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THE NEUROSCIENCE OF ART: AN EXAMINATION OF UNIQUENESS

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THE NEUROSCIENCE OF ART: AN EXAMINATION OF UNIQUENESS

A case for understanding the interdisciplinary connection between neuroscience and art

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Make art and be kind.

ABSTRACT

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The Neuroscience of Art: An Examination of Uniqueness

Advisor's Name: Robin Hextrum MFA/MA; Jamey Maniscalco Ph.D.

Reader's Name: Mark Basham Ph.D.

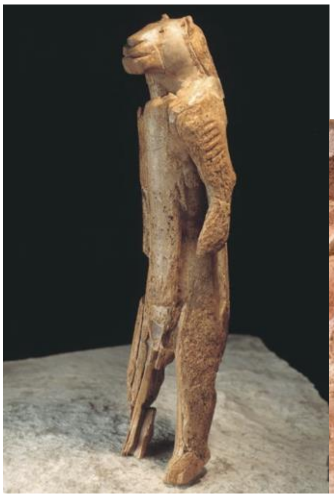
The field of Neuroaesthetics has an overwhelming potential for helping us to understand the world and human behavior through consideration of both neuroscience and art. Looking at the production of art across human history, it is clear we have evolved with art as every culture has developed some style and desire for art without influence of other peoples. The intriguing and undeniable psychological phenomenon of pareidolia raises the question of why the visual system might be set up in a way that leads to illusions and visual suggestions. The amygdala is also involved as the nuclei's reaction to perceived or imagined threats causes intense body changes. Art, as a rewarding experience, could then be seen as biologically necessary to offer some release of dopamine and a "feeling good" response. I argue that the human brain was evolutionarily *designed* for art. Many animals can be taught to make human-styled art using both painting and drawing techniques. Animals also make their own style of art as it is clear there is deliberate choice in the spider's web when it comes to spatial design. In most species of birds, nest building is a learned behavior and this, coupled with the variation in nest structure, reveals the high levels of choices birds make in the design of their nest. And finally, when looking at bees and the construction of their hives, their abilities far surpass what we commonly think possible. Thus, when looking at the

products of spiders, birds, and bees, these animals have aesthetic composition preferences in the design of the structures they make. Therefore, while art is *not* unique only to humankind, art is *necessary* to humankind.

CHAPTER ONE: ART AS A NECESSITY

Art has always been a part of my life. I have always felt the urge to create and find myself engrossed when looking at others' artwork. However, I do not think I am alone in this. Many people enjoy the visual arts and find themselves getting lost in paintings. The art of music connects to people strongly. Many of us have favorite songs we sing along with and know every word to. There are the culinary arts which give people their favorite dish and leave their bodies satisfied. There are the language arts, performing arts, and many other kinds of arts that exist in our world. One way or another, art is something that is a part of everyone's life. But what is art? And more importantly *why* do humans make art? Is this a coincidence that so many people feel such an array of emotions from such an array of arts, or is there a neurological explanation for why we all seem so drawn to these types of artistic expressions?

One of the defining features of mankind is a fascination with storytelling, the expression of emotions, and the visual arts. This can be seen across the world. For instance, consider a time before global communication was developed but there was art 35,000- 40,000 years ago. The oldest anthropocentric animal carving, the Lion Man of the Hohlenstein Stadel, comes from southwest Germany around 38,000 years ago (Figure 1). Likewise, cave art of stenciled human handprints from that same time was found in Indonesia at the Sulawesi Cave (Figure 2). At this time in Spain there are stone cave paintings of animals and abstract symbols known as the cave of El Castillo (Figure 3). The Burrup Peninsula Rock Art was found in western Australia at this time which shows clear petroglyphs (Figure 4; Adhikari et al., 2022). These are just a few examples. There are many more well-known artistic artifacts from this time all over the world. If art was not essential to the human condition, then why does every society come to it on its own in isolation from the rest of the world? Perhaps art was an essential form of communicating basic needs that then transitioned into a more aesthetic, abstract expression.




Figures 1, 2, 3, 4. Pictures demonstrating art around the world made in the range of 35,000 –40,000 years ago. From left to right in the top row: The Lion Man of the Hohlenstein Stadel from southwest Germany and the Sulawesi Cave Art from Indonesia. From left to right in the bottom row: the El Castillo Cave Art of Spain and the Burrup Peninsula Rock Art of Australia (Adhikari et al., 2022).

I propose that art, as something that displays human expression, connects people to each other, and beautifies the world, must also be fundamental to not only our human nature but to human survival. At the least, survival on a societal level. Art in all of its manifestations (visual art, music, literature, dance, theater, and more) is an important feature of human societies because it serves as a cohesive symbolic communicative system conveying cultural norms, history, ideas, emotions, aesthetics, and so on. Consequently, I will explore the idea that the creation and perception of art is *necessary* for humans and other species. With the critical importance of art to humankind, this begs the question “is art unique to mankind?” Through consideration of the similar neurological processes that go on with the creation of art in both non-human animals and people, I will make a case for the idea that art is *not* unique to mankind yet art is necessary to mankind’s survival. Finally, I will suggest that the acknowledgment of the arts and their necessary role in culture have yet to be fully accepted, and consequently the importance of the arts needs to be reevaluated.

Art has a magical power to bring people into new worlds and states of mind. What I find most enjoyable about art is looking at it. Talking about art and the conceptions behind it is an enriching and stimulating experience, and the act of making art is one that transcends time and fully consumes you in a way that nothing else can. Yet, it is looking at a finished piece, whether it is one you created or one you are viewing, that truly consumes your thoughts in an incomparable way. We often look at a piece of art created by someone from a different space and time, yet instantaneously *feel* some emotion or cue some meditative thoughts from the work. This is truly a sense of time travel. Sometimes the artist and the date are completely unknown and other times it may be your neighbor painting next door, yet either way there is an inherent connection between people made possible by art. But what is this space-time connection between the artist, the canvas, and the viewer? Moreover, how could it be something that we all connect to in an individual, uniquely felt capacity? In order to understand why we have the reaction to art we do, we must first start with the development of art production throughout the history of mankind.

One might ask where the world’s oldest art is located and when it was created? For many years, France’s Chauvet cave paintings from 37,000 years ago held this honor, until the discovery of Spain’s El Castillo caves from more than 40,800 years ago (Than, 2012). However, in the last year the limestone Leang Tedongnge Cave found in Sulawesi, Indonesia has been discovered depicting a painting of three pigs from 45,500 years ago done by Neanderthals (Brumm et al., 2021; Figure 5). There are a few key takeaways here. Firstly, the ability for Neanderthals to have effectively captured the figure of a pig reveals that this probably was not the first time they creatively recreated things they saw from the physical world after viewing them. This reveals a probable longer established timeline for the creation of art, both through the comfort of making pigments from fruits and the accuracy of the pig figures. Second, the consistent continual discovery of caves with pre-existing art shows that this is the oldest known cave *for now*. What is also notable here is that the environmental circumstances around these found arts had to be just right in order to naturally preserve the works for as long as they have, even though much of the pigments are now gone, which indicates that there are likely many more older pieces of art that weren't preserved at all due to natural forces.

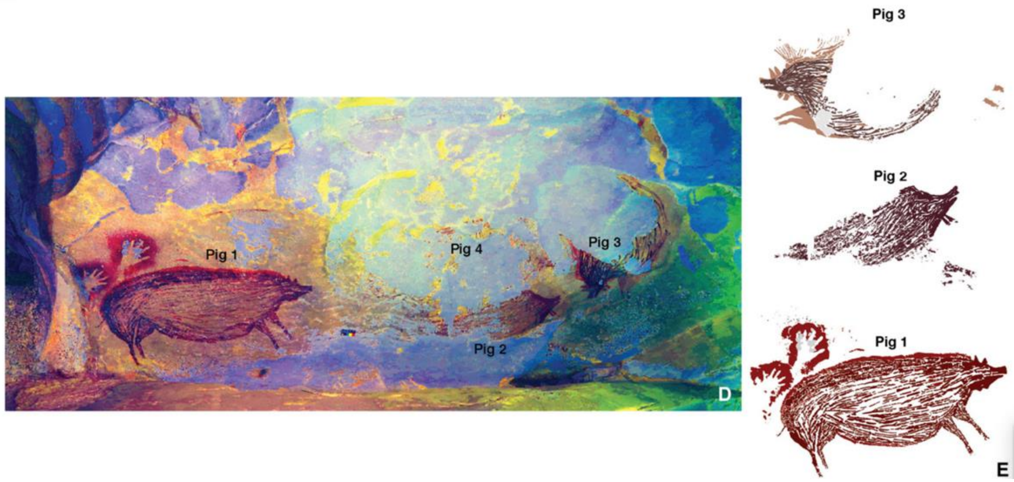


Figure 5. Three pigs drawn on a cave wall and handprints showing the oldest detected art in Leang Tedongnge Cave found in Sulawesi, Indonesia (Brumm et al., 2021).

When looking at the development of art, we must come to a definition for what qualifies as art. One of the most prominent American philosophers and educators, John Dewey (1859-1952) must be considered in this discussion. Dewey is most notable for cofounding the philosophical movement *Pragmatism* - a school of thought that prioritizes action over fixed principles. In his *Art as Experience* (1934), Dewey perceptively draws a connection between human emotions and art as “every art communicates because it expresses. It enables us to share vividly and deeply in meanings… For communication is not announcing things… Communication is the process of creating participation, of making common what had been isolated and singular” (p. 6). In saying this, he helps define art as a process to communicate one’s own emotions while simultaneously connecting with others. This distinguishes the function of art as primarily storytelling, narrative art - the ability to share experiences from one individual to another. In this way, the cave clearly demonstrates a story telling component through the visual communication that there are pigs in motion.

However, when looking at early cave paintings is it important to note that they are *paintings* which are drawings done through a wetter, more pigmented medium. It logically follows, then, that drawing and other forms of art could be even older as they were developed first as the foundational explorations of art. This can drastically change the timeline for the oldest art discovered to date. Recent archaeological evidence suggests that early humans found pieces of rock or a bone that naturally resembled something else, were intrigued by these objects, and decided to keep those objects with them similarly to how early humans used found objects as tools (Bednarik, 2003). This ‘found art’ was then modified to exaggerate whatever resemblance seen in the object - often an animal-like form. One possible explanation for the spreading of this found art is that someone who found a rock or piece of bone that looked like an animal would have shown it to others, which could have served as a motivation for others to also collect and accentuate rocks with these perceptually suggestive features (Bednarik, 1994). I would even entertain the thought that these found arts could be some of the first fashion accessories or home decorations, as the intended purpose is unknown.

The Makapansgat is a pebble from about 3,000,000 years ago with patterns on it that make it look like a rendition of a human face (Figure 6; Dart, 1974). The pebble was found near bones of *Australopithecus* people, predecessors of modern humans some three million years ago. This artifact is from the paleolithic era which is a cultural period of the Stone Age beginning with the earliest chipped stone tools in western Asia and southern Europe (Dart, 1974). Coincidentally, when we broaden our views of art beyond the modern definitions of technique and form, it seems that the beginning of tool usage also coincided with the beginnings of art. This pebble has etchings and imprints on it that make it clearly resemble a face. It is interesting to consider early people communicating with each other and using this etched pebble as a means of storytelling. Culturally, artifacts like this do not seem to be recognized as valued art, as traditionally more classical forms such as paintings seem to take precedence and preference. From here we must ask questions about what we consider art to be. Does it need to be on a cave wall to be a contender for the title of our first known art, or do patterns on sticks and rocks also make the cut? We must consider what the nature of art is and how long, if *always*, art has been around for people.

