Fall Meeting of the Comparative Cognition Society 2015

October 16, 2015
7:30 AM-5:00 PM
Wrigley Room
Hyatt Regency Chicago (Downtown)
Chicago, IL

www.comparativecognition.org

Fall Meeting of the Comparative Cognition Society 2015

All Sessions Held in Wrigley Room

7:30-8:15	Registration (Coffee provided)
8:15-9:20	Choice and Timing
9:30-10:30	Reward and Variability
10:40-11:25	Memory
11:25-1:00	Lunch Break
1:00-1:45	Spatial and Pattern Learning
1:55-2:55	Perception
3:05-3:50	Complex Cognition and Flexibility
4:00-5:00	Keynote Presentation – Verner Bingman

Important Note to Presenters: Talks should be no longer than ten minutes (five additional minutes scheduled for discussion and transition)

Comparative Cognition Society

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Choice and Timing

Session Chair: Olga Lazareva

8:15	**Welcome and Introduction**
8:20	Catherine C. Hill & Kimberly Kirkpatrick (Kansas State University) **Effects of Dietary Manipulations on Body Weight, Locomotor Activity, and Impulsive Choice in Rats** To better understand the relationship between impulsivity and obesity, the present study utilized rats to determine how diet specifically contributed to weight gain, locomotor activity, and impulsive choice behavior. All rats completed a pre-locomotor task before being divided into three groups (high-fat, high-sugar, and control) where diet composition differed, but energy budget remained the same by controlling for the number of calories each group received each day. The high-fat group received chow with a lard supplement, the high-sugar group received chow with a sugar-gelatin supplement, and the control group received all chow. After eight weeks on the diet manipulation, all rats completed a post-locomotor task, which showed that the high-fat group moved significantly more than the high-sugar and control group. The difference in locomotor activity existed despite the fact that the high-fat group weighed more than the high-sugar and control group. Results on the impulsive choice task, completed after the postlocomotor task,showed that the high-sugar and high-fat group made significantly more impulsive choices than the control group. Taken together these results indicate that composition of the diet, opposed to number of calories, has important impacts on weight and behavior.
8:35	Sarah L. Stuebing, Andrew T. Marshall, Ashton Triplett, Kimberly Kirkpatrick (Kansas State University) **Exploring the Gender Gap: Individual Differences in Impulsive Choice and Timing in Female Rats** Impulsivity, timing, and individual differences therein are widely studied for their contributions to decision-making and maladaptive behaviors such as gambling, obesity, and addiction. Such experiments often utilize rat models to identify sources of individual differences, and previous research has indicated that individual differences in timing precision are a significant predictor of individual differences in impulsive choice. The predominant use of male rats in this research highlights the wide gap in the literature regarding female decision-making, leaving the mechanisms of impulsive choice in females poorly understood. This experiment aimed to assess individual differences in impulsive choice and timing in female rats through a smaller-sooner (SS) versus larger-later (LL) choice paradigm. Timing was evaluated via peak-procedure trials intermixed with free- and forced-choice trials. Impulsive choice and timing behavior were comparable to male Sprague Dawley rats from previous studies conducted in our laboratory, suggesting that female impulsive choice and timing processes may be similar to males.

8:50	Rebecca M. Rayburn-Reeves, Muhammad A. Qadri, & Robert G. Cook (Tufts University) **Time Matters: Category Learning by Pigeons in a Midsession Reversal Task** Recent research on midsession reversal learning has revealed that pigeons make systematic anticipatory and perseverative errors around the reversal location, suggesting they are using the time within sessions as a cue for which of two stimuli is likely correct on a given trial. The repetition of the same stimuli across trials, however, means their values are constantly changing and relative to the pigeon's perception of its location within the session. The current experiment tested midsession reversal learning of categories (flowers (S1) and cars (S2)), where every trial presented a unique stimulus pair from each category and, across sessions, these pairs were presented on the same trial (e.g., Trial 1: flower1, car1), allowing us to create stimuli with absolute values of reinforcement. Interestingly, pigeons showed similar errors around the reversal as has been previously found with two stimuli, suggesting that category learning emerges prior to item specific encoding and pigeons anticipate the category shift based on time. Probe tests revealed a strong reliance on the time-based cue, with some evidence that item-specific information is important closer to the reversal. These results have implications for the timing and order by which pigeons learn to use categorical and item-specific features in pictorial discriminations.
9:05	Carter W. Daniels & Federico Sanabria (Arizona State University) **Bout-Like Behavior in Fixed-Interval Performance: Implications for Theories of Interval Timing** Packet theory of interval timing suggests that behavior under the control of fixed-interval (FI) schedules of reinforcement is organized in bouts; and dynamically controlled by the FI hazard function. Rats were trained on a FI 90-s schedule of food reinforcement, and were then exposed to a 5-day pre-feeding probe. Inter-response times (IRTs) decrease as a function of time in the FI; their distribution was well described by a biexponential, bout-like distribution with three dynamic parameters: the mean within-bout IRT, the mean between-bout IRT, and the mean length of a bout. Although all parameters changed within FI trials, the increase in bout length accounted for most of the observed IRT decay. Pre-feeding resulted in fewer and shorter bouts. Taken together with previous research, these results suggests that behavior in FI schedules is organized in bouts whose length reflects a potential response-reinforcer association, and pre-feeding decreases motivation and possibly reinforcer expectation. Implications for theories of interval timing and generality across species are discussed.
9:20	**10 Minute Break**

