University of Nevada, Reno

The Interaction of Faces in Foveal and Peripheral Vision

A thesis submitted in partial fulfillment
of the requirements for the degree of

Bachelor of Science in Neuroscience and the Honors Program

by

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Abstract

Facial perception is a well-explored topic in scientific history. As humans have developed the ability to process facial features as early as five days old. Facial perception is crucial to human development and social interaction. Human vision is best in the foveal region, while it is seen to decline in the peripheries. Basic stimuli such as shapes and figures have been studied in the foveal and peripheral vision. Very little information is known about facial perception in the foveal and peripheral areas. Is face perception specialized for vision in the fovea? Is there interaction between faces in the fovea and the periphery? Three experiments were designed to study four eccentricities. Each experiment studied the average accuracy of the participants determining the gender of the foveal stimuli at fixation and in the surround. The participants included college students at the University of Nevada, Reno. Overall, we witnessed a significant effect in accuracy based on the peripheral and far peripheral eccentricities. Contrast effects in face perception show an absence of an effect which is typically significant in most stimuli. The results from this study suggest that facial perception requires a higher level of brain processing.

Acknowledgements

I want to start off by thanking my mentor, Dr. Webster, for helping me build the foundation of this study. In addition, I would also like to thank Dr. Scott Gwinn for assisting me in creating the stimuli and collecting data from participants of the experiment. I couldn’t have done it without your help and support.

To my family, I want to thank you for always motivating and pushing me to become a better person every day. Lastly, I want to thank my friends who have supported me since the beginning of my undergraduate career.

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I. Introduction

A. General Overview

The human ability of facial recognition is essential for developmental and social interplay between species. Facial recognition is automatic in human development and has been apparent since infancy (Simion and Di Giorgio, 2015). It is a skill that we've automatically acquired since birth in order to distinctly characterize individuals according to age, identity, social status, gender, attraction, and more importantly emotions (Leopold and Rhodes, 2010). Building human relationships is based on social interactions through face recognition (Haxby, et. Al., 2000). Immediately, we associate facial recognition with the visual networks involved in the process. Looking closely into these networks, we see a link with facial stimuli causing activity in anterior temporal regions, including the amygdala (Gorno-Tempini et al., 1998). Familiarity and constant exposure to the same faces, for instance celebrities, can generally trigger responses in certain individuals (Gobbini and Haxby, 2007).

B. Complexity of Face Perception

Face perception is unique from most visual stimuli since you must take into account facial features in order to evaluate certain expressions and characteristics of an individual. The complexity of facial perception is not automatic as it involves active social and cognitive processes (Nook, et al., 2015). Moreover, facial perception is influenced by previous experiences and expectations that can easily effect the response (Nook, et al., 2015) Certain facial features of an individual can differentiate them from others. These features can give us information about their identity, background, gender and social standing (Leopold and Rhodes, 2010). For years, humans have used faces in social interactions by involving emotional states. Faces are not only used for communicating and exhibiting emotion, the bases of attraction are also identified with facial features (Leopold and Rhodes, 2010). Since faces are unique as a stimulus, this study explores the factors that can affect perception of faces in two types of vision.

C. **Contrast and Assimilation**

Contrast and assimilation can influence a fixated image either by enhancing or depleting certain features such as size, color, or sharpness. Contrast is defined as an "opposition or juxtaposition of different forms, lines, or colors in a worth of art to intensify each element's properties and produce a more dynamic expressiveness" (dictionary.com). Assimilation on the other hand is defined as the "state or condition of being assimilated, or of being absorbed into something" (dictionary.com). Facial stimuli may appear distorted depending on the influence of its surround. Since face perception is complex, it may be difficult to distinguish features of a face if it is affected by its background. As a result, the accuracy for determining features of the fixated face ultimately declines. Holistically, there are certain aspects of the human face that makes it unique from other testable stimuli. It is interesting to explore how contrast and assimilation affects facial perception in the human eye.

