality will also be evaluated.

Social Transmission of Food Preference in Groups of Rats

Chelsey Damphousse, & Noam Miller (Department of Psychology Wilfrid Laurier University)

P23 Living in a group has several benefits. The more individuals are in one location, the greater the opportunity for sharing information concerning the location and quality of food. For example, it is well known that rats adopt the food preferences of conspecifics with which they interact. Although these experiments demonstrate basic information sharing, they have mostly been conducted using pairs of rats. Since the sharing of information in a naturalistic setting typically takes place within groups of individuals, we aimed to explore the dynamics of social food preference transmission within a group. As an increasing body of research shows, the flow of information through a group may depend on differences in individual personalities. We therefore began by conducting personality tests prior to placing rats into groups of 3. Groups were then constructed to consist of a specific mix of personalities and allowed to explore a large open field in which powdered food of several flavors could be found. Using a combination of both the social food preference task and the exploration of a novel environment, we provide an explanation of how the transmission and sharing of social information might take place in a natural setting.

Rats Do Not Show the Bystander Effect

Julia E. Meyers-Manor, & Emily Sanford (Macalester College)

P24 Rats are able to act prosocially, and have displayed responses indicative of emotional contagion. In humans, the presence of additional bystanders decreases altruistic helping behaviors through the Bystander Effect. This current study set out to: 1) determine whether rat helping is affected by social context, and 2) determine whether rat helping behaviors are motivated by a desire for prosocial contact or by empathy. Free-roaming rats were placed into an arena either individually, or in groups of two or five, and another novel rat was placed in a Plexiglas restrainer in the center of the arena. The opening rate of the restrainer was much higher in the two and five rat conditions than in the individual condition. This heightened helping rate indicates that there is no bystander effect, and in fact that additional rats increase altruistic behavior. This could be explained by the the presence of more rats leading to heightened empathetic arousal, leading to an increased helping rate. These results indicate that helping is not motivated solely by a desire for prosocial contact, since the helping rate was higher when contact was already available. This indicates that helping may in fact be an "empathetic" response.

To Save or Spend? The Cache Decision in Wild Fox Squirrels

Amanda Robin, Judy Jinn, & Lucia Jacobs (Department of Psychology University of California Berkeley)

P25 Food-storing species, such as tree squirrels, face a complex series of decisions when harvesting and storing seeds for future consumption. The process by which an individual animal decides to eat or cache a given food item within a foraging session is not fully understood. Understanding the factors involved in the apportionment of time and energy to storing or eating a single food item is a significant piece to solving this puzzle. In the present study, we examined the effect of energetics on the eat vs. cache decision in free-ranging fox squirrels (*Sciurus niger*). We asked if the time of day had an effect on a squirrel's decision to cache a food item, using a series of 30 peanuts. This procedure was replicated in the winter and the summer in order to examine the effects of season. We found that this eat vs. cache decision was influenced both by the time of day at which the item was encountered and by the number of items already processed in that foraging session. Preliminary results of the seasonal replication suggest that season along with the time of day and number of previously encountered items play significant roles in the eat vs. cache decision.

Measuring the effects of chronic social stress on cognitive control in group-housed rhesus monkeys (*Macaca mulatta*)

Thomas C. Hassett, & Robert R. Hampton (Emory University)

P26 Cognitive control is critical for human success in academic, occupational, and social domains. Individuals who experience chronic stress, such as those living in poverty, are more likely to exhibit impaired cognitive control relative to the general population. However, it has been difficult to determine the extent to which chronic stress, specifically, impairs cognitive control in poverty, because poverty is associated with other factors such as exposure to toxins, poor diet, and reduced educational opportunities that might impact cognition. Group-housed rhesus monkeys provide a powerful animal model for the study of the relations between chronic stress and cognitive control that allows for control and manipulation of some of these factors. Rhesus monkeys live in large social groups, organized into linear dominance hierarchies, where social subordination is known to associate with chronic stress. We have developed three computerized tasks to measure three core components of cognitive control in rhesus monkeys, working memory, inhibitory control, and cognitive flexibility. Pilot data we have already collected from our laboratory-housed monkeys demonstrate the feasibility of 2 of the 3 tasks. We will present these data, state our hypotheses about the relation between stress and cognitive control, and describe how we will evaluate them in group-housed monkeys.

Motivational and cognitive implication of judgment bias ('optimism'/'pessimism') in rats.

Rafal Rygula, Jakub Kregiel, Joanna Golebiowska, Michal Rychlik, & Robert Drozd (Polish Academy of Sciences)

P27 In humans, cognitive judgment bias (CJB) has a powerful influence on decision-making processes. Present studies have been designed to investigate the motivational and cognitive implications of CJB, measured as a stable and enduring behavioral trait, in animal models of behavioral despair, approach and avoidance motivation, feedback sensitivity and gambling. For this, in a series of ambiguous-cue interpretation (ACI) tests, we identified rats displaying 'pessimistic' and 'optimistic' traits. Subsequently, we investigated the trait differences in the forced swim test (FST), operant progressive ratio (PR) schedule of reinforcement paradigm with reward and punishment, probabilistic reversal learning (PRL) and rodent slot machine task (rSMT). We report that 'optimists' spend significantly less time immobile than 'pessimists' in the FST, show increased approach but not avoidance motivation in the PR schedules of reinforcement, show increased sensitivity to positive feedback in the PRL task and are statistically more likely to gamble in the hopeless 'clear loss' situation. The data are discussed in terms of neurobiological mechanisms of the observed effects and their possible implications for mental disorders. This work was supported by the National Science Centre (research grants: OPUS-2014/13/B/NZ4/00214 and Sonata bis dec-2012/07/E/NZ4/00196) and the statutory funds of the Institute of Pharmacology Polish Academy of Sciences.

Juggling two guided skills: An investigation of cognitive flexibility in pigeons

Sara Futch, Vanessa Zarubin, & Alliston Reid (Wofford College)

P28 Behavioral flexibility in naive homing pigeons (*Columba livia*) was assessed through their ability to juggle two different key-press sequences in multiple schedules. Pigeons were divided into two separate experiments in which cues were presented in differing locations, a cue in the middle (CIM) and a cue on the side (COS). Pigeons in both experiments completed multiple phases, in which environmental cues were systematically removed to force pigeons to rely on practice cues that developed as a result of experience and practice. Accuracy and discriminability measures demonstrated that pigeons in the COS experiment were better able to juggle skills than in the CIM experiment, but both groups demonstrated behavioral flexibility. Birds were also able to perform at high accuracy levels when guiding cues were removed, demonstrating the development and effectiveness of practice cues. Discriminability measures provided a way to measure the influence of practice cues on the selection of response sequences, which generated quantitative comparisons of stimulus control by environmental versus practice cues.