Figure 6. The Makapansgat pebble (Dart, 1974).

As such, this idea of coupling an early human history with the making of art is backed by anthropocentric research as "the expression of meaning using color, line, sound, rhythm, or movement constitutes a fundamental aspect of our species' biological and cultural heritage. All known human societies have developed aesthetic systems that use diverse forms of visual representation, body art, music, literature, or performance to convey culturally important meaning" (Huston et al., 2015, p. 2). This finding is not a casual statement. Rather, to acknowledge that this is something that every society has participated in reveals a fundamental need for the development of art. This begs the question, if art wasn't essential to the human condition, then why did every society come to it on its own? With no external influence from areas around the world all people seem to come to this creative process on their own. Some researchers go so far as to argue that "art and aesthetics are, therefore, inherent constituents of the human mind, and contribute to our species' identity, distinguishing it from its living and extinct relatives" (Huston et al., 2015, p. 17). This is a colossal understanding, as the importance and intrinsic necessity of the arts is truly seen through this lens.

Even so, societally there are many different approaches to art. This can generally be seen as "western artists are inclined to capture a specific moment in a visual scene and fix the physical position of the viewer. In contrast, when looking at a Chinese landscape painting, there is no distinct point to guide viewers... it has a dynamic quality that integrates successive time windows" (Bao et al., 2016, p.2). There are many differences including subject matter, techniques, and significance when it comes to these different categories of art, but another notable feature is found when tracing the function or purpose of the artwork. In non-western, African art from the pre-colonial African continent, art work was commonly produced for a specific function, whether that be ritualistic or religious, and from the moment it came into existence this function determined its preservation and use by some delegated person. This could be the head of the village or a healer, priest, or shaman type of figure (Melcher and Bacci, 2008). Due to an ongoing relationship with this specific person the artwork was often preserved and well kept.

In Western art, however, pieces are generally produced for an aesthetic rather than utilitarian function, and consequently often never find a home nor long-term preservation. Artworks that have been produced for an individually chosen and highly specific function, such as commissioned by a rich patron, are at risk of being left behind once their patron ceases to own them. It is not a coincidence that the highest number of Western paintings that have survived from the pre-modern era is of a religious subject; having been commissioned by the Church, they were produced to fulfill functions shared by an entire community as opposed to one single individual. The amount of art lost due to lack of preservation is unknowable, yet I find it important to understand when we study and consider art that we are not looking at *all* art across cultures, rather all art available to the general public for viewing. Furthermore, I think the manner in which a culture choses to preserve art speaks loudly about how much meaning and connection they found with it.

Upon a more modern reflection, Dewey (1934) argued that there is continuity between works of art and everyday activities, and to apprehend the aesthetic one must begin with understanding the events of daily life. He goes on to confidently claim that every person is capable of being an artist, living an artful life of social interaction that both benefits and beautifies the world. In saying this, Dewey is signifying that art is something that must be practiced and observed daily to be fully realized. Dewey is revealing a positive association between the creation of art and societal success. I believe there are common necessities for human survival that most are familiar with, for instance food, water, and shelter. However, from Dewey's description, I argue that art, as something that displays human expression, connects people to each other, and beautifies the world, must also be fundamental to not only our human nature, but to human survival. At the least, survival on a societal level. It is this thought, however, that begs the question, is art unique to humankind?

CHAPTER TWO: THE NEUROSCIENCE OF ART PT. 1 (HUMANS)

In order to understand the prevalence and significance of art in human cultures we should examine the foundational neuroscience behind art perception and production. Neuroaesthetics is a relatively new sub-discipline of aesthetic studies. Neuroaesthetics was a term coined in 1999 by neuroscientist Semir Zeki, known for his research on primates' visual systems, yet did not receive a formal definition until 2002 (Nueroaesthetics, 2023). I would like to explore this fairly new field, as there is still much to understand about the connection of neuroscience and art. Many areas of the brain become activated and involved when looking at, processing, and creating artwork. Generally, the thalamus and the primary visual cortex are needed for *viewing* art (Taylor-Clarke et al., 2002), the amygdala, insular cortex, and periaqueductal gray for emotionally *feeling* art (Rotshtein et al., 2001), the hippocampus for *remembering* art (Bird and Burgess, 2008), the basal ganglia for offering *contextual understandings* to art (Leisman and Melillo, 2013), and the prefrontal cortex for *deciding* how we respond to the art (Sakagami, 2007). This is just a scratch of the surface of areas activated in the brain when it comes to the arts, as when talking about music, cooking, or performative art there are various other regions and pathways engaged. For our purposes, I will narrow our biological focus and continue to look at visual art when considering the neurological processes going on in both making and perceiving art.

I argue that by understanding how the brain processes art, we can truly understand that art is a necessity. First and foremost, when talking about the visual arts, we must consider the visual system. The visual system is divided into multiple distinct neuronal coding phases. The first is when the wavelength of light that is reflecting off the art in question travels to the eye. In this phase, the light is sensed by the retina and translated into neuro-electric signals. This is an extensive mechanism in and of itself, but the main idea here is that like "an automatic camera adjusts its own exposure, the retina maneuvers the intensities and contrasts of the natural world into a manageable operating range" (Masland and Martin, 2007, p. 15).

From here, information is sent through the lateral geniculate nucleus (LGN) in the thalamus to the primary visual cortex in the occipital lobe where the information is processed (Bear et al., 2001). The visual system is really creating a perception with very limited input, as seen through blindspots and scotomas where the visual system is known to fill in and create the visual experience (*Brain*, 2022). This process is a nice reminder that:

> In this age of video films and television it is tempting to think of vision as just another way of making a picture, but cameras can only record what they see: they cannot interpret or identify the images they create. No camera, no matter how sophisticated, can match the ability of the human visual system to make sense of an infinite variety of images (Livingstone, 1988 p. 79).

Interestingly, the visual system is being activated constantly, yet not instantaneously as the whole process takes anywhere from 13 milliseconds to 15 seconds. This means we are lagging a little bit behind the real time loop of experiencing something by seeing it, understanding what we are seeing, making the appropriate action from our understanding of what we saw, to then seeing the next thing. Nevertheless, I find significance in that all of this must go on for us to then sit back and enjoy the beautiful sights of the world, particularly appreciating art.

While it has been generally understood and accepted for the last centuries in neuroscience that the primary cortex is where visual processing truly begins and occurs (Johns Hopkins Medicine, 2001), recent studies have found that another area of the brain might also be involved in visual processing. Recently, neuroscientists have begun to ask, do the emotional attributes of a stimulus interact with its sensory-perceptual processing? Could the *amygdala,* the small almond- shaped structural collection of neurons that is known to regulate emotion and memory, activate the fight-flight responses, and is associated with the brain's reward system, also be substantially involved in the visual system? (Johns Hopkins Medicine, 2001; Figure 7).

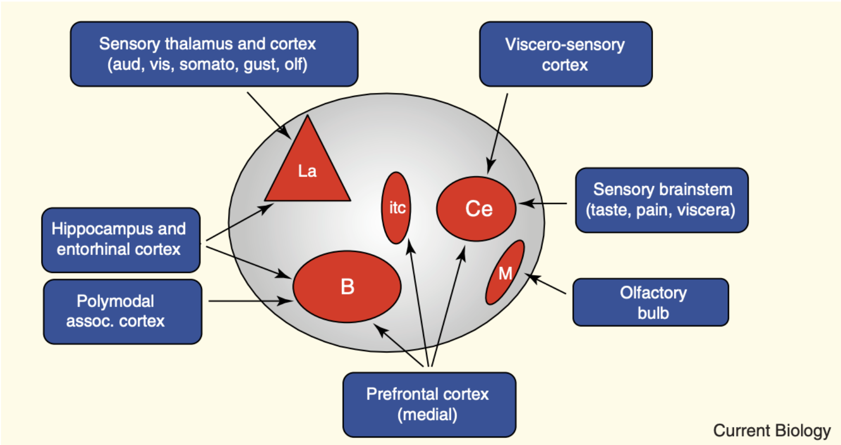


Figure 7. Inputs to some specific amygdala nuclei. Abbreviations of amygdala areas: B, basal nucleus; Ce, central nucleus; itc, intercalated cells; La, lateral nucleus; M, medial nucleus. Sensory abbreviations: aud, auditory; vis, visual; somato, somatosensory; gust, gustatory (taste). (LeDoux, 2007).

The amygdala has long been associated with emotion and motivation, playing an essential part in processing both fearful and rewarding environmental stimuli (Hass-Cohen and Carr, 2008). Moreover, the amygdala reacts long before conscious awareness begins, between approximately 20 and 100 milliseconds (ms) after a stimulus (Repa et al. 2001). This quick response has the potential to dramatically alter important brain and body functions through connections to the sympathetic nervous system (SNS), the fastest nervous system in the body. It is clear that the "rapid amygdala initiation of the SNS's flight or fight response enables reactivity, recovery during stress, and crises or survival situations. By comparison, conscious actions like pushing a button after seeing a flashed light generally take individuals about 220 ms" (Hass-Cohen and Carr, 2008, p. 7). Notably, even more discriminating tasks such as pushing a button in response to a flashing red stimulus while not pushing the button for a white one, requires nearly half a second to happen (420 ms) (Kosinski 2006). This difference in reactions reveals the importance of the amygdala as it is very quickly reacting and offering emotional components to experiences. When considering visual art, such as paintings, it is obvious that the visual system is involved as we are seeing some artwork, but it is equally important to understand and acknowledge that our brain is having an inherent, rapid reaction to the emotions expressed in the artwork through the processing of what we are seeing assessed in the amygdala. In this way, the *content* of the artwork in addition to the artwork itself has an undeniable neurological response.

If the amygdala is connected to viewing art, could that mean the fight-or-flight response generated in the amygdala is also tied in with the viewing of art? The fight or flight response is a physiological reaction that occurs in response to a perceived harmful event or threat to survival (McCarty, 2016). However, this response can be activated even when you are not in any real danger. Sometimes, even willingly seeing something scary can trigger the response. Pleasure follows the fight or flight response a second later as higher neocortical structures assemble sensory details and discover the illusory threat was just that - illusory (Hass- Cohen and Carr, 2008). After seeing a frightening image but then realizing it is only a painting, fear becomes relief, laughter discharges muscle tension and hypervigilance diminishes as the slower, more cautious, refined inhibitory, cortical feedback arrives (Bear et al., 2001). There are many emotional triggering pieces of art, many that include animals and elements of fantasy. If conditioned cues repeat often, the amygdala habituates or ceases responding to the stimuli which is why images may look less frightening the more familiar you are with them. One famous piece from the Romanticism Movement, done by Spanish artist Franscisco de Goya, shows an uncomfortable portrait of a Titan named Saturn eating his son (Figure 8). This piece is quite famous and known for being a frightening, uncomfortable painting, and consequently is one that can be seen to activate an emotional response for its viewers.

