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Annotated Bibliography Entry Peer Review

These annotated bibliography entries are organized in order of importance.

Cornell, H. N., Marzluff, J. M., & Pecoraro, S. (2012). Social learning spreads knowledge about dangerous humans among American crows. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1728), 499–508. https://doi.org/10.1098/rspb.2011.0957

Article Summary

The main objective for this article was to understand the roles in individual learning and social learning when crows learn about interspecifics (humans). Individual learning is 'firsthand' and an accurate way to gain information however it is costly. Social learning is not as reliable, but less expensive way to acquire information. Corvids use both methods to gain information, and this is seen especially in predator recognition. The previous studies have investigated learning of dangers in a laboratory setting and there has been demonstration of influencing behaviour through stimulation but that is not able to demonstrate social learning.

The experiment was conducted in a field setting and with wild crows. Researchers used a distinct face mask to trap, band, and release crows. This was recognized as a 'dangerous mask' by the crows. Crows that were captured showed individual learning by responding with scolding (harsh alarm caws) after being released. Later, crows that were not captured and were able to recognize and respond to the dangerous mask showed horizontal social learning. Young crows that were able to scold the dangerous masks displayed vertical learning.

The researchers discovered crows would use both individual and social learning to influence their behavior, they also found that crows were flexible in using either method of learning to correctly identify danger. The captured (banded) crows were able to distinguish the dangerous masks more accurately from the neutral ones when compared to crows who were never captured. This reaffirms the accuracy individual learning has over social learning.

The significance of the findings advance knowledge of understanding social learning and explores why an animal may put resources into learning. Predator species, especially humans have diverse reactions and interactions with corvids, and it is beneficial for them to be able to distinguish dangerous ones from favourable ones.

Article Contribution

This article is chosen as part of my literature review because it directly explores how social learning occurs in the information transfer of recognizing interspecifics. This article gives insight into an explanation of why a species would put resources into recognising a species that is not their own and explains how this behavior increases the fitness of corvids.

This study supports previous findings that many of a crow's behavior is socially learned especially in treating individual humans differently. This paper demonstrates crows' ability to distinguish between humans that are dangerous and those that are not through social learning.

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Marzluff, J. M., Walls, J., Cornell, H. N., Withey, J. C., & Craig, D. P. (2010). Lasting recognition of threatening people by wild American crows. *Animal Behaviour*, *79*(3), 699–707. https://doi.org/10.1016/j.anbehav.2009.12.022

Article Summary

The main objective for this article was to demonstrate that crows can quickly and accurately recognize human faces that are deemed dangerous. The previous studies demonstrated that animals are able to recognize individual human faces in laboratory settings. This is phenomenon has not been quantifiably investigated in wild animals.

The experiment was conducted by trapping, banding, and releasing crows at multiply locations while wearing a unique face mask. The scolding (harsh alarm caws) and mobbing (contagious scolding with more than one bird) of the crows in response to the dangerous mask was compared to prior the trapping and different masks that were not worn (neutral masks) when trapping. When the masks were presented to the crows side by side, the scolding occurred for the person wearing the dangerous mask and not the person with the neutral masks.

The researchers discovered crows are able to rapidly learn and remember for a long time after the study the mask that was dangerous. Even when the mask was worn by people that were different sizes, ages, genders and had different walking patterns. This demonstrates that the face of the mask was what the crows were able to recognise. Researchers also discovered that the aggressiveness of the crow's scolding was related to the danger levels of the areas (how much people at the location persecuted crows).

The significance of the findings clearly demonstrates crows' ability to distinguish between faces and remember them even after time had passed. This ability for recognition is for dangers or threats as perceived by the crows. This study demonstrates a crow's ability to learn about threats and allows them to avoid such threats in the future. The findings of this study indicate there is fitness benefits in learning then storing information about individual members of another species.

Article Contribution

This article is chosen as part of my literature review because this study demonstrates corvid ability to learn and recognise and distinguish individuals from a species that is not their own. This study specifically shows the ability of corvids to learn rapidly as recognition occurred after a single exposure hence, this demonstrates the incredible ability of corvid recognition. This study also gives explanation into the fitness benefits of such recognition.