Assessing pre-crastination in the pigeon (*Columba livia*) using a virtual environment

Victor Navarro, & Edward Wasserman (The University of Iowa)

P29

Procrastination is the tendency to postpone the initiation or completion of a task. The opposite, pre-crastination, is the tendency to complete tasks as soon as possible, sometimes even at the cost of increased physical effort (Rosenbaum et al., 2014). In a virtual environment, we trained pigeons to carry an object–by pecking it–toward the end of a path in order to obtain food reinforcement. On each trial, two choice paths and their corresponding objects were presented. The starting location of each object was randomized, and each peck moved the object a fixed distance toward the end of the path. We found that the pigeons preferred the object located closer to the end of the path rather than the one they could reach first; in other words, they chose the option associated with less effort instead of pre-crastinating. Moreover, pigeons' choices depended on the difference between the objects' locations. In subsequent phases, we rearranged the relationship between the object's starting position and its associated amount of work to be uncorrelated or reversed. Although performance was disrupted each time a new contingency was introduced, in just a few sessions, the pigeons ultimately learned to choose the option associated with less effort.

Ingroup bias for contagious stretching in budgerigars (*Melopsittacus undulatus*)

Janine Militello, Lexington Swartwood, Serena Sackett, & Andrew Gallup (State University of New York at Oneonta)

P30

Previous observational research suggests that stretching may be contagious in budgerigars (*Melopsittacus undulatus*). Here we provide the first experimental investigation of this response. Using a repeated measures design, birds were tested as pairs alongside familiar and unfamiliar conspecifics with and without visual barriers. Our results show that stretching frequency was temporally clustered only when the birds could see one another, corroborating previous observational findings. Additionally, for the first time, we show an ingroup bias in this response. That is, while the frequency of stretching did not vary as a function conspecific familiarity, a close temporal coupling of stretching was present only when cage mates were paired together. These findings are discussed in relation to recent research investigating higher forms of social cognition in this species.

The Role of Iconic and Working Memory Processes with an Increasing Number of Items in a Location Change-Detection Task

Ronnie Lee (Texas Christian University), John Magnotti (Baylor College of Medicine), Joshua Wolf, James Taylor, & Kenneth Leising (Texas Christian University)

P31

We previously investigated the contributions of iconic and working memory processes in humans and pigeons using a location change-detection task which required participants to touch a visual item (colored circle) that changed in spatial position across a brief delay (0, 100, or 1000 ms). Other manipulations included the number of items in the display (2, 3, or 4 items) and a visual mask inserted in the delay. The data from pigeons indicated that the mask disrupted performance at 0 and 100 ms delays, but not at 1000 ms. The data for humans revealed an overall decrement with the mask, but no interaction of mask by delay. The goals of the current experiment were to investigate whether a mask by delay interaction in humans may be observed by increasing the number of items (4, 6, or 8) in the display. And secondly, to investigate whether location-change detection performance across an increasing number of items resembles a U-shaped function, such that more non-changing items aid in the selection of the changed item. The results will be discussed in terms of the attributes of the memory mechanisms (e.g., iconic memory) supporting location-change detection performance.

Mirror-mediated behavior in pigeons

Alexis Garland, Emre Ünver, & Onur Güntürkün (Ruhr University Bochum)

P32

A number of species which are unable to pass the mark test can locate objects by using the reflective properties of a mirror. These species seem to understand how visual reflection functions but cannot apply it to their own image. We tested this discrepancy in pigeons – a species that does not pass the mark test. Indeed we initially discovered that pigeons can successfully find a hidden food reward using only the reflection. However, tested under monocular conditions the pigeons approached and attempted to walk through the mirror rather than the physical food, displaying similar behavior to patients with mirror agnosia. These findings clearly show that pigeons do not use the reflection of mirrors to locate reward, but actually see the food peripherally with their near-panoramic vision. A re-evaluation of our current understanding of mirror-mediated behavior is necessary – especially taking more fully into account species differences in visual field. This study suggests that use of reflections in a mirrored surface as a tool may be far less widespread than currently thought.

Poster Session II - Saturday Evening

P33

Personality, cognition and habits behaviours in horses: evidence from a contingency degradation task

Léa Lansade (INRA UMR 85 CNRS UMR 7247 Université Tours IFCE Nouzilly France), Etienne Coutureau, Alain Marchand (INCIA Université Bordeaux CNRS UMR 5287 Talence France), Cyrielle Ballé, Floriane Polli, & Ludovic Calandreau (INRA UMR 85 CNRS UMR 7247 Université Tours IFCE Nouzilly France)

The relationship between personality and learning abilities has become a growing field of interest. Studies have mainly focused on the relationship with performance, such as the speed of acquisition. In this study, we assume that personality could be also related to the process involved during learning, particularly in the balance between goal-directed and habits forming processes. To identify these processes, we conducted a contingency degradation protocol. This study investigated 1/ whether in general, horses are able to adjust their response according to the contingency between an action and a reward and 2/ whether there are any relationships between certain personality profiles and a predisposition to switch more rapidly to habitual processes. Twenty-nine horses were submitted to personality tests followed by a degradation contingency protocol. Results show that, overall, horses were sensitive to contingency degradation between their action and the reward. That means they are able to form a sophisticated mental representation of the consequences of their actions. Therefore this study provides new theoretical knowledge on cognitive skills in herbivores. Nevertheless, there was interindividual variability: the horses presenting the most fearful personality were less sensitive to the degradation, showing they would be more prone to switching towards a habitual process.

P34

Cephalopods: A unique lineage to understand convergence and evolution in the construction of advanced learning and memory systems

Jennifer Basil (CUNY Brooklyn), Binyamin Hochner (Hebrew University of Jerusalem), & Frank Grasso (CUNY Brooklyn)

Cephalopods (Octopuses, cuttlefish, squid and nautiluses) are a large and ancient group of marine animals with complex brains. Forms extant today are equipped with brains, sensors, and effectors that allow them to not just exist beside modern vertebrates as predators and prey; they compete fiercely with marine vertebrates at every scale from small crustaceans to sperm whales. We review the evolution of this group's brains, learning abilities and complex behaviors. We outline evidence that that while competition with vertebrates has left a deep impression on the brains and behavior of cephalopods, the original re-organization of their complex brains from their molluscan ancestors may have been forged in ancient seas millions of years before the advent of bony fishes. Cephalopod brains suggest evolutionary convergence into a universal organization of with activity-dependent long-term plasticity mechanisms. However, the properties of the neurons, neurotransmitters, and mechanisms of long-term potentiation are highly variable among different species. Thus, these complex networks may have evolved independently multiple times. Though memory and learning networks share similar organization and cellular processes, there are multiple ways of constructing them. We now expand our brain studies to the plesiomorphic Chambered Nautilus.