Figure 8. Painting, "*Saturn devouring his Son"* (1819-1823) by Francisco de Goya showing a visually uncomfortable mythological portrait (*Saturn devouring his son 1819-23).*

Furthermore, "Anxiety and fear-based reactions may be stimulated while making, discussing, titling or simply looking at art that reveals previously stored amygdala-based memories" (Hass- Cohen and Carr, 2008, p. 8). This shows a real, visceral reaction to viewing art. While this fight-or-flight physiological process can clearly indicate fear, it can also result in the release of dopamine and the activation of the reward pathway in the amygdala, as you feel good about "surviving" what you have viewed or witnessed. Dopamine is a neurotransmitter involved in widely varied forms of human behaviors, including sensations of pleasure, normal motor functions, impulse control, drug addiction, concentration, gambling, and other functions (Flaherty, 2005).

Moviegoers and thrill-seekers endlessly seek new twists to prevent amygdala habituation or de-conditioning -- and I think art-lovers do, too. The amygdala's reaction to perceived or imagined threats causes intense body changes. This can be positive or negative as studies of neuronal activity in the monkey amygdala and of autonomic responses mediated by the monkey amygdala show that, contrary to a widely held view, the amygdala is just as important for processing positive reward and reinforcement as it is for negative (Murray, 2007). This shows us that making and viewing art is a rewarding experience, through the activation of the fight or flight response tied in with the emotional and visual processing of art in the amygdala. Art, as a rewarding experience, could then be seen as necessary to offer some release of dopamine and a “feeling good” response.

What the amygdala is doing is restructuring memory to incorporate lexical and visual knowledge (Adolphs et al., 2000). There are some gender differences in this, as for instance, a male’s right amygdala shows more activity during emotional memory processing, particularly related to visual images, whereas in females the left amygdala is more active (Cahill, 2006). Consequently, this follows that there could also be gender differences when viewing and making art. We can explore this idea further since men’s right amygdala and women’s left amygdala react to happy faces and activity increases in the corresponding hemisphere, yet women also show an increased left amygdala activation during depression that men do not (Cahill, 2006). This means women might be processing or depicting the image of a happy person in a painting while also having the same area activated during their own depressive episodes which could potentially affect both the potency and warp the direction they view the art in in ways that it won’t for males. This could bring forth the idea that men and women might *feel* the same artwork differently, and on different emotional levels, due to various mood localizations in neurological processing.

Such research argues that the emotional qualities of a stimulus do affect sensory and perceptual understandings (Niedenthal and Kitayama, 2013; Taylor et al,. 2000; Anderson and Phelps, 20001), yet this is still a fairly new and disputed idea as there is also research that suggests it does not (Young et al., 1993; Haxby et al., 2000). However, in macaque monkeys, the amygdala at the very least helps to interpret visual social information, such as facial expressions, like when the amygdaloid complex is lesioned the monkey struggles to make appropriate behavioral responses within its group (Emery and Amaral, 2000). The extensiveness of the connection between the amygdala and the visual cortex is becoming more and more clear. The emotional load of visual stimuli modulated the monkey's perceptual threshold, producing higher thresholds for emotional stimuli (Rotshtein et al., 2001). What this means is that the more emotionally invoking a stimulus is, something that expresses *feelings* such as happiness, sadness, anger, etc., the more the primate will put energy towards interpreting and being aware of the content.

This idea that the emotional valiance of stimuli can determine the degree to which it is cognitively understood is also seen in humans as researchers argue that we must "consider that a critical function of the human amygdala is to enhance the perception of stimuli that have emotional significance... Examination of patients with either left or right amygdala resections shows that the enhanced perception of aversive words depends specifically on the left amygdala" (Anderson and Phelps, 20001, p.15). This is a critical revelation because it shows, for example, that the negative emotional context behind the content we take in determines our response to the content. We instinctively give more attention to adverse stimuli than we do for neutral stimuli. This could mean that art that makes some suggestion of emotion, whether positive or negative, will innately queue a higher-level processing pathway in our brains compared to art that does not trigger an emotional response.

Another noteworthy point of intersection between neuroscience and art arises when asking the question, "why do some artworks continue to 'survive' historically while others seem to fade away without popular acclaim?" Why does some art seem to work while other pieces do not? One possible explanation that has become more accepted recently is the idea that many different art techniques utilize the eyes and the visual processing system's natural tendencies as a channel to evoke other senses, cognition, emotions, and even the motor system. This use of manipulating our visual system to be attracted to certain arts and put effort towards their preservation can be seen by stimuli that emulate facial features. As seen with the Makapansgat pebble, humans tend to visually extract meaningful patterns from unorganized, unintentional forms. This is an idea known as *Pareidolia* [from the Greek *para* (beyond) and *eidolon* (appearance)], a phenomenon where specific objects tend to be perceived from a random stimulus such as seeing faces from a cloud (Figure 9; Melcher and Bacci, 2008).

Figure 9. Example of pareidolia as a face can be seen in clouds, rock formations, or any number of random objects (Melcher and Bacci, 2008 p. 352).

Be honest, do you see anything jump out at you in this image of clouds? The intriguing and undeniable psychological phenomenon of pareidolia raises the question of why the visual system might be set up in a way that leads to these illusions and visual suggestions. An anthropological explanation is that recognition of faces and animals is particularly important for survival. It is better on a survival standpoint to mistakenly think that one has seen an animal than to completely miss noticing a predator in hiding (Melcher and Bacci, 2008). This has been understood for quite a while through research showing an impressively high sensitivity and focused awareness response across species when looking at stimuli that resemble two staring eyes (Coss, 1968). We tend to see the fronts of cars in this way, as we see headlights as eyes and recognize faces within our automobiles. Our appreciation for art could then be based on evolutionary survival needs. I then argue that art was born out of adaptations to allow for survival and consequently became integral for species survival and well being.

Furthermore, when someone is presented with a fleeting image, they can detect at amazing speed and with little to no effort whether, if at all, there were animals in a picture (Rousselet et al., 2002). It is also noteworthy that humans can still detect with the same speed and accuracy whether an animal is present in a scene even with the addition of another task (Li et al., 2002). Thus, there is an overwhelming amount of strong evidence that humans have the ability to quickly and accurately detect faces and animals. This is important because it implies a specialized system to notice and process these images.

In the history of art, portrait painting is one of the oldest and most established forms of trans-millennial visual arts. Portraiture, art that copies the image of a person, can be traced back at least around 5,000 years ago to ancient Egypt (Tate, n.d.). It is not by chance that with the development of civilizations and more deliberate intentions of creating art also came the development of capturing the human image. Faces provide important cues, sometimes quite subtle, for social interactions. With the bringing together of people to form and live in civilizations, the inability to correctly perceive the meanings of facial expressions would be a crippling problem for surviving in a social group. Thus, the motivation and bias to focus art towards faces early on in the visual arts is clear. This explains why faces are widely thought to be a ‘special’ stimulus for our visual system (Farah et al., 1998). This sensitivity to facial stimuli was not overlooked by artists, as many artists use this suggestive visual power even in abstract art to ‘suggest’ faces in their depictions, often with just a few hints that suffice as cues for the visual recognition system. As previously discussed, art is about human expression but also *sharing* that expression with others. Thus, any way to share these expressions more easily and efficiently will, and are, being utilized. Artists and various art movements have pushed this idea of suggestive human form to intrigue viewers yet still capture their attention. This is evident in one of the more modern and highly successful art movements known as *Cubism* where the works of one of the founding artists, Pablo Picasso, plays with and offers new approaches to the human form (Figure 10).

Figure 10. *Portrait de Femme au Beret Ecossais* by Pablo Picasso (1937) that shows the use of facial distortion and suggestion yet clear focus in painting.

Interestingly, in a study in humans of the visual sensitivity to inverted faces, the differential activation of the amygdala in the various experimental conditions could be explained by considering either the emotional load (arousal), the negative valence, or bizarreness of the images. Emotional load (arousal) appears to be tied up with thalamic and brain-stem activation while negative valence is more related to cortical response. The amygdala is densely connected with both cortical and subcortical regions and thus could play a role in mediating between these two networks in the process of viewing artworks (Rotshtein et al., 2001; Figures 11 and 12). It is likely that artworks like Picasso's and other Cubist painters tap into more neurological activation than the artist consciously realizes.

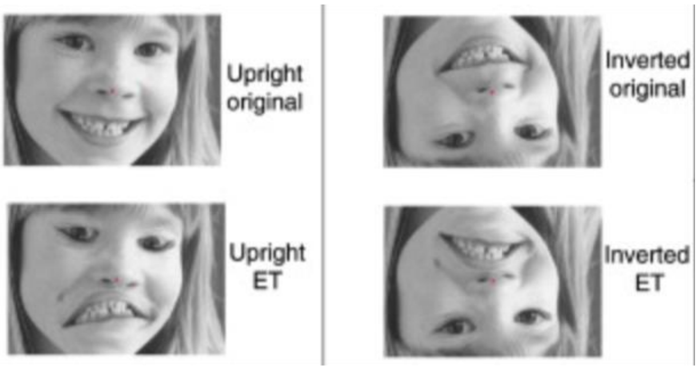


Figure 11. Examples of “expressional transfiguration” (ET) of children’s faces through the inversion of various facial features to assess brain response.

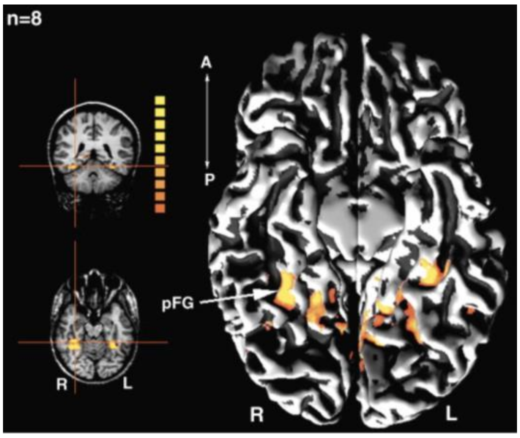


Figure 12. Averaged analysis map showing a significant effect on fMRI for the facial manipulation in the amygdala complex.

There are generally two accepted overarching types of visual processing in neuroscience: top-down and bottom-up processing. Bottom-up processing begins with the retrieval of sensory information from the external environment to build perceptions based on the current input of sensory information while top-down processing is the interpretation of incoming information based on prior knowledge, experiences, and expectations (Martin, 2021). For this example, we can consider the hypothetical image of two different clusters of dots on the cave wall. One cluster of dots is arranged to vaguely suggest a pig, and another cluster of dots is chaotically and randomly arranged with no suggestive form. The set of dots that is arranged in a way to offer suggestive form that ‘looks’ like a pig inherently yields a different and more focused interpretation from the viewer than the random cluster of dots on its own. This is an example of context creating a top-down effect on interpretation (Bar, 2004). Thus, it is clear that the way in which we neurologically process things directly, and entirely, affects our view of art.