Facial stimuli are easily affected by how it is presented to the human eye and whether its surround has the power to assimilate the image effectively. Certain image features can be enhanced by the surround which can affect the accuracy of the individual to describe the fixated image. Assimilation for facial perception can be compared to the Delboeuf illusion, in which two of the same size black circles are placed side by side. Both of the circles is surrounded by an annulus—a white circle surround, but they vary in size (see Figure 1). Real world application can be exhibited by the idea that eyebrow positioning or the use of eye shadow can make eyes appear larger (Morikawa et. al., 2015). The idea that application of eye shadow around the human eye can be compared with the Delboeuf illusion, with the annulus representing the shadow background (Morikawa et. al., 2015). When facial features are assimilated in a certain background, they may appear larger or smaller, depending on their surround.

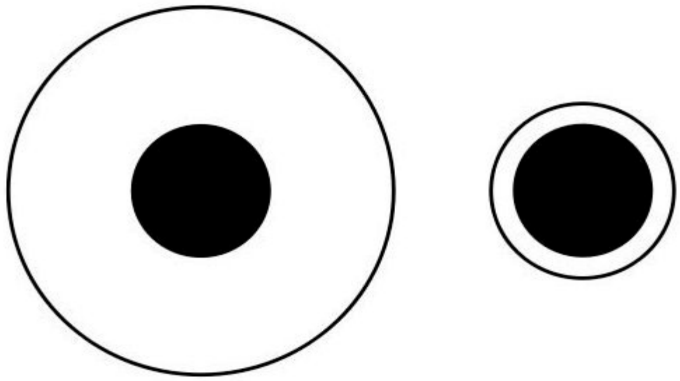

Figure 1. ***Delboeuf Illusion***

The Delboeuf Illusion shows two circles surrounded with annuli. The size of the annuli affects the perception of the interior (black) circle.

The idea of size contrast came about when the Ebbinghaus illusion was introduced by Edward Titchener in the early 1900s (Haffenden et. al., 2001). The illusion consists of two equally sized circles, but one is surrounded by large circles and the other is surrounded by small circles. The illusion revealed that many individuals perceived the circle surrounded by smaller circle, larger in size (Roberts et. al., 2004). Size perception can be affected by various factors such as facial expressions. Depending on the emotion of the face, size perception plays a role in the stimulated cognitive networks involved (Kanwisher et. al., 2006). Size perception is essential for facial identification, not only with facial expression, but also to determine social status in recognized faces. We see that perception is determined by the amount of exposure. The exposure factor is able to enhance or decrease the value of a stimulus in the exact dimension. This pattern can also be applied into the basis of attraction. We can compare facial attractiveness through continuous exposure and comparison with a less or more attractive face according to social standards.

Lightness and color can also influence the appearance of faces depending on the perceived reflectance. Mach bands are a classic example of lightness perception in which our receptive fields are able to distinguish and separate each band into sections since the following band is a darker color than the previous (see Figure 2.). Lightness of faces is closely applicable to skin tone in facial perception. We can categorize individuals based on their skin tone variance, which can determine their race (Willenbockel et. al., 2011).

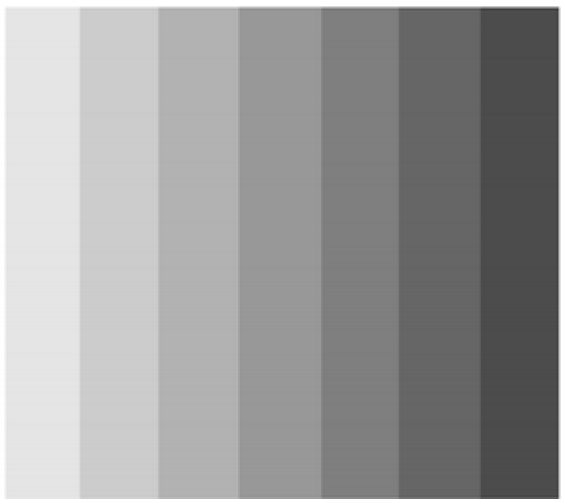

Figure 2 ***Mach Bands***

The Mach Band illusion triggers retinal ganglion cells which amplify the contrast between shades of grey once they meet at the midpoint.