P35

Socio-behavioral asymmetries in Colombian spider monkeys (*Ateles fusciceps rufiventris*)

Emily R. Boeving, Giulianna A. Kendall, & Eliza L. Nelson (Florida International University)

Fission-fusion is characterized as a fluid social dynamic in which groups split into cliques and reunite. In fusion events, monitoring individuals and detecting emotion may be critical for maintaining relationships among conspecifics. Previous studies suggest the right hemisphere may be specialized for arousing social behaviors while the left hemisphere may be specialized for routine activities. We tested the hypothesis that social behaviors are differentially related to hemispheric specialization. We predicted a left side bias across three dyadic socio-communicative behaviors that occur at fusion events: face-embrace-vocalization, embrace, and arm-and-tail wrapping. Additionally, we predicted a right side bias for grooming, as it is a routine social behavior. We utilized an ad libitum sampling method to record 186 hours of matched-to-time samples of observational data (N=16). Binomial tests indicated embrace and face-embrace-vocalization were both lateralized to the left side of the body, $p < .01$ while grooming was lateralized to the right side of the body, $p < .05$. Arm-and-tail wrapping occurred almost exclusively along the midline. The results build upon previous findings indicating delineation of function between brain hemispheres.

P36

SNARC effect in pigeons?

Caitlin Golder, Olga Lazareva (Drake University), & Regina Gazes (Bucknell University)

The spatial-numerical association of response codes (SNARC) effect is the tendency to respond faster or more accurately to the smaller numbers when response is located on the left than when it is located on the right (and vice versa for the larger numbers). The SNARC effect is presumed to reflect an automatic tendency to order numbers and magnitudes from left to right in Western cultures. We trained pigeons to select a smaller of the two simultaneously presented arrays of circles. All circles had the same diameter so that the larger arrays also occupied larger areas. Once the pigeons learned the task, they were presented with a novel, non-differentially reinforced pairs of arrays. Upon completion of the testing, the contingencies were reversed and the birds had to learn to choose a larger of the two arrays; after that, the testing was repeated. The order of the tasks was counterbalanced across the birds. The majority of the birds displayed a strong SNARC effect, although its direction (left-to-right or right-to-left) was not consistent across the birds. Future research will explore the control of SNARC effect by magnitude of the array and by its surface area.

List learning in rats using odor stimuli: Effects of delay and list length

Catharine Nealley, Aliana Raulerson, Mark Galizio, & Kate Bruce (University of North Carolina Wilmington)

P37 Delayed-match-to-sample procedures have been used to test memory in a variety of species, including rodents using odor stimuli. At short delays (1-2 sec), high accuracy is maintained, but after 1-2 minutes, performance drops to chance (Otto & Eichenbaum, 1992). Wright (2007) argued that the list-learning procedure is a more ecologically valid variant of the delayed-matching procedure, as it creates functional relations between list items. In a parametric study, we determined how memory load (6, 12, 18-item lists) and delay (5 sec, 1, 10, 20, 60 and 90 min) affect memory in 4 rats, using a modified Odor Span Task. For most rats, as list length increased, recall decreased. At delays to 20 min, there was little effect of delay; however, at longer delays (60 and 90 min), performance neared chance for all lists. That rats performed with high accuracy on the list task for relatively long delays, compared to the DMTS study on rats and work on list learning with pigeons and monkeys, underscores the importance of procedures used to examine the effects of delay on memory. The list procedure and the use of odor stimuli may be more ecologically valid approaches to the study of memory in rats.

An automated version of the rodent Odor Span Task

Angela Goolsby, Madeleine Mason, Katherine Dyer, Catharine Nealley, Michael Mathews, Andrew Caliri, Samantha Hess, Sarah Krichbaum, Kate Bruce, & Mark Galizio (University of North Carolina Wilmington)

P38 The Odor Span Task (OST) is a procedure that is increasingly used to assess working memory capacity in rodents. The procedure involves placing the rat or mouse in an arena in which odor stimuli can be presented using cups filled with scented materials or covered by a scented lid. An incrementing non-match to sample procedure is used such that selection of each odor produces food reward when first presented, but not on any subsequent presentations. Thus, correct selections depend on the subject remembering which stimuli have already been presented. The use of an arena setting with manual stimulus presentation makes the OST labor-intensive and necessitates a number of controls (for cuing, scent of the food reward etc.), and thus an automated version of the OST would be of value. The present study used an operant chamber equipped with a 15-channel olfactometer. Seven rats were trained on successive conditional discrimination procedures (Go-No-Go) under the incrementing non-matching-to-sample contingency and developed high rates of responding to odor stimuli when they were initially presented and relatively lower rates of responding on subsequent presentations of that stimulus supporting the use of this automated version of the OST to study memory processes in non-human subjects.

How do you know that? Discerning the status of newly self-generated knowledge using memory for source

Jessica A. Dugan, & Patricia J. Bauer (Emory University)

P39 Semantic memory, our repository of knowledge, is unmarked by details of time or place (Tulving, 1972). It is reasonable to expect that the episodes during which knowledge is acquired are marked by such contextual details. The present research was an investigation of eight-year-olds' memory for the context of their newly self-generated knowledge. Children were read story passages presenting novel facts that could be integrated to self-generate new knowledge. Following a one-week delay, we asked them to identify where they learned each fact from a set of choices. Rather than choosing the option depicting "I figured it out myself," children selected the second story as the source of their new knowledge on 94% of correctly recalled trials. This suggests that children are aware that they are integrating after learning the second fact in each story pair. Future extensions to nonhuman primate models will be discussed

Examining the effects of perirhinal cortex lesions on rats' ability to perform two different tests of object-recognition memory

Emily Cole, Joelle Ziade, Amanda Simundic, Pawel Jastrzebski, & Dave G. Mumby (Concordia University)

P40 Object-recognition memory is commonly assessed in rats using the novel-object-preference (NOP) test. This object-recognition test takes advantage of rats' natural tendency to explore novel objects more than familiar ones when both are presented in a familiar environment. Previous research has shown that rats with perirhinal (PRh) cortex lesions fail to display a novel-object preference on the test, which is then presumed to reflect a failure in object-recognition memory. Some recent observations, however, have raised concerns about the internal validity of the NOP test as a gauge for object-recognition abilities. The goal of the present experiment was to assess the effects of PRh cortex lesions on rats' ability to perform a new object-recognition task developed in our lab (a modified delayed nonmatching-to-sample (DNMS) task). Rats with PRh cortex lesions were capable of learning and performing the modified DNMS task relative to control rats. Conversely, when we tested rats with PRh cortex lesions on the NOP test, they failed to exhibit a novel-object preference following a short delay. This discrepancy in rats' performance on the two tests further adds to the concern that a failure to exhibit a novelty preference on the NOP test may not necessarily reflect the status of object-recognition.

Experience improves numerical acuity in nonhuman primates

Sarah Jones (Berea College), & Elizabeth Brannon (Duke University)

P41 We investigated change in the approximate number system (ANS) in three rhesus macaques, using a nonsymbolic ordering task. Prior to Time 1, macaques were trained to order a subset of the numerosities 1-9. Between Time 1 and Time 2, all three macaques received extensive training on numerical tasks. We estimated numerical acuity by modeling Weber fractions (w) and found that all three monkeys showed a reduction in w from Time 1 to Time 2 demonstrating an effect of training. Additionally, our results indicate that individual differences in numerical acuity in nonhuman primates may be stable over time. These results suggest that numerical experience affects the acuity of the ANS, but is insufficient to eradicate individual variability.

