Pigeon Vision:

Exploring Illustrative Processes

Master Thesis
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Abstract

Scientific illustrators rely on a variety of illustrative techniques to create comprehensive depictions of complex topics and subjects. The applications of these techniques can greatly impact not only the illustrative and stylistic choices of the individual artist but the information depicted as well. In many cases, a figuratively rendered illustration will not sufficiently convey scientific illustration, therefore abstraction is applied to highlight key elements, eliminate unnecessary components, and create an effective illustration. This thesis examines the application of existing methods of abstraction within the context of ornithological illustration. Additionally, the application of these techniques is explored within the concept of picture and abstraction planes. This thesis uses interdisciplinary literature review, visual research, and process-based illustration research to define a process for creating ornithological illustrations. The outcome of this thesis is divided into two separate visual components. The first Component is a series of nine illustrations based on the visual capabilities of the Common pigeon. These nine illustrations are further divided into three subjects: 1. The Pigeon's Field of Vision, 2. Ultraviolet and Contrast Perception, and 3.The Common Pigeon. Each of these subjects is comprised of three illustrations created using varying levels of abstraction. These illustrations test out the aforementioned abstraction scales within the context of ornithological illustration and are a culmination of literature review and visual research. The second component of this thesis is an experimental guide book highlighting forty-three of the fifty-three visual experiments conducted throughout the thesis. This field guide book examines the context of science visualization in the context of ornithology. In conclusion, through process-based research, this thesis determines that applying illustrative abstraction techniques to ornithological illustration pushes the illustrations beyond species identification, allowing for images to include information on additional processes associated with the depicted birds.

Keywords: Ornithological illustration, scientific illustration, abstraction, illustration, birds

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During my time at Aalto University, birds have been the one consistent theme and subject in much of my illustrative work.

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The wonders of modern medicine and great doctors.

This thesis would not have been possible without you

Introduction

Scientific illustrators rely on a variety of illustrative techniques to create comprehensive depictions of complex topics and subjects. The applications of these techniques can greatly impact not only the illustrative and stylistic choices of the individual artist, but the information depicted as well. In many cases, a figuratively rendered illustration will not sufficiently convey scientific illustration, therefore abstraction is applied to highlight key elements, eliminate unnecessary components, and create an effective illustration. My thesis is a process-based approach to examining scientific illustration and the relationship between art and science. More specifically, it aims at creating and taking a research-based approach to illustration composed of literature review, visual research, and process-based visual research in the form of illustration and image-making. When applied to the illustration process, interdisciplinary research helps an illustrator by informing illustrative choices and ultimately impacting the final illustrative outcome. Furthermore, this thesis applies existing scientific illustration methods such as artistic license (Goodsell & Johnson, 2007) and abstraction. Throughout my thesis, these methods are used to create ornithological illustrations ranging from figurative, literal representations of birds, to more abstract representations. Creating such a spectrum of visual works is an attempt at investigating the sliding scale of literal to abstract visual images, a scale which existence has been suggested through Guild of Natural science illustrators (GNSI) lecturer, scientific illustrator, and senior editor of Scientific American, Jen Christiansen (Christiansen, 2018). I used the methods of abstraction to analyze the scale from literal to abstract as sourced through a literature review concerning the creation of scientific illustrations.

In this thesis, one area of investigation and experimentation was conducted through examining, critically analyzing, and reflecting on the presentation of ornithological information. As a result of my investigation and experimentation, nine speculative illustrations concerning select features of the visual capabilities of pigeons were created. Each of these nine illustrations examines the scale between literal and abstract scientific illustrations. In addition to these nine illustrations, I created a conceptual field guide using and curating content from the visual experimentation process of the research phase.

Selecting the Pigeon as a Subject for Illustration

The common pigeon, also known as the Rock dove, is the focal species of my thesis illustrations. The pigeon has been selected as the pigeon is a common, near-universally known species, making it familiar to a broader and international audience. This allows me to focus on other characteristics of the pigeon's life as opposed to focusing on species identification as the subject matter of my scientific illustrations. Another potential species under initial consideration was the crow, however, crows are comprised of a multitude of subspecies, therefore the species contains more local variations. This could potentially become a problem in which people unfamiliar with sub-species such as the Hooded crow, may not be able to identify it as a crow. Pigeons, more specifically the Common pigeon, belong to the Columbidae family (Encyclopædia Britannica, 2020).

I determined the pigeon to be a near-universally recognizable species based on multiple factors. Firstly, the Common pigeon inhabits a vast variety of urban and rural environments, therefore, making it more identifiable by a larger audience, as well as potentially a universally recognizable species (Encyclopædia Britannica, 2020). Secondly, common pigeons have a well-documented and well-recorded relationship with humans. Examples of this relationship can be found throughout the arts and sciences, as well as examples throughout human history, such as the depiction of pigeons on ancient currency, or documentation of pigeons as a source of food (Encyclopædia Britannica, 2020). There is substantial evidence within art, archeology, history, and science to suggest that there has been a long-standing established relationship between pigeons and humans.

To examine and explore research and illustrative processes for information based illustration, I chose to focus on specific characteristics of the pigeon, which based on research into scientific illustration, would pose as a challenge to my existing process as well as a starting point for critically analyzing scientific illustration. More specifically, one area of my thesis is exploring the different methods of artistic license (Goodsell & Johnson, 2007) and techniques employed by scientific illustrators. Unlike more traditional ornithological illustration which tends to focus on the depiction of species for quick identification, focusing on a lesser understood and speculative topic leaves room for a more artistic and abstract approach to scientific illustration. This is more akin to the types of techniques applied to scientific illustrations for fields such as physics, or molecular and microbiology, which rely on methods such as selective disclosure and distortion (Goodsell & Johnson, 2007) to communicate and express ideas and concepts effectively. Lastly, focusing on the topic of simulating bird vision, specifically pigeon eyesight, allows one to focus more on the potential consequences of abstracting scientific illustration and analyze what implications exist for inaccurate works.

***Figure 1**: Picture plane exploring figurative to abstract birds. Based on Christiansen's science visualization*

Abstraction Planes

Experimenting with abstraction is one facet of the illustrative process explored through my thesis. In order to better understand abstraction's role in scientific illustration, one critical component of this thesis is the exploration of pictorial and abstraction planes. The idea of exploring the spectrum of abstraction which can occur in scientific illustration stems from the concept of the picture plane, introduced to me initially through the context of comics in Scott Mcloud's (1994) "Understanding Comics." Discussed within the context of comics, Mcloud's concept places resemblance, representing figurative art, as opposite to meaning, with meaning, in this case, representing a literal or iconic depiction, and places the picture plane at the triangle's apex. In this context, the picture plane represents more abstract works (Mcloud,1994, p.52-53). Interestingly, a similar pictorial plane or scale from figurative to abstract is discussed within the context of scientific illustration, information graphics, and science visualization by GNSI lecturer, Scientific illustrator, and Senior editor Jen Christiansen who states "I tend to think of information graphics as a continuum, with figurative representations at one end and abstract representations on the other" (Christiansen, 2018). Christiansen's model resembles a straight line which poses figurative opposite of abstract. Christiansen's model places representative illustrations above figurative and data visualizations above abstract while inserting illustrated diagrams in the middle (Christiansen, 2018). Before exploring the existence of such planes within my own thesis and illustrative process, I created a scale to place within the context of my thesis. Based on the literature review, I created two different models, one of which reflects Mcloud's theory and the other more akin to Christiansen's science visualization model. While Mcloud's picture plane examines a third component called meaning, my thesis explores the two dimensions of resemblance and abstraction, focusing specifically on examining the space between figurative and abstract illustration through the process of creating ornithological illustrations.

Outcomes

Figurative to Abstract Pigeon Illustrations

I applied the idea of pictorial planes, or planes which address the spectrum of literal and figurative illustration and abstract illustration, to my process of illustration. As a result of this application, a series of nine pigeon based illustrations are created to explore the varying degrees of which abstraction can be applied to scientific illustration. These nine illustrations are further broken down into three topics and each topic is further developed into three illustrations ranging from literal representations to more abstract illustrations of data. This process of illustration essentially creates a sliding scale from the most pictorial and literal to the most abstract representation of a bird possible. Visual research and the examination of existing ornithological illustrations found in published scientific media such as field guides dedicated to birds and historical ornithological illustrations informed the creation of each illustration. During the process of visual research, I discovered that many of the illustrations found within ornithological illustration are figurative, highly literal representations, as emphasis is placed on conveying information required for species identification. However, I am interested in investigating if abstracting such identification specific illustrations allows for the illustrations to include information on other processes associated with these birds.

Illustration Type A

Illustration Type B

Illustration Type C

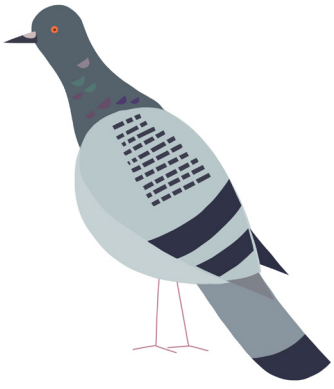


***Figure 2**: Examples of the abstraction spectrum used in the thesis illustrations.*

Outcomes

Conceptual Field Guide to the Birds

Based on visual research and structural analysis of existing bird guides, I constructed my own field guide as a method of curating the illustrative and infographic based work. My guide book shares common features with these traditional guide book examples such as the inclusion of "plates", or in this case illustrations, taxonomic information such as family and scientific names, common names, in addition to information regarding the species (Whitney & Sandelin, 2004). However, the Conceptual Field Guide to The Birds differs from these traditional guide book examples as it is not an accurate recreation of the works in which it is derived. In other words, I did not intend to make a functioning bird guide but set out to examine the structures of existing bird guides. I wanted to borrow elements of the traditional guide book setting to format the works of my thesis within the context of science visualization and information design.

I created the Conceptual Field Guide to The Birds by completing the following; nine speculative pigeon illustrations , forty one illustrations created as visual experiments, and two additional works investigating the structure of ornithological information such as bird topology charts, and spectrograms. Bird topology charts are focused on displaying and explaining bird anatomy while spectrograms visualize bird vocalizations. Each of these works reflects the interdisciplinary nature of the thesis which focuses on investigating the intersections between art, science, illustration, and science visualization. This investigative work was completed during the two-year duration of my studies within the visual communication department at Aalto University. After completing the illustrative and research-based work, I sought out methods of curation and organization to examine the context and in which ornithological illustration typically exists (e.g., bird identification or field guides, often found in the format of books and website applications). After initial review, I chose to focus on bird field guide books because they are prime examples of the intersections between art, design, science, illustration, and science visualization demonstrated in a commonplace and accessible setting. Consequently, I conducted additional visual research examining examples of bird field guides such as A guide to field identification birds of North America (Robbins, Bruun, & Zim, 1983), the David Sibley guide books series (Sibley, 2014) and the observer's Book of British birds (Benson & Warwick, 1952). In addition, I reviewed the bird section of the regionally specific, and less taxa specific, Field Guide to the Cascades and Olympics (Whitney & Sandelin, 2004), a book on the pacific northwest area of North America.

Research & Literature Review

Visual Research

Visual research is a crucial facet of my process as it helps me understand the pre-established types of works that exist within ornithological illustration. Visual research was conducted by collecting and compiling existing scientific bird illustrations in addition to more abstract examples of bird illustration. I initiated the process of visual research by collecting and compiling existing bird illustrations that I myself made and analyzing them for varying levels of abstraction. Next, I created a system of organizing my existing illustrations by sorting them using a sliding scale of pictorial to abstract bird representations. In addition to curating my own work, I sought out historical ornithological illustration examples such as the illustrative works of John James Audubon in The birds of North America (National Audubon Society, n.d.). For contemporary examples, I looked at the works of Arthur Singer (Robbins, Bruun, & Zim, 1983) and David Allen Sibley (Sibley, 2014). As for examples of abstracted ornithological illustration, I supplemented the above ornithological works and illustrators with an investigation into the illustrations of American illustrator and modern artist, Charley Harper (2002). Although Harper's illustrative works may not be classified as a scientific or ornithological illustration, I focused on his bird illustrations as they are a potential source of abstraction in illustrations, which clearly depict recognizable bird species.

In addition to visual research focused on illustration based science visualization, I also investigated examples of infographics and diagram based scientific illustration. This provided me with an overview of the style, and format, as well as handling of bird-related subject matter required for me to make my own ornithological illustrations. For example, while reading literature on the visual capabilities of birds, I thoroughly analyzed figures, scientific illustrations, and examples of science visualization which appeared in the literature. This came in the form of collecting diagrams depicting the field of vision for specific species or simulated images depicting the ultraviolet perception capabilities of birds and effects on foliage. In particular, illustrations with articles by Martin and Osorio (2019) and Tedor and Nisson (2019) influenced my pigeon illustrations.

Literature review

Interdisciplinary literature review was another crucial facet of this process-based thesis. Interdisciplinary research supports content generation, informing illustrative decisions in addition to the illustrative process, and visual experimentation. In regards to content generation, of particular interest is the simulation of bird vision through illustrative representations and processes. Examples of such illustrations are potentially more representational and scientific in origin and intention while being more abstract and conceptual in approach. In order to create my own renditions of such illustrations, I needed to establish a more in-depth understanding of simulated bird vision potentially by understanding it from an illustration based research perspective. Before beginning my illustrations I reviewed scientific literature to gain knowledge of bird vision, specifically the pigeon's vision. I began by investigating the mechanics of how bird's eyes work. My source material was scientific academic journals and peer-reviewed studies on bird vision. When information or literature was audience specific, relying on the reader having established prior knowledge on the subject, or was too difficult to comprehend ,I sought out alternative interpretations of the texts and terms discussed in the original studies and reviews.

During this investigative process I discovered a plethora of existing research concerning how bird eyesight functions. Therefore, distilling and selecting the parts in which to form and inform my illustrations was a challenge. This section focuses on my findings from the literature review, what information I chose to apply to my illustrative works and process, and how I interpreted these concepts in my illustrations. The first half of this section focuses on scientific literature review discussing selected visual capabilities of pigeons. The second half of this literature review section is dedicated to discussing literature review regarding scientific illustration methods. A section later on will discuss how specific aspects of this literature review were applied to the main illustrative component of this thesis, the nine pigeon illustrations.

Literature Review

Bird Vision

One area of focus during my scientific literature review was bird eyesight– how it functions, and how the anatomy of a bird's eye determines its visual perception of the world. I focused on pigeon vision as I was initially unsure of visual discrepancies between bird species and I wanted to keep my illustrations on speculative bird vision pigeon specific. I sought out information from primary sources, mainly research articles from scientific journals. I also established a base understanding of bird vision as discussed by secondary and tertiary articles and press releases made with the intent of educating a more generalized audience. In the 2010 article "Vision in Birds," authors Martin and Osorio discuss the visual capabilities, and the ocular structure of various bird species. One example they discussed is Columba livia, also known as the Rock pigeon, Rock dove, or Common pigeon. The authors focus on the formation of bird visual capabilities through the various ecologies surrounding a species. They report that the structure of a bird's eye is impacted by these ecologies (Martin & Osorio, 2010) which in turn impacts a birds vision. Structural differences in a bird eye impact spatial resolution, location of blind spots in field of vision, ultraviolet sensitivity, and depth perception (Martin & Osorio, 2010). This particular article provided me with background knowledge regarding bird vision that I then used to develop an artistic algorithm and set of guiding principles for illustrating pigeon vision.