The idea of simultaneously comparing two distinct colors originated from Chevreul's definitions. The Definition of Simultaneous Contrasts presents us with the concept of two objects with the same color and different tones, compared simultaneously proving that the eyes is able to create its own modifications on the intensity of each color (Chevreul et. al., 1888). We can apply the same concept with facial perception. If we were to compare two of the same faces, with varying tones, simultaneously we can easily differentiate between the two skin tones and can visualize a tone scale in our minds. Hue variations can also be presented by the Bezold-Brucke effect and how intensity can lead individuals into one side of the color spectrum (Lillo et. al., 2004).

The stimuli's orientation can also influence identification accuracy of facial stimuli. There is a particular effect used in photography which can be applied to create a miniature effect on the image. The orientation in which the photograph is presented can affect how an individual perceives it. This effect is eminent in facial perception. Face processing depends on whether it is presented in an egocentric or environmental orientation since it can lead to various outcomes (Davidenko and Flusberg, 2012). Faces can also be presented in an inverted or upright manner, which can also trick cortical processing that some features are distorted (Davidenko and Flusberg, 2012).

D. What Makes Face Perception Unique?

Facial stimuli are special compared to other common stimuli due to topics such as the face inversion effect. The visual system is often responsible for the difficulty in recognizing faces in different orientations (Farah et. al., 1995). Whether the face is isolated in features or inverted as a whole, humans still have trouble analyzing a face since it is difficult to mentally rotate it in the mind (Rakover and Teucher, 1997).

It is well studied that people with Autism spectrum disorder have difficulties in facial recognition due to early abnormalities in neurological facial processing. Individuals with Autism spectrum disorder are known to use holistic processing in facial perception, more specifically a bottom-up processing which is directed mainly to certain features of the face. Studies involving ASD and facial perception typically involved the FFA and the amygdala, which processes emotion (Golarai et. al., 2006). Surprisingly, studies have shown that individuals who suffer from prosopagnosia are able to have an easier time evaluating inverted faces vs. upright faces, which is the opposite effect of face inversion (Farah et.al., 1995).

As discussed previously, faces are a complex due to social and personal interpretations that humans are predisposed to. Face perception is unique since it is eminent to make interaction possible. The summation of a face's features make it stand out from other stimuli (Little et. al., 2011).

There are certain effects that are particularly unique to faces. The inversion effect is the discovery in which an individual's ability to recognize inverted faces is less accurate than when recognition of faces that are upright (Rakover and Teucher, 1997). This concept is explored in the Thatcher Illusion, a phenomenon that exhibits an increase difficulty to recognize certain features of an upside down face. This effect was created by placing two of the same photos, side by side, inverted. The face on one side is inverted normally, without altering the features. Meanwhile, the picture next to it has been manipulated so certain features (such as the eyes and mouth) are flipped (Thompson, 1980). Since humans associate faces directly with the individual impressions of expression, the lack flipped features present a distorted face without proper or recognizable facial expression as shown in Figure 3.

Figure 3. ***Margaret Thatcher Illusion***

This illusion is called the Thatcher Illusion. Both pictures are inverted, yet one of them has certain features altered (boingboing.net)..

Another effect that is unique in faces is the composite face effect. The composite face effect is exhibited by creating combinations of difference faces, in order to create an original face. Components are taken from various faces and features are aligned to create a new identity (Taubert and Alais, 2009). The composite face illusion shows how faces are processed holistically. Holistic processing is the "encoding of the overall structure of the face, in which face parts and their relations are not explicitly represented, but glued together in an undifferentiated whole (Tanaka and Farah, 1993). The composite face effect is evidence that holistic processing is impaired with inverted faces (Mondloch and Maurer, 2008). Face processing can be directly affected by the composite face effect since adults have increased difficulty with the top half of the face, when paired with a bottom half of another face (Mondloch and Maurer, 2008).