Reward and Variability

Session Chair: Kenneth Leising

9:30 Molly McGuire (Oakland University)

Using an Ambiguous-Cue Task to Assess Cognitive Bias in Western Lowland Gorillas

Three silverback gorillas were trained in an ambiguous-cue paradigm where pairs of two dimensional shapes were presented on a touch-screen computer in a forced choice task. One two dimensional shape was always reinforced (P), one was never reinforced (N), and one was reinforced half the time (A), making it ambiguous. Training sessions consisted of four PA trials and four NA trials. Testing sessions included two probe trials in which the ambiguous items were paired with novel items and choices of ambiguous items indicated optimism. The gorillas were presented with four different sets of items for approximately two weeks each during a browse manipulation study. We systematically manipulated browse availability over the four consecutive two-week phases. The gorillas displayed individual differences in learning PA and NA trials and in their choice of ambiguous items on test trials. We are currently presenting novel sets to assess cognitive bias across seasons.

9:45 Aaron P. Smith & Thomas R. Zentall (University of Kentucky)

Does the Value of Conditioned Reinforcers Drive Suboptimal Choice Regardless of Their Frequency?

Previous research has shown that pigeons prefer an alternative that, 20% of the time, is followed by a stimulus that always predicts reinforcement but 80% of the time signals omission over an alternative that is followed by a stimulus that predicts reinforcement 50% of the time and rewards 2.5x as much food. This suboptimal choice appears to result from (1) the pigeons' insensitivity to the frequency of reinforcement, (2) insensitivity to the conditioned inhibitor (signal for reward omission), and (3) hypersensitivity to the predictive value of conditioned reinforcers (100% signal). If this mechanism is correct, it may explain why some pigeons making a spatial discrimination inconsistently prefer an alternative that, 50% of the time, provides a signal for food or omission over an alternative that always provides a signal for reinforcement. This stimulus value hypothesis predicts indifference under these conditions as both alternatives provide a perfect signal for reinforcement (100%), which may result in idiosyncratic preferences for either color or spatial location. To test this hypothesis, the present experiment employed shape stimulus alternatives that varied in spatial location, showing that the pigeons were indifferent. The value of the conditioned reinforcers was then manipulated to demonstrate sensitivity to their value.

10:00	W. David Stahlman (University of Mary Washington) & Kenneth J. Leising (Texas Christian University) **Irrelevant Stimulus Pre-Exposure Moderates the Relationship Between Pavlovian Learning and Respondent Variability in Rats** A common control condition in Pavlovian latent inhibition tasks involves the repeated presentation of an "irrelevant" stimulus (i.e., A-) prior to trials where a new stimulus is forward-paired with a biologically relevant outcome (i.e., B+). Experiment 1 utilized this procedure in the investigation of the within-subject relationship between learning in latent inhibition (LI) and bar-pressing variability. Unexpectedly, we found a large negative relationship between learning in LI and instrumental variability only for the group that received "irrelevant" stimulus presentations prior to Pavlovian conditioning. In Experiment 2, we explored this relationship further by systematically varying the number of A- stimulus presentations prior to the presentation of B+ trials. The data indicate that the number of A- trials does not affect learning of B+ alone, but does moderate the relationship between B+ learning and instrumental variability.
10:15	Jennifer R. Laude and Mark T. Fillmore (University of Kentucky) **The Role of Rewarding Experiences While Intoxicated on Subjective Responses to Alcohol** The effect of experiencing a history of reward while intoxicated on the appetitive properties of alcohol is a relatively unexplored area of study. Such an experience could increase the rewarding properties of alcohol and result in escalation of use. Using a sample of moderate to heavy drinkers, this study tested whether experiencing a rewarding history while mildly intoxicated would increase the appetitive properties of the drug relative to another condition in which a boring or mildly aversive activity occurred throughout the drinking episode. Changes in the subjective liking of alcohol effects and desire for the drug were measured after each treatment (rewarding experience *or* non-rewarding experience). Subjective responses to the drug and expectancy effects were also examined as a function of subjects' recent drinking history. These results have implications for the limited success of behavioral interventions aimed at reducing drinking that fail to consider the role of the environment.
10:30	**10 Minute Break**