Field of Vision

One particular area of interest during the literature review was the visual field of pigeons. To give my illustrations the depth required for analyzing scientific illustration, I sought out information to further develop my knowledge base. Martin and Osorio (2010), describe visual fields as "the three-dimensional (3D) space within which the eyes can receive visual information at any one instant;" And as an angular coordinate system based on conventional latitude and longitude while being centered on the head (p.32). At this sphere's center would be the bird's head. Birds, of course, do not see everything around the sphere, and species-dependent, will have various blind spots in their vision. In the Martin and Osorio (2010) article, the existence of these blind spots is modeled by a photograph of a bird captured in a way in which it appears that the bird is looking at the camera. However, the camera is located in the bird's blind spot, just outside of its retinal visual field (Martin & Osorio, 2010). This raised a particular question for me: can birds see their own beaks, if so, how does this information factor into my illustration? This question was mostly answered within the Martin and Osorio (2010) article. The short answer is that some bird species do see their own beaks while other species do not. In regards to pigeons, Martin and

Osorio suggest that pigeons, as well as other bird species “that lunge or peck at food with the bill [...], or take prey in the feet (eagles) probably cannot see their bill”(Martin & Osorio, 2010, p.35). Bird species that fit this description were then further classified within the article by type based on their visual field. This type was Type 1 fields (Martin & Osorio, 2010, p.35). In addition to the majority of Type 1 field bird species likely not seeing their own beak, Type 1 field birds "have a blind area to the rear of the head, which varies in width from about 40(degrees) in herons to 100(degrees) in eagles” (Martin & Osorio, 2010, p.35). With this in mind, I took note of pigeons most likely not seeing their own beaks and opted to include this as a suggestion as to what to include in the pigeon vision based illustration series. However, I was still uncertain about the exact width of blind spots in a pigeon’s visual field. This uncertainty prompted further investigation into the pigeon’s field of vision. I located a scientific infographic concerning this subject in “Binocular Disparity” which discusses binocular disparity in non-primate species. Lazereva’s infographic demonstrated the pigeon’s complete field of vision in comparison to humans and two other species of birds(Lazareva, 2017). According to Lazerva’s infographic, pigeons have a blind area located at the back of their head with a width of 44 degrees (Lazareva, 2017). This particular graphic influenced the several of my thesis illustrations and is discussed more in depth later on.

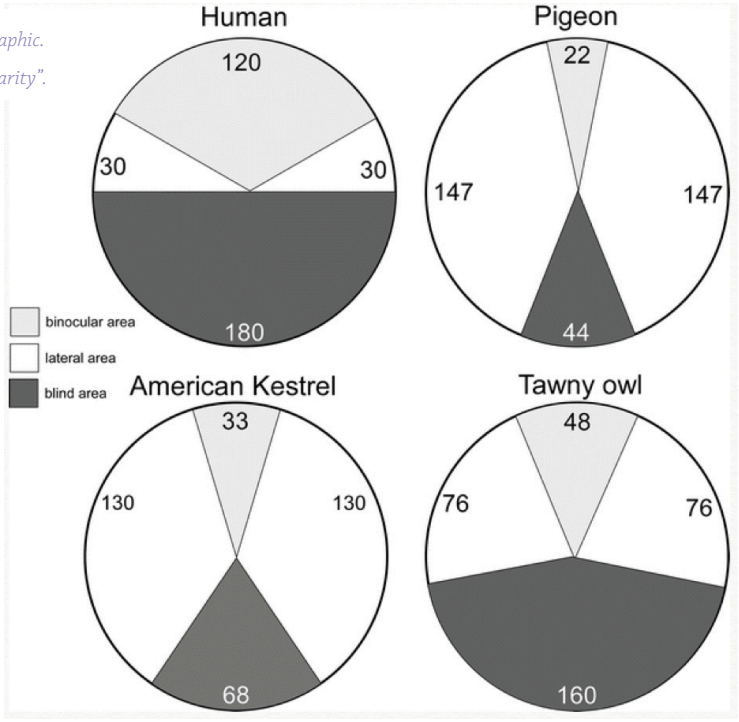


***Figure 3**: Lazareva's infographic. Image from “Binocular Disparity”.*

Ultraviolet and Colour Vision

In addition to seeking out literature on the pigeon's field of vision, I sought out information regarding the pigeon's photoreceptors and perception of colour. In "Ultraviolet (UV) light perception by birds: a review", Rajchard (2009) suggests "the ability to perceive the near-ultraviolet part of the light spectrum (the wavelength 320–400 nm) has been indicated in a range of animal species: at least 35 diurnal bird species (obviously mainly diurnal raptors, frugivorous, nectarivorous and insectivorous species (p.351). Being able to perceive ultraviolet light is a result of the ocular structure of a bird's eye. As suggested by Martin and Osorio in "Vision in birds"(2010) , this ocular structure varies depending on the different ecologies surrounding bird species. Like human eyes, a bird's colour vision is a result of cones and rods within the eyes structure. Concerning this structure, Rajchard (2009) suggests "many birds (obviously the majority of species, e.g., many non-passerines) have a violet-sensitive single cone that is obviously sensitive to UV wave- lengths. Other species (e.g., some passerines) have a single cone that has maximum sensitivity to UV light" (p.352).

After procuring initial information regarding a bird's ability to perceive ultraviolet light, I wanted to further investigate the implications of these findings. One theory speculates that the perception of ultraviolet light enhances environmental contrast, in particular foliage contrast (Tedore & Nilsson, 2019). Tedore and Nilsson's(2019) investigated their theory on the simulation of bird vision via specialized camera models designed to mimic the different photoreceptors of a bird's eyes). Their results suggest ultraviolet vision capabilities in birds potentially allows them to better register contrast in foliage, in other words, depict contrasts between the shades of green in leaves .The simulated bird vision was developed as a way to test whether the dissemination of leaf contract would be impacted by environment types. In their study, three different areas of various levels of forestation were examined. However, of particular interest to me was the study's findings and examination of colour discrepancies in bird's vision. To analyze bird vision, the simulated camera captured a series of foliage photographs. These photographs were then processed to depict bird vision, mainly through the use of different photoreceptors in the bird's eye (Tedore & Nilsson, 2019). The results indicated that the highest contrast was depicted in the images dedicated to the ultraviolet cones. However, Tedore and Nilsson (2019) noted that "false-color images cannot replicate what animals actually see, but provide the best approximation available"(p.3). Interestingly the authors did not exclusively focus on a particular bird species, and kept their investigation of bird vision more broad and generalizable to all birds. I applied their findings to my pigeon illustration series to supplement the information collected from the literature by Martin and Osorio (2010) and Rajchard (2007), however I acknowledge the fact that the findings in the Tedore and Nilsson (2019) study are not pigeon specific.

Literature Review

Scientific Illustration

In addition to bird vision and perception, another area of interest in my thesis is ornithological and scientific illustration, therefore I found it critical to examine and explore the theory, practice, and process behind such illustrations. I examined and curated both contemporary and historic examples of ornithological scientific illustration. I examined the process, practice, and examples of visual techniques used in scientific illustration. For background information regarding the traditional processes, methods, and styles of scientific illustration I referred to" Scientific Illustration: A Guide to Biological, Zoological, and Medical Rendering Techniques, Design, Printing and Display" discusses pre digital techniques for creating scientific illustrations. In addition to reading material concerning figurative illustration techniques, I investigated the use of abstract illustration techniques within scientific illustration; whether using abstraction techniques affects the reader's perceptions; and if the application of such techniques aids or hinders the comprehensibility of a scientific illustration. I then applied the information acquired by investigating these different facets of scientific illustration to create visual experiments in addition to a series of nine illustrations focused on the pigeon's visual capabilities. This section of the literature review is dedicated to explaining the relation between my thesis illustrations and scientific illustration, as well as providing context for the abstraction techniques discussed and applied throughout the thesis. This section also defines scientific illustration within the realm of visual communication design.

Scientific Illustration as Visual Communication

In order to discuss scientific illustration within the context of this thesis, I conducted a brief literature review focused on scientific illustration. This literature review uncovered theoretical and interdisciplinary aspects of scientific illustration as well as provided insight into the process of creating scientific illustrations. Much of the literature review material was sourced from the Guild of Natural Scientific Illustrators, one of the leading organizations within the field of scientific illustration's community. The GNSI, as it will be addressed throughout the thesis, focuses on supporting the scientific illustration community through educational and professional development opportunities as well as publications and networking events (Marques, 2019).

Scientific illustration is a form of illustration or visual communication, which exists within the realm of visual communication design as a form of science visualization. It is one facet of information design with connections to data visualization. This placement of scientific illustration is discussed more in-depth in

a lecture presented by Jen Christiansen, senior editor at Scientific American, hosted by the GNSI in July 2018. In her lecture, "Visualizing Science: Illustration and Beyond", Christiansen posed the question, in regards to scientific illustrators, "where does the illustrator end and the infographer begin? How does data visualization fit it?" The question is thoroughly explored through examples which highlight and imply that effective scientific illustrations are a collaborative effort between the disciplines of illustrator and infographer. Christiansen theorizes, based on experiences as both an editor and scientific illustrator that the inclusion of both infographers and scientific illustrators together could help solve more complex visualization tasks such as those that deal with visualizing scientific uncertainty (Christiansen, 2018).

At these interdisciplinary crossroads, elements from infographics and information design can be applied to scientific illustration. These applications can be in the form of combining sets of data and typography with traditional realistic scientific illustrations, or the creations of charts and graphics which employ illustrations to better convey information to a general or specific audience. More simplified graphics such as the diagram of the pigeon's field of vision, in addition to other similar bird fields of vision charts, reflect elements of the visual communication disciplines information design and illustration. For example, Martin and Osorio's (2010) "Vision in birds" contained visual graphics which serve as examples of the hybridization of the two communication disciplines. One specific example of this interdisciplinary hybridization is Figure 4, titled "Depiction of visual fields" (p.35). In this example, illustration is applied to depict the visual field of the Short-toed snake eagle. In Figure 4 illustration serves to explain the "vertical extent and position of [the] binocular field in the sagittal plane" (p 35). The Short-toed snake eagle is illustrated in profile view with its beak facing left. Overlain on top of the bird, starting in the middle of the bird's eye is an 81-degree angle shaded in light grey. This light gray area represents the bird's binocular area.In this particular example illustration is employed to effectively communicate the position of the bird's binocular field.

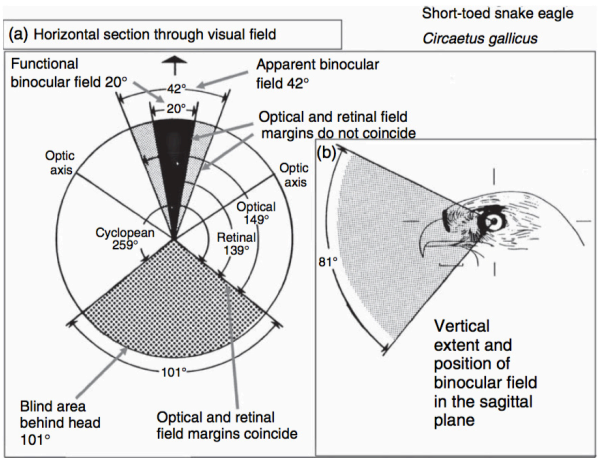


***Figure 4**: Depiction of visual fields. Image from "Vision in Birds", 35.*

Forms of Scientific Illustration

In addition to being one facet of visual communication design, scientific illustration is itself an interdisciplinary field communicated through a variety of means and mediums. The goal of scientific illustration is to convey a range of scientific subject matter and concepts. The material discussed reflects the discipline of work in which the scientific illustration is to be grounded. Ultimately, this, in turn, is reflected in the overall outcome, presentation, and format of the final scientific illustration. The interdisciplinary qualities of scientific illustration are noted by the GNSI, on the GNSI's website, who suggest, "science illustration is much more than pictures in a textbook. It encompasses all forms of visual science communication, including animation, comics, murals, sculpture, and even forms of jewelry. It can play a vital role in conveying information from any realm of science, from archaeology to astronomy, botany to cartography, zoology to molecular biology, and many others" (Marques, 2019). In other words, scientific illustration is interdisciplinary not only within different disciplines and fields of science but within the various disciplines of art as well. More traditional forms of scientific illustration are the standard and commonplace illustrations seen in textbooks and research journals. However, there is still a place for three-dimensional art formats such as sculptures that recreate dinosaurs. In relation to my thesis, scientific illustration is created through the more traditionally accepted and commonplace medium of illustration. More specifically, through the use of digital illustration for the pigeon illustration series, but through use of other art mediums throughout the visual experiment section of the thesis. The process of illustration and image making is discussed in-depth later on in the thesis.

Abstraction Techniques in Scientific Illustration

Another component of literature review was examining the abstraction techniques used by scientific illustrators. Scientific illustrators must employ a variety of illustration techniques in the creation of effective scientific illustrations. In some cases, simply rendering or illustrating a topic or concept cannot create a comprehensive scientific illustration. Abstraction is a key technique used by scientific illustrators to aid in conveying the necessary information. It also plays a critical role in the creation of many of my thesis illustrations. During my investigation of abstraction techniques for scientific illustration, I discovered the methods of selective disclosure and distortion as suggested by David S. Goodsell and Graham T. Johnson (2007), as being techniques of artistic license. Selective disclosure and purposeful distortion are highlighted as two key examples of abstraction techniques in their article "Filling in the Gaps: Artistic License in Education and Outreach" with applications of the techniques being explored and examined within the context of molecular illustrations, mainly the work of Irving Geis, Graham T. Johnson, and David S. Goodsell. One potential definition for artistic license by Goodsell and Johnson (2007), in the context of scientific illustration is that "at the most basic level, artistic license is often used to fill in knowledge gaps. We never have the complete story in science, but the artist

needs to create a convincing picture, so decisions have to be made about missing pieces and how to render them. Solutions may be as simple as drawing a dotted line to connect two protein domains of known structure or as complex as creating an artistic rendition of an accretion disk around a black hole"(p. 2760). I used artistic license to fill in knowledge gaps in the pigeon vision illustration series, such as the lack of information on how pigeons perceive the scale in their field of vision. As a result of applying artistic license techniques, instead of accurately depicting the scale of objects, more effort was placed into depicting the area in which pigeons could see. In other words, my illustrations focus on the pigeon's field of vision, instead of accurately portraying how pigeons perceive their surroundings. This example is further discussed in the process section of my thesis, in which I provide an in-depth analysis of each of the nine individual pigeon illustrations in the context of Goodsell and Johnson's theories.

Goodsell's and Johnson's "Artistic License"

Artistic license, also referred to as manipulations or global manipulations are not only tools used to solve illustrative challenges posed by depicting often complex scientific concepts, artistic license also serves as a tool to foster new understandings, aid in teaching, and demonstrate complex topics (Goodsell & Johnson, 2007). Goodsell and Johnson also suggest "global manipulations are often used, for example, to enhance the comprehensibility of scientific images. These may include the use of false colour schemes, optimization of contrasts and hues, and cropping for emphasis. The goal of applying any of these techniques is to make a clearer image without unduly distorting the presentation of the data" (p.2759).