This study supports previous findings that many animals can recognise human faces and corvid ability of individual and social learning.

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Swift, K. N., & Marzluff, J. M. (2015). Wild American crows gather around their dead to learn about danger. *Animal Behaviour*, *109*, 187–197. https://doi.org/10.1016/j.anbehav.2015.08.021

Article Summary

The main objective for this article was to demonstrate crows responding to conspecifics that have died by mobbing (contagious scolding– harsh alarm calls with more than one bird), demonstrating caution when in areas where death has occurred, and learning about new predators after seeing their closeness to dead crows. Many animals have been shown to avoid areas where species of their animal has died. The previous studies have demonstrated animals responding to predators and associated signs.

The experiment was conducted in three phases: a conditioning phase, stimulus presentation phase, and post-exposure phase. The crows went to sites where they were fed. Then a stimulus was presented at the site, either an experimental or control stimuli. Then while food was continued to be provided and in one trial a masked individual stood near the food. Experimental stimuli included (1) dead crow and mask, (2) hawk and mask, (3) hawk, dead crow, and mask. Control stimuli included (1) mask only and (2) food only).

The researchers discovered that crows learn to associate places with predators when they witness a dead conspecific. Crows are also able to learn and remember people that seem to be associated with these events. When a masked person was present, and they did not directly kill the crow but was present when there was a presentation of the dead crow the other crows associated the mask with danger. The strongest response to stimuli in the form of mobbing and avoiding of food was when a hawk was presented with a dead crow.

The significance of the findings is that corvids quickly learn of danger (after one training event) and remember such an event. Crows also draw connections when presented with stimuli, they do not need to witness a dangerous event to consider something to be dangerous.

Article Contribution

This article is chosen as part of my literature review because it demonstrates the ability of corvids to learn quickly from dangerous events and remember them for long time periods after such an event has occurred. This study also demonstrates their ability to learn through drawing their observations in that a proximity to a dead crow indicates danger even without having seen the death of the crow occurring.

This study supports previous findings that dead conspecifics can be learning opportunities for animals and animals will avoid places where they associated with a death of their species.

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Blum, C. R., Fitch, W. T., & Bugnyar, T. (2020). Rapid learning and long-term memory for dangerous humans in ravens (*Corvus corax*). *Frontiers in Psychology*, *11*, 581794. https://doi.org/10.3389/fpsyg.2020.581794

Article Summary

The main objective for this article was to study the individual raven's learning speed, selective long-term memory, and effects of social dynamics on individual alarm calls (when in the face of danger). The researchers specifically tested the ravens' ability to distinguish between the dangerous and neutral masks in a long-term context– over the four years of the experiment. There have been previous studies done regarding corvid learning for other species (not ravens).

The experiment was conducted in three phases; the first phase was the presentation phase this is where the masks were presented to the ravens. The second phase was the training phase and the association phase, where the dangerous mask was presented with a dead raven allowing ravens to associate the potential danger of a predator. The third phase was the testing of associations even without the reinforcement of learning.

The researchers discovered that ravens scolded (harsh alarm caws) the dangerous mask with greater intensity (duration) than when compared to the neutral mask, even after a long time (four years) ravens continued to scold the dangerous mask with greater intensity, and there was large variation observed in individual ravens and their scolding participation.

The significance of the findings by researchers are that ravens can learn quite rapidly– after only four presentations the behavior displayed to the two masks were distinguishably different. In addition, distinguishing between the two masks was maintained over four years remarkably this was done without reinforcement of associations after the training phase. This demonstrates the ability for ravens to have long term memory. They also found that between individuals, the large amount of variation in scolding participation was attributed to social factors like dominance and was also relative to the number of males in the group; suggesting scolding could be used as a status signal.

Article Contribution

This article is chosen as part of my literature review because it directly investigates corvid social learning and the information transfer between the individuals. This study explores ravens' recognition of individuals from other species (humans in this case).