Dissociating principal and medial axis predictions: Effects of training enclosure size

D. Gregory Sullens, Spencer J. Price, Bradley R. Sturz, & Kent D. Bodily (Georgia Southern University)

P42 Incidental-learning procedures are often used to determine the stimuli that control spatial reorientation in diverse species. A common procedure is to train subjects to approach a discrete landmark prior to testing in the absence of the landmark. Global geometric cues, such as the medial axis of space and the principal axis of space, have both been suggested to account for spatial reorientation in variety of animals (e.g., rats, pigeons and humans). Additionally, the control of spatial reorientation by the global geometric cues has been suggested to vary based upon the size of the enclosure—with smaller enclosures producing greater control by global geometry. In the present study, we trained human participants to approach rotationally-equivalent corners (i.e., north-east and south-west) of a rectangular enclosure in a desktop virtual environment. We manipulated the size of the training enclosure between groups. Following training, all participants were tested in an I-shaped enclosure which dissociated predictions made by medial-axis and principal-axes accounts. Results provide evidence of orientation by principal axis that is dependent on training enclosure size—supporting principal axis accounts of spatial reorientation across species.

An interference test of the spatial representation of order in chimpanzees (*Pan troglodytes*)

Rachel F.L. Diamond, Robert R. Hampton (Emory University and Yerkes National Primate Research Center), & Ikuma Adachi (Primate Research Institute of Kyoto University)

P43 Humans organize their thinking about order and quantities using mental representations with spatial characteristics. Few studies provide evidence suggesting that similar spatial representations support memory for order in nonhuman primates (Adachi, 2014; Gazes et al., 2012). We directly test whether the ability to order lists in chimpanzees is dependent on a spatial representation mechanism. Chimpanzees were trained to remember the spatial location of a stimulus on a touchscreen computer. We then embedded either an order task or a control visual matching task, matched for difficulty, into the delay of the spatial memory task. If a spatial representation supports execution of the order task then performance on the order task should be impaired when it is embedded within the spatial memory task and resources for spatial cognition are limited. In contrast the visual matching task should not be impaired, even though it is equally difficult, because it does not compete for spatial processing resources. Preliminary results suggest that performance on the order task decreases more when it is embedded within the spatial memory task than does performance on the matching-to-sample task. These findings suggest that our closest living primate relatives use spatial cognition for processing order, much as humans do.

Observation of search strategies facilitates and inhibits subsequent learning of spatial relations among locations

Matthew C. Bruster, Kent D. Bodily (Georgia Southern University), Michael F. Brown (Villanova University), & Bradley R. Sturz (Georgia Southern University)

P44 Recent comparative research has investigated the influence of social information on spatial learning (see Brown, 2011). Previous work from our lab found evidence that observational learning influenced human learning of spatial relations among locations in virtual environment search task. A group of participants watching an avatar complete a spatial pattern learning task in an optimal fashion made fewer errors and more search moves consistent with the hidden spatial pattern compared to a group of participants watching an avatar complete the spatial pattern learning task in a random fashion. In the present experiment, one group of participants watched a virtual character complete a spatial pattern learning task using an optimal search strategy (Optimal) while a second group watched a virtual character complete the spatial pattern learning task using a random search strategy (Random). A third group was not exposed to any search strategy (Control). All participants then completed the spatial pattern learning task. Results indicate a combination of facilitation of learning in the Optimal Group and an inhibition of learning in the Random Group relative to the Control Group. Collectively, these results are conceptually consistent with those obtained with rat subjects and have comparative implications for social influences on spatial behavior.

Does chemo-tactile sensory discrimination ability influence space use in the fiddler crab *Uca pugilator*?

Arthur Golub, Stephen G. Volz, & Frank W. Grasso (Brooklyn College)

P45 The ecology, phylogeny and innate burrow-homing behavior of fiddler crabs suggest they could possess generalized spatial memory ability. Previous research showed that arthropods including crustaceans such as lobsters, shore crabs, and fiddler crabs, use chemoreceptors on their feet for chemo-tactile (touch-taste) object discrimination. We hypothesized that fiddler crabs use chemo-tactile ability to support spatial memory. As a first step towards this we designed an arena with three regions: a brackish water region (66% of the arena); a food-flavored sand region (17%); and non-flavored sand region (17%). We measured the time crabs spent in each region over a 24-hour period. The animals (n=13) varied widely but unsystematically in their use of the dry and wet regions. We found significant differences in the proportion of time the crabs spent in the flavored versus non-flavored region $t(12) = 2.21$, $p=0.047$. Contrary to our predictions the crabs spent significantly more time on the non-flavored region. This suggests that the animals found the flavored side somehow aversive. We conclude that fiddler crabs can sense the difference between these two regions in a way that influences their use of space. This demonstration is a foundation for studies exploring putative spatial memory processes in fiddler crabs.

A phylogenetic analysis of spatial memory in freshwater crustaceans

Flora Muslumova (BioMimetic and Cognitive Robotics Lab), & Frank W. Grasso (Brooklyn College)

P46 Crayfishes are a successful and diverse taxonomic group with world-wide distribution, intensely studied for their behavior and neurobiology. Studies of their spatial memory capacity indicate several evolutionary innovations and losses. Learning the distribution of spatial memory across these species will aid understanding the ecological fit of memory ability to environmental demands. Through a literature search on 191 species, we accumulated quantitative values of 11 attributes related to spatial memory for 27 species of crayfish from 9 genera: *Cherax, Pacifastacus, Astacus, Austropotamobius, Procambarus, Cambarellus, Barbicambarus. Orconectes, Cambarus*. Cluster analysis using these attributes divided these 27 species into 5 classes, which were rank-ordered based on their degree of suitability for spatial memory. We mapped these five classes onto a published molecular phylogeny to study the relative evolutionary relationships between these species. We found the ancestral state of our crayfish species showed heavy reliance on correlates of spatial memory. These correlates were lost for some sub-taxa; they (particularly burrowing behavior) reappeared in some derived species, indicating reinvention. A heterogeneity index was used to identify taxa with strong gradients of spatial ability. The genera *Procambarus* and *Orconectes* are the best candidates for comparative studies of the mechanisms and evolution of spatial memory in crayfishes.