I demonstrated and applied a few of these mentioned manipulation techniques, such as the use of false colour schemes and optimizing hues and contrasts, in the pigeon vision series of this thesis. These illustrations convey and demonstrate information regarding how pigeons can perceive ultraviolet light. In particular, false-colour schemes were applied to an otherwise grayscale image to signify that a pigeon's perception of the world differs greatly from our own. Not only does substituting ultraviolet light for vibrant shades of purple create a more visually striking illustration, but it also enhances the illustration's comprehensibility.

Abstraction Techniques

According to Goodsell and Johnson (2007), examples of abstraction or artistic license which can occur within scientific illustration are: 1. Filling in the gaps, 2. Selective disclosure, and 3. Distortion (–these techniques can fall under the terms artistic license or global manipulations) (p.2759). Throughout the thesis, all of these techniques have been applied and used to create my illustrations, in particular the pigeon vision series of illustrations. However, selective disclosure and distortion were the most applied and thoroughly examined scientific illustration techniques.

One method of global manipulation demonstrated by Goodsell and Johnson (2007) is selective disclosure, in which scientific illustrators as well as any additional contributors, select which information or aspects of the concept will be highlighted in the illustration. In other words, it is a tool used to focus on crucial and essential information. Goodsell and Johnson (2017) suggest that "through selective disclosure, which is similar in character to reductive approaches used in science, scientific illustrators can simplify a topic by stripping away all distracting information to focus attention on the subject at hand" (p.2760). To demonstrate this technique, Goodsell and Johnson discuss molecular illustrations and the challenges posed to illustrators creating such scientific illustrations. While discussing the molecular illustrations included in their essay, the authors imply that their examples, despite appearing naturalistic, still omit much of the molecules in their cellular environments. In their example illustrations, selective disclosure has been applied to determine which molecules are omitted in order to make an effective and comprehensive scientific illustration. The use of selective disclosure appears to be a common trait amongst molecular illustrations as Goodsell and Johnson imply "most molecular illustrations also depict only a subset of atoms, for example highlighting the active site, the backbone, or the surface characteristics" (p.2761).

Selective Disclosure

I applied selective disclosure to my ornithological illustrations created throughout the duration of this thesis. This includes the illustrations created during the visual experimentation phase of the thesis. Selective disclosures use, however, was the most critical during the creation of the pigeon vision series of illustrations. Examples of the technique's application are found in both the abstracted and literal pigeon vision illustrations. One particular case are the pigeon illustrations in my illustration "Series Three: the Common Pigeon." In particular, the series Type A illustration and its two variations. In these examples, selective disclosure was applied to varying degrees. In the first illustration variation, the use of selective disclosure has been minimal. This is demonstrated by the inclusion of the urban background, which although not as detailed as the pigeon itself, still retains much of its detailed information. In contrast, variation two of the same illustration uses selective disclosure to a more extreme degree. As a result, the background has been completely eliminated in order to direct all attention onto the viewer.

Selective Disclosure Examples

Illustration Title	Reason for Application	Demonstrated By
Type A Series 2: UV & Contrast	To determine which parts of the illustration required the most figuratively rendered detail.	The leaves rhombus-like shape and doubly-serrate edges.
Type A Series 3: Common Pigeon	To direct attention towards the Common pigeon, the bird's anatomy, and structural coloration.	Complete elimination of background, using blur effects or eliminating select details.
Type C Series 3: Common Pigeon	To direct attention towards the Common pigeon, the bird's anatomy, and structural coloration.	Elimination of select physical traits and features through stylistic choices.

Another global manipulation technique discussed by Goodsell and Johnson (2007) is purposeful distortion, or distortion. Distortion allows scientific illustrators to solve illustrative challenges such as depicting objects with varying degrees of scale from macro to microscopic (Goodsell & Johnson, 2007). Using distortion as an illustration technique allows for the comparison of objects, shapes, sizes, and scales in settings that would otherwise be impossible. Goodsell and Johnson suggest "purposeful distortion of a subject is sometimes required to compensate for the fact that an illustration cannot capture actual spatial and temporal scales" (p.2761). The challenge of spatial and temporal scales is even more difficult for illustrators working on molecular scales in which any abstractions techniques applied may need to be amplified, as "scientists often explore subjects with large spatial and temporal scale ranges, and artists are called upon to make them clear" (p.2761).

To demonstrate this technique's ability to clarify subject matter, Goodsell and Johnson cite a particular molecular scientific illustration by Johnson located in the textbook Cell Biology written by Tom Pollard and Bill Earnshaw as an example. The illustration, also included in Goodsell's and Johnson's article, titled Cell Signaling, depicts the process of cell signaling, which they propose as an extreme case of purposeful distortion, claiming that "the illustration [...] uses a heightened perspective distortion to display objects over several orders of magnitude in scale, and compresses processes that occur over a wide range of time scale" (p.2761). In other words, Johnson's illustration not only includes a highly distorted sense of scale to portray the process of cell signaling but a significant distortion of time as well.

Distortion

In addition to selective disclosure, I applied purposeful distortion, or simply distortion, to the ornithological illustrations I created. As is the case with selective disclosure, distortion was mainly used as an illustrative tool aiding in creating my "Pigeon Vision Illustration series". Although previously discussed as an example of artistic license, every illustration created for the "Illustration One Series: Pigeon's Field of Vision", focused on depicting the pigeon's field of vision, relies heavily on the global manipulation technique distortion. This applies to the series, A, B, and C Type illustrations, in which I applied distortion of scale to each illustration. In this particular example, the compression of space was used to render knowledge gaps regarding how pigeons perceive scale. In order to focus my attention on recreating an illustrative version of the pigeon's field of vision based on existing scientific diagrams, I distorted the scale of the pigeon's vision so that it closely reflected a human's perception of scale. As a result, objects such as leaves, and a crushed plastic water bottle appear more akin to the scale of a human being looking downwards at their own feet. In addition, I used distortion to illustrate the brick sidewalk so that the scale closely resembles that of human perception.

Similarly, I applied distortion of scale throughout the rest of the Illustration "Series One: Pigeon's Field of Vision" illustrations partly as a result of this series developing the least in terms of abstraction. This is a result of my particular illustration methods, in addition to the graphic quality of Lazareva's (2017) infographic concerning binocular disparity and the pigeon, which was used as reference material to model my illustration after. By using this graphic as the basis for even my figurative illustration, my illustration series already had an established level of abstraction.

Although I applied distortion to most of my thesis illustrations to some degree, it is the least visibly evident technique . This was a result of the majority of the illustrations focusing on less abstract scientific concepts, as well as ornithological illustration's inclination to depict concepts on a non-molecular scale. For example, I applied distortion of scale to all of the illustrations in Illustration "Series Three: the Common Pigeon", which represents standard species identification-based scientific illustrations. However, the distortion is not apparent in the illustrations. This is particularly true of the series A Type illustration, a figurative representation of a pigeon. In reality, while creating this illustration, I used distortion to counteract the limitations and restrictions of scale inherited by the tools and process in which I produced the illustration. Therefore, in order to fit within the confines of the digital dimensions of the file, such as the height and width of the artboard, the pigeon illustrated in "Illustration Series Three" is not illustrated using a life-size scale, nor is it when reproduced in the final outcome of the thesis, the Conceptual Field Guide to the Birds." In this case, I applied distortion to the illustration of the pigeon to bring it from a life-size bird to a smaller scale A4 sized illustration.

Out of all three abstraction techniques, selective disclosure, distortion, and filling in knowledge gaps (Goodsell & Johnson, 2007), selective disclosure, and distortion play a significant role in the abstraction of my "Pigeon Vision Illustration series". Additionally, selective disclosure and distortion have been applied to my visual experiments created as visual, process based research during my thesis. The application of these abstraction techniques is discussed in depth in both the visual experimentation section and process section.

Process Based Research: Visual Experimentation

After completing interdisciplinary literature review, the first being scientific studies on bird vision, and the second being on scientific illustration and abstraction techniques, I applied my findings to create a series of illustrations. These illustrations, considered one section of the overall thesis, demonstrate the application of research to create illustrations. Based on my research, I created what I called "Pigeon Vision." Pigeon vision is a selection of information interpreted and depicted through scientific and ornithological illustrations. One challenging component of this thesis was determining which information regarding the complex visual system and speculative assumptions on how pigeons perceive and visualize the world I wanted to make the focus on my illustration. In regards to interpreting such information, it is important to note that it is impossible to truly and accurately recreate an exact representation of bird vision. Despite conducting research into this area, there are still considerable knowledge gaps in my understanding of bird vision, as the literature suggests, it is nearly impossible to truly understand the perception of pigeons, and birds in general.

Visual Experimentation

Throughout the thesis, I kept an experimentation sketchbook. I used the sketchbook to keep track of the different mediums and materials used for the thesis illustrations. While conducting process-based research, I experimented with a variety of different mediums, for example, pencil, pen, marker, watercolour and watercolour pencils, gouache, coloured pencil, as well as mixed-media illustrations. In addition to conducting these visual experiments as practice or to try out the different mediums, I used this as a time to generate textures to model Adobe Photoshop brushes after. Additionally, I used photograph references from Google images as well as the Encyclopedia of Life's database (https://eol.org/).

Beforehand, as well as during the process of creating my final thesis illustrations, I dedicated time to experimenting with ornithological illustrations. This experimentation took the form of creating bird illustrations in different styles and mediums as well as different illustrative processes. The results of these experiments are curated on Instagram on an account called "Birds_of_Bean." Over approximately one year, I created over fifty bird illustrations in connection to this thesis. Seven of these illustrations were created using acrylic. Three of these illustrations were created using watercolor. One was created using gouache. Twenty of these illustrations were created using ink-based mediums, mainly in the form of pen and ink. One illustration was a text-based experiment in typography using published information on the Great tit species to see how typography impacts the perception of the displayed information. Many of the illustrations created during experimentation are digitally illustrated using Adobe Photoshop.

The styles of these illustrations are based on my visual research. Some of my illustrations reflect a more traditional scientific illustration style to aid viewers in species identification. Four of my experimental illustrations were created in a style which reflects the more abstract shape and color based illustrative work of the American illustrator Charley Harper (www.charleyharperartstudio.com). These four illustrations were created in acrylic and rely on shapes and flat colours to depict birds. In addition, each of these illustrations uses simple shapes and line work. I Intended these four illustrations to represent the birds in a less traditional way that is not typical of scientific illustration because I wanted to experiment with how abstract illustration could be used for depicting identifiable

species. For example, I wanted to see how flat colours and shapes could be applied to illustrate the structural colouration of the Eurasian magpie's plumage. In addition, I wanted to use shapes and colour to exaggerate other properties of the Eurasian magpie to make the species easily identifiable. I would not consider these illustrations to be scientific, however they were a crucial part of creating a style of abstraction for the final thesis illustrations. In particular, the visual experiments which I applied this style of illustration significantly impact the abstract renditions of Illustration "Series Three: the Common Pigeon".

To demonstrate the significance of these experiments within the context of my thesis, I have selected five, of over thirty-five, of my illustrations to analyze and explain. These illustrations included in this section provide the best examples of my concept and process, and how I arrived at the final illustrations in my thesis. All of the visual experiments created during this project have been carefully curated in the final thesis outcome: "The Conceptual Field Guide to the Birds." This field guide is discussed in further detail in the outcome section.

Example 1

Western tanager
Piranga ludoviciana

Western tanager
Piranga ludoviciana

Explanation of Concept

The Western tanager illustration was one of my first experiments using a more traditional ornithological illustration style. However, the background of the illustration is loosely rendered in comparison with more traditional ornithological prints such as those found in the works of John James Audubon as seen in the "Bird of North America Series" (National Audubon Society, n.d.). In the case of my particular visual experiment, the background is less rendered than the Western tanager. This type of illustration would be more useful for species identification, as the information it provides is focused on the bird. This particular illustration is of a male Western tanager, which is a North American bird species common in the western United States and Canada. However, the species is much more widespread throughout Mexico (Cornell Lab of Ornithology, n.d.). I created the Western tanager illustration in Adobe Photoshop using a Windows Surface desktop computer. It is a bitmap image. A photographic reference was used to make sure the final image had the correct anatomy, colouration, and proportions. I applied methods of Goodsell and Johnson's (2007) Artistic license techniques, particularly selective disclosure via the elimination of nearly all of the background information. This allows for the illustration's intended audience to focus on the foreground of the image, in this case, the depicted bird species.

Process

This illustration was created using a digital illustration process. I used multiple layers, the simple round default brush, and varying opacities to render this illustration. The technique used to create this image reflects a more traditional painting technique such as oil or acrylic, in which a slow build-up of colour and shading is used to create the bird's form. However, this image also uses reductive painting techniques such as slowly erasing layers to blend and shade colours. The background colour was used due to it also being the colour of the illustration's original sketch.

Connection to Final Illustrations

The Western tanager illustration was intended as a practice illustration. I set out to test and determine which software and hardware I wanted to use for the final illustration. Additionally, the main purpose of the Western tanager illustration was to test a more realistic drawing style to practice and develop before starting the final thesis illustrations. In addition, the Western tanager illustration was my first application of selective disclosure, in which the background is completely eliminated in order to direct attention to the bird.

Example 2

Common starling
Sturnus vulgaris

Common starling
Sturnus vulgaris

Explanation of Concept

The Common starling illustration was a digital art experiment to test out custom made painting brushes for feather textures. In addition, this illustration was an experiment in illustrating structural colour, the iridescent patches which appear in the feathers of certain bird species such as the Common starling. Like the Western tanager illustration, I applied selective disclosure, focusing less on the overall texture of the feathers, instead opting for a rougher brush based method. This allowed me to focus my attention on illustrating the bird's iridescent colours as well as spotted plumage. In addition, I applied selective disclosure, to nearly eliminate all information in the illustration's background. Similarly to the Western tanager illustration, there is no illustrated information regarding habitat or environment. Alternatively, the Common starling's background is depicted as a single branch set against a haze of purple. This is a result of me focusing on visualizing more literal information regarding the bird's plumage.

Process

This illustration was created using a digital illustration process similar to that of the Western tanager illustration. However, there is one key difference between the illustrative processes of both illustrations. This difference is a result of the digital tools used to create the two illustrations and the brushes used to create them. In particular, the Western tanager illustration was illustrated using Adobe Photoshop's default round brush, whereas the Common starling was illustrated with custom brushes of my own creation. Therefore, the Common starling illustration was an experiment on the repurposing of previously created digital illustration tools. In addition, I created several practice illustrations before the Common starling illustration. Each of these previous illustrations took a different approach to rendering the iridescent properties of the bird's feathers. In the end, I decided upon a method which employed the use of the dodge effect tool in Adobe Photoshop. In addition, I made sure to exaggerate the colours used in my illustration's initial colour layer.

Connection to Final Illustrations

Much like the Western tanager illustration, the Common starling illustration is both a practice and test illustration. I wanted to test out a potential process for illustrating more figurative interpretations of bird species. More specifically, I wanted to see if I could make my illustration process more efficient with the use of pre-textured and customized digital illustration brushes. The results of these tests proved to reduce illustration time, therefore making the illustrative process more efficient. In addition, as is the case with the Western tanager illustration, selective disclosure was applied as demonstrated by the simplicity of the illustrations minimal background.