The ability to recognize certain stimuli quickly and easily makes it easier, then, for artists to add decorative elements, accurate features, and artistic style. Only once we learned to recognize a bull based on a pattern of marks on a wall could human creativity and ‘artistry’ be added. Furthermore, because the perception of color and details are biologically limited to the fovea in the eye, we must move our eyes and bodies in order to survey a visual scene fully which is an engaging process (Melcher and Bacci, 2003). Thus, I suggest that the stimuli, or artwork, that plays into our natural visual preferences towards animal and facial recognitions is preserved and kept in circulation.

But what happens when we are *making* art? First, the amygdala also activates during appetitive learning (conditioning learning something new with an associated reward), recognizing members of the same species, and while recognizing social cues and emotionally valenced facial expressions (Suslow et al., 2006; Izquierdo and Murray, 2004). This shows that the amygdala is not only connected to the primary visual cortex in the visual system, but it is also tied to the hippocampus through learning and memory. The left amygdala helps consolidate declarative memory for emotionally arousing events, especially if stimulated by a high interest, ambiguous, visual image or during visually elicited positive emotions (Adolphs et al., 2000; Haman et al., 2002). This combination of a visual understanding and corresponding emotions are then fed to the hippocampus as episodic memory (memories of recent or past experiences) will always be hippocampus-dependent if it is associated with rich mental imagery of an environment (Bird and Burgess, 2008). Consequently, the shift from *art perception* to *art making* overlaps greatly in the hippocampus as you remember on some level the art you have previously seen and tap into this understanding when you make your plan to create. The processes of viewing and perceiving art and making art are not entirely independent.

However, when making art the basal ganglia and motor processes must then be brought to the forefront of discussion. The motor cortex has a clear primary function, to generate signals to direct the movement of the body (*Physiology, motor cortical*, n.d.). It consists of the primary motor cortex, premotor cortex, and the supplementary motor area. However, the basal ganglia also influences and modulates the activity of the motor cortex and the descending motor pathways (Basal ganglia, n.d.) The context-dependent activity in the basal ganglia is acquired through learning. For instance, midbrain dopamine neurons respond to external sensory stimuli as a reward during early stages of learning motor tasks (Kimura, 1995). This shows that there is some reward associated when learning to make art through the further activation of dopamine neurons in the basal ganglia. Yet again, art and the act of creating is revealed to make the individual “feel good.”

In neuroscience, a ganglion is a collection of neuronal bodies (Bear et al., 2001). While the exact areas of basal ganglia are disputed among neuroscientists, they generally include the putamen, the globus pallidus, the caudate nucleus, and the substantia nigra. The substantia nigra is a critical region of the brain to produce dopamine within the basal ganglia, and depletion of this production or cell death here results in what is known as Parkinson’s disease (Dauer and Przedborski, 2003). Parkinson’s disease (PD), characterized by tremors and motor incoordination triggered by severe depletion of dopamine, is commonly treated with dopaminergic medication (Zaidel, 2014).

Interestingly, artists suffering from PD continue to produce art, despite the tremor in their dominant hand (Lakke, 1999). In both professional artists with PD and *de novo* PD artists (artists who begin producing art after disease onset), there is a link between dopaminergic medication and increased rate of artistic output while patients without medication don’t produce as much art (Chatterjee et al., 2006). This is a positive relationship between the presence of dopamine, through medication, and one’s creative urges. A high presence of dopamine, as a neurotransmitter known for enacting the feeling of pleasure and motivation, is then directly linked to production of art. Thus, it seems that neurotransmitters, such as dopamine, are likely essential for creativity. Moreover, this shows that a symptom of PD is loss of artistic desire which makes clear that cell death in the basal ganglia results not only in accepted essential functions such as motor coordination, but also in art production. Why is it that we have such a resistance towards acknowledging that the production of art is also an essential function, as it seen to be directly affected by this disease just as much as there is loss of motor control? Through this understanding, we can shift the cultural lens in which we view art from as a silly hobby to a sophisticated and essential function that is hindered or facilitated through neurotransmitter presence.

When it comes to the prefrontal cortex, the lobe actively deciding to make art and how to go about it, there are several different functional divisions, including the dorsolateral, ventromedial, and orbital sectors (Sakagami, 2007). Each of these regions plays some role in affective processing and different aspects of emotional regulation. Art therapy, a field dedicated to incorporating creative methods as a bridge between psychotherapy and art, may come into play here. Making artwork therapeutically may generate a sense of entering a mental space in which fear and anxiety (disruptive emotions) decrease, while action, intuition, thoughtfulness and positive emotions increase (Hass-Cohen and Carr, 2008). From this, we might hypothesize that creating art in a therapeutic environment could facilitate amygdala guidance of emotional attention for those suffering from trauma. Humans evolved a unique ability to understand and transform their inner experiences through art long ago. Rich, dynamic sensory input distributed by the thalamus flows through intricate, interlocking feedback relationships with cortical areas that shape awareness. Art therapy invokes these feedback functions while revealing and engaging disruptive areas of affective expression emerging from subcortical structures, such as the amygdala. In art therapy, reconditioning the amygdala is critical. Moments that were previously traumatizing are allowed a space and added time to be addressed in a safe and calm environment through the act of producing art. This offers another potential reason for why humankind has chosen to make art for millions of years, as perhaps previously provocative memories and stimuli processing are de-conditioned or habituated in making art.

Looking at art through this mechanistic lens of what happens in neurological systems shows that regardless of if you are perceiving or making art, so much of the brain is activated. And again, this is just the visual arts - not to mention music, cooking, dance, or any other art form. The connection between these neurological structures both in visual art perception and production happens seamlessly and effortlessly, suggesting that the modern human brain may have developed hand in hand with the development of art. When looking at all the areas of the brain affected in art, and even at the neurotransmitters naturally present within the brain, I would go so far as to argue that the human brain was evolutionarily *designed* for art. While evolution does not actually design anything as organisms have an array of traits and those with traits that are more beneficial to a specific environment get passed on more than those with traits that are less advantageous in that specific environment, it still remains that art is biologically advantageous enough that it has been a part of the human experience seemingly as far back as we originate.

The fact that so much of the brain is connected through art shows that it is clearly more important to the human species than a mere hobby. We must be willing to look at the long history of art production, the neurological mechanisms present in the brain utilized for art, and the rewarding benefits of art to truly understand the importance, and necessary nature, of art in human life. Wladyslaw Tatarkiewicz, a polish art historian, wrote in his *A* *history of six ideas: An essay in aesthetics* (1980) that there are only two things that can be said about art: that it is a human activity, not a product of nature, and that it is a conscious activity. This is a bold claim, and one that requires the evaluation of actual ethological studies in order to have a real merit.

CHAPTER THREE: THE CREATION OF ART BEYOND MANKIND

There have been many studies on primates creating art for over a century now. One of the first studies is with chimpanzees and dates back to 1913 in which chimpanzee doodles and scribblings were compared to those of human children (Ladygina-Kohts et al. 2010). However, as seen through most research of this time, the scribblings of the chimpanzee themselves were not considered with any real focus or importance, rather the researchers were interested in a more general assessment of what primates are capable of doing.

It was not until 1951 that chimpanzee drawings were examined in more detail such as the consideration of the locations in which they mark their strokes and other design elements were first considered (Schiller, 1951). In this study, it was also found that chimpanzees seem to have varied responses to making art when presented with papers that already have some pre-existing drawings on them. This can mean anything from losing interest in drawing on the paper altogether when the paper is previously marked all the way to chimpanzees diligently working to complete the rest of the pattern they are presented with. The expressed interest in this question of validity when animals create and perceive art has been one sparking intrigue in researchers' minds for a long time.

A series of experiments by Dr. Desmond Morris has truly become the pinnacle for primate art consideration. Desmond Morris is a renowned zoologist, ethologist, and surrealist painter. Morris began a series of investigations from 1956-1958 revealing that apes can gain emotionally rewarding experiences through the act of drawing on paper. Morris found that when presented with pre-established asymmetrical patterns on paper, chimps will work diligently to balance and complete the pattern on the other side. This surprisingly attentive response of the chimpanzees can best be understood with the realization that "the earliest visual sensory impressions of an anthropoid must be (1) faces, which frontally are practically two dimensional and possess symmetrically paired components in eyes, teeth, ears, eyebrows and unpaired medial but symmetrical nose and mouth, and (2) the fan pattern of hands, again a relatively flat object" (Bleakney, 2010, p. 477).This suggests an evolutionary basis for aesthetic appreciation in both humans and non-human apes.

Morris wrote many books such as *The Biology of Art* (1963), *The Naked Ape* (1967), and *The Artistic Ape: Three Million Years of Art* (2013) in which he goes over his research and many intriguing findings. Most famously, a three-year-old ape called Congo was very curious and impetuous. However, throughout his experiments Morris noticed behavioral shifts within Congo. When the chimp was given a pencil to begin drawing his high energy levels dropped and he became intensely focused (Figure 13). Notably, there were no rewards given for Congo's drawings, rather the chimpanzee found drawing rewarding enough to continue it on his own. From the beginning, Congo was attracted to beam-like shapes - scattered radial lines spreading and protruding out in every direction from a central spot. Again, this may be due to an innate evolutionary familiarity and consequent fondness for the aesthetic expression of symmetries. Curiously, throughout the drawing sessions it became clear that Congo didn't care to look at or return attention to his pieces after he created them. However, a shocking result was found when Morris and his team tried to disrupt Congo *during* his drawing process and stop the chimpanzee from drawing by removing the paper. Upon interruption, Congo began screaming and expressing displays of temper. How important was making art to Congo? Did the beam-like images *mean* something to him? In confused awe, Morris remarks "it seemed extraordinary that a chimpanzee should be so upset when attempts were made to stop an activity as specialized as picture making. . . Why on earth should it have such a powerful appeal for an animal that shows no inclination to perform anything like it in the wild?" (Morris, 2013, p.28). This highlights how upset Congo became when his art was disturbed, and shows some level of an emotional connection between the chip and his work.

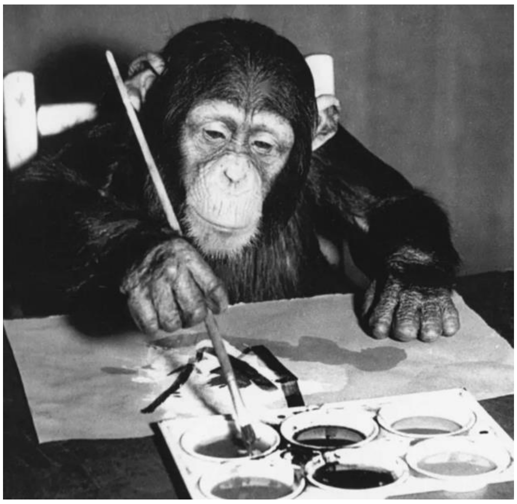


Figure 13. Congo painting on paper. (*Congo the chimpanzee:* The Mayor Gallery, 2019).