Crayfish *Procambarus clarkii* show shelter fidelity under laboratory conditions

Anastasia Pluish (BioMimetic Cognitive Robotics Lab), Stephen G. Volz, Tracey Castillo, & Frank W. Grasso (Brooklyn College)

P47 In field studies *Procambarus clarkii* have not shown burrow fidelity, leading some investigators to conclude this species has inferior spatial memory relative to other crayfish species. A natural indicator of spatial memory is burrow fidelity, the persistent re-occupancy of one burrow. We investigated burrow fidelity in the crayfish *P.clarkii* in the laboratory, using controlled environmental conditions and identified individuals. We hypothesized *P.clarkii* would show shelter fidelity when given a choice. We tested 11 *P.clarkii* in a three-phase experiment: phase-one had no shelter; phase-two a single shelter; phase-three two shelters. Placements of initial shelters were counter-balanced to control for side preferences. We recorded each animal's location and shelter occupancy 5 times daily. The initial shelter was occupied significantly more frequently than the second shelter during phase-3 (Chi-Squared(1)=88.89 $p<<0.001$). The time spent in the initial shelter quadrant was significantly different across the three phases ($F(2,108)=24.18$ $p<0.0001$, Eta-Squared=0.31). A second study, in which half the shelters were relocated in phase 3, replicated our earlier fidelity results and additionally found a significant sex-by-shelter-relocation interaction $F(1,130)=6.04$ $p<0.02$. We conclude that *P.clarkii* have strong capacity for distinguishing shelter locations and speculate that they have much stronger capacities for spatial memory than previously asserted.

Black-capped chickadees do not flexibly employ win-shift or win-stay foraging strategies in a spatial working memory task

Christopher J. Course, Nicole A. Guitar, Caroline G. Strang, & David F. Sherry (The University of Western Ontario)

P48 Foraging animals can employ two strategies: win-stay to return to the location of food, or win-shift to avoid that location in the future. Depleting or slowly replenishing resources should promote a win-shift strategy, whereas abundant or rapidly replenishing resources should promote a win-stay strategy. Chickadees forage on foods that may promote a win-shift strategy (e.g. insects) or a win-stay strategy (e.g. seedheads). We tested two groups of chickadees (n = 7/group) on spatial memory tasks to determine their spontaneous foraging strategy and whether they could flexibly employ either strategy depending on reward contingencies. In these tasks birds found food rewards in phase A, and after a short interval, searched again in phase B with reward contingencies in phase B reinforcing either a win-shift or win-stay strategy. The number of searches they could make in phase B was varied across three different motivational conditions. Chickadees showed a win-shift strategy within each phase, but did not employ a win-shift or win-stay strategy across phases, regardless of reinforcement contingency or motivation. While chickadees successfully employ a win-shift strategy within a foraging bout, they appear indifferent to the renewal and depletion properties of food sources over a longer time scale.

Geometric and tactile cue conflict in the absence of visual sense: Evidence from the reorientation paradigm

Marshall L. Green, Jonathan E. Roberts (Armstrong State University), & Bradley R. Sturz (Georgia Southern University)

P49 Some mobile organisms must orient in the absence of vision. Previously, humans have been found to learn the geometric configuration of an environment in the absence of visual input when tested in the reorientation paradigm (Sturz et al., 2013). To further investigate the use of tactile sense during reorientation, we placed beacons and enclosure geometry in conflict in the absence of visual sense. Adult humans were trained to locate a target object located in one corner of a rectangular enclosure, each corner containing a unique textural cue and the target object associated with the same texture throughout training. During the test trial, all beacons were shifted one corner such that the location of the target object as specified by geometric cues conflicted with the target location as specified by the trained textural cue. Participants' first searches were allocated to the location of the trained textural cue. Importantly, participants' second searches were allocated to the geometrically equivalent corners. Collectively, results appear consistent with cue conflict results obtained during sighted orientation in that a beacon strategy dominated initial search; however, geometric information was utilized after this initial beacon strategy failed. These results have comparative implications for orientation in the absence of vision.

A 'later-destination attractor' bias in humans and rhesus macaques (*Macaca mulatta*)

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P50 How different organisms organize and move through space is a classic question in comparative psychology. En Fu and colleagues demonstrated a new multiple-target navigation bias in humans that has not yet been demonstrated in a non-human species. The bias, termed the 'later-destination attractor' bias was observed when human participants navigated within a room to a series of tables at which the participant performed a short task. Importantly, both routes that a participant could choose to take to the initial, centralized destination were equally efficient. Because the two routes were equally efficient, participants were not expected to demonstrate any preference for which route they should take when this initial target was the only destination. Indeed, participant choice among the routes was not significantly different from chance. Nevertheless, when the participant was required to visit one or more additional destinations, participants did demonstrate a preference in how they approached the initial destination. Specifically, a participant more commonly chose the path to the initial destination that set out in the same direction as s/he would need to later travel to the secondary destination (even though proceeding in this way was not any more efficient). The present study explores (1) whether this later-destination attractor bias will be replicated in the context of a computerized, two-dimensional wayfinding task and (2) whether joystick trained rhesus macaques (*Macaca mulatta*) demonstrate the same bias as humans.

Avoidance learning in the fiddler crab, *Uca pugilator*

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P51 Fiddler crabs' innate burrow homing behavior makes them natural subject for studies of invertebrate spatial memory. Since most evidence is from field studies one goal of our project is to develop and validate methods for studying spatial learning in fiddler crabs under controlled lab conditions. We hypothesize that this burrow-homing ability extends to a generalized spatial memory ability. To that end we have developed a new method for implanting electrodes in the gills of fiddler crabs, through which we can deliver electric shocks to freely behaving animals. We developed a new arena to study crab spatial memory in a place learning paradigm. In this a crab is free to explore and electric shock is administered when the animal enters an experimenter determined region of the arena. We present results from 12 animals each of which experienced 3 days of 3 hour training sessions, and a subsequent extinction trial in day 4 where shock isn't presented. Our initial results indicate, with high variability, weak preference for the non-shock side of the arena. Currently will present presenting preliminary results of our first series of trials, and a discussion of some methodological issues we have encountered implementing this new experimental paradigm.

Integration of conflicting temporal expectations in Pavlovian-instrumental transfer

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P52 Temporal relationships between cues and outcomes are integral components of associative learning, but are infrequently studied in the context of Pavlovian-instrumental transfer (PIT). Previous work has shown that systematically varying delays during the Pavlovian phase mediates the temporal qualities of operant responding in sensory-specific PIT (Delamater and Holland, 2008). In a recent study (presented at SFN, 2015), we extended these results to general PIT. We concluded that incentive salience is maximal at the time when a reward is most likely to be delivered. These results will be compared with those from the current experiment, still ongoing, which investigates how conflicting temporal expectations are resolved in PIT. In operant conditioning, rats integrate conflicting temporal expectations arising from presentation of a compound cue using an averaging process (De Corte and Matell, 2015). The current experiment uses a single time delay in the Pavlovian learning phase (15 or 30 seconds), and a second time delay (60 seconds) in the operant learning phase. The results are expected to show whether rats integrate or sum conflicting temporal expectations across learning contexts, and may be informative about whether temporal information encoded in Pavlovian and operant learning contexts is processed and retrieved in similar or dissimilar manners.

Temporal patterns in behavior of the cephalopod mollusk, Chambered Nautilus.