This study supports previous findings on the quick learning abilities of corvids. However, many previous studies were conducted on wild populations and tests were restricted to short time frames or limited exposure intensity regulation. This study is conducted in a laboratory setting, allowing exploration in individual variation in bird anti-predator response for the consistency over time and in different social settings.

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Boucherie, P. H., Blum, C., & Bugnyar, T. (2020). Effect of rearing style on the development of social behaviour in young ravens (*Corvus corax*). *Ethology*, *126*(6), 595–609. https://doi.org/10.1111/eth.13010

Article Summary

The main objective for this article is to examine how the rearing-style (hand-raised, parent-raised, mix of both) affects the social development of ravens. In particular, researchers evaluated how the difference of rearing styles affected ravens' strength of relationships and social interaction pattern later on in their lives. There have been previous studies investigating social systems of birds and their socio-cognitive skills, corvids have been an area of interest for many researchers. The previous studies have been conducted on hand-raised ravens and the effect of this rearing-style on the social behavior of ravens has not been detailly explored.

The experiment was conducted with captive ravens, which were spit in three groups; there were hand-raised ravens, parent-raised ravens, and ravens that were raised by both methods. The relationship strength, patterns of relationships among groups of ravens and social interaction patterns were analyzed.

The researchers discovered the method with which the ravens were raised does not drastically affect the relationships in terms of quality or structure. They also found that hand-raised ravens had more connections with other ravens but generally had relationships of lesser strength; the type of social bonds formed are affected. This suggests that the social background of young ravens affects the development of their social interaction. Researchers also discovered that interactions with same-aged peers was important in social development, in addition to being raised by parents.

The significance of the findings by the researchers is that the social behavior of ravens is greatly shaped by how they are raised and will distinctly impact their social behavior as well as social competence as adult ravens. The researchers also found that social competence of ravens is greatly shaped by having repeated and different opportunities to interact socially.

Article Contribution

This article is chosen as part of my literature review because it explores the social behavior of ravens and the social learning of ravens and the factors that influence it. To understand how ravens learn socially it is important to understand and investigate the effects of development as it plays a big role in shaping adult ravens and how they will interact. This further affects ravens' information transfer since that is mediated by social learning.

This study supports previous findings that ravens are dependent on conspecifics and especially their parents to learn and it will affect their social behavior.

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Boucherie, P. H., Loretto, M.-C., Massen, J. J. M., & Bugnyar, T. (2019). What constitutes "social complexity" and "social intelligence" in birds? Lessons from ravens. *Behavioral Ecology and Sociobiology*, *73*(1), 12. https://doi.org/10.1007/s00265-018-2607-2

Article Summary

The main objective for this review article is to illustrate the socio-ecological conditions ravens face as non-breeders and how this relates to their social behavior and socio-cognitive skills. Previous studies have been conducted on breeding system of ravens and subsequent relationships formed with those in partner or breeding relationships. However, a significant part of a raven's life can be non-breeding; this article looks to explore this area regarding social complexity.

This review was done through reviewing research that has been completed over the last 30 years. Through the exploration of raven social life, group dynamics, exploration of raven social relationships, their socio-cognitive skills, their social knowledge etc. through which the social complexity of ravens can be explored.

From this review, it is determined that raven's social life can be characterised with flexible group sizes, composition and is a mix of cooperation and competition surround social opportunities and challenges. It is found that size and composition of non-breeder groups can change independently of food availability, and structure of these groups can be developed this is because some individuals will prefer to stay at certain sites. Ravens are shown to call when a social partner was close but not yet at a foraging site and cease calling as soon as their partner arrived, this suggests a possibility that ravens may recruit specific individuals.

Ravens have very complex social interactions with individuals of the same species. Even with monogamous relationships, ravens can still form complex relationships. Importantly, relationships can go beyond relationships with reproductive partners and those that are kin or "friends"; group relationships are of high importance as well. Hence, it is important to explore individual perspectives when investigating the social complexity of ravens because a more comprehensive view across life stages and social contexts are taken into consideration.