Facial perception is unique since people are able to use holistic processing for faces since it is much more of a challenge to ignore a certain area of a face than it is to ignore a section of another type of stimulus. There is a link between holistic processing and facial recognition (Richler et. al., 2011). The term holistic processing can be interpreted as processing that considers a whole object, including and integrating all parts of a stimuli, instead of processing it into chunks (www.merriam-webster.com). Holistic processing can be supported by the composite effect, which supports the holistic idea of face processing. In the composite face effect, a top half of one face is aligned with the bottom half of another face. Many individuals find it difficult to recognize the top half of a face when it's pair and aligned with a new bottom half, compared to when they are misaligned (Cassia et al., 2009). Holistic processing is responsible for these results since we recognize a face as a sum of its parts (Cassia et. al., 2009). In addition to holistic processing, individuals commonly use detection. Detection is classified as facial identification through specific facial features by comparison to other faces (Tsao et. al., 2008).

E. Brain Areas Involved with Face Perception

Functional neuroimaging has aided in identifying the three regions that are involved in visual face perception. These specific regions are located in the occipital-temporal extra striate visual cortex. The occipital-temporal region includes the inferior occipital gyrus, and more specifically the fusiform face area (FFA) which respond stronger to most faces compared to any other stimuli, shown in Figure 3.

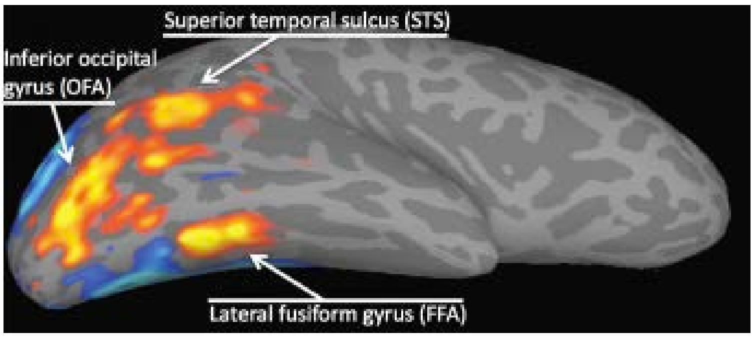

Figure 4. ***Activation of the Occipital-temporal Extrastriate Visual Cortex to Facial Stimuli.***

The three regions of the occipital-temporal extra striate visual cortex are responsible for the strong responses to facial stimuli (haxbylab.dartmouth.edu).

Since holistic processing shows that the whole face must be taken into account prior to facial identification, it's interesting to investigate what part of the visual system involves facial recognition. Is face perception specialized for central vision?

F. Foveal vs Peripheral Vision

The fovea is described as a "small rod less area of the retina that affords acute vision" (www.merriam-webster.com). The fovea consists of a compact group of cones which are the photoreceptor cells that are able to detect color (www.medicinenet.com). These cones are concentrated in a certain area in the retina. In Figure 4, the diagram of the eye, we see the location of the fovea centralis, shown as a pit in the retina.

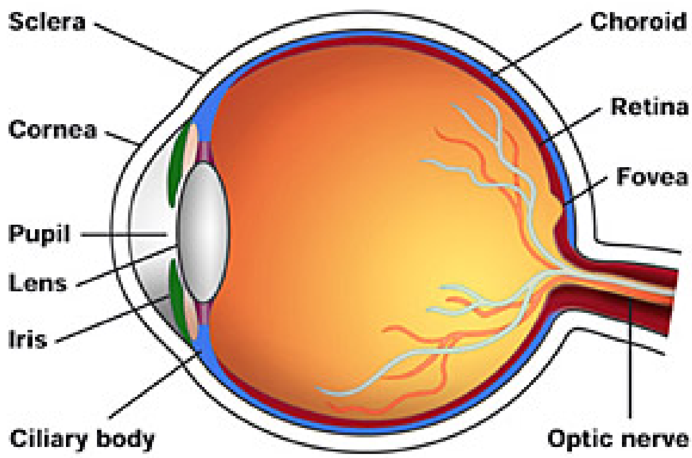

Figure 5. ***The Eye***

A simplified and labeled version of the eye is shown with the small depression in the retina called the Fovea Centralis (appsychology.com).