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P53 Chambered Nautilus makes repeated daily migrations from deep to shallower waters, foraging along coral reefs. It is unknown what modulates these daily rhythms – perhaps the detection of light drives the dives to deeper depths, or these daily rhythms could be an expression of an endogenous circadian clock. We continuously videotaped a captive group of nautiluses (N=5) under three L:D conditions, of 4 days each. We measured their activity levels, movement patterns, and inter-animal associations for one minute every 10 minutes. First animals were exposed to 12:12 L:D for 4 days to determine if they would entrain to a set light cycle. We then released them into constant darkness (D:D) for 4 days to determine if they expressed an endogenous free-running rhythm with a set period (Tau) in the absence of external cues. Finally, we re-exposed the nautiluses to the 12:12 light cycle to determine their re-entrainment patterns after free-running in darkness. Nautiluses show clear entrainment to 12:12 Light: Dark, with peak activity in darkness, beginning around subjective dusk. In D;D, subjective dusk/night activity rhythms persisted, although the free-running period was less than 23h. This is the first demonstration of endogenous biological rhythms in Chambered Nautilus.

An investigation of tool use abilities in young children (*Homo sapiens*) and orangutans (*Pongo pygmaeus pygmaeus*)

Taylor O'Leary, & Caroline DeLong (Rochester Institute of Technology)

P54 The purpose of this study was to investigate tool use abilities in children and orangutans. In Experiment 1, a female orangutan, Kumang, completed six different mazes across six sessions (two easy, two intermediate, two difficult) using a custom-built puzzle box. We found that she was successful on 16/30 trials (including only 1/10 difficult maze trials). Kumang took approximately the same amount of time (M = 65 s) to successfully complete the mazes. In Experiment 2, 20 children (ages 2-5 years, M = 3.5) were tested. The observational group watched an adult human model complete each maze first. The trial-and-error group had no model. We found that both groups succeeded on the easy and intermediate mazes, and that children completed one difficult maze significantly more often than the other. When successful, the children in both groups took about the same amount of time to complete each maze (M = 37.5 s), however 9/10 children in the observational group succeeded on the difficult mazes, whereas only 4/10 children in the trial-and-error group succeeded. Both the children and orangutan successfully used stick tools. A future study will explore observational learning in orangutans with Kumang and her daughter Bella.

Examination of object manipulation and weaving behavior in cotton-top tamarins (*Saguinus oedipus*)

Erica Hoy Kennedy, Kathryn Bell, Renee Anderson, & Jennifer Tyrell (Frostburg State University)

P55 Tool use in nonhuman primates is influenced by hand morphology and finger movements as well as conceptual understanding of the tool. Compared to other New World monkeys, cotton-top tamarins are limited in terms of their capacity for tool use. However, they are able to select objects for manipulation based on functionally relevant properties and can be trained in captivity to use tools. Our colony of cotton-top tamarins has been observed manipulating objects in relation to surfaces. Tamarins have been observed weaving small sticks through plastic mesh repeatedly without any associated food reward. We aimed to gain a better understanding of this behavior as a possible precursor to tool-use by presenting 12 tamarins with seven objects differing in length, flexibility, and composition. Time to contact, along with duration and frequency of contact, were measured for each object. Preliminary results show no significant difference in duration of time the objects were handled for males versus females, and there was also no preference in manipulation of rigid versus flexible objects ($p > .05$). Additional analyses will further investigate what properties of objects are preferred for manipulation in order to gain a better understanding of weaving in tamarins.

Problem solving and tool use in three species of otter

Robert Gormley, & Preston Foerder (The University of Tennessee at Chattanooga)

P56 Sea otters are well known tool users, yet the cognitive capacities of other otter species have been sparsely studied. Precedent exists for non-tool using species closely related to native tool users to display comparable abilities under experimental conditions. The social intelligence hypothesis predicts complex cognitive capacities in socially complex species. Using the Aesop's Fable paradigm – wherein subjects drop stones into a cylinder half-filled with water to acquire floating out-of-reach food items – we assessed North American river otters', Asian small-clawed otters, and giant river otters abilities to solve a novel tool-mediated problem. Sticks and water were presented with the stones, providing opportunities for tool use. No otters successfully completed the task. Interaction with the apparatus decreased significantly across sessions, possibly contributing to the otters not solving the task. A better understanding of the similarities and differences in the cognitive abilities of these species can inform future conservation efforts.

Acoustic features and context of vocalizations by wild capuchin monkeys during spontaneous tool use

Qing Liu, & Heather Laski (State University of New York at Oswego)

P57 Wild bearded capuchin monkeys (*Sapajus libidinosus*) routinely use heavy stones as hammers to crack open hard palm nuts in our research site in Piaui, Brazil. To our knowledge, vocal repertoire of this species of *Sapajus* has not been studied and no study has examined their vocal behavior in relation to this percussive tool use behavior. It is usually assumed that vocalizations in a foraging context are food associated calls and they are usually emitted by females and immatures, rarely from adult males. From 305 nut-cracking episodes, we focus on the vocalizations that were not emitted in response to other individuals in an overtly social situation (such as aggression or contact calls) and we also excluded alarm calls. We assume we are left with vocalizations that are uttered to oneself while using a tool. However, these vocalizations seem more than just food associated calls and adult males emit calls frequently during nut-cracking. In this presentation, we describe the acoustic features of the vocalizations and their temporal patterns in relation to nut-cracking events such as positioning, strikes and successful outcome of cracking open the nut. We aim to determine if vocalizations during nut-cracking has any significant relationship to their tool use behavior.

The influence of neophobia, human familiarity and human attentional state on eating behavior in blue jays

Katelyn Evenson, Debra Hansberry, Senia Sikkink, & Kristy Gould (Luther College)

P58 Individual differences in blue jay temperament, in the form of neophobic behavior, were assessed. Next, the amount of time to eat food in the presence or absence of a person was investigated. The person could be either familiar or unfamiliar, and had different attentional states (looking at the bird, looking down, back turned, eyes closed). We assessed neophobia in three ways, independent of the familiarity/attentional state experiment. There were no correlations between neophobia measures and the time it took a bird to eat when exposed to manipulations of human familiarity or attentional state. However, the familiarity of the person had an impact on the time it took to eat in the experiment, while the attentional state of the human did not. Individual differences in time to eat were found for these two variables as well and will be discussed. While it appears that our measures of neophobic behavior are not a good indicator of how a bird will perform in experiments where they are exposed to humans, it may be a good indicator of how a bird will perform in novel situations during habituation and training procedures before an actual experiment takes place.

Comparative cognition at Brevard Zoo

Darby Proctor (Florida Institute of Technology)

P59 Recent legislative changes in the United States have made it more difficult for research facilities to maintain nonhuman primates. As such, other venues for exploring nonhuman primate behavior and cognition must be sought out. One option is to move comparative cognitive testing into zoological settings. Here, I report on the beginnings of a comparative cognition research program at Brevard Zoo in Melbourne, FL formed in collaboration with Florida Institute of Technology. Brevard Zoo is committed to making science part of the visitor experience in addition to more traditional zoological goals of education and conservation. While working in zoos has some limitations for researchers, there are also important benefits of doing research in a public space that may not be readily apparent, including exposing the public to science and reduced costs relative to maintaining an animal research facility. As it becomes more difficult due to legislation and the public perception of "animal research," moving towards a zoo model may be essential for the future of comparative cognition.