In a series presented on live television, Congo was presented with a new medium, painting, and continued to develop his displays of the beam-like shape over the course of many sessions. On the 22nd session in 1957, Congo reached his peak painting control and capability. By this point he was able to manipulate the beam pattern, titling and splitting it in the manner of a professional human artist. He continually worked on varying the beam--adapting it with the addition of radial lines and curved bases and playing with compositional balance in designated spaces and pattern variation through the use of dashed and solid lines (Figure 14). Congo's work was appreciated by many artists as notable as Pablo Picasso, who established the art movement *Cubism*, and Joan Miro, an abstract-surrealist painter, both of whom independently purchased some of the chimpanzee's works. Furthermore, Morris' sessions lit a fire under the wings of animal-art research in the sciences, and resulting studies soon took off.

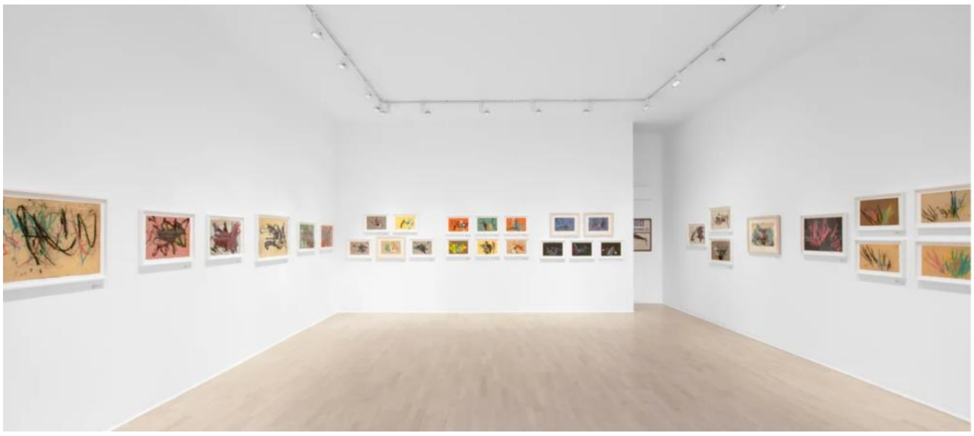


Figure 14. A gallery exhibition of the private collection owned by Desmond Morris which shows 55/400 pieces created by Congo displaying beam development and variation (*Congo the chimpanzee:* The Mayor Gallery, 2019).

From here we can look beyond primates, which have close evolutionary ties to humans, and examine if other, more distantly related animals create art. Established in 1998, the Asian Elephant Art & Conservation Project (AEACP) is a non-profit organization that aims to raise awareness about the declining number of Asian elephants in the world. Founded by Russian performance artists Komar and Melamid, a project was done where Asian Elephants were taught by mahouts, their trainers, how to paint with their trunks. Notably this artistic process of the elephants did not happen organically as it did with primates, as the mahout gave the brush to the elephant and maneuvered its trunk paired with verbal encouragement in various training sessions so that it learned to recreate a desired composition (Cole, 2011). Amazingly, through this process, the elephants will go beyond the abstract art produced by primates and are able to paint clear, unmistakable portraits *of* elephants themselves (Figure 15). Videos of these performances have gone viral with millions of views across the globe, and as such, so has a discussion on the merit of the elephant's creativity. One critic goes so far as to say, "despite the illusion created by the video, however, the mahout is a full collaborator in [the elephant's] paintings: he draws the original painting, teaches the elephant to copy it, then, in the actual performance, chooses the elephant's brushes and colors of paints" (Samman, 2009, p.162). This suggests that training, mimicry, and imitation do not produce valid results in and of themselves. In effect, there is a question raised here about creativity and *intent.*

Figure 15. Still image from a video of the elephant Suda painting an elephant (FSchleyhahn 2009).

I would argue, however, that imitation is a key step that enables us to progress faster in that we do not have to relearn what is already understood. This can be seen in the art world as 19th century academic academies in Europe were built on methods of copying human figure models to develop honed skill sets. Many art students today carry on this tradition of a master copy, where they paint a version of a famous work of art in order to better understand it. Beyond art, imitation is needed to learn most things. Reading and writing, for instance, is not something that developed organically for me. Rather I have had a lifetime of western classroom education that started with a foundational repetition of forming letters, words, and sentences that ultimately led to the ability to express my own ideas some years later. Likewise, elephants may need initial instruction in how to make art, in an anthropocentric sense, but that does not mean that they are not creating, or it is any less impressive of a feat simply because they were taught. There is a certain amount of pompousness tied to the arts in which many people want to categorically claim what *is* and *is not* valid art. Rather than an exclusionary approach, I like the thought that "I don't pretend to know what art is, and I don't know why people believe in it, but I know that they do. It's a question of faith, maybe, needing to believe in something bigger than ourselves… But one thing I'm fairly sure of: if something makes you ask the question, Is it art?, there's a very good chance that it is" (Fineman 2000, p .49). I like the openness of this idea, as it pushes back against the labeling of art in an absolutist way- something that we seem to easily get caught up in. Why must we be able to declaratively call a piece of work art or not? I don't believe it takes anything away from any existing artwork to acknowledge other artworks, regardless of their merits.

Let's move beyond art for a moment and zoom out to see if we can get a better understanding of animal processes. Are non-human animals intelligent? When it comes to animals there have been many disputes about their levels of intelligence. One standard that many use when considering intelligence is a "theory of mind" test. Aptly put, the theory of mind is "explain[ing] people's behavior on the basis of their minds: their knowledge, their beliefs and their desires, and we know that when there is a conflict between belief and reality it is the persons' belief, not the reality that will determine their behavior" (Frith & Frith, 2005, p. 644). What this means is that a display of mind also shows a display of following what is told to be true from given information regardless of the reality of a situation, and consequently a mind will act according to what it *believes.* Theory of mind is important as it allows for introspection and one's ability to evaluate one's own thoughts and mental state (Frith & Frith, 2005). However, after decades of debate by many scientists, there is no current consensus on whether or not non-human animals have a theory of mind and understand varying mental states.

There is another approach that many scientists use to determine and categorize intelligence levels which is centered around tool usage. An animal's ability to use tools could indicate intelligence as "the use and manufacture of tools have been considered to be cognitively demanding and thus a possible driving factor in the evolution of intelligence"

(Teschke et al., 2013, p. 11). Again, there has been decades of debate by many scientists as to whether non-human animals can adequately use tools or not. In one test, a banana was placed just out of reach of chimpanzees in a cage yet they were given a stick near them. Without hesitation, the chimpanzee grabbed the stick and used it to pull the banana towards them. Thus, the primates were seen as intelligent tool-using animals. Notably, elephants were given the same problem of a banana out of reach and a stick to use at their disposal, and interestingly the elephant *never* picked up the stick with its trunk and consequently they could not reach the banana (de Waal, 2017). Thus, elephants were seen as *less* intelligent due to their lack of intuitive tool using. For many years, no further questions were asked and the lower intelligence of the elephant was understood.

Finally, after many years, researchers reconsidered the tool in question and whether use, or lack of, of this tool was a fair assessment of *elephant* intelligence. While humans and other primates might opt to use a stick as it can be used as a natural extension of one's arm, an elephant smells out of its trunk and so if it picked up a stick it would accordingly limit its own awareness by blocking its smell to the banana. By picking up the stick with its trunk, all the elephant would smell and be focused on would now be the stick! Thus, a tool that is useful to one species might hinder another. Notably, when given a similar problem of a banana out of reach high on a tree branch but allowed a different tool like a box to utilize, the elephant will position the box directly below the banana, step onto the box, and then easily reach the fruit (Figure 16; de Waal, 2017). Thus, when considering tool usage as a defining feature of intelligence the challenge is to find tests that fit an animal's temperament, interests, anatomy, and sensory capacities (de Waal, 2017, p. 18).

De Waal explains that "there are lots of wonderful cognitive adaptations out there that we don't have or need. This is why ranking cognition on a single dimension is a pointless exercise. Cognitive evolution is marked by many peaks of specialization. The ecology of each species is key" (de Waal, 2017, p. 12). What he is saying here is that different species have different strengths and weaknesses, so when it comes to something like intelligence assessments we must understand that there are many ways to solve any problem and that the human approach or approaches similar to it are not the only *correct*, or even most efficient, way. Consequently, when judging animals' intelligence, or even the ability to create and perceive art, we must be able to look beyond human and primate standard expectations and be open to other species' equally valid yet completely different approaches.

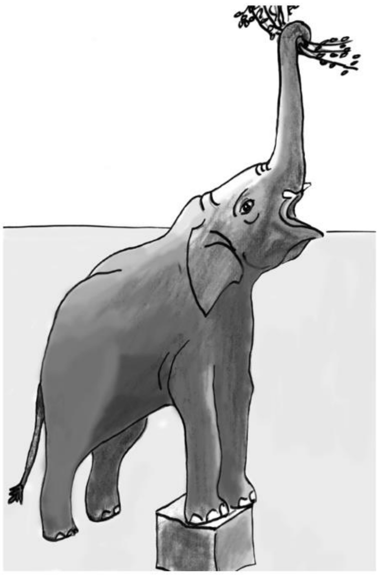


Figure 16. Image of an elephant using a box as a tool to reach a banana. (de Waal, 2017).

Thus, if we can reevaluate our means of measuring animal intelligence and find shocking results, I believe it should also follow that we can reevaluate the extent to which animals make and create art *beyond* human and primate notions of art. From here, we can look directly at nature itself to see the creations of art. For instance, is the spider's web not an intricately woven structure? Is the beaver's dam not crafted and placed with intention? Is the bird's nest not deliberately made? Is the bee's honeycomb not a tessellated sculpture? While some may say these structures exist because they serve practical, survival purposes for the animals, which is true, I would argue that there are many ways for things to be functional, yet animals also deliberately choose to create using an array of particular methods. Why is it that when a human manipulates string it is called knitting, crocheting, or some kind of weaving but when a spider does it is seen purely as an evolutionary survival tactic separate and independent from any creative processes or outlets for the animal? Looking beyond an anthropocentric lens of art, we must ask why these animals make structures in the beautifully unique ways in which they do and what, if anything, do these designs mean to them?

An American philosopher of art, Denis Dutton, said when it comes to animal art, “it is also difficult to discern any purpose, sense of an action plan or an endpoint to which the work is heading. It only appears to have these qualities because of [human suggestion]” (Dutton, 2011, p. 56). Due to the lack of verbal communication animals can use, the reality is they are not advocating for their art to be considered, or even able to tell us what their intentions are behind creation. Yet, despite their absence of self-advocacy, by looking into the neurological processes involved when animals make things, we can try to distinguish what their intent truly is.

CHAPTER FOUR: THE NEUROSCIENCE OF ART PT. 2 (NON-HUMANS)

Analyzing the brain activity in humans and animals is the main research goal and focus in the field of neuroscience. We have established that animals create human-style paintings and displays when prompted, but we must also investigate if animals make art on their own. Is there art present in nature, or is the development and need for art something that is unique to mankind? Just like we did with tool usage and the idea of intellect, through this chapter we may have to redefine what we call art and be willing to shift our lens outside of the human perspective to properly evaluate and recognize the presence of artistic abilities and creativity in nature. The key question here arises when we ask if what is going on when humans make art is neurologically similar to when animals are making art that is natural to them. One animal we can first consider when trying to evaluate natural art is the spider and correspondingly its web.