Memory

Session Chair: Stephen Fountain

10:40 Jonathon D. Crystal & Amanda R. Doyle (Indiana University)

Apolipoprotein E Deletion Protects Spatial Working Memory

The apolipoprotein E gene (APOE; a major cholesterol carrier that supports lipid transport and repair in the brain, and binds amyloid-β protein in cerebrospinal fluid) is the major genetic risk factor for Alzheimer's disease. APOE knockout (KO) and wildtype (WT) rats were trained in an 8-arm radial maze. A working memory load was imposed by adding a brief retention-interval between an initial encoding opportunity and a subsequent memory assessment. After a brief retention interval, APOE deletion produced a significant increase in accuracy. Importantly, this improvement in accuracy can be attributed to the working memory load imposed by the brief delay because the APOE KO and WT rats had equivalent performance when the delay was absent. This difference in performance was documented by a significant interaction of genotype X retention-interval. Consequently, the improvement cannot be attributed to differences in spatial perception, learning, motivation, motor control, and other non-specific factors. These data suggest that APOE deletion protects spatial working memory. The discovery of a protective effect on memory creates opportunities to ultimately identify and harness the signaling pathways that may protect memory in Alzheimer's pathogenesis.

10:55 Alexandra E. Smith, Stefan Dalecki, & Jonathon D. Crystal (Indiana University)

Dissociation of general spatial memory and source memory

Rats retain source memory (memory for the origin of information) over a retention interval of at least 1 week, whereas their general spatial memory (radial-maze locations) decays within ~1 day. We have argued that different forgetting functions dissociate memory systems. However, the two tasks used different reward values. The source-memory task used multiple pellets of a preferred food flavor (chocolate), whereas the general-spatial-memory task provided access to a single pellet of standard chow-flavored food at each location. Thus, according to the reward-value hypothesis, enhanced performance in the source-memory task stems from enhanced encoding/memory of a preferred reward. We tested the reward-value hypothesis by comparing general-spatial memory accuracy using multiple chocolate or chow pellets at each location. The reward-value hypothesis predicts superior memory for high-valued rewards. We documented equivalent spatial memory accuracy in a standard 8-arm radial maze task. A 24-hr retention interval produced an equivalent impairment in spatial-memory accuracy for both flavors. These data are inconsistent with the reward-value hypothesis and lend support to our interpretation of earlier data as documenting a dissociation of source memory and general spatial memory.

11:10 Vincent J. Coppola & Verner P. Bingman (Bowling Green State University)

Neurocognitive Aging in Homing Pigeons

Despite the abundance of research investigating the neural correlates of cognitive aging in mammals, it was not until recently that neurocognitive aging in avian models began to gain interest. Over recent years our lab has worked towards characterizing memory decline in older homing pigeons (10+ years). Specifically, we have reported robust age-

	related impairment in spatial working memory and the acquisition of spatial-feature reference memory. Our ongoing work aims to identify gross neuroanatomical correlates of memory impairment. Thus far we have found, as expected, that older homing pigeons have smaller forebrains than younger pigeons (< 4 years) and that there's a positive correlation between forebrain size and memory. Unexpectedly, however, we found that the dorsomedial (DM) sub-region of the hippocampal formation (HF) was actually larger in older pigeons and that there's a negative correlation between DM size and memory (i.e., as DM size increased memory actually declined). These findings, together with the findings of another lab that the number of HF neurons increases with age, suggests that the pattern of hippocampal aging in birds may differ from that reported to occur in the mammalian hippocampus.
11:25	**Lunch Break**