The behavioral effects of environmental enrichment in a large sample of captive tigers (*Panthera tigris*)

Lilly Sage McCoy, Kate M. Chapman, & Luke Gould (University of Arkansas)

P60 Many nonhuman species experience increased levels of stress in captivity, resulting in stereotyped behaviors (e.g. pacing, over-grooming) and reduction in species-typical behaviors. Animal facilities often implement environmental enrichment to modify, diversify and improve the captive environment to reduce negative behaviors and increase positive behaviors. While previous studies have examined the effects of environmental enrichment on captive felids, significant effects have been rare due to small sample sizes (N = 2-5) available in animal facilities. The present study evaluated the efficacy of several types of environmental enrichment in a sample of 33 captive tigers (*Panthera tigris*) housed in large, outdoor enclosures at Turpentine Creek Wildlife Refuge. Using focal-animal sampling and time sampling, we assessed tiger behavior using a comprehensive ethogram in both enrichment and baseline conditions. The within-subjects paradigm evaluated the following enrichment types: scent-only, scented-organic object, scented-inorganic object, unscented-inorganic object and feeding enrichment. On average, we found that tigers engaged in behaviors classified as 'active' roughly 30% of sessions, regardless of enrichment condition. Results indicated that tigers displayed fewer negative, stereotypical behaviors (e.g. pacing) during enrichment sessions compared to baseline sessions. In addition, feeding enrichment was most effective; tigers displayed more active behaviors in these sessions compared to baseline sessions.

The effects of age and declawing on the behavioral patterns of captive tigers (*Panthera tigris*)

Kate M. Chapman, Lilly Sage McCoy, & Luke Gould (University of Arkansas)

P61 The legal and illegal exotic animal trade has led to increasingly higher number of tigers living in captivity in the United States. Many of the tigers living in private homes are declawed to prevent damage to people and property. While it has been established that declawing leads to increased pain and the incidence of arthritis, it is not known how declawing affects the overall behavioral patterns in tigers. We evaluated the behavioral effects of declawing and advanced age in a sample of 33 captive tigers (*Panthera tigris*) housed in large, outdoor enclosures at Turpentine Creek Wildlife Refuge. Using focal-animal sampling and time sampling, we assessed tiger behavior using a comprehensive ethogram in both enriched and baseline conditions. We found that declawed tigers (N=12) spent less time engaged in behaviors classified as 'active' compared to claw-intact tigers (N=21). Older adult tigers (11-15 years, N=12) and geriatric tigers (16+ years, N=11) spent less time engaged in active behaviors compared to adult tigers (4-10 years, N=9). Adult tigers were nearly 1.5 times as active as the older adult and geriatric tigers during observation periods. The effects of declawing and advanced age also emerged for several specific behavioral categories.

Bond formation in a managed collection of male common bottlenose dolphins (*Tursiops truncatus*)

Wendi Fellner (Disney's Epcot's The Seas), Barbara A. Losch, & Heidi E. Harley (New College of Florida)

P62 Dolphins live in a fission-fusion society. Adult males form long-lasting social bonds spending > 50% of their time together. In a managed collection of dolphins, one goal is to emulate social structures that exist in the wild as well as place compatible pool mates together. Here we use longitudinal observations of synchrony and other social behaviors as indicators of compatibility and bond formation within a group of 4 males. Synchronous relationships differed between pairs, ranging from spending 5 to 43% of their time overall swimming synchronously. The behavior of 2 dolphins changed with the arrival of 2 additional dolphins, transforming from no synchronous swimming to spending > 80% of their time swimming synchronously. When divided into pairs, the two youngest dolphins spent 9% of their time engaged in joint activities while the oldest two spent 2% of their time with each other. Some members spent more time socializing with a member of the opposite pair through a mesh gate (1 to 12% of each dolphin's time). Synchronous behavior can elucidate subtle relationships between individuals. Recognizing their expressed preferences for swimming partners can help inform management decisions about group housing arrangements that lead to optimum compatibility and welfare.

Persistence, frustration, and boldness in wild fox squirrels

Michelle Ramey, Mikel Delgado, & Lucia Jacobs (University of California Berkeley)

P63 Recent studies in primates have shown that frustration responses and persistence may be stable, repeatable aspects of individual differences (personality). Personality, or behavioral syndromes, have been documented in a variety of species, but most rodent studies have focused on captive animals and traits such as boldness, activity, and exploration. In the current study, we used a population of wild fox squirrels to look for evidence of frustration and persistence traits and explored how they were related to boldness. We measured behavioral differences between individual squirrels using two tasks: in the first task, we measured boldness by recording latency to approach a novel stimulus; in the second task, we measured persistence and frustration by presenting squirrels with a puzzle box and a surprising omission of reinforcement. We anticipate that we will find stable differences between individuals across trials, and that scores in boldness will be correlated with time spent persisting at a task and frustration responses (such as tail flagging). Such a finding would support the feasibility of studying animal personality in the field, as well as suggest that there may be additional underexplored personality traits, such as frustration responses and persistence, that are worth investigating in non-human animals.

Effects of early life challenges on adult life success in zebra finches

Ahmet Kerim Uysal (University of South Florida), Douglas G. Barron (Arkansas Tech University), Lynn Martin, & Toru Shimizu (University of South Florida)

P64 Effects of early-life stress on adult behavior and phenotype are well-documented in different animals. Although various types of stressors (e.g., nutritional restriction, corticosterone administration) have been studied in birds, little is known about effects of immune challenge. Early-life immune challenge may cause long-term effects on behavior and fitness of adult individuals and have a significant impact on disease transmission in bird populations. In this study, we treated three cohorts of 14 day-old nestlings with Polyinosinic: polycytidylic acid (Poly I: C), an agent mimicking viral infections. When they became 4-5 months old, we investigated effects of immune treatment on behavior (e.g., general activity, neophobia, sociality, and attractiveness) and phenotypic traits (e.g., cheek color, body size). The results based on the first cohort showed an increased general activity and fainter cheek color in the treatment group compared to the control. Although we have not yet confirmed significant effects on any other behaviors and phenotypes, the results so far suggest that early-life immune challenge did affect adult behavior and phenotype related to disease transmission as well as mating success.