Our center of gaze is dependent on vision in the fovea, we can also refer to this gaze as our central vision. The central vision requires the work of a large concentration of receptors which lead to the highest acuity and ability to recognize color for higher visual resolution (Ludwig et. al., 2014). Visual acuity is defined as "the clarity or sharpness of vision" (www.aoa.org). Visual acuity is highest in the center of gaze or foveal vision. Vision details are revealed through the foveal vision in the retina, which means that humans perceive high resolution vision in this area (Amblard and Carblanc, 1980).

Although foveal vision is the clearest point in which the image can be perceived, peripheral vision also proves to have its own influence to the naked eye. Peripheral vision is classified as the aspect of the visual field that is not necessarily in the center. There are certain sections of peripheral vision which include: near, mid, and far peripheral. Typically, visual acuity decreases the farther you are from foveal vision. For instance, far peripheral vision is providing low acuity as opposed to the center of gaze (foveal vision). There are known problems in categorizing and identification in extra foveal vision since it is limited in speed and accuracy (Strasburger et. al., 2011). Since foveal vision is limited to a certain region, foveal analysis requires additional assistance from peripheral vision (Ludwig et. al., 2014). Peripheral vision is necessary to select a new fixation location for the fovea to direct its focus. As a result, we see cycles of fixation occur with foveal analysis (Ludwig et. al., 2014). Although peripheral and foveal vision work together to build the overall picture, peripheral vision obtains information independently from foveal vision without affecting the response (Ludwig et. al., 2014). Vision in the peripheries has shown an obvious performance decline in with a constant stimulus (Weymouth, 1963). There is a constant debate to whether overall vision declines in the peripheries. Studies show that moving stimuli appears to be equally accurate even using peripheral vision (Faubert and Herbert, 1999). Moreover, the Aubert and Forster phenomenon is a prime example of how indirect vision, vision outside the central gaze, shows direct changes in visual acuity especially when comparing central and peripheral vision (McFadden, 1910). When strictly comparing size and contrast sensitivity, there is no significance between the differences in foveal and peripheral vision with facial identification (Makela, et al, 2001). It's definite that visual acuity declines in the peripheries, but with the complexity of faces as a stimulus, there is not quite a clear answer. The study explores how faces in the fovea and periphery interact. How good are humans are differentiating faces in the fovea versus the periphery and do the contrast effects listed previously, affect these responses? I hypothesize that the faces in the fovea, at central gaze, will affect the responses to the faces in the periphery.

In this study, we want to explore the effects that faces have on our visual perception. Exploration of foveal vision can reveal the true influences of vision in the periphery. The first question we want to explore is the accuracy of face processing using peripheral vision. Next, we also want to incorporate the image at fixation versus the peripheral image and explore its accuracy. Lastly, we want to investigate whether surrounding faces provide contrast and assimilation to a face at fixation. Certain objectives that are open to exploration are the ideas of contrast and assimilation, lightness and color, and the comparison of fovea and peripheral vision.

G. Vision Overview

Our vision can play tricks on us depending on the method that most stimuli are presented. For instance, the flashed face distortion effect is an illusion that consists of faces that flash very quickly across a screen. Individuals must fixate their gaze on a cross in the center while a various set of face flash quickly before their eyes. Eventually, the facial features look exaggerated and appear unattractive to participants (Tangen et. al, 2011). Effects like the face distortion effect exhibit the uniqueness of facial processing. Contrast effects are also known to affect most stimuli, but it has not been tested effectively with faces. Do faces show a contrast effect? I hypothesize that faces will not show a contrast effect since they are stimuli that are processed differently in the brain.