Article Contribution

This article is chosen as part of my literature review because it explores the social aspect of corvids. It is important to understand how corvids interact socially because I want to explore their ability of social learning. The type and quality of relationships play a big role into social learning.

This article advances the knowledge in that it explores relationships outside of monogamous relationships which has been studied extensively although a significant part of raven life is non-breeding.

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Miller, R., Laskowski, K. L., Schiestl, M., Bugnyar, T., & Schwab, C. (2016). Socially driven consistent behavioural differences during development in common ravens and carrion crows. *PLOS ONE*, *11*(2), e0148822. https://doi.org/10.1371/journal.pone.0148822

Article Summary

The main objective for this article was to determine the role of development and social context on the variation of individual behavior in corvids. The differences in corvid behavior impacts their learning and ability to perform tasks, and their life history. The previous studies have explored differences in individual behavior for non-human species but have not focussed on how this variation changes as the animal develops.

The experiment was conducted by presenting corvids with new food and objects in two contexts– when they were alone and in a group setting during the developmental stages of the bird (from young to almost adulthood). Bird interactions with these new objects was videotaped. The corvids were then observed with how they interacted with the new objects (which measured interest level) and how much the corvid moved/changes in location (which measured activity level).

Overall, the researchers discovered throughout corvids' development they were quite unpredictable in their behavior when facing new objects. Researchers found that corvids behave differently when alone compared to being in a group. Some corvids also interacted similarly to other corvids when in a group setting indicating the strong effect of a bird's social environment. The researchers discovered the ability of corvids to be flexible in their behavior (different ways of interaction depending on presence of other birds) and the big role social environment plays in influencing social learning.

The significance of the findings is that corvids are highly adaptable and able to change and adjust to their surroundings when needed. This is demonstrated by the lack of predictable behavior when alone and when in group settings. In addition, this study was conducted on corvids throughout their development and the lack of consistent results may further demonstrate the adaptability that is needed for corvid's growth.

Article Contribution

This article is chosen as part of my literature review because it explores how social learning of corvids can influenced. In addition, researchers found the corvids are very capable in adapting their behavior which is important when interacting with other species.

This study supports previous findings in that there is high flexibility or variation in individual behavior throughout development.

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Mates, E. A., Tarter, R. R., Ha, J. C., Clark, A. B., & McGowan, K. J. (2015). Acoustic profiling in a complexly social species, the American crow: Caws encode information on caller sex, identity and behavioural context. *Bioacoustics*, *24*(1), 63–80. https://doi.org/10.1080/09524622.2014.933446

Article Summary

The main objective for this article was to explore variation of the structure of crows' calls by looking at various call types– alarm, foraging reinforcement, and territorial calls. In addition, the researchers explore the information encoded in the call that gives information about the caller's age, sex, identity, and any behavioral context. Previously, variation in corvid's calls has been explored, but research done only focuses on one call type in each study.

The experiment was conducted on 18 wild crows and their calls. Their calls were recorder then analyzed using pitch algorithms and parameters. The different parameters set for analysis included frequency, amplitude, and spectral parameters. The results of the analysis were then used to determine variations that may be associated with information on the caller's behavioral context, age, sex, and identity. Behavioral context is the reason for the call, so whether it is for alarm, a territorial display or calling others to a food source.

The researchers discovered that the sex and identity of the calling crow can be distinguished in a call, but the age of the crow could not be determined. They also found that most of the variation calls seems to be from the behavioral context.

The significance of the findings is there is a lot of information encoded in the calls of a crow. The most variation in a call occurs for behavioral context. This may suggest the importance for crows to communicate the different reasons for a call. This study demonstrates a crow's ability to gain information about others without needing to be present and from a distance. This is significant since there is less need for the energy expenditure in cases where it is not needed (ex. crows do not need to go to food source to get information about it).

Article Contribution

This article is chosen as part of my literature review because this study demonstrates the ability of and the extent to which crows to encode information into their calls. This is important when considering the information transfer between corvids because the method through which this occurs is shown.