Example 3

Eurasian magpie
Pica pica

Eurasian magpie
Pica pica

Explanation of Concept

The Eurasian or Common magpie illustration was created with acrylic paint. In addition, this particular illustration reflects the visual research phase of my thesis. More specifically, the art style I used was influenced by the work of American illustrator Charley Harper (The Mill Pond Press Companies, 2002). While creating this illustration, I focused on depicting the magpie's structural colour as well as overall anatomy. One key feature of this illustration is that the illustration style I used does not reflect art styles typical of scientific illustration. As a result, the illustration is more of an experiment into abstraction. Another important feature of this illustration is that I carefully considered the illustration's background elements. For example, the background elements were selected for their visual contrast with the subject matter, as well as depicting a potential habitat of the Eurasian magpie. In addition, this illustration served as my introduction to the acrylic medium.

Process

This image was created using a traditional illustrative process. My materials were canvas, acrylic, and pencil for the base sketch. First, I created my initial sketch directly onto the canvas, focusing on basic shapes to create the general and characteristic anatomy of the Eurasian magpie. Next, after creating an abstracted art style, I began experimenting with bright, contrasting colours for the magpies and background scenery. Initially, my goal was to use matte colours. However, despite my attempts to give the illustration a matte finish, my paints lacked strong enough pigments. Consequently, I required multiple coats to cover the canvas as desired. As a result, the background became a gradient of yellows and oranges. In addition to unintentional colour results, I used photographic references to determine the most vibrant shades of structural colouration in the magpie's plumage. The painted line work is inspired by the ornithological work of Charley Harper (The Charley Harper Art Studio, 2008).

Connection to Final Illustrations

During the visual research stage of my project, I discovered the abstract shape and colour based gouache work of illustrator Charley Harper (The Charley Harper Art Studio, 2008). I felt that the style of Harper's work could potentially lend itself to scientific illustration. Therefore, I used the Eurasian magpie illustration to experiment with and construct a similar art style to apply to my final thesis illustrations. The Eurasian magpie illustration is the second illustration in a series of four separate works inspired by Harper. One key relationship between the Eurasian magpie and final thesis illustrations is that the Eurasian magpie visual experiment influenced the art style of many of the final thesis illustrations. One example in particular is the Illustration Type B of Illustration "Series Three: the Common Pigeon". This specific illustration is discussed in detail in the process section of my thesis.

Example 4

Steller's jay
Cyanocitta stelleri

Steller's jay
Cyanocitta stelleri

Explanation of Concept

The Steller's jay illustration is similar to both the Western tanager and Common starling illustrations in the sense that it focuses on being a figurative representation of the bird species depicted. However, one key difference is that careful consideration of background content was taken in the creation of Steller's jay illustration. Although still considered a minimal background, I incorporated elements of the bird's natural environment. In this case it is the inclusion of the red huckleberry branches. In addition, I carefully considered which regional variation of the Steller's jay I illustrated. In this case, I have illustrated the particular variation located in the species's westernmost range. Bird's originating from this region lack the white facial markings common among Steller's jays from its eastern range.

Process

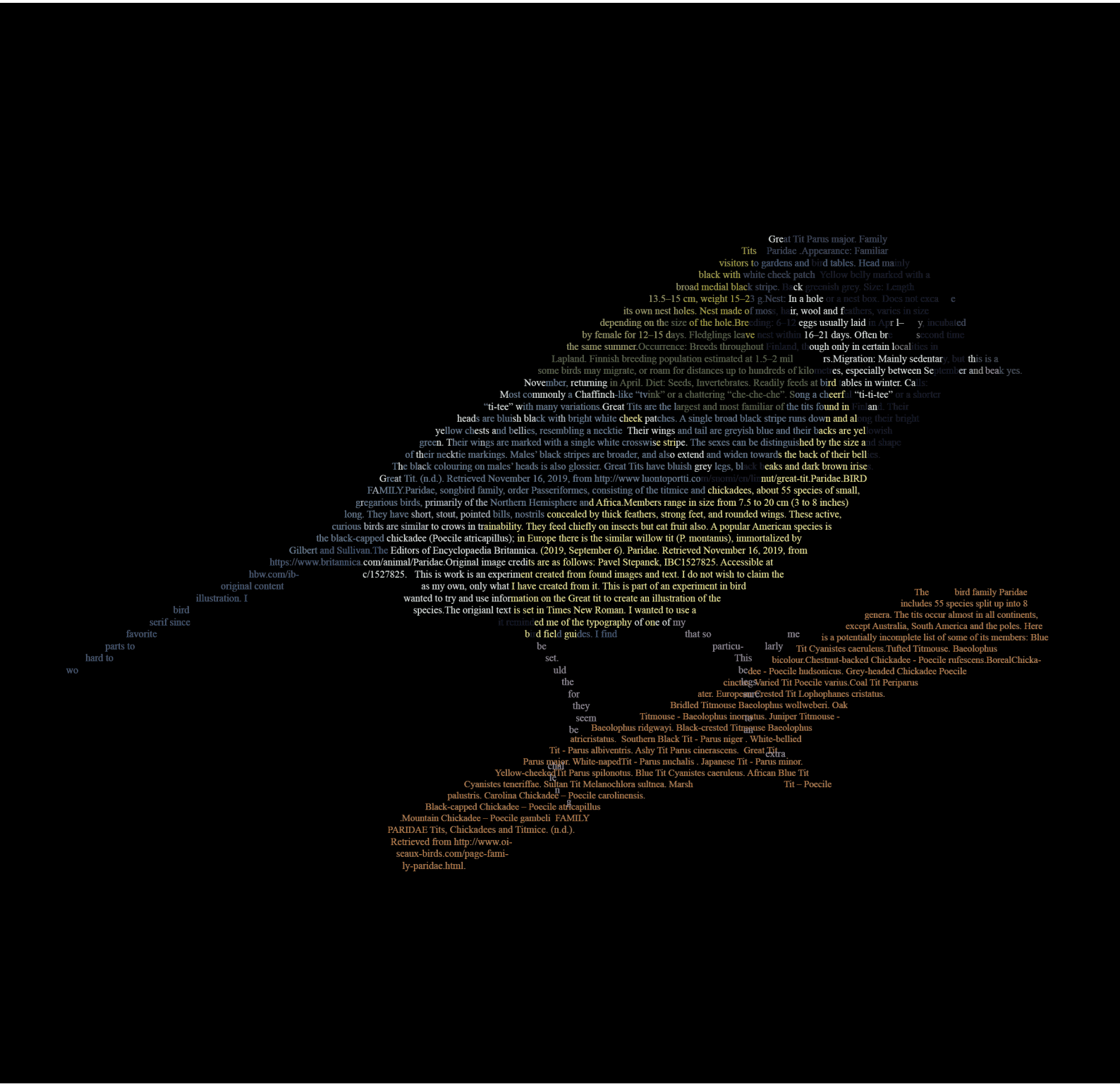
The Steller's jay illustration was created using a traditional ink drawing process. This illustration consists of two separate drawings, the first being the branches, and the second the bird, created on different days, but on the same sheet of standard sketchbook paper. In the case of both illustrations, the illustrative process consisted of pencil sketching, erasing the initial sketch, and then recreating the illustration using standard ink drawing pens. This illustrative process took roughly two to four hours.

Connection to Final Illustrations

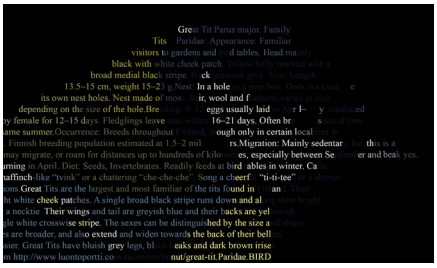
While the Steller's jay illustration is less connected to the final thesis, it is a good reflection of the visual research component of my thesis. Visually, this illustrative experiment was based on grayscale victorian engravings, lithographs, and woodblock bird prints. However, it is only visually based on these as a result of me not having the proper tools required to replicate the process of making such illustrations. In addition, I included the Steller's jay illustration in this section to serve as an example of an illustrative approach used multiple times during the visual experimentation process.

Example 5

Great Tit
Parus major



Great Tit
Parus major



Explanation of Concept

In addition to illustrative experiments, I decided to create a type-based illustration focused on information regarding the Great tit. This experiment was created using information sourced from various ornithological websites such as Cornel Lab of Ornithology's (Allaboutbirds.org) in addition to the bird specific sections of Naturegate's (luontoportti.com). Additionally, the original source material's citations are located within the bird's form.

Process

I did not have an established process for creating this typographic illustration. To begin the experiment, I sketched out a rough outline of a Great tit using Adobe Photoshop. I then transferred this sketch into Adobe Illustrator as a vector-based shape outline. Next, I created body type material sourced from identification websites such as Nature Gate's (luontoportti.com), Cornell Lab of Ornithology's (allaboutbirds.org), The British RSPB's (rspb.org.uk), and the Encyclopaedia Britannica's(Encyclopædia Britannica, 2020) dedicated entry on Great tits.

I set the body type using the typeface Times New Roman. I wanted a basic typeface that was easy to work with, but appeared similar to the type used in more traditional field guidebooks. After filling the shape with the body type, I then adjusted the individual words and letters to create the distinctive outline of the Great tit. Finally, once the type was set and adjusted to the desired shape, I selected sections and coloured them based on photographic references of the bird. Although the resulting illustration is not a legible, nor functional illustration,as the text is difficult to read, it was a good exercise in typography. In addition, this illustration and process is an exploration into the relationship of type, image, and information design regarding birds.

Connection to Final Illustrations

In connection to the final thesis illustrations, both the Great tit illustration and the final thesis illustrations examine different approaches to the types of abstraction which can occur in illustration via illustrative process. For example, the Great tit illustration is the abstraction of text and image through typography, while the thesis illustrations examine abstraction caused by artistic license techniques. In addition, the Great tit experiment explores illustrative processes through less traditional techniques. Therefore, unlike the Western tanager, Steller's jay, and Common starling illustrations which are more visually aligned with my more figurative thesis illustrations, the Great tit illustration is visually more aligned with the thesis's abstract pigeon illustrations.

Production

Pigeon Vision: Thesis Illustrations

The main objective of this thesis was to create a series of ornithological illustrations representing the Common pigeon in order to test out abstraction planes within the context of scientific illustration. Each of these illustrations reflect the information sourced during the literature review of the thesis. Additionally, many of the visual experiments conducted influenced the art style and illustrative process decisions of these final illustrations. In total, I created a series of nine pigeon illustrations based on the literature review and research phase of the thesis. This section is dedicated to discussing the individual works in relation to literature review on bird vision and scientific illustration. In addition, key elements of the illustrative process are discussed when necessary. This is a result of much of the illustrative process being similar for each illustration. Therefore, I only discuss the individual instances in which the process changes for a particular illustration.

Process

After conducting the literature review and visual research portion of this thesis, I began highlighting, sorting through, and selecting which information I wanted to use to create a series of illustrations ranging in different levels of abstraction. Afterwards, I created three separate illustration series. Illustration series one and two are based off of the information I created the pigeon vision visual system on. Illustration series three is based on the visual research portion of my thesis. The aim of the series three illustrations are to explore more classical, and representational ornithological illustrations. All nine of these illustrations are created digitally in Photoshop using customized digital tools for textures in addition to making the illustrative process more efficient. After acquiring the knowledge I needed to start my illustrations, I began by sketching out three different illustrative series, as well as notes on how I wanted each series to progress. These sketches became a set of guidelines on how I wanted to proceed with the final visual system. I have included all of my process sketches in the "field notes" section of my conceptual bird guide book.

Organizational System

Subjects and Abstraction

My final nine thesis illustrations are divided by subject and level of abstraction. There are three different series of illustrations, which represent field of vision, ultraviolet sensitivity and contrast, and a standard representation of the Common pigeon. The scale of abstraction from figurative to more abstract interpretation reflects the range of visual styles and techniques I examined. I organized and coded the illustrations by name in addition to the level of abstraction. Each subject; the pigeon's field of vision, how the pigeon perceives ultraviolet and contrast, and the Common pigeon, is defined as a series, whereas the individual illustrations within the series are labeled by letters A, B, and C.

This system of organization was created to aid in discussing the illustrations in the context of a pictorial scale, or the spectrum from figurative to abstract as discussed by Christiansen (2018) and Mcloud (1994) in the introduction section of this thesis. For review, both these examples of figurative to abstract scales place figurative, or resemblance on one end of a spectrum opposite to abstract. Christiansen's model uses the terms figurative and abstract, while Mcloud's model reflects a triangle in which resemblance is placed in an opposite corner to meaning and the pictorial plane. In the Mcloud model, abstraction is discussed using the term "pictorial plane"(Mcloud 1994). Both models highlight an illustration's ability to progress figuratively and abstractly. In the case of this thesis, this figura-

tive to abstract plane is represented by the A and C type Illustrations. The letter A denotes that an illustration is intended to reflect a more figurative approach to scientific illustration. The letter C denotes that an illustration is intended to reflect a more abstract approach to the same illustration. In other words, A represents the figurative and C represents the abstract.

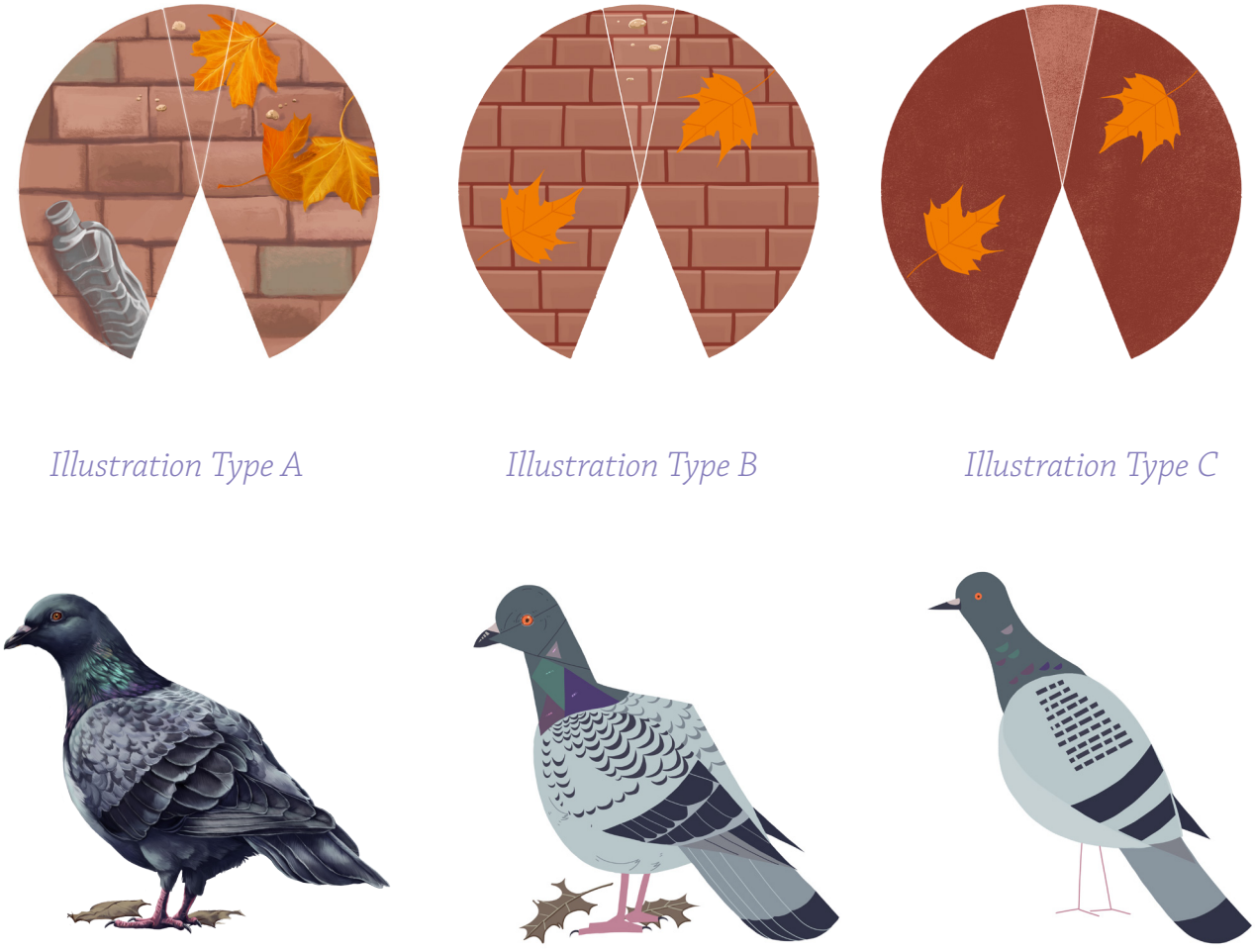


***Figure 5**: A,B, and C type illustrations from series one and three of the thesis.*

Illustration Series 1

Pigeon's Field of Vision

The field of vision (FOV), is based off of existing scientific illustrations and diagrams which depict the full range of vision a particular bird species may have. The FOV of birds is species dependent, and these different fields of vision are categorized into types (Martin & Osorio, 2010). Pigeons belong to vision type one and are speculated to not see their beaks (Martin & Osorio, 2010, p.35). Illustration Series One uses this traditional diagram as a structural template. Likewise, the illustration reflects the most commonly seen version of the diagram: an overhead view. All three illustrations in this series are modeled off of a diagram sourced from Olga Lazareva's (2017) "Binocular Disparity" which focuses on discussing stereopsis in nonhuman animals. I used this particular scientific diagram, which compares humans, pigeons, American kestrels, and Tawny owls, as it appeared to be the most creditable diagram regarding the pigeon's field of vision, clearly identifying the key areas such as the binocular field, lateral area, and blind area of each species.