Often fiber manipulation may be considered art in humans when sewing or knitting. Given this, is the spider’s web art as well or does it just serve a functional purpose for the spider as they use it to catch their food? How does a spider’s brain activity affect its web? In the last few years, the analysis of the spider's brain has recently become the focus of attention for more and more scientists in order to fill this gap of brain activity understanding. The design of spiderwebs commonly has a “fractal” design (Namazi, 2017), which means simply that it is composed of non-regular geometric shapes that have the same degree of non-regularity on every level. While the fractal structure of spiderwebs is important for catching the spider’s food, the spider’s brain activity is able to affect the baseline structure and pattern of its web (Su et al., 2022).

One thing to consider here is the nature of the web. How is a web made, and is it uniform to the spider species? Is the spiderweb innate to the spider and consequently is every spider’s web more or less the same? In beginning to answer these questions we can consider a few studies. In one study, researchers tested garden spiders' web production by giving them a range of psychoactive drugs and found out that drugs affect the size and shape of the web rather than what they predicted, which was that it would only affect how long it takes spiders to build them (Namazi, 2017). Based on the results, the shape of the spider's web changed more and its design became irregular at higher doses of drug application. This study is important because it signifies that the spider's web is not something that they can just naturally spin without any thought. Rather, the construction of a web down to its size and shape is something that the spider is actively making decisions about, and thus when they have hindered neurons due to drug application, they produce different styles of webs.

In another study by a NASA research group, researchers continued the previous investigation on the influence of psychoactive drugs on European garden spiders in order to study the effect of toxicity of drugs on spiders. They digitized and processed the images of the web in order to compute numbers of sections and average areas, perimeters, and radii of cells. They found that a more toxic drug causes a more deformed web, which is more sections the spider failed to complete in comparison to a normal web (Figure 17, Namazi, 2017). In general, the application of drugs caused the spider to become drowsy and spin its web with huge gaps. Again, this study continues to be significant because it shows that the web is not merely an innate product of the spider; it is instead something that they consciously decide as proven through its hindrance.

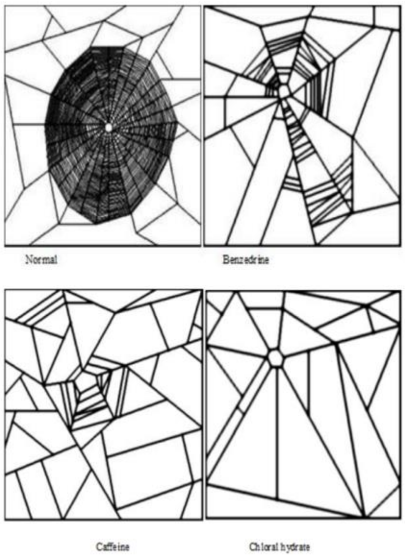


Figure 17. Samples of spider's web (collected in experiments) in different conditions. As it is clear in this figure, web patterns changed enormously in case of each drug application (Namazi, 2017).

While some may argue that requiring focus, attention, and intent are also required for a more basic, utilitarian web that exists just to catch food, I push back and ask them why they are so resistant to acknowledge that there is any artistic display within arachnids? Does it threaten humankind's own production of art in any way to acknowledge that other species also have some level of creative discretion? Ultimately these results demonstrate the relationship between the complexities of the spider's web and brain signal, as the overall decline of fractal exponent of the brain signal due to drugs is mirrored in the overall decline of fractal exponent of the spider's web (Namazi, 2017). Fractal dimension stands for complexity; when the spider's brain signal is less complex, spiders build webs that are also less complex. A high degree of decision making within the spider is revealed as there is a correlation between the spider's brain signal fractal dimension and its web fractal dimension, and a correlation between the spider's brain signal entropy and its web entropy.

In another interesting study that shows a more targeted connection between the arts and a spider's web, the arrangement of spider fibers was compared to sound wavelengths produced in music. The architecture of a spider web is done in an organization that spans orders of magnitude in length from molecular silk proteins to micrometer-sized fibers. Similarly, but in a completely different physical manifestation, music has a hierarchical structure composed of elementary sine wave building blocks that can be combined with other waveforms to create complex timbres, which are then arranged within larger-scale musical compositions (Su et al., 2022). Although apparently different, spider webs and music have many similarities in their arrangement, which to me seems even more evident that the web could be some form of art for the spider.

Another animal taxon to consider when looking at an animal's natural production of art is birds. Birds' nests might be the most recognizable structure of any built in the natural world, so what is this branchy sculpture? There have been centuries of observation regarding bird species, yet until recently there has been surprisingly little known about how birds build nests and what is going on in their brains while they build them. Myriad experiments have attempted to prove that nest building is genetic (Bluff, Weir, Rutz, Wimpenny, & Kacelnik, 2007; Hansell & Ruxton, 2008; Raby & Clayton, 2009; Seed & Byrne, 2010; Zentall, 2006). However, most of this research is based upon untested assumptions since there is little known information on how birds "know" how to build a nest and consequently this may not actually be the case. We will consider what is going on when birds are both physically *making* their nest and then what is going on when birds are *thinking* about their nest.

In the 19th century, the British biologist Alfred Russell Wallace held the idea that learning might be involved in nest building and not entirely due to instinct. However, in *Descent of Man*, Darwin (1871) argued that inexperienced birds will build nests comparable to those of experienced builders on their first attempt. In this account, he contrasted avian nest building with human motor skills, which typically improve with practice (Darwin, 1871). Nearly 150 years later, there is now evidence that nest building in both free and captive birds is learned as they test varying selections of building materials, nest structure, nest location, and building dexterity (Muth and Healy 2011, 2012; Muth et al. 2013; Walsh et al. 2013; Bailey et al. 2014, 2015; Walsh et al. 2010; Mennerat et al. 2009; Hoi et al. 2012; Walsh et al. 2011). This research is critical to understanding that nest building is a learned skill, and could suggest that other ideas from popular culture about what are intrinsic abilities to animals may also be incorrect and instead be something they are choosing to do regardless of their biology. If nest building is learned and not innate, then it is possible that nests are *not* just used for function and instead might also be works of art.

The drastic differences from nest to nest in bird families are evident both on a group level and on an individual level. For example, long-tailed tits (*Aegithalos caudatus)* construct domed nests that are composed of moss and up to 600 spider egg cocoons. Once most of the dome is built, the birds cover the outside of their nests with lichen flakes, which adhere like Velcro to the spider silk incorporated into the nest walls. Finally, the birds create an entrance hole to the nest, complete the nest roof, and line the nest with an estimated 2600 feathers (Thorpe 1956; Hansell 2000). Tinbergen (1953) classified the nest-building process in long-tailed tits into 13–14 discrete, highly distinct actions in order to produce their type of nest. The sequence of nest-building actions can be called the “effective sequence,” a term coined by Collias and Collias (1964) to describe the development of nest-building behavior in another type of bird, the African Village weaverbirds. While the effective sequence of some birds such as the long-tailed tits and weaverbirds involves multiple distinct actions over long periods of time, the core nest building effective sequence for all birds is collecting nest materials followed by construction of that material at the nest site. This is important to consider because it shows that nest building, like art, might have core elements but is ultimately a varying and complex procedure depending on the artist or the bird.

Nest building has recently become an area of interest for neuroscientists as because nest building involves multiple sequences of discrete organized motor actions this behavior offers an opportunity to study how the brain organizes discrete actions into motor sequences using a naturally occurring behavior. This has been really important for our understanding of the brain as there are now consistent findings with the suggestion that the posterior motor pathway is involved in the production of all movement, first proposed when neuronal activity in this pathway was found to positively correlate with locomotor behavior performed by sensory-deprived birds (Hall et al., 2015).

Nest building requires varying degrees of manipulative skill to shape, stitch, and weave nest materials into different nest structures, which I would argue is similar to human's ability to both manufacture and use tools. This goes back to the question posed in the last chapter about how "smart" we deem other species to be if they can not use tools and could be another opportunity for us to view what a tool would be to each species. Evidence to support this suggestion comes from the demonstration that cerebellar foliation, the amount of tissue folding and layering on the cortex or surface of the cerebellum, increases with increasing complexity of the nest structure. Birds that build nests of greater structural complexity possess cerebella that are increasingly more foliated (Figure 18; Hall et al., 2015).

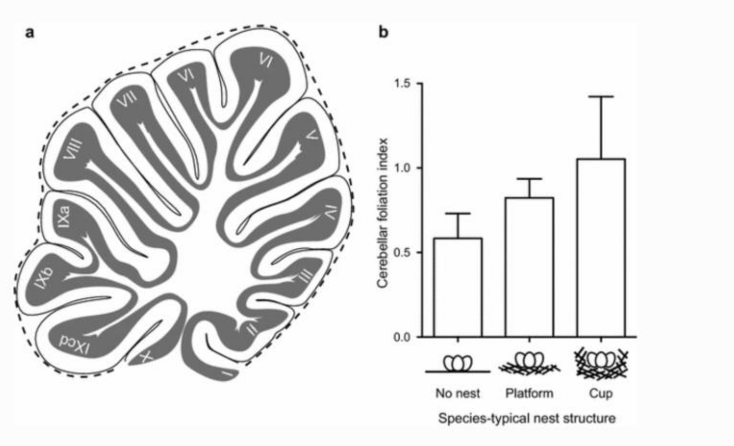


Figure 18. Cerebellar foliation, or folding, is found in more elevated levels in birds that build more complex nest structures such as ones that are designed as a thick platform or even with curved walls (Hall et al., 2015).

Because the techniques that birds use to build their nests are so detailed and varied, we can use them to understand how much is actually going on neurologically and with their motor control in the building process. Techniques range from the sculpting of burrows from substrate excavation through the molding of mud or salivary mucus by vibrating their head and shaping breast and feet movements. Some birds even pile up materials via subsequent bill manipulations, coupled with side-to-side shaking movements, in order to entangle or intertwine nest components. Other birds weave hanging nest baskets using intricate tuck, looping, and interlocking bill-made stitches to fasten and secure grassy materials together (Collias & Collias, 1984; Hansell, 2000). Whatever the technique and method employed, the important thing to note here is the variation in which birds craft and create their nests. This unnecessary variation in nest building shows that birds go above and beyond to craft certain structures which highlights fulfilling a desire over a basic need in their building process. This shows nest building as art, as it pushes past the basic, easier nest construction and instead towards a more complex structure due to the bird's desire.

While we now understand how complex and varied the techniques are in building a nest and that the motor pathways involved push the bird to use natural tools which could signify an even higher than previously thought level of intelligence, there is still a question of intent. Ultimately, the question I'm trying to answer here is, is this art? While motor pathways are involved in the construction of the nest, what is going on when birds are *thinking* about their nest? Do they have a perception of what they are building and are they actively designing it? At its root, the scientific question here is what brain region(s) in a bird are activated when they think about their nest? Interestingly, pharmacological drug manipulations that temporarily reduce neuronal activity in the brain at the site of injection can be used to observe the subsequent effects of nest-building behavior, if any, that result from an specific brain area hindrance (Naie and Hahnloser, 2011). This is critically important to understanding how a bird thinks, and is a way to demonstrate whether neuronal activity in a given brain region is necessary for the production of nest-building behavior. Because many of the relationships between neuronal activity and nest building could occur in neuron populations that use specific hormone and neurotransmitter signals including vasotocin, mesotocin, and dopamine, it would also be possible to use gene silencing techniques or pharmacological agonism and antagonism to manipulate activity specifically within these chemical signaling pathways (Hall et al., 2015; Tobin et al., 2010).