Spatial and pattern learning

Session Chair: Martin Acerbo

1:00	Karen E. Doyle (Marygrove College) & Stephen B. Fountain (Kent State University) **Rats Employ Both Association and Chunking Strategies to Produce an Interleaved Pattern** To what extent do rats abstractly chunk subpatterns in order to produce a rule-based interleaved pattern? Employing the serial multiple choice paradigm in an octagonal operant water chamber, rats were presented with a target "run" response subpattern (123456) and an interleaved alternation response subpattern (787878) presented as the pattern 172837485768, manipulated between groups for serial pattern element cuing and rule structure. Although subjects acquired this interleaved pattern, consistent performance required extended training (48 repetitions per day for 70 days). Following acquisition, groups were transferred to a modified interleaved pattern consisting of the identical target "run" response subpattern (123456) and a "shifted" interleaved alternation response subpattern (878787) presented as the pattern 182738475868. Following transfer, performance on the identical target response subpattern was initially devastated but recovered rapidly. Results from both acquisition and transfer conditions indicate that although the presence of pattern structure and cueing did improve initial pattern acquisition, rats did not solely employ a cognitive chunking strategy. Rats may have used a combination of learning strategies, employing information from cognitive chunking, ordinal position, and associative cueing.
1:15	Murray R. Horne (California State University, East Bay) **Schizotypal Traits Affect Virtual Navigation in an Environment with a Distinctive Shape** Schizotypy is a personality construct that is used to measure ones proneness to psychosis or psychotic-like personality characteristics. In three experiments, participants completed the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) which measures schizotypal personality across four dimensions (unusual experiences, cognitive disorganization, introvertive anhedonia, and impulsive non-

	conformity). They then took part in a virtual navigation task where they were required to learn about the position of a hidden goal with reference to geometric cues of a rectangular (Experiment 1) or kite (Experiment 2) shaped environment. In Experiment 3, participants had to rely on colored landmarks to find the hidden goal in a square-shaped arena. People who scored high on the unusual experience dimensions showed a marked deficit on the virtual navigation tasks that required the used of geometric cues but no impairment on the use of landmarks. Implications to both the clinical and spatial learning domains will be considered.
1:30	James D. Rowan, Elise Harris, Khawla Benyamine, Rosamond Goodson, Misba Momin (Wesleyan College), & Stephen B. Fountain (Kent State University). **The Serial Multiple Choice (SMC) Task as a Neurocognitive Screen of the Effects of Drugs and Toxins** It has long been argued that serial-pattern learning (SPL) is sub-served by multiple cognitive/neurobiological subsystems. Because of this, the task used to study SPL, the Serial Multiple Choice (SMC) task has proven to be a sensitive screen for assessing the effects of drugs and toxins on higher cognitive functions used in pattern learning. Variations of the SMC (a 2 choice and an 8 choice) have been used in both mice and rats. Different exposure regimes have examined such effects as early exposure during adolescence or chronic exposure in adulthood. Overall findings support the idea that multiple systems are required for learning serial patterns. There is evidence for at least 2 subsystems: one that encodes the information following the most basic, lowest order, rule; and one that encodes exceptions to this rule. The second seems to be more easily impaired by drugs and toxins. This finding is true for both early adolescence exposure and adult chronic exposure.
1:45	**10 Minute Break**

Perception

Session Chair: James Rowan

1:55	Kenneth J. Leising (Texas Christian University), James Taylor (Texas Christian University), Ronnie Lee (Texas Christian University), Anthony Wright (University of Texas Medical School at Houston), & Joshua Wolf (Texas Christian University) **Was that Always There? Manipulations that Influence the Location Change-Detection Performance of Pigeons** Change detection procedures are commonly used to assess the properties (e.g., capacity of objects) of working memory. In our study, we trained pigeons to complete a spatial ("where") change detection task. Pigeons were trained to peck a visual item (colored circle) presented on a touchscreen that changed location across a brief delay (0, 50, or 100 ms). Performance was unaffected by how long the items were displayed before the change, how far the changed item traveled, or the retention delay. Increasing the number of items on the display did alter performance in the expected direction; however, change detection performance did not improve across sessions as additional items were added. The results will be discussed in terms of the attributes of the