Illustration Type A

Illustration Type A is the most detailed rendered illustration series. One important piece of information regarding this illustration is that it is not without abstraction, nor are all incidents of this abstraction intentional. However, the main tool of abstraction I applied in the creation of this particular illustration would be Goodsell's and Johnson's idea of distortion (Goodsell & Johnson, 2007), In the case of this particular illustration, distortion was used to fill in the gaps, which couldn't be discerned from the available literature. Despite research into the perception and eyesight of pigeons, it was unclear of how pigeons perceived scale. It was also difficult to perceive scale and distance information from the scientific diagrams used as a model for this illustration. Perhaps these illustrative diagrams themselves used tools such as selective disclosure and distortion (Goodsell & Johnson, 2007) to focus mainly on depicting and explaining the field of vision of pigeons. Instead of pursuing the impossible task of accurately depicting pigeon vision, I distorted my illustration to focus on illustrating what I speculated could show up in a pigeon's field of vision. In this case, it is a brick pathway, a crushed bottle and some leaves drawn as if the bird were looking directly downward.

There are two versions of illustration Type A. One is a diagram in which the binocular field of vision is l twenty two degrees, the lateral area of vision is147 degrees on both sides of the pigeon's head, and the blind spot is forty four degrees

and located at the back of the bird's head. Another occurrence of unintentional abstraction is that the placement of the bird's head is suggested, but left unspecified. Therefore, the placement of beak is suggested as pointing forwards, but it is unclear how far forwards its placement truly is. For clarification, beak placement is unclear as there is, species dependent, a naturally occurring small blind spot in the bird's binocular area (Martin & Osorio, 2010). This also led to me excluding the blind areas around a bird's beak which can exist in some species. As previously discussed, pigeons belong to Vision type 1, which are birds that "lunge or peck at food with the bill [...], or take prey in the feet (eagles) probably cannot see their bill"(Martin & Osorio, 2010, p.35). I made my creative decisions and speculative illustrations based on the literature reviewed. Despite my extensive research, I was unable to determine for certain if pigeons had any sort of frontal blind spots. My illustration may falsely suggest that they do not have such blind spots, which may or may not be accurate.

Illustration Type B

Seeing as the Type A illustration of this series was initially abstracted through accident and necessity, the series as a whole progresses abstractly less so than both the Ultraviolet and Contrast and the Common pigeon illustration series. As is the case with image Type A, I disregarded accurately depicting scale, therefore the illustration does not accurately represent how pigeons perceive the world. I applied distortion in order to fill my knowledge gaps concerning the true scale in which pigeons perceive the world. Instead of aiming for an accurate scale, a more human scale is applied. Interestingly, when comparing the Type A and B illustrations, the Type B illustration appears to place the pigeon at a different scale than that used in the Type A illustration. Consequently, this creates the illusion of the pigeon being larger, or perhaps situated higher above the ground as would be the case if the bird was flying.

Next, I applied selective disclosure to the Type A illustration, as a tool to determine which details to retain or eliminate. One key difference between the Type A and B illustrations is that the B illustration substitutes textures with the use of colour to represent details and shading. For example, the red bricks are represented by simple rectangles outlined in a darker shade. Additionally, the bottle has been eliminated and replaced by a leaf. Another key feature of this illustration is that more emphasis is placed on the pigeon's binocular area, the area a bird sees with both eyes, depicted by the use of a lighter shade.

As is the case with all illustrations in this particular series, illustration is used to embellish the existing diagram, merely representing objects that a pigeon living in an urban environment may see. In this case, I illustrated bricks, leaves, and bread crumbs. In addition, another similarity among all illustrations in this series is that the illustration is structured and modeled after the diagram which appears in Lazareva's article (2017) on stereopsis .

Illustration Type C

Visually, there are similarities between the Type B and C illustrations of this series. For example, the leaves featured in the Type C illustration are borrowed from the Type B illustration. The Type C illustration has another key similarity to the Type B illustration in which the same colour palette has been applied to both images. In this case, I selected the darkest shade used in the bricks, in tandem with the lightest shade, to create the three-toned image. One key illustrative feature of the Type C image is that I applied selective disclosure to further eliminate details regarding the illustration's urban setting. One example of this is that the illustration uses textures as opposed to lines to represent the bricks. This texture was created using a custom made Photoshop brush. Additionally, this particular texture brush was used throughout several of the illustrations created during the process phase of the thesis.

As is the case with illustrations A and B of this series, distortions application was essential in creating this illustration. However executing both selective disclosure and distortion of scale proved difficult in the creation of the type C illustration. For example, without details such as brick textures, the scale of which this particular illustration depicts is hard to comprehend. This is regardless even with the inclusion of the leaves, as the size of the leaves is left undefined. Consequently, the illustration could be an extreme close up or far away view. However, this is not necessarily a problem as the illustration is not focused on the accurate depiction of scale.

Similarly to illustration Type B, illustration Type C places emphasis on the pigeon's binocular area of its FOV. However, this area is depicted less subtly than in the Type B illustration due to the fact that the area is rendered in a significantly lighter colour in order to stand out. This illustrative detail is one feature that leads to this particular illustration heavily reflecting the chart like structure of the Lazareva diagram (Lazareva, 2017). In fact, of all the illustrations created during this thesis, the Type C illustration of this particular series is the most akin to infographics.

Illustration Type A

Illustration Type B

Illustration Type C

Illustration Series 2

UV and Contrast

The visual reference materials used to create the illustrations in series two stem from simulated foliage images in Tedore and Nilsson's (2019) study on how the ultraviolet vision capabilities of birds enhances foliage contrast. In particular, I based the illustrations of this series on the study's Figure 2 graphic, which contains a series of digitally altered images offering a speculative interpretation of how birds see the world. However, Tedore and Nilsson point out "that false colour images cannot replicate what animals actually see, but provide the best approximation available"(p.3). Therefore, the illustrations I created based on this study and the visual representations of these findings are an approximation. In addition, the accuracy of my illustrations is further hindered by the fact I have to take artistic liberties to compensate for human's inability to perceive ultraviolet light. Examples of such artistic liberties are the colour schemes used in the final versions of the illustrations in this series. For instance, I used violet hues rendered through Adobe Photoshop's colour balance and editing layers to acquire the final colour scheme. As a result, the final illustrations appear unrealistically colourized with intense contrast. These illustrative choices are intentional, because I wanted the main focus of this image series to reflect how different, in comparison to people, the world may appear to pigeons. Exaggerating colours and contrast implies that pigeons perceive a visually different world, in which the contrast of foliage is magnified by their ultraviolet colour sensitivity, as is suggested in the original findings of the Tedore and Nilsson study (2019).

Illustration Type A

As is the case with all Type A illustrations, this particular illustration is rendered in a more figurative art style. More specifically, the painting style was used as an attempt to mimic the photographs from the original study these illustrations are based on (Tedore & Nilsson, 2019, p.3). I applied Goodsell's and Johnson's (2017) selective disclosure technique for abstraction in the creation of this image. For example, while still considered a detailed drawing, information and details such as leaf veins and background subject matter were omitted. In other words, the subject matter in the foreground is brought to attention by the abstraction of the illustration's background. Another key illustrative tool used to create this series was the use of scientific studies as reference material. Illustration Type A of this series heavily references the original source material from Tedore and Nilsson's study on ultraviolet and foliage contrast (2019). This particular Type A illustration is based on the study's Figure 2, featured on page three of their

publication. Figure 2 consists of a sampling of foliage from deciduous habitats located in southern Sweden. One critical aspect of Figure 2 is that it features three different views of this deciduous setting. Each view is then speculatively colourized and edited to depict bird's vision through different photoreceptors in their eye. This study uses all four photoreceptors: ultraviolet, green, blue, and red, to simulate twelve different bird vision images. In relation to these images, my Type A illustration is based on the speculated perception of the ultraviolet photoreceptor. This particular image is titled "View Three"(Tedore & Nilsson, 2019, p.3). I selected to use "View Three" as reference material due to the species of tree it may feature. This assumption informed my decision to use the Silver birch tree species as subject material. Additional research led me to determine that this species would be a good choice for my illustration. Coincidentally, it was easy to obtain reference material concerning the identification and common physical traits of the tree's leaves. In particular, I gathered reference and source material on Silver birch leaves from Nature Gate's, web page regarding the Silver birch tree (luontoportti.com). In addition, I used Oregon State University's College of Agricultural Sciences website page dedicated to landscape plant species (landscapeplants.oregonstate.edu/plants).

One key feature of this particular Type A illustration is that I created three variations. Variation one features a two-toned image split directly in half in which one part is cast in violet hues while the other is rendered in green. Variation two features the same illustration using only the violet colour scheme. Variation three features a colour scheme more akin to that of Figure 2. In the original Tedore and Nilsson study (2019). Artistic license (Goodsell & Johnson, 2007) was used to select which colours were used to create this illustration. Selecting these colours was a conscious decision due to the fact that my images needed to represent a speculated world view which human perception could not see as humans lack the ability to perceive ultraviolet light. Thus, this unseeable colour spectrum had to be substituted by something visible. To solve this problem, I selected violet due to its high contrast when paired with colours such as green, demonstrated in the two-toned illustration. The aforementioned two-toned illustration features the colour green as an attempt to represent normal human vision. In addition to adjusting the colours of the foliage featured, I also focused on enhancing the contrast of all three versions of the illustration, except for instances in which the colour green was used, as the green sections represent human vision.

One consequence of colouring these illustrations is similar to that of Tedore and Nilsson's study (2019) Figure 2 which noted "[...] false-color images cannot replicate what animals actually see, but provide the best approximation available"(p.3). Therefore, I returned to abstraction techniques such as artistic license, selective disclosure, and distortion (Goodsell & Johnson, 2007). The colours are chosen partially for aesthetic appeal as well as based on approximations chosen to make up for the gaps within my knowledge. As a result, even with their figurative art style, these illustrations are abstracted and speculative. They are not accurate presentations of how pigeons perceive the world but educated illustrative guesses.

A *UV and Contrast*

Variation 1

Variation 2

Variation 3

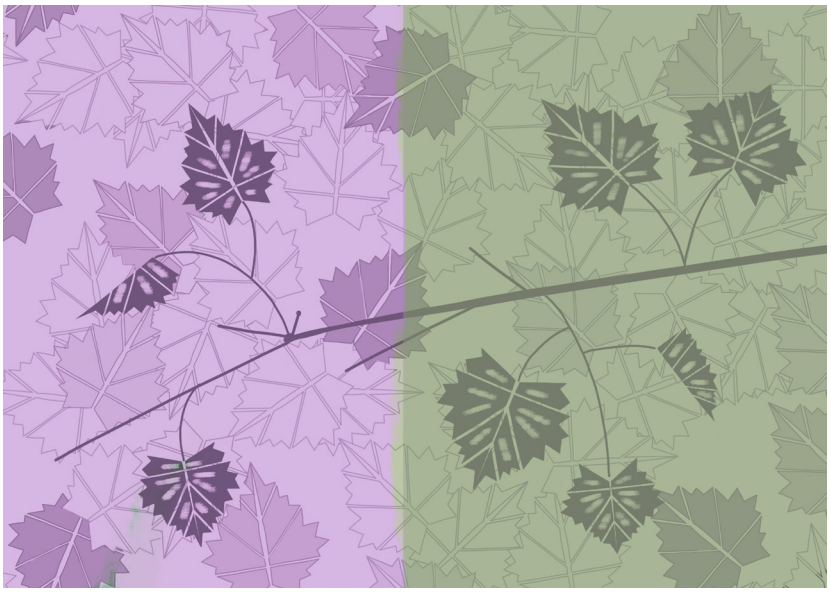
Illustration Type B

I applied selective disclosure to the visual research and literature I found on silver birch leaves to recreate the aforementioned Type A illustration through a more abstract style. The same material from Nature Gate's (luontoportti.com) as well as Oregon State University's College of Agricultural Sciences website page, more specifically photographs of silver birch leaves from the OSU website, was heavily referenced to develop a shape-based art style similar to that of the Eurasian magpie painting completed during the visual experimentation phase of my thesis. I began by identifying what I perceived to be key features of the leaves such as their shape and doubly serrate edges. Next, I created multiple iterations and sketches of leaves and shapes which highlighted these traits. Once again, I returned to Figure 2 of Tedore and Nilsson's study (2019) and used their speculative colour approximations to generate my own approximations of how birds may perceive colour. Using the information from Figure 2 in addition to colour palettes from Illustration Type A, I created five different digital variations of the Type B illustration.