Although some say that nest building is simply functional as it allows for a space for reproduction to take place, this is untrue because the birds may continue to modify their nest structure even once they are living in it with eggs, chicks, or an incubating parent (Breen et al., 2016). For all this variability in all aspects of nest building, an important question is whether one or more parts of the nest-building process involve decision making. Given that birds have long been models for investigating learning and memory and for examining brain-behavior relationships, it is remarkable that such a famous avian behavior has remained so little explored. Present observational and experimental data collected from both the field and the laboratory tdemonstrate that nest building in birds is not fixed, is experience--dependent, and reflects inter- and intraspecific information use (Tables 1-3; Breen et al., 2016). In doing so, these data offer belated confirmation of Wallace's belief that, indeed, learning and consequently decision making plays a dominant role in birds' nest building. Below are three tables examining various types of birds and demonstrating how field research shows that most of them must *learn* how to construct their nest. Notice any patterns among these various bird types under the "conclusion" column?:

Species	Author	Methods	Result	Conclusion	Mechanism
Learning in nest-building birds: Historical evidence *1) Early-life experience affects birds' nest building*					
Zebra finch (*Taeniopygia guttata*)	Sargent (1965)	Males' nest preferences tested between (a) natal & first nest and (b) first & second nests built	Natal nest habitat influenced first-time builders' decisions, but colour & substrate did not; habitat effect decreased between first & second nests	**Birds' nest building is experience-dependent**	Imprinting
American robin (*Turdus migratorius*)	Scott (1902)	For 2 years pairs provided with mud, grasses, and rootlets; in 3rd year also provided a circular nest basket	First 2 years females did not build normal nest; 3rd year they built in nest basket provided	**Birds' nest building is not fixed**	Motor learning
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	Scott (1904)	For 2 weeks pair provided with nest materials; in 3rd week also provided an artificial nest	First 2 weeks birds began and then aborted building repeatedly; 3rd week added nest lining to, and laid in, artificial nest provided	**Birds' nest building is not fixed**	Motor learning
Domesticated canary (*Serinus canaria domestica*)	Veraline (1934)	Birds reared in artificial containers	Birds reared in artificial containers did not build nests that resembled those built by birds reared in normal nests	**Birds' nest building is not fixed**	Motor learning
	Hinde (1958)	Males reared in complete or partial absence (30 min/day exposure) of nest material tested for nest building ability as adult	Males exhibited abnormal building behaviours as adults (e.g., carrying material in and out of nestbox or plucking and building with own feathers)	**Birds' nest building is not fixed**	Motor learning
Village weaverbird (*Ploceus cucullatus*)	Collias & Collias (1964)	Males reared in absence of nest material tested for material colour, length and rigidity preferences; tested as adult	Males exhibited normal material preferences but less capable at weaving than non-deprived birds, deprived birds' weaving skills improved over time	**Birds' nest building is not fixed**	Motor learning
2) Birds' nest-site selection is plastic					
Yellow wagtail (*Motacilla flava*)	Schiermann (1939)	Observed females' choice of nesting location	Subgroups of females found to nest not on the ground (typical), but above ground (atypical)	**Birds' nest building is not fixed**	N/A
Redhead (*Aythya americana*)	Hochbaum (1955)	Observed females' choice of nesting location	Subgroups of females found to nest not over water (typical), but on land (atypical)	**Birds' nest building is not fixed**	N/A

Species	Author	Methods	Result	Conclusion	Mechanism
Black lark (*Melanocorypha yeltoniensis*)	Fijen et al. (2015)	Manipulated dung quantity (absent or present) for artificial nests in 6 experimental plots; exposed to grazing cows	Artificial nests surrounded by dung less likely to be trampled by cows than those where dung was not present	**Birds' nest building is not fixed**	N/A
5) Local reproductive success affects birds' nest-site selection					
Black-legged kittiwake (*Rissa tridactyla*)	Boulinier et al. (2008)	Reproductive success manipulated so that certain nesting areas were 'better' than others	Birds nested in new location the following year if they and their neighbours experienced predation, but did not change location if they but not their neighbours experienced predation	**Birds' nest building is experience-dependent**	Social learning
Prothonotary warbler (*Protonotaria citrea*)	Hoover (2003)	Manipulated outcome of birds' breeding attempt (success or failure); measured dispersal distance between each attempt	Between-year breeding-site fidelity varied: successful birds more likely to return to the same area than unsuccessful birds	**Birds' nest building is experience-dependent**	Associative learning
Piping plover (*Charadrius melodus melodus*)	Rioux et al. (2011)	Analysed demographic (nest location) and behavioural (breeding success or failure) data collected over 8 yr period	Birds nested in new location the following year if they and their neighbours experienced predation, but did not change location if they but not their neighbours experienced predation	**Birds' nest building is experience-dependent**	N/A
6) Birds use interspecific information to select a nest site					
Flycatcher (*Ficedula spp.*)	Seppänen & Forsman (2007)	Tits' nestboxes manipulated so that all boxes have same arbitrary symbol; tested flycatchers' nestbox choice	Flycatchers nested in boxes that matched the box-types of resident tits	**Birds' nest building involves interspecific information use**	Social learning
	Seppänen et al. (2011)	Number of eggs/chicks of resident tits counted when migratory flycatchers made nestbox choice	Flycatchers more likely to copy nestbox choice as number of eggs/chicks increased in resident tits	**Birds' nest building involves interspecific information use**	Social learning
7) Birds actively reject the nestbox choice of poorly performing heterospecifics					
Flycatcher (*Ficedula spp.*)	Loukola et al. (2012)	Number of eggs of simulated resident tits manipulated (low or high) when migratory flycatchers made nestbox choice	Flycatchers actively avoid the nestbox choices of resident tits with low simulated clutch sizes and copy those with high simulated clutch sizes	**Birds' nest building involves interspecific information use**	Social learning, Counting, Associative learning
	Loukola et al. (2014)	Number of eggs of resident tits manipulated (low or high) when migratory flycatchers made nestbox choice	Flycatchers actively avoid the nestbox choices of resident tits with low clutch sizes and copy those with high clutch sizes	**Birds' nest building involves interspecific information use**	Social learning, Counting, Associative learning

Species	Author	Methods	Result	Conclusion	Mechanism
8) Birds' material choice may reflect interspecific information use					
Baltimore oriole (*Icterus galbula*)	Williams (1934)	Provided pairs natural (plant) and unnatural (coloured yarn) materials over 10 yr period	Birds increasingly included unnatural material into nests; convergence of colour preference	**Birds' nest building is not fixed**	N/A
Kingbird (*Tyrannus spp.*)	Williams (1934)	Provided pairs natural (plant) and unnatural (coloured yarn) materials over 10 yr period	5 years after orioles first did so (see above), females began to include unnatural material into nests	**Birds' nest building is not fixed**	N/A
American robin (*Turdus migratorius*)	Williams (1934)	Provided pairs natural (plant) and unnatural (coloured yarn) materials over 10 yr period	8 yrs after orioles first did so (see two above), and 3 yrs after kingbirds (see above), females included unnatural material into nests	**Birds' nest building is not fixed**	N/A
Cedar waxwing (*Bombycilla cedrorum*)	Williams (1934)	Provided pairs natural (plant) and unnatural (coloured yarn) materials over 10 yr period	8 yrs after orioles first did so (see three above), and 3 yrs after kingbirds (see two above), birds included unnatural material into nests	**Birds' nest building is not fixed**	N/A
Blue tit (*Cyanistes caeruleus*)	Mennerat et al. (2009)	Analysed plant composition of multiple nests built by the same females in two distinct study plots across 3 yr period	Between-year nest composition consistent within females but different across the two plots	**Birds' nest building is not fixed**	N/A

Tables 1, 2, 3. Tables demonstrating various bird types and in descending order historical evidence that nest building is not necessarily innate or "fixed," how nest site selection is not innate, how nest material is not innate, and how reproductive success is also not innate. Together these tables show many bird types and provide evidence that for all of them there is some level of decision making happening when they construct nests.

And finally, when talking about the craft of nest building let us consider the aesthetic choices that go into this process. In testing color preference of building tools we can consider colored poker chips. Poker chips elicit decisions similar to those elicited by potential natural decorations, such as colored flowers or fabrics that can be found and picked up by birds in nature (Diamond,1986). Since man-made objects can be standardized and have experimentally determined availability, they offer advantages for analyzing bowerbirds' decorating decisions. These tests with poker chips showed that *A. inornatus* males do select among potential decorations by hue and that different individuals and populations differ in their selection criteria. For example, when color chips picked up by individual birds and placed in or near their nest were tracked, it was found overwhelmingly that birds have varying color preference of chip choice and stick to their preferences. Furthermore, when stacking chips of different colors they stacked the chips so that their same preferred colors were generally stacked on top. Additionally, observations of birds showed that decorating decisions are not automatic, but instead they involved trials and "changes of mind." For instance, a bird initially brought red and lavender chips inside his nest and then grouped the red chip next to a red fruit and discarded the lavender chip back in the forest (Figure 19; Diamond, J. 1986). This is important because it highlights that there is decision making in bird's nest building and, with all of the aesthetic variation that goes on in this building process, that nest building is an artistic process for birds. This shows that if we are able to look beyond a human lens of what is considered valid art, that art indeed is not unique to mankind.

Figure 19. Photo of a bowerbird returning the lavender chip out of his nest displaying color selection and rejection (Diamond, J. 1986).

Another animal group we can consider when looking at natural arts is bees. Again, there is the question of animal intellect and how much their behaviors are due to innate urges versus intentional choice behaviors. Human decision making strategies are strongly influenced by an awareness of what is deducted to be certain or uncertain factors that go into making a right choice. Humans seek more information and defer choosing when they realize they have insufficient information to make an accurate decision, but whether animals, especially insects like bees, are aware of uncertainty is under debate. There was a study that examined how honey bees (*Apis mellifera*) responded to a visual discrimination task that varied in difficulty between trials. Free-flying bees were rewarded for a correct choice, punished for an incorrect choice, or could avoid choosing by exiting the trial and opting out. Bees opted out more often on difficult trials, and opting out improved their proportion of successful trials. Bees could also transfer the concept of opting out to a novel task. These data showed that bees selectively avoid difficult tasks they lack the information to solve. This finding has been considered evidence that nonhuman animals can assess the certainty of a predicted outcome, and bees' performance was comparable to that of primates in a similar paradigm (Perry et al., 2013). Just as bees assessment is seen in their lives as they decide to craft and construct their hives, creating art is a premeditated task that also involves assessing outcomes.