	memory mechanisms (e.g., iconic memory) supporting location-change detection performance.
2:10	Allison H. Hahn, Joshua J. H. Yong, Kimberley A. Campbell, Jenna V. Congdon, John Hoang, Neil McMillan, Erin N. Scully, & Christopher. B. Sturdy (University of Alberta) **Discrimination of Conspecific and Heterospecific Call Notes with Acoustic Similarity** Black-capped chickadees (Poecile atricapillus) produce a chick-a-dee call composed of four note types (A, B, C, D). D notes are broadband, contain harmonic-like features, and are longer in duration compared to the other notes in the call. A previous study (Avey et al., 2014) examining immediate early gene (IEG) expression in black-capped chickadees found similar neural activity in auditory brain areas following playback of conspecific D notes and acoustically similar heterospecific notes, suggesting that overall acoustic similarity influences the neural activity. In the current study, we examined the discrimination of these conspecific and heterospecific notes by black-capped chickadees using a go/no-go task. Birds were trained with six call types produced by birds of varying phylogentic relatedness (black-capped chickadee, chestnut-backed chickadee, tufted titmouse, male zebra finch, female zebra finch, and black-capped chickadee notes played in reverse) in a between-category discrimination task. Our results suggest that birds use fine acoustic features to discriminate the call notes irrespective of phylogeny. Taken together, the results of the current study and the previous IEG study suggest that behavioral and neural responses are not solely influenced by phylogenetic differences between subjects and the signaler.
2:25	Zoe Johnson-Ulrich & Jennifer Vonk (Oakland University) **Picture-Object Correspondence in an American Black Bear** Many animal species can recognize objects from moving and static photographic stimuli. Bears can discriminate between and categorize photographic stimuli, but it is unknown if they recognize the visual stimuli presented on computer screens as representative of real life objects. In this study, we presented an American black bear with a pair of real objects and trained her to target to one of the objects. Once she had reached a level of 87.5% correct responding, we presented her with as photographs of the same objects on a touchscreen computer in a two choice discrimination paradigm. She performed at 87.5% correct on her first session with photographs, demonstrating transfer from real objects to corresponding photographs. In Phase 2, we presented the bear with photographs of a second pair of objects and assessed transfer by presenting the real objects after the discrimination had been learned. Successful transfer and fewer sessions required to reach criterion performance are indicated of picture-object correspondence in the black bear.

2:40	Martin Acerbo (Iowa State University) **Localizing Figure-Ground Segregation in Avian Brain** Separating figures from grounds is a fundamental visual process that in primates takes place in the striate cortex (area V1) and extrastriate cortex (area V2). It is less clear where this process takes place in avian brain. Because figure-ground segregation in primates occurs relatively early in a course of visual processing, we have concentrated on exploring the potential involvement of thalamic areas of thalamofugal visual pathways in figure-ground segregation. We found that nucleus rotundus (Rt) and its inhibitory complex have higher metabolic activity after figure-ground discrimination than after control tasks. A follow-up study confirmed that a chemical lesion of inhibitory complex of Rt selectively impaired figure-ground discrimination while leaving color and shape discrimination intact. Finally, we showed that pharmacological manipulation of GABA receptors impairs different facets of figure-ground segregation. Taken together, our results demonstrate that figure-ground assignment in avian brain occurs at the thalamic level, and that Rt and its inhibitory complex may therefore be functionally equivalent to the mammalian striate cortex.
2:55	**10 Minute Break**

Complex cognition and flexibility

Session Chair: Jon Crystal

3:05	Alexander Dunkel (Independent) & Isaiah Cottengaim (New Mexico State University) **The Little Lemur Who Spoke: Theory of Mind in Lemurs?** Theory of Mind research is often limited to larger brained, “intelligent” animals, particularly monkeys and apes. “Lesser intelligent” animals, such as lemurs, have received minimal to no attention for seemingly obvious reasons. Four independent and unexpected events experienced by an animal trainer, primate keeper, and researcher pose interesting questions about ToM and related research. Although experiments could not be performed when these unique opportunities presented themselves, a detailed background check of the most stunning case—involving a ring-tailed lemur (Lemur catta) named Lenny or “Obi”—eliminated most alternative explanations, such as previous training. In all cases, the lemurs used direct eye contact to engage the recipient, appeared to express need, and were familiar with the recipient. The observer had also previously imitated lemur vocalizations to demonstrate empathy in stressful situations for at least three of the four lemurs. Strong levels of trust appear to play an important role in whether or not an animal will attempt to exhibit possible ToM behaviors towards a human. Familiarity with human behavior may also be a prerequisite for eliciting this behavior. Future avenues of research are considered.
3:20	Maxime Cauchoix (Institute for Advanced Studies in Toulouse) , Cole E, Aplin L, Quinn JL, Morand-Ferron J **Life History Consequences of Cognitive Flexibility in Wild Great Tits (Parus major)** Flexibility, the ability to adjust behaviour when environmental conditions change, often appears like an adaptive trait that should be favoured by natural selection. However, the