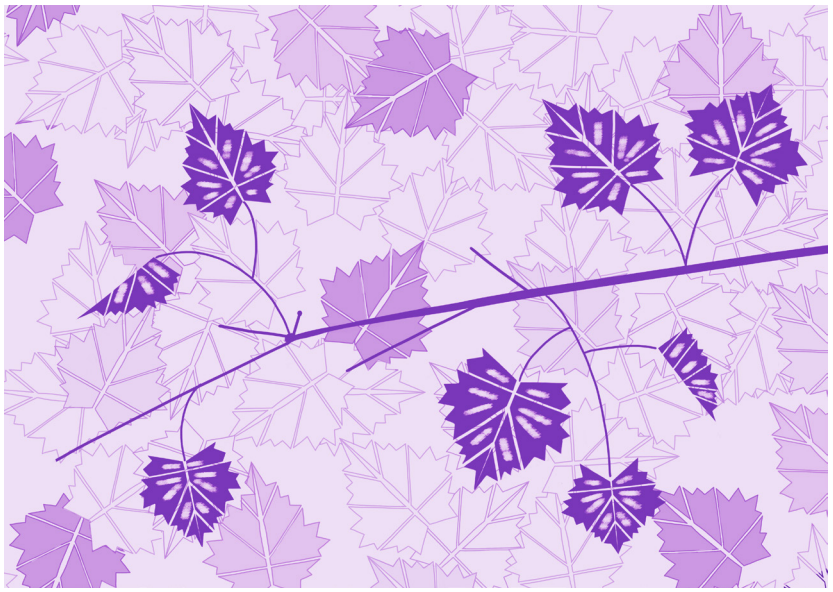
As with illustration Type A, the colour palette and contrast are applied using the photograph editing tools within Photoshop. I tried replicating the same green and violet hues from Type A to recreate a two-toned variation. However, I found the resulting variation lacked the desired level of contrast required to effectively create a speculative illustration based on the Tedore and Nilsson study(2019). Therefore, I created a second variation applying the same colour balance settings with higher contrast settings. The third Type B variation is an attempt to recreate the colour palette used in variation three of the Type A series. However, despite replicating the same processes and settings, I failed to reproduce similar results. I speculate this to be a consequence of the original Type A illustration containing a wider range of colour in addition to a higher illustrative exposure. In other words, the original illustration is much brighter to begin with. The last two variations in the type B series are grayscale illustrations. The first of the grayscale illustrations, variation 4, features a background in which some of the leaves are filled with various shades of gray. The final illustration of this series, variation 5, was an attempt at creating a lower-contrast version of variation 4. This was achieved by lowering the contrast of the initial illustration as well as leaving the background leaves as outlines. The grayscale illustrations are a reflection of the original simulated photographs from Tedore and Nilsson's study (2019).

B *UV and Contrast*

Variation 1

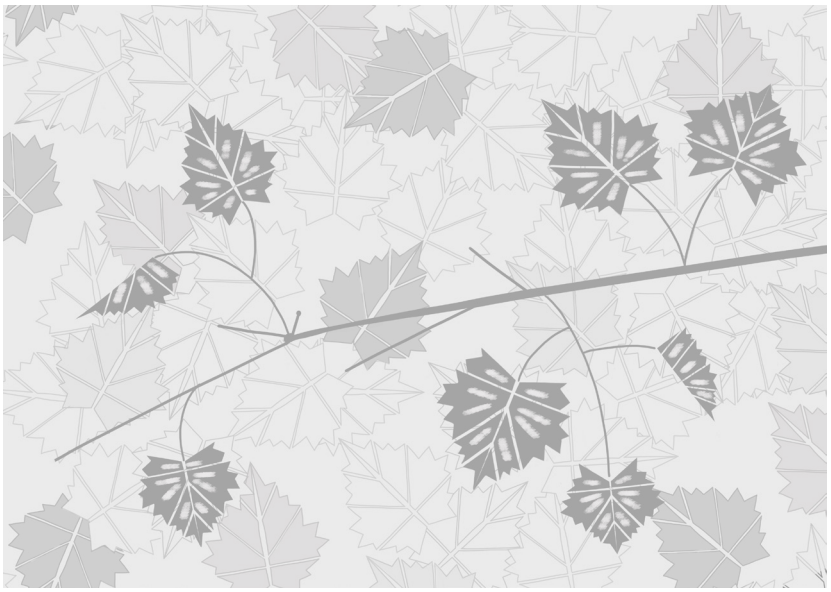


Variation 2



Variation 3

Variation 4



Variation 5

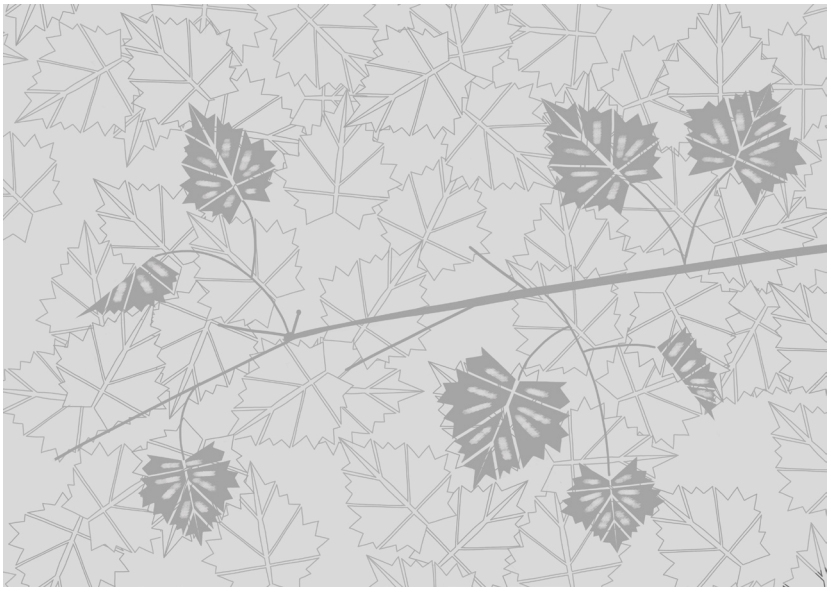


Illustration Type C

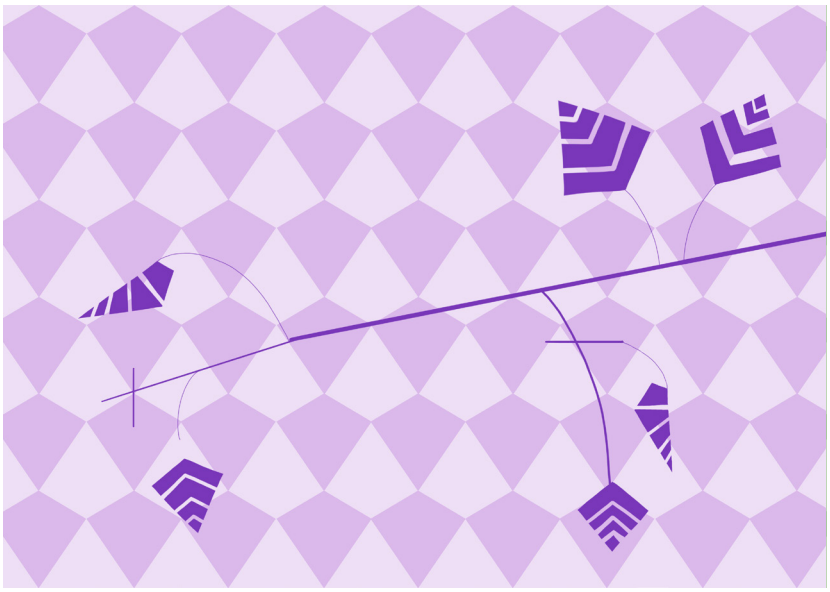
The process for creating the Type C illustrations of this series was reminiscent of logo design. However, instead of symbolizing a concept or company, I created icon-like representations of the silver birch leaf. Initially, I sketched eight different leaf concepts. The sketches in the first two versions of this series unintentionally disregard information regarding the leaves doubly serrate edges.

Another feature of these four illustrations is that the same violet and green colour palette is applied. In addition, I modified the illustration by increasing the contrast intensity. One key difference between the process of creating the Type B and C illustrations is that the Type C illustrations used illustrative elements created in Adobe Illustrator. Illustrator was used to create the leaf shaped pattern featured in the background. The rest of the illustrative process was completed in Photoshop. Similarly, as applicable to each illustration within the Ultraviolet and Contrast illustration series, the colours used to create the final illustrations are produced using the colour balance and contrast editing tools in Photoshop. In this particular series, variation one has been significantly altered and colourized to intensify the contrast of the illustration, whereas variation two's contrast has been significantly decreased to provide stark contrast within the series. This is prominently demonstrated when the violet and green illustrations are placed in comparison.

My decision to apply higher contrast settings for the violet illustrations stems from Tedore and Nilsson's study (2019), which found through simulated photoreceptors that "the green channel was surprisingly unhelpful for visualizing leaf-contrast"(p.2). On the other hand, the study led to the conclusion that the ultraviolet photoreceptor provided the most contrast (p.3). My intention when creating this series was to focus on depicting these findings through my illustrative choices.

C *UV and Contrast*

Variation 1



Variation 2

Illustration Series 3

the Common Pigeon

The visual reference material used to create these illustrations stems from a series of photographs of a pigeon wandering the streets of Seattle. These are photographs I had taken prior to beginning my thesis. My decision to use my own photographs of a pigeon as a reference is due to me having complete copyrights.

Illustration Type A

When compared to the Type A illustrations of the previously discussed series, this particular Type A illustration is the most figurative of the thesis illustrations. In this series there are two Type A variations, one with a background and one without. I intended this pigeon illustration to demonstrate a figurative representation of the Common pigeon. As a result, the illustration style used reflects the figurative styles experimented with during my thesis. More specifically, the Type A pigeon illustration was created after finishing the European starling illustration, therefore illustrated with many of the same techniques, brushes, and tools. This style also reflects the styles investigated during the visual research portion of my thesis. As a result, the illustration's art style reflects ornithological illustration aimed at species identification. For these reasons, I choose to highlight certain characteristics of the pigeon such as plumage, eye colour, anatomy, and the iridescent qualities of its neck feathers.

Any abstraction that incidentally occurs within the illustrations is a result of the illustration process itself, in other words, by being a drawing it can, to some degree, be considered an abstraction. However, within this illustration, there are instances in which I intentionally applied selective disclosure. Instance one occurs in the first variation which, while still including a background, I applied selective disclosure to eliminate non-essential details and background information. One example of selective disclosure's application is the subtle lense blur effect which directs the viewer's attention to the pigeon. Another example is the loose, texture-based illustration style of the cement, leaves, and fencing. For this version, the background remained to place the depicted pigeon in an urban context.

In contrast, in the illustration's second variation, I applied selective disclosure to further omit the background. In this particular case, the urban setting back-

ground has been completely eliminated and replaced by the use of an effects brush. As a result, the illustration features a lavender haze surrounding the pigeon. Coincidently, this abstract background occurs throughout most of my digitally created visual experiments. However, as opposed to completely eliminating the background, some initial background information is retained such as the leaves placed at the bird's feet. These leaves were kept in place to provide the illustration with selected information derived from the original background context. In addition, the leaves lend themselves to creating a sense of scale and space.

***Figure 6**: Type A illustration of the Common pigeon. This is the most figurativly drawn version of this series.*

A *the Common Pigeon*

Variation 1

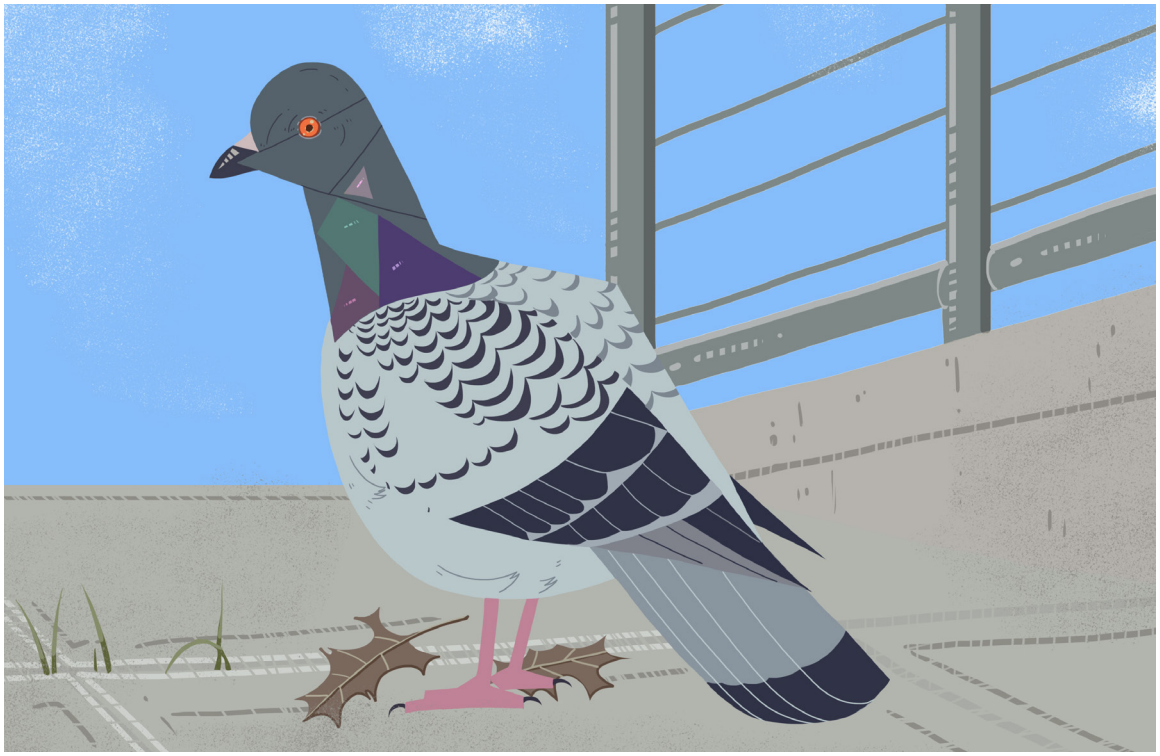
Variation 2

Illustration Type B

To create this Type B illustration I applied selective disclosure in addition to deviating from a realistic illustration style to illustrate the same pigeon photograph. One example of how I applied selective disclosure in order to create illustration Type B is the complete elimination of all background information in variation two of this illustration sub-series. However, I applied selective disclosure to variation one to create a minimalistic representation of the same urban setting depicted in illustration Type A. In addition, I applied selective disclosure to determine which information regarding plumage pattern, coloration, structural colour, and pigeon specific anatomy traits I wanted to depict in this abstracted version. Unlike illustration Type A, all abstraction of this image was the result of conscious decision making and planning. Several different stylistic approaches to the overall shape and anatomy of the abstracted pigeon were sketched out beforehand. The initial sketch is a combination of two different ideas as the head and neck were collaged from different sketches.

The style I created for illustration Type B is based on the illustrative style of Charley Harper (The Charley Harper Art Studio, 2008). My goal for this illustration was to represent the Common pigeon through shape and colour. The resulting style used reflects the experimental styles of my visual experiments, mainly the Anna's hummingbird, Eurasian magpies, and Northern saw-whet owl acrylic illustrations. However, unlike these visual experiments, which are acrylic on canvas, the Type B pigeon illustration is created digitally using Adobe Photoshop.