An investigation of spatial working memory in mice

Stephanie E. Jett, Kris O'Donnell, Joshua Taylor, Oscar Lopez, James Coley, Margot Fontenot, Adam M. Stern, Benjamin Hill, Jonathon Audia, & Diego Alvarez (University of South Alabama)

P65 Wild-type mice were tested on spatial working memory (SWM) abilities utilizing spatial memory and visible displacement (transposition) tasks adapted from the Primate Cognitive Test Battery (PCTB). Rodent models have a long history of being used to measure SM with tasks such as radial arm mazes and water navigation tasks. These tasks, while vital for measuring basic SM abilities and, more recently episodic-like memory, may not fully explore the breadth of SWM, which has been suggested to necessitate executive functioning capabilities such as behavioral inhibition and flexibility. Due to their close phylogenetic relationship to primates, it is possible that cognitive convergence has led to rodents possessing similar SWM capabilities to primates. Of the fifteen mice tested on three SWM memory tasks, only four mice met criterion on the basic SM task. Of those four, only one reached criterion on the unbaited transposition task and the most complex baited transposition task. Despite a high degree of individual differences in performance, these results are significant due to the fact that it is the first demonstration of the ability of rodents to follow visible displacement, providing preliminary evidence for the possibility of cognitive convergence between the species, despite varying ecological and environmental pressures.

Piercing the veil of scavenger ecology to understand scavenger behavior and cognition

Adam M. Stern, & Stephanie E. Jett (University of South Alabama)

P66 While other trophic systems are better understood in terms of the interplay between ecology, behavior and cognition, scavenging systems are less well understood. Though the only vertebrate obligate scavengers are the vultures, scavenger behavior is engaged in opportunistically by almost all vertebrate predators. Engaging in scavenging behavior is, in part, linked to the ecological pressures present. For instance, as cities grow outward, many vertebrate carnivore species are moving inward, exploiting the new urban habitats. The abundance of anthropogenic food items available in the urban environment has started to decouple predator/prey relationships as predators are relying less on predation and more on opportunistic scavenging to survive. In addition, each trophic system necessitates emphasis on differential behavioral and cognitive toolkits. Predation, for example, emphasizes visual processing, while caching species rely heavily on spatial memory. It could be hypothesized that the scavenging toolkit relies more heavily on visual and spatial processing, problem solving, and organismic valuation of food (e.g. quantity and quality). Behavior is the product of cognitive processes, the survival value of which can only be evaluated within the framework of ecology. Building on previous work, we propose a theoretical framework to link the evolution of cognitive processes to differential ecological pressures.

Olfactory enrichment for California sea lions: A product of evolution or cognition?

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In the wild, California sea lions (*Zalophus californianus*) in particular are exposed to a wide variety of sensory information, which cannot be replicated in captive environments. Therefore, unique procedures are necessary for the maintenance of physiological and psychological health in captive animals (Wells, 2009). The effects of introducing of natural scents has been investigated with big cats (Szokalski, Litchfield & Foster, 2012; Wells, 2009), canids (Steele & Steele, 2005), and other species (Fay & Miller, 2015; Wells, 2009) yet this had not been examined in marine mammals. This project explores the behavioral effect of scent, added to the environment with the goal of improving the welfare of captive sea lions. By introducing two scent types: 1.) Natural scents, found in their native environment, and 2.) Non-natural scents, not found in their native environment. Scent enrichment was found to significantly impact sea lion behavior as demonstrated by a reduction in pattern swimming, an increase in habitat utilization, and a reduction in stereotypical behavior. However, there were no differences in behavior between natural and non-natural scent conditions indicating that enrichment was likely based in cognition rather than environmental causes.

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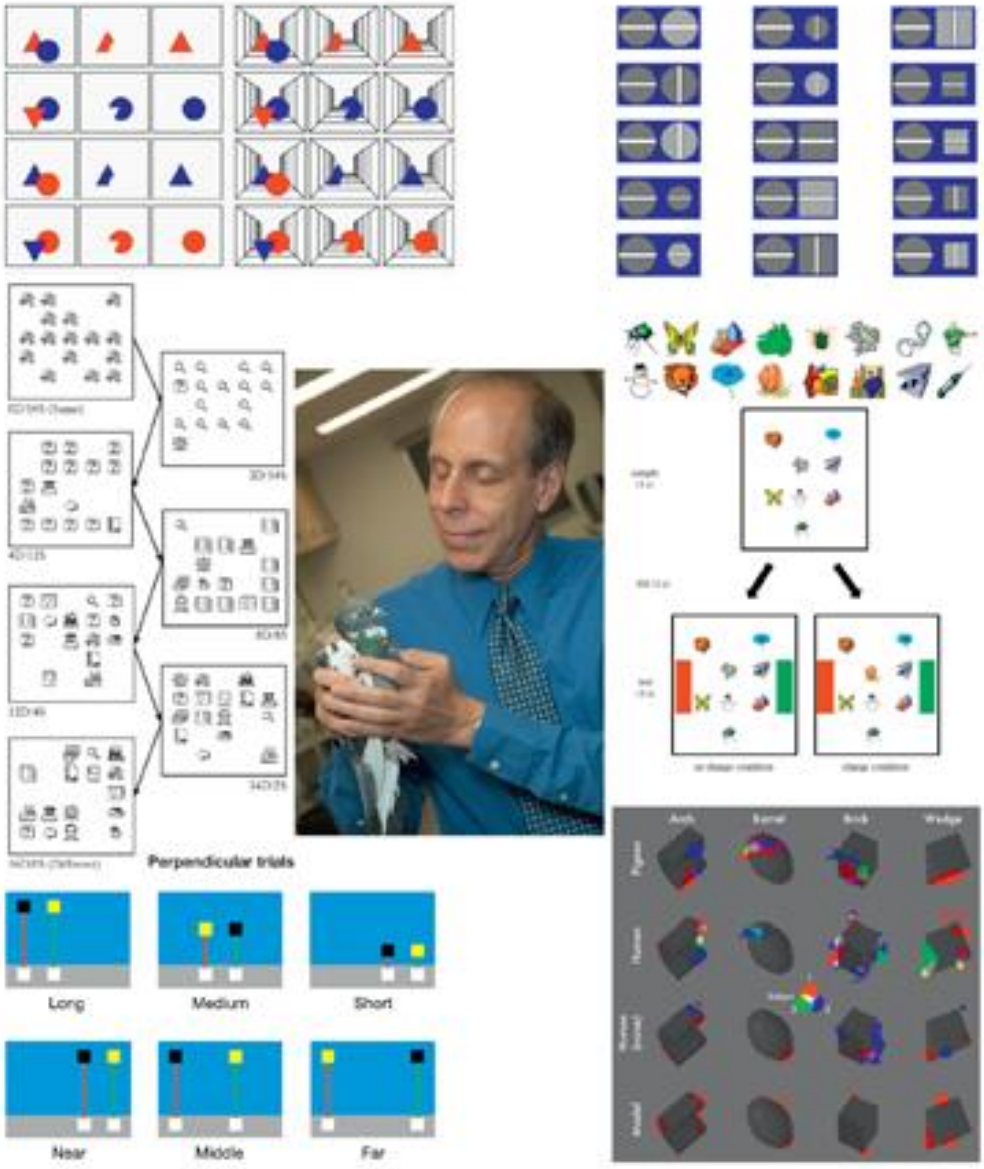

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