This study will explore and compare how faces are perceived in the fovea and the periphery. Human development and brain processing are heavily involved in facial perception. Since facial perception has always been a complex task due to contrast, assimilation, lightness, and color. The background information that I have previously provided from these papers have motivated me to explore the differences of facial perception in the fovea and the periphery. In order to explore this topic, I’ve performed three experiments which include, accuracy, fixation, and surround. These experiments will be conducted using college students at the University of Nevada as participants.

The main questions I want to explore is as follows: How do faces in the fovea and periphery interact? I hypothesize that facial accuracy will decline as you move into the periphery. In addition, I also want to explore the following question: Do faces exhibit a simultaneous contrast effect or an opposite effect? I hypothesize that faces will show simultaneous contrast effects as well as an opposite effect, due to the background knowledge provided in the introduction. Although most stimuli are affected by contrast effects and declining vision in the peripheries, faces involve a higher level of processing, which is necessary to explore since it could alter perception of gender as evaluated by college students.

II. Methods

A. Participants

A total of ten participants were asked to participate in the experiment. The ten participants were conducted to the study based on their background in psychology and are between the ages of 19-22 years old attending the University of Nevada, Reno.. Each participant was required to sign a consent form after a quick overview of their tasks. The study was conducted in a laboratory setting at the Mack Social Science building in the University of Nevada, Reno. Participants were asked to sit in a chair that was 57 cm viewing distance of the presented stimuli. A mouse was provided and each participant was required to respond by clicking left for male and right for female. The responses were recorded after a 2 second interval of being presented on the screen.

B. Stimuli and Apparatus

Using the program Abrosoft Fantamorph, 24 male and 24 female images were combined and averaged to create a single male and a single female image, used as a baseline. Using these two male and female images, a series of a hundred faces were created from 0:100 to 100:0 in 1 percent intervals. In order to navigate facial features, Adobe Photoshop program was used with a 240 x 327 pixel ellipse display. The images created were shown on a Cambridge Research Systems Display++ monitor at a resolution of 1920 x 1080 pixels and a refresh rate of 120 Hz. Each participant was required to view the monitor at 57 cm and an angle of 8.64 x 11.77 degrees. The standard gender faces were preset in the FaceGen program and were artificially created.

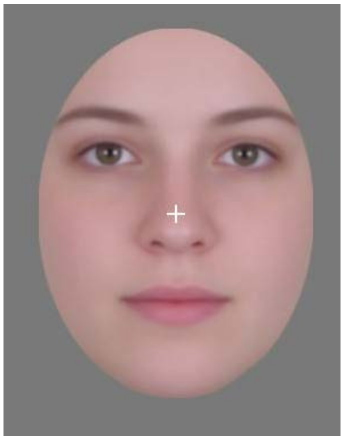

Figure 6. ***Default Female Face***

A standard female face at fixation

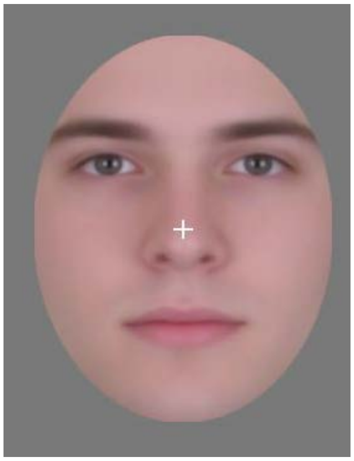

Figure 7. ***Default Male Face***

A standard male face at the fixation point, created with FaceGen.

Figure 8.. ***Androgynous Face***

. A standard androgynous (50/50 mix between male and female) face at fixation

In Figure 6. We see a female face at the fixation point. This standard female face is attained as the face with the most extreme female facial features that the program offers. Figure 7 shows a standard male face at fixation, while Figure 8 is the standard androgynous face. The standard androgynous face is selected based on the 50/50 contribution of the male and female face in the continuum.

III. Experiment 1a: Face Discrimination in the Fovea vs Periphery

A. Overview

The purpose of this experiment is to evaluate the accuracy of each participant in identifying whether the face is male and female in different eccentricities. The first question we want to answer is: how accurate is face processing in the fovea vs the periphery? As mentioned in the introduction, there are differences in stimulus discrimination in the peripheries. It would be interesting to test peripheral decline using faces. This experiment was divided into 4 different conditions: foveal, parafoveal, center, and peripheral.