Variation 1



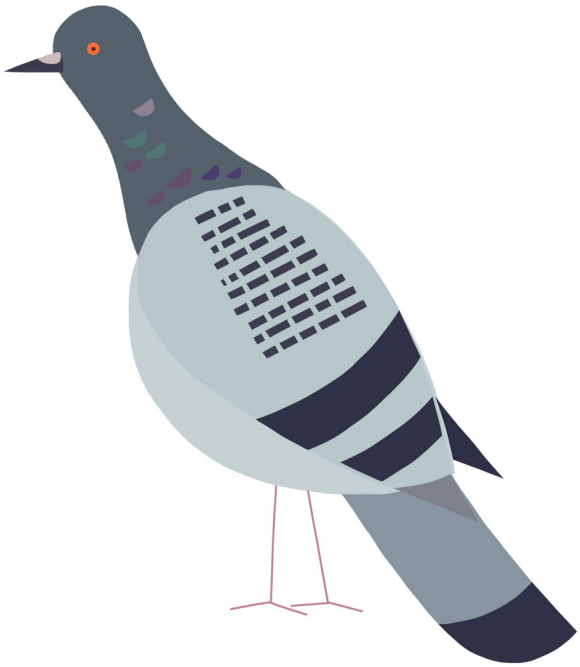
Variation 2

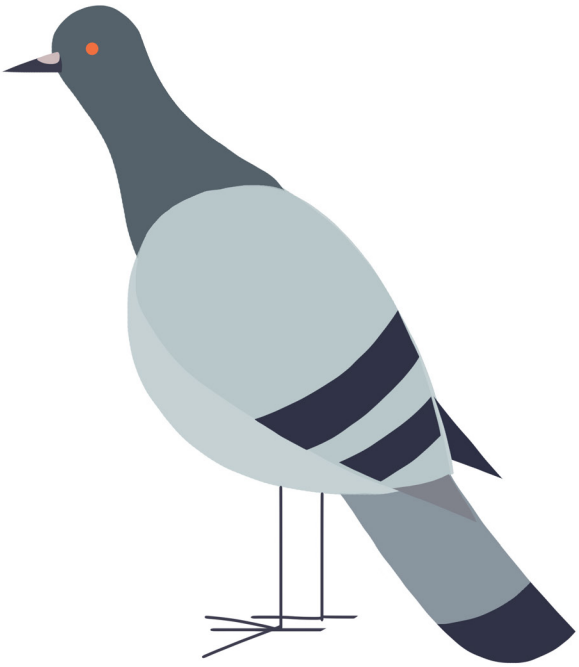
Illustration Type C

As is the case with the Type B series art style, this Type C illustration is influenced by Charley Harper's work (The Charley Harper Art Studio, 2008). Furthermore, the Type C illustration of this series is a further abstraction of the Type B illustration – both illustrations were created at the same time and within the same file. The Type C illustration is a result of me investigating the use of rounded shapes versus the more angular shapes used in Type B. As a result of investigation, I created four different variations of the Type C illustration for this series. Variations one and two eliminate all background information from the original reference photograph. Variations three and four depict the photograph's setting through the use of minimal background elements and illustrative style. I applied selective disclosure to create these different renditions of the Type C illustration. Variations one and two differ based on the inclusion or elimination of specific details such as the pigeon's pupil, structural colouration, and the check like pattern of the pigeon's plumage. Whereas variation one includes all of the aforementioned details, variation two eliminates these features. Another more anatomical difference between the two variations is the representation of the pigeon's feet and legs. Variation two, despite lacking visual information regarding plumage, displays the anisodactyl toe arrangement, with three toes in the front and one in the back. Variation one vaguely depicts the pigeon's leg and foot anatomy, depicting only two toes along with the pigeon's flesh-colored legs.

Variations three and four include information regarding the original photograph's background. In the case of these two variations, I only found it necessary to provide the pigeon with a platform, or plane, for placement. I decided to focus on the cement sidewalk from the original reference material. One key, but subtle difference between variations three and four is the application of digital textures applied through brushes. For example, in variation four the iridescent neck feathers of the pigeon are not represented by shapes as is the case with variation three. Likewise, the same texture brush was applied to the cement sidewalk.

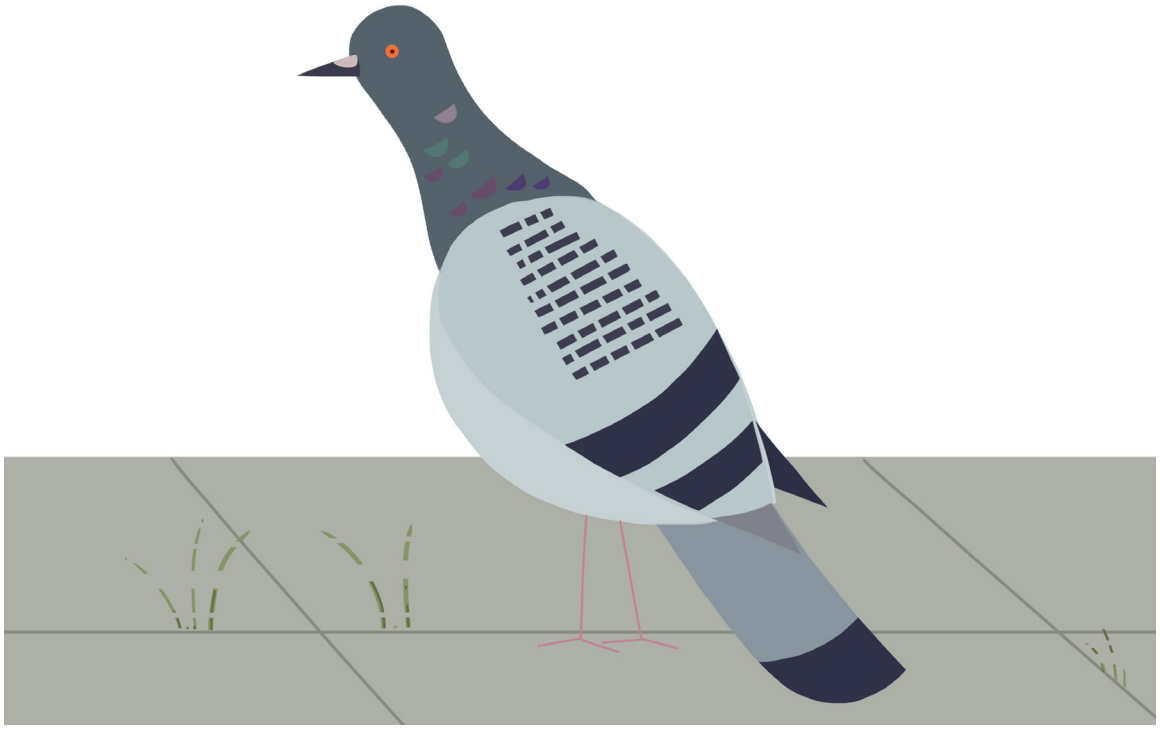
Variation 1

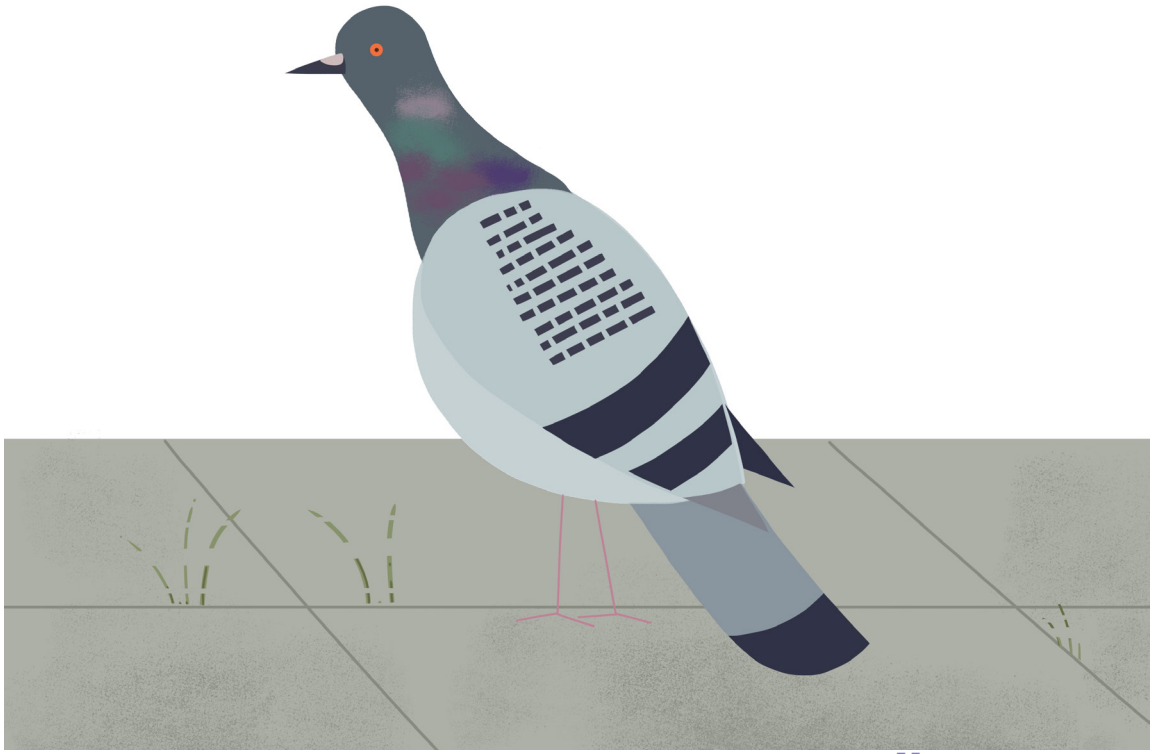




Variation 2

Variation 3





Variation 4

Outcomes

Guide Book and Illustrations

During this thesis, I created fifty three bird illustrations, literature review, visual research, and process based visual experimentations. In addition, I created a bird field guide titled "The conceptual Field Guide to the Birds". This book contains a selection of the visual work created during my thesis."The conceptual Field Guide to the Birds" was designed to mimic a traditional bird field guide book. This section of the thesis discusses the final visual results of my research and examination of the illustrative process. The first half of this section is dedicated to discussing the "The conceptual Field Guide to the Birds." The second half provides a brief overview of the illustrative works created throughout the duration of my thesis.

Guide Book

The Conceptual Field Guide to the Birds

The final bird book is modeled off of existing bird field guides. In particular, I focused on the Golden press guide book A guide to field identification birds of North America (Robbins, Bruun, & Zim, 1983), the David Sibley guide books series (Sibley, 2014) and The Observer's Book of British Birds (Benson & Warwick, 1952). In addition, I looked at regional guide books such as The Field guide to the Cascades and Olympics (Whitney & Sandelin, 2004), a book regionally specific to the pacific northwest area of north America. I conducted visual research into the organizational structure, design, and layout of some of the most popular guidebooks, such as the Sibley Guides series (Sibley, 2014). My conceptual guide book uses the taxonomic order as an organizational system for the birds. This approach was easy to apply as a result of me drawing multiple species within certain bird families such as the Corvidae, in which I illustrated magpies, crows, jays, and jackdaws. Taxonomic information regarding the families of birds was gathered through a google search and then verified by online sources such as the Cornell Lab of Ornithology (allaboutbirds.org).

In my guidebook, the birds are organized by family, then different member species are arranged by alphabetical order based on their scientific name. I choose to use the taxonomic system because it is commonly applied within bird guide books, although often optimized for efficient species identification and comparison. Overall, the design and layout of the conceptual book is simple. I wanted to reflect on the style of traditional guide books as well as create a layout which focused attention towards the visual content of the book and not the book's design. In addition, analysing existing field guides influenced the size of the final guide book. Despite many of my illustrations being larger to medium-sized and detailed, I decided to present my work in a size which reflected my visual research on guidebooks. Therefore, I chose to make the final guide book A5 sized, similar to that of a standard field guide. I also used Instagram as a platform for documenting my thesis illustration process.

Additionally, the typographic decisions for the field guide portion of my bird book follow a pre-established format based on the international codes of nomenclature and the established rules used for writing scientific names. I have chosen to apply elements of this system throughout the guide book to aid in organizing the birds by their family and scientific name in addition to my typographic choices. Written information regarding these guidelines as well as their exceptions was sourced from the AU Journal of Technology. The guidelines which are applied to the book are:

> 1. Capitalize [the] first letter of generic name, while the rest, including the whole of the specific epithet, in small case. Leave a single space be-

> tween generic name and specific epithet. In case[s] where the author's name is to be included, use standard abbreviation for the authors' name.
>
> 2. Use italics for generic name and specific epithet, but not the author's name. In handwritten manuscript, or when use[ing] a typewriter with no italics, underline what are to be italicized.
>
> 3. Names lower than species level are to be treated in the same way as the binomial, i.e. italicized; note that the word subspecies, race, variety, forms, etc. which are abbreviated, are not italicized. The same is true for strains or lines of domesticated animals; varieties, clones, and ecotypes of cultivated plants; trade or registered (grex) names, which are not italicized (Research and Publications Assumption University Thailand, 2001).

I focused on guideline one which is applied by ensuring that only the first part of each bird's common name is capitalized. However, as with the case with many bird books, I made one exception to these rules in which I chose to not italicise the generic, or common name, of each bird species. Instead, I used a san serif bold typeface to contrast the serif italics of the family and scientific names. This reflects typographic elements uncovered through visual research, as many of the bird guide books I examined tend to follow, a variation of these guidelines, but not strictly.

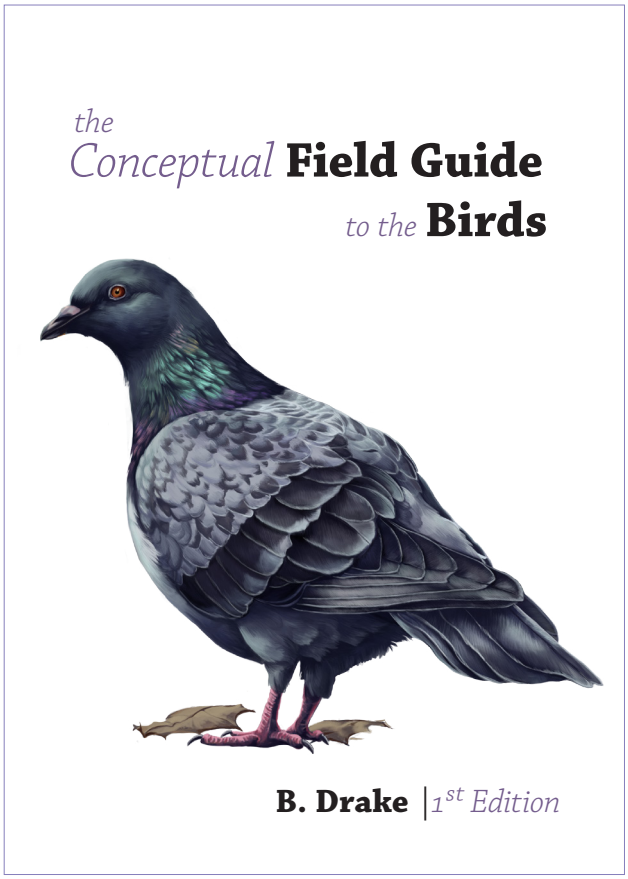
Investigating Bird Related Infographics

In addition to including a species identification section hosting the visual experiments of my thesis, I included two related products created using material from my thesis. Both products were assignments from courses at Aalto University. These two products are located in the Topology of a Bird and the Bird Spectrogram section of the "Conceptual Field Guide to the Birds". These sections reflect infographic components included in many bird field guides. The topology of a bird is a section standard in many bird guide books. This section features a diagram discussing the anatomy of a bird. In the case of my conceptual field guide, this section is recreated through a project titled Slide Puzzle. Slide puzzle originates from a workshop hosted by Tine Melzer at Aalto university during the winter of 2020. I wanted to play with the relationship between type and image in the context of bird anatomy. Slide Puzzle features two illustrations created during the visual experimentation phase of my thesis.