This study supports previous findings in specific information regarding the caller is encoded in the calls that crows make. This study further expands upon the information encoded in calls in different call types.

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Nácarová, J., Veselý, P., & Bugnyar, T. (2018). Ravens adjust their antipredatory responses to con- and hetero-specific alarms to the perceived threat. *Ethology*, *124*(8), 609–616. https://doi.org/10.1111/eth.12764

Article Summary

Animals that have a common predator can have heterospecific alarm calls where two different species of animals have alarm calls for the same predator. The main objective for this article was to test the response of ravens to alarm calls, comparing the response to conspecific and heterospecific calls. The previous studies have emphasized the importance of alarm calls.

The experiment was conducted by playing three different recordings– alarm calls from the same species, alarm calls from another closely related species, and bird song (controlled variable). These recordings were played in the enclosures of wild boars and wolves after they were fed. The wild boars and wolves were considered low threat and high threat predators, respectively. Ravens would forage in these enclosures after the animals were fed. Ravens were recorded when these recordings would play and when ravens left the feeding site when the recordings sounded, it was counted as a response to predation. Raven response to calls from their own species was compared with calls from another species in both low predation threat and high predation threat situations.

The researchers discovered that ravens responded to their own calls (conspecific calls) with greater intensity when in the presence of high threat predators than when in the presence of low threat predators. Ravens also had a stronger response to the heterospecific call in the presence of the high threat predator. The response to the heterospecific call in the presence of a low threat predator was the same as the control.

The significance of the findings is that ravens understand the heterospecific calls. This means there is learning and interspecific recognition. This also demonstrates the adaptability of ravens to respond to potential threats and their remarkable ability to remember and recognise stimuli from other species.

Article Contribution

This article is chosen as part of my literature review because it demonstrates the learning ability and adaptability of corvids. It also demonstrates the complexity of calls of corvids and how they can encode specific information and illicit an appropriate response to a specific threat.

This study supports previous findings regarding the importance of alarm calls for anti-predatory response. This study also supports that specific information is encoded in corvids' calls.

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McIvor, G. E., Lee, V. E., & Thornton, A. (2018). Testing social learning of anti-predator responses in juvenile jackdaws: The importance of accounting for levels of agitation. *Royal Society Open Science*, *5*(1), 171571. https://doi.org/10.1098/rsos.171571

Article Summary

Social learning can help young to respond properly to surrounding dangers. The main objective for this article was to test if vocalizations from the same species can be used for anti-predator learning. The previous studies have determined that recognising predators is an important development that happens in animal's early life.

The experiment was conducted on young corvids by presenting two animals a stuffed fox which was considered the real threat and a toy elephant (considered as a new predator). After this initial presentation, the toy animals were then presented while adult bird calls were played. There were two types of calls– one was indicative of danger while the other was not. In the last phase, the birds were again presented the toy animals but without the pairing of any adult bird calls, their response to the toy animals was observed.

Interestingly, the birds seemed to have accustomed to the toy elephant and despite the training of associating it with danger calls the birds had no alarm response. The responses to the fox remained the same through the experiment, with the birds reacting to it as a predator. The researchers discovered there was little social learning that occurred during their study. They found that the response of the bird was related to how agitated the individual was prior to the presentation. The response to the fox may indicate that the bird already recognizes it as a predator prior to the experiment.

The significance of the findings is that the condition of the animal such as the agitation of the animal is an important consideration prior conducting anti-predator studies since this will influence the response the animal gives when presented with the stimuli. It is also important to understand how individual behavior affects their response to predators.

Article Contribution

This article is chosen as part of my literature review because consideration of the state of the animal is important especially when conducting studies regarding recognition of predators. The understanding of how an animal learns about dangers is important and plays a critical role in corvid ability to recognise individuals of other species since corvid recognition is so intricately tied to predator and threat recognition.

This study supports previous findings in that animals already learn early in their lives to recognize which are predators to them.