When it comes to bees' hive crafting, the hexagonal shape of the cells of the bees' honeycomb has intrigued scientists for ages. Why do bees build these kinds of cells? And how do they achieve such a spectacular structure? The wax-made comb of the honeybee is a masterpiece of animal architecture. The highly regular, double-sided hexagonal structure is a near-optimal solution to storing food and housing larvae, economizing on building materials and space. Elaborate though they may seem, such animal constructions are often viewed as the result of 'just instinct,' lead by inflexible, innate behavioral routines. An inspection of the literature on honeybee comb construction, however, reveals a different picture. Workers have to learn, at least in part, certain elements of the technique, and there is considerable flexibility in terms of how the shape of the comb and its gradual manufacture is tailored to the circumstances, especially the available space. In the two-century old work by François Huber, glass screens were placed between an expanding comb construction and the intended target wall and the bees took corrective action before reaching the glass obstacle by altering the ongoing construction so as to reach the nearest wooden wall (Huber, 1814/1926). These results clearly suggest a form of spatial planning skills, which is a key component in any understanding of visual arts.

The construction of hexagonal honeycombs requires the coordinated and cooperative activities of many dozens of individuals (Figure 20). Workers manufacture and manipulate wax into a highly regular hexagonal pattern, a mathematically close to perfect solution to honey and brood storage, and in the process have to evaluate the space available and the current state of construction, and process a diversity of communication signals from others, as well as proprioceptive input, for example to align the combs with gravity (Gallo and Chittka, 2018). These rich instinctual repertoires of many insects have often been thought to come at the expense of learning capacity. However, very few behavioral routines are fully hardwired and even comb construction skills have to be partially learnt by honeybees (Von Oelsen and Rademacher, 1979).

Figure 20. Construction of new comb in the honeybee *Apis mellifera* (Gallo and Chittka, 2018).

While many people think that honeycomb building is an innate bee motor skill without decision making or variety, that is simply not the case. To put it in perspective, just as humans may have two obvious baseline locomotive actions, walking and running, we are still capable of many others that simply do not fit into those categories. We can crawl, walk on all fours, jump on one leg, walk on crutches, and a multitude of other actions. Furthermore, we can easily adapt our locomotion to a current need, spatial environment, or any form of injury. Likewise, bees by default build hexagonal cells of two dimensions (smaller ones for workers, larger ones for drones), but depending on need, they can also build pentagonal or heptagonal cells, cells that are wider or smaller near the orifice than they are at the base, or use wax for building barriers at the hive entrance to keep out intruders (Huber, 1814/1926). This shows that the construction of the beehive, like the spider's web, is not a pattern set in stone but rather a process of particular design based on individual bee choice. Just as there is individual preference in art that artists make, we can see the creative process indicated here as well.

The capacity of bees to "measure" distances is demonstrated by several evidences such as, for example, the deposition of either haploid or diploid eggs by the laying queen into comb cells, according to their size, or the regular spacing of adjacent combs in the nest, obtained by the building workers (Grassé, 1959). In any case, comb construction is the result of a collective behavior, involving hundreds of individuals, where no central control structure exists and individuals follow simple rules related to the structure of the environment, in a way that the environment influences the behavior which in turn changes the environment, a mechanism that is known as "stigmergy" (Nazzi, 2016). Overall, this process involves a series of if-then decisions based on each unique building circumstance.

The comb construction abilities demonstrated by honeybees extend beyond a simple algorithm of applying wax to a set pattern; rather, adaptability and error recovery are evident. While it is true the insects have a number of perhaps basic, partially hard-wired routines to manufacture the elemental structure of the hexagonal cell, it is also true that they have the capability to adapt the basic method in order to overcome errors or incompatibilities, to observe and remedy disruptions, to use parts of an elemental cell to correct surface irregularities or to join incompatible sections and, where continued growth would be inadvisable, to take corrective action (Jeanson et al., 2005; Von Oelsen and Rademacher, 1979). Different workers continue cells where others have left off, and do so correctly no matter the previous state of the cell, by inspecting one another's constructions to amend them where necessary. Huber noted several bees working on a small area of comb, one of which placed some wax in a misaligned location. An observant co-worker was seen relocating the wax better aligned to the current construction (Huber, 1814/1926). These examples of adaptive behavior are of a small scale, yet show the choice and awareness present in the building process.

Finally, when it comes to bees it is also interesting to note that there is an aesthetic color preference when it comes to what flowers they choose to pollinate. Bumble bees show innate preferences for certain colors not only prior to color learning but also after intensive learning when choosing among very different novel colors (Gumbert, 2000). The choice for bees pollination behavior requires a unique perceptual dimension, possibly that of color saturation or that of hue perception comparable to components of color perception in humans (Lunau et al., 1996). This shows that deliberate choice and cognitive abilities are exercised in beehive construction, in addition to flower pollination choice, and that it too can be viewed as an aesthetic, artistic, and creatively flexible process for bees.

Thus, by looking at the construction of a spider's web and the spatial preferences in designing the pattern of the web, it is clear that the spider is not simply churning out a web. When it comes to most species of birds, there is an aesthetic, color preferences as they go out of their way to find materials in certain colors even when they can easily find the same materials in different colors close to them. This aesthetic preference, coupled with the variation in nest structure reveals the high levels of choices birds make in the design of their nest. And finally, as demonstrated by honeybees, honeycomb construction extends beyond a simple algorithm of applying wax to a set pattern, as bees are able to adapt and recover from errors in the building process and even work together. This is remarkable as spiders, birds, and bees show innate preferences for certain aesthetics and structural organizations. When looking at the products of spiders, birds, and bees, it is clear that these animals have aesthetic composition preferences that they are *choosing* to participate in. Just as we choose the design and composition elements in our paintings, so do animals in their art. We must be open to look beyond our manner of art, that is done in a human style, to see that other animals are also creating all around us. It is a beautiful thing to realize that there is art all over the world made by many different types of life, and might just make us slow down a little bit to appreciate it.

CONCLUSION

The field of Neuroaesthetics, as a new sub-division of aesthetic studies, is one that has an overwhelming potential for helping us to understand the world and human behavior through consideration of both neuroscience and art. This field has only been formally accepted for 21 years, and consequently there is still much room for new research to be added. I hope that my research here may be used to offer some support for the importance and necessity of arts. Visual arts have a wide array of purposes across human cultures, and goes back to the origins of humankind even before language. We are continually and perpetually finding new cave paintings that break the record for "oldest deemed discovered art." Humans, and human type peoples, have been making art for a very long time. When looking at the production of art across human history, we have evolved with art as every culture has developed some style and desire for art without influence of other peoples. The fact that all people come to art in isolation shows that some component of art is necessary to humankind or it wouldn't be developed all over the world and during every time period that humans have existed. When looking at the long history of art coupled with a neuroscientific understanding of what is going on when viewing and creating art, it is clear there is an intrinsic and necessary quality of art for survival.

When it comes to the neurological processes involved in making and perceiving art, it is clear much of the brain is being stimulated. The intriguing and undeniable psychological phenomenon of pareidolia raises the question of why the visual system might be set up in a way that leads to these illusions and visual suggestions. When looking at art, we are engaging the visual system, along with many additional neurological structures. For example, the amygdala is also seen to play a significant role in viewing art. As we look at uncomfortable or scary art the amygdala's reaction to perceived or imagined threats causes intense body changes. Recent amygdala research has revealed that the nuclei are also associated with feelings of reward. Making and viewing art is a rewarding experience, through the activation of the fight or flight response tied in with the emotional and visual processing of visual arts in the amygdala. Art, as a rewarding experience, could then be seen as biologically necessary to offer some release of dopamine and a “feeling good” response.

When looking at all the areas of the brain affected in art, and even at the neurotransmitters naturally present within the brain, I would go so far as to argue that the human brain was evolutionarily *designed* for art. While of course evolution does not intentionally design any part of life, it still remains that art is biologically advantageous enough that it has been a part of the human experience seemingly as far back as we originate. Moreover, the fact that so much of the brain is connected through art shows that it is clearly more important to the human species than a mere hobby. We must be willing to look at the long history of art production, the neurological mechanisms present in the brain utilized for art, and the rewarding benefits of art to truly understand the importance, and necessary nature, of art in human life. Through this understanding we can begin to have a cultural shift towards higher art appreciation, which is only a good thing that will benefit people as it is seen that the art *is made to* be created and viewed by the brain.

From here, we can look out past ourselves and see that we are not alone in having a neurological predisposition for visual arts. In addition to art being a necessary component for humans, we should be open to accepting the presence of art making in animals and move away from viewing art solely through a humanistic lens. When looking at the production of art both in human-guided methodologies and species-specific natural craftings, it is clear that animals are also capable of art. Animals have been doing art and making artistic choices for just as long as humans have because art is transcendent of any one species and instead impacts all life.

Just as the intelligence of other species is wrongly assessed through biased, farcical, non-conclusive tests, so is their production of art. Many animals can be taught to make human-styled art through the use of both painting and drawing techniques. While some would say that animals being taught to make art is not them creating themselves, rather a mere imitation of their trainers art I would push back on this close minded notion. The act of imitation and reward is a key component of most learned things, and is not something to dismiss so lightly. Just as we learn to read and write through repetition, imitation, rewards, and praise we are still readers and writers with our own merits. Likewise, I believe that art made by animals is just as credible, impressive, and valued as *human art* regardless of how the animal learned. I also must wonder here, why is it so threatening to humans to acknowledge that other animals can create and perceive art? Does it take anything away from the works of Picasso that an elephant can also do a self portrait? I think this is an insecurity in humankind to claim something for ourselves, when in reality artistic expressions are available and fundamental to all life. This can be seen in nature as animals make many types of their own art, if only we can be open enough to appreciate what they are doing.

When looking at the construction of a spider's web and the spatial preferences in designing the pattern of the web, it is clear that the spider is not simply churning out a web. Rather, the spider is making deliberate choices as seen through the relationship between the complexities of the spider's web and its brain signals. When it comes to most species of birds, as seen on Tables 1-3, it is clear that nest building is in fact a learned behavior and not something just innate to birds. Moreover, birds have aesthetic, color preferences as they go out of their way to find materials in certain colors even when they can easily find the same materials in different colors close to them. This aesthetic preference, coupled with the variation in nest structure reveals the high levels of choices birds make in the design of their nest. This unnecessary variation in nest building shows that birds go above and beyond to make their nest in a certain way which highlights a motivating desire over *need* in their building process. And finally, when looking at bees and the construction of their hives, it is clear that their abilities far surpass what we commonly think possible. As demonstrated by honeybees, their honeycomb construction extends beyond a simple algorithm of applying wax to a set pattern, as they are able to adapt and recover from errors in the building process and even work together, building off of each other's work. As noted in chapter 4, it is also interesting to observe an aesthetic color preference of flowers bees pollinate. This is remarkable as bees show innate preferences for certain colors before and after color learning. Thus, when looking at the products of spiders, birds, and bees, it is clear that these animals have aesthetic composition preferences coupled with high degrees of choice in the design of the structures they make.

Art is not only an expression made by life, but a key component for life to operate successfully. Brains have an evolutionary quality of enjoying both aesthetics and designs and have preferences towards the display of these matters. This tendency towards art is not a species dependent quality. However, the presence of art can be particularly noted in humankind as we have clearly developed hand in hand with it. The perception of art socially, then, must be reevaluated as a more respected area and work field. Art is, after all, something that every human being can participate in.

Therefore, while art is *not* unique only to humankind, art is *necessary* to humankind.

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