Slide puzzle aims to demonstrate how type and illustration can substitute one another through collage. However, these substitutions prove to be inaccurate and playful in nature. For example, Slide puzzle labels and replaces sections of the bird illustration, swapping locations with other parts of the bird's anatomy. The Bird Spectrogram section is not as common in bird books, however, guides

such as the earliest 1966 edition of the Golden press A Guide to Field Identification Birds of North America are one of the earliest examples of spectrograms being included within field guide pages (Robbins, Bruun, & Zim, 1983). In this specific example, spectrograms are peppered throughout the information pages of the guide book. I created spectrograms for two species, European robin and Eurasian jackdaw.

In addition, the Bird spectrogram section of my guide book includes spreads from the original project as initially designed. I created this project during a course called Design as Writing at Aalto University during the spring of 2019. More specifically, this project was for the Design as Writing collaborative book assignment. The project consists of two experimental poems titled "Ti" and "Bah". "Ti" and "Bah", named after the sounds the Eurasian robin and Eurasian jackdaw make, translate the visual forms of sound into poetry. I listened to and transcribed the sounds of the two bird species, turning their songs into text. The typography of the poetry reflects the original layout and design of the bird spectrograms.



Page Number: 124 pages
Number of Illustrations: 34

Next Few Pages: *Spreads from the Conceptual Field Guide to the Birds. The final book is roughly 120 pages. These pages have been selected to reflect the range of layout and illustrative works.*

Bombycillidae

Cedar waxwing
Bombycilla cedrorum

The Cedar waxwing is of the *Bombycillidae* family. Its found most commonly in North America, but can be spotted else where on occasion. It's similar looking to the Bohemian waxwing. Occasionally the two species end up in the same flock. I have been drawing this, slowly not working on it often, for a while now. I think it's done now.

Cedar waxwings
Marrowstone Island, Jefferson

About a dozen to a dozen and a half cedar wax wings in a flock But about five of the birds were eating sand hoppers on the beach. The birds seemed to be well adapted or used to eating the sand hoppers. I sat about five feet away from the birds, using sand to try and attract their attention. Three wax wings at one point perched on a log. They made their soft whistle sound. At one point a cedar waxwings seemed to be sitting in a large foot print and all that could be seen was its head. A bird came two feet from me, many seemed to be curious and cautious of me, I tried exposing sand hoppers for the birds. None of them came close enough to eat any of the exposed sand hoppers.

Around 5:00 to 6:30
Beach at high tide
July 15th Sunday

Digital illustration created in Adobe Photoshop using the default round brush at different opacity and pressure settings.

MAY 6, 2019

26 ⇊

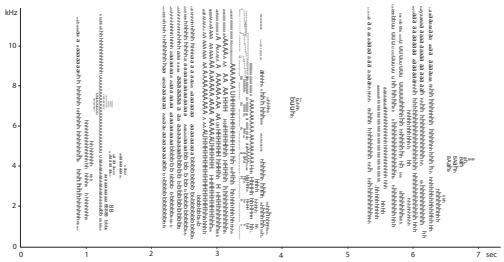
Corvidae

Jackdaw
Coloeus monedula

A jackdaw! I am in love with these clever little corvids. They have such lovely silver eyes. I've been reading the "Perennial Retainers" as I fall asleep. I highly recommend it.

Traditional illustration created using pencil and ink on standard sketchbook paper. The original illustration is A5/ half letter sized.

OCTOBER 18, 2019



34 ⇊

⇊ 35

DECEMBER 25, 2019

Traditional illustration created using acrylic on canvas board. The original painting is poster sized.

Traditional illustration created using pencil and watercolour on cold press watercolour paper.

APRIL 8, 2019

Trochilidae

Anna's hummingbird
Calypte anna

The Anna's humming bird is a common and brightly coloured species of the pacific coast line in addition to some inland locations. This species is a frequent feeder visitor back home. This painting is for my grandfather. I experimented with a different art style more align with that of the late Charley Harper.

Traditional illustration created using acrylic on canvas. The original painting is poster sized.

DECEMBER 22, 2019

92

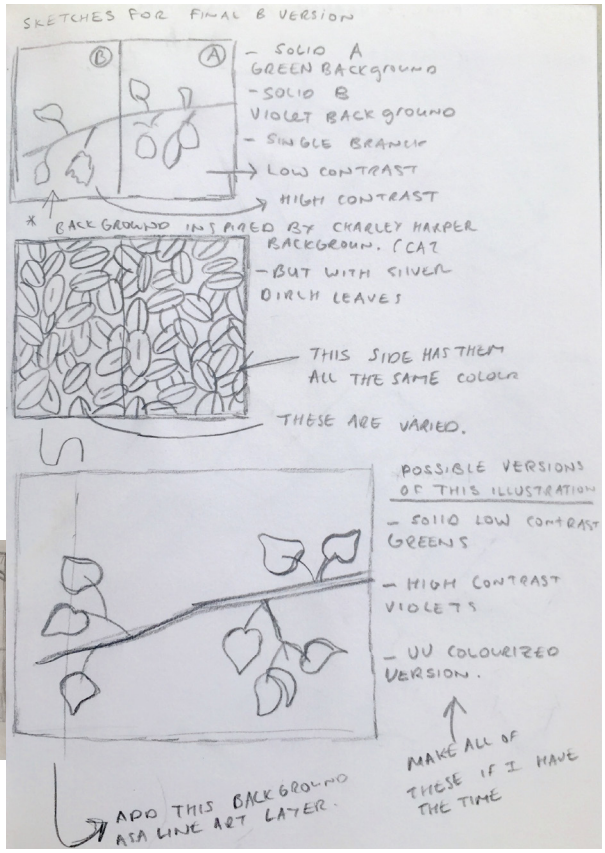
Process

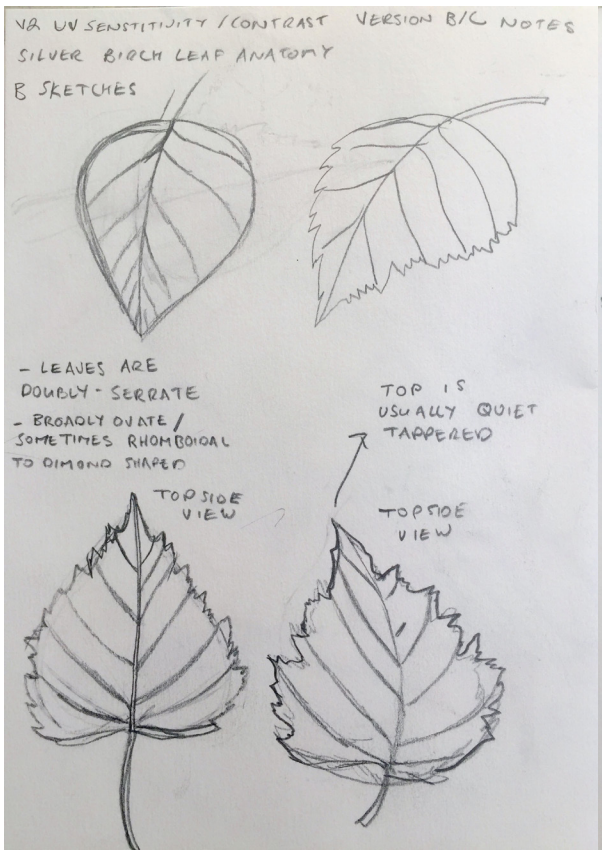
Illustration Series Two
Ultraviolet and Contrast

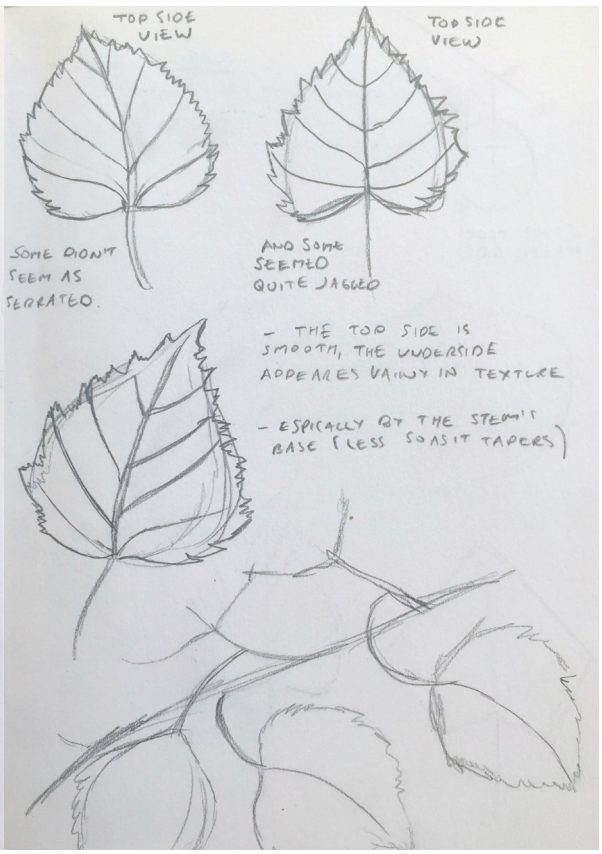
The visual reference materials used to create this illustration stem from the simulated foliage images from Tedore and Nilsson's (2019) study on how the ultraviolet vision capabilities of birds enhances the appearance of contrast in leaf foliage (Tedore, Nilsson, 2019, p.3). In particular, I specifically based the illustration of this series off of the studies Figure 2 graphic, which contains a series of images that have been digitally altered in an attempt to accurately represent a speculative interpretation of how birds see the world. However, Tedore and Nilsson point out "that false colour images cannot replicate what animals actually see, but provide the best approximation available" (Tedore, Nilsson, 2019, p.3). The illustrations are at best only an approximation.

Type A Illustration
Realistic Representation

102







Illustrative Outcomes

The illustrative results of this thesis are the creation of nine researched-based pigeon illustrations with multiple variations for each illustration. However, these are not the only illustrations created for this thesis. In addition to the main thesis illustrations, a total of forty three illustrations were created as visual experimentation through process-based research. Therefore, In total, fifty three illustrations were created throughout the duration of this thesis. All of these illustrations were created as reflections of the research examined through literature review as well as illustrative process. The creation of these illustrations is from an interdisciplinary standpoint, in which science and visual communication forms, such as illustration are applied together. In addition these illustrations were created using a variety of different mediums and employed a variety of different illustration styles. These styles are reflections of the visual research component of my thesis.

Conclusion

In conclusion, this thesis conducted a process-based approach to examining ornithological illustration in addition to investigating the intersections of art and science. A research-based approach to illustration composed of literature review, visual research, and process-based visual research in the form of illustration, was applied to my illustration process. Furthermore, this thesis discussed that when applied to the illustrative process, interdisciplinary research aids an illustrator by informing illustrative choices and ultimately impacts the final illustrative outcomes. In other words, this thesis investigated the role and impact of interdisciplinary research and literature have when applied to the process of illustrating.

In summary, I examined ornithological illustration in the context of abstraction through process-based illustrative work. More specifically, I used illustration to analyze existing pictorial planes. Additionally, I created my own picture plane to investigate the implication and applications of abstraction techniques found in scientific illustration. Such techniques, for example, selective disclosure and distortion (Goodsell & Johnson, 2007) are applied to scientific illustration to enhance illustration comprehension. The techniques and methods used during this thesis were discovered through literature review focused on interdisciplinary literature. For example, I reviewed scientific articles and journal publications focused on bird vision in addition to academic publications focused on scientific illustration and science visualization.

In addition to interdisciplinary literature review, I conducted visual research which examined historical and contemporary examples of ornithological illustration. In particular, I examined the works of John James Audubon (National Audubon Society, n.d.), Arthur Singer (Robbins, Bruun, & Zim, 1983), and David Allen Sibley (Sibley, 2014). The work of these three illustrators served as examples of figurative ornithological illustrations. In contrast to these figurative examples, I examined the illustrations of American illustrator Charley Harper (The Mill Pond Press Companies, 2002). I focused on Harper's ornithological illustrations, although arguably, Harper's illustrative works may not be classified as scientific. However, Harper's ornithological work served as examples of abstraction in illustrations clearly depicting recognizable bird species. Therefore,

many aspects of these illustrations were applied to both the final thesis pigeon illustrations as well as visual thesis experiments.

After completing the literature review and visual process-based research I created a series of nine pigeon illustrations using scientific illustration techniques such as selective disclosure and distortion (Goodsell & Johnson, 2007). These illustrations were created in order to examine picture planes. This examination was conducted in order to better understand abstraction's role in ornithological illustration. I constructed my own abstraction plane and methods based on Mcloud's Pictorial Plane (Mcloud,1994, p.52-53) discussed in "Understanding Comics," which places resemblance on a spectrum opposite of the pictorial plane, which represented abstracted works. In addition, I analyzed a similar picture plane within the context of science visualization, discussed by GNSI lecturer, Jen Christiansen. Christiansen's model places representative illustrations above figurative and data visualizations above abstract (Christiansen, 2018). Elements of both examples were then applied to my illustrative process to create a visual spectrum of ornithological illustrations from figurative to abstract. This was done by creating three illustration types, A, B, and C, for each illustrative series. In this visual system Type A illustrations represented figurative interpretation, while Type C illustrations represented the abstract end of the spectrum.

Initial Objectives Versus Outcomes

The comprehensibility of the abstracted illustrations was not tested as initially proposed in earlier thesis concepts. Instead, I focused on the process of creating abstracted scientific illustrations. One key component of information based illustration, such as scientific and ornithological illustration is comprehensibility. However, comprehensibility is developed through illustrative processes. In addition to developing the tools and drawing ability required to create comprehensive illustrations, illustrators need to grasp additional methodological techniques such as abstraction. As an illustrator with a more figurative art style, my first inclination when rendering a concept is to take a figurative approach. Consequently, many of my earliest visual experiments took a figurative approach to ornithological illustration. Through literature review and additional visual experimentation, I developed personal techniques for abstraction. Additionally, I used figurative and abstract techniques to render identical concepts. For example, the Eurasian magpie, Common Starling, and Common pigeon Type C Illustration depict structural plumage colouration through different illustrative approaches.

Directing my attention towards the process of making abstracted illustrations, allowed me to better examine and develop a process with potential for future investigation. This process is as equally important as exploring the illustration process leads to the development of my own artistic and illustrative practices.

Therefore, the exploration of abstraction in the context of ornithological illustration was completed. This concept was explored through the use of different art styles and approaches to depicting the same illustration through different iterations. It was additionally completed through visual experiments where the illustration style ranges from the more figurative European starling illustration to the shape and colour based Eurasian magpie and Anna's hummingbird painting.

Initial Objectives Versus Outcomes

Future investigation is warranted on the impact of abstraction on the comprehensibility of scientific illustration and science visualization. In other words, a deeper analysis using qualitative and quantitative research methods, on how the application of abstraction techniques affects the comprehension of concepts being illustrated would be beneficial. Such a study could examine the effects of applying abstraction techniques in addition to the unintended consequences of their use. Another area of research could focus on misconceptions which can be generated through the use of abstraction techniques such as selective disclosure and distortion.

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