	fitness consequences of direct measurement of cognitive flexibility remain unknown. Reversal learning tasks, in which subjects need to adjust their behaviour to shifts in reward contingencies based on stimulus dimension, is a well-established and standard method to measure cognitive flexibility in comparative psychology. Here we used fully automatised and portable operant boxes to record performances of free-ranging Great tits in a colour reversal learning task and subsequently followed-up their reproductive success. Fourty-four individuals successfully performed the task. We were able to monitor reproductive success of 15 of these birds. We found a positive link between reproductive success (average fledging mass) and individual differences in cognitive flexibility. These results hold when controlling for differences in total time required to perform the task, suggesting that motivation or accessibility to the devices do not drive this effect. Moreover, reversal-learning performance cannot be explained by individual differences in personality, dominance or group size. Our results support the idea that under certain environmental circumstances that remain to be determined, cognitive flexibility may be adaptive.
3:35	Olga F. Lazareva (Drake University) **Relational learning, space, and hippocampus** Transitive inference (TI) is a form of deductive reasoning which allows one to derive a relation between items that have not been explicitly compared before (if B > C and C > D, then B > D). Although TI has often been assumed to be performed by spatially organizing the stimuli, the evidence for spatial basis of TI in non-human animals have been sparse until recently. In addition, it is not clear whether spatial learning is involved in TI because it requires manipulating relational information, or whether spatial learning serves as a substrate for many forms of relational learning. I will review the evidence indicating an involvement of spatial learning in TI in humans, rhesus monkeys, and pigeons. I will also present new data that suggest hippocampal involvement in a simple relational task, transposition that does not require manipulating relational information. Overall, the accumulating research supports the hypothesis that spatial learning may serve as a substrate for abstract relational learning in general.
3:50	**10 Minute Break**

Keynote Address
Verner Bingman (Bowling Green State University)
Introduced by Olga Lazareva

4:00 - 5:00

Space and the Vertebrate Family of Hippocampal Homologues: Making a Case that Birds Navigate in a World of their Own

The homologue of the mammalian hippocampus resides in the dorsomedial forebrain of amphibians, reptiles and birds, and what binds these structures is not only their common anatomical ancestry, but also a modular-like dedication to the neural representation of space. Immediate early gene data from disparate taxa, common toads and chicks, highlight a conserved role of the dorsomedial forebrain in the representation of boundary geometry used to locate a goal. But it is probably in migratory birds and homing pigeons where, in the context of space, the dorsomedial forebrain (hippocampus) may achieve its functional apogee. In homing pigeons, map-like, like corrective re-orientation taking place over tens of kms is supported by the hippocampal formation, and there are now data indicating a hippocampal role in the pre-mnemonic perception of space; data that recall philosophical arguments on the nature of psychological space. Lesion, network organization and unit recording data suggest “navigational computations” derived from the interface of perceptual-memory space are lateralized to the left hippocampal formation of homing pigeons. By contrast, the hippocampus of both hemispheres may support the inclusion of space as a contextual cue exploited for memory-related pattern segregation; a role in memory that even in homing pigeons is associated with declining performance with age. Although “space” is the common functional theme found in presumptive hippocampal related structures in all vertebrates, the role of the hippocampal formation in avian spatial cognition provides a not so subtle reminder that selective pressure and “spatial natural history” are elements that shape the evolution of taxon-specific, structural-functional designs.

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Membership in the society supports the following activities:

- A primary activity of CCS is sponsorship of the annual International Conference on Comparative Cognition (CO3), which has been held annually each March in Melbourne, Florida since 1994. Both Faculty/Professional Scientist members and Student members of CCS receive a discount on CO3 conference fees. To promote student interest in comparative cognition, student conference fees are kept at a minimum. CCS sponsored a second conference in 2008 and 2009 (Fall conference held in coordination with the annual meeting of the Psychonomic Society.
- CCS has been a leader in electronic publishing and in an effort to provide the products of our science to scientists, students, and the general public at no cost and in a format that allows dynamic illustrations of animal behavior and analyses of that behavior. The current portfolio of electronic publications supported by members of the society includes:
  - *Comparative Cognition and Behavior Reviews* - The first four volumes of this annual online journal of are available.
  - Two cyberbooks have been published in cooperation with the society
    - *Avian Visual Cognition*
    - *Animal Spatial Cognition: Comparative, Neural, and Computational Approaches*
  - *Proceedings of the Annual Conference on Comparative Cognition* - conference proceedings include some full-text PowerPoint™ presentations

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