B. Procedure

Using computer generated facial stimuli from created from FaceGen, participants will be exposed to up to 60 computer generated images of male or female faces while manipulating various stimuli. While fixating their gaze on a white cross in the center of the screen, the participant will have two identical images on both sides of the cross. By the end of the image set increased in difficulty depending on responses. Accuracy was monitored using a 3 down 1 up staircase method. This was reiterated with 0.75 steps, which interprets into 3 correct images consecutively decreased by 75%, and one incorrect answer would increase by 75%. The 75% variation is manipulated by slightly decreasing or increasing the gender strength. This would interpret into the next face in the continuum. Faces were intermixed between 50:50 male/female ratios. 60 images were shown for each condition. The data was calculated by computing the percentage of correct responses and fitted with a Weibull function.

C. Stimuli

The face discrimination experiment was split up into four parts. There are four eccentricities that were tested: center (foveal) (Figure 9), parafoveal (Figure 10), periphery (Figure 11), and far periphery (Figure 12). Aside from the center condition, the parafoveal, periphery, far periphery conditions had two faces, which were copies of one another, next to the fixation cross. The foveal eccentricity (Figure 9) is directly in the center of the screen. The faces eventually appear further and further apart until they reach the extreme condition of the far peripheral eccentricity (Figure 12).

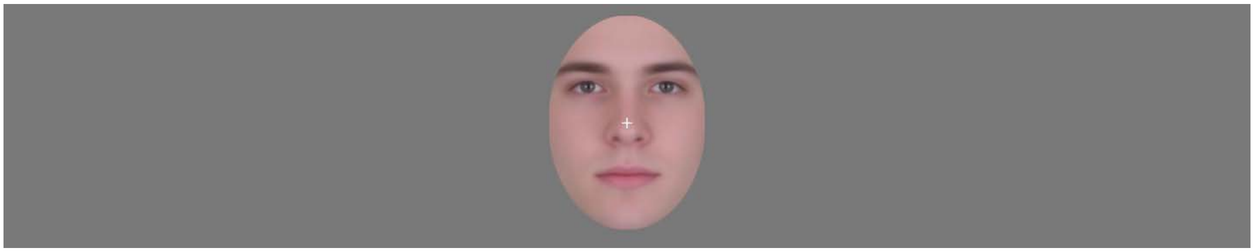

Figure 9. ***Experiment 1a: Male Face at Fixation***

The first condition shows a male face in the center behind the fixation point.

Figure 10.. ***Experiment 1a: Female Faces in the Parafoveal Eccentricity***

These two faces are the standard female faces in the parafoveal eccentricity.

Figure 41. ***Experiment 1a: Male Faces in the Periphery***

This image shows two male faces in the peripheral condition.

Figure 12. ***Experiment 1a: Female Faces in the Far Periphery***

This image shows two female faces which are copies of one another, in the far-peripheral eccentricity.

D. Results

The data from the accuracy portion of the study was accumulated and calculated using a 2x4 ANOVA. The variables for this ANOVA included Face Gender and Eccentricity. The main effect for face gender was calculated to be $F_{1,9} = 1.772$, $p = .216$, $\eta\rho^2 = .164$. The Face Gender main effect showed no significance according to the p value calculated. The eccentricity main effect was calculated at $F_{3,7} = 7.244$, $p = .015$, $\eta\rho^2 = .756$ which distinguishes the difference of accuracy between conditions. The p-value calculated showed significance between eccentricity levels. In order to measure the correlation between face gender and eccentricity a main effect interaction was calculated at $F_{3,7} = 1.193$, $p = .38$, $\eta\rho^2 = .338$, showing no significance. Three planned pairwise comparisons were conducted via Bonferroni correction with a critical alpha equalling .017 and a 2 tailed t-test was used to compare significance between eccentricity levels. Between the two conditions of 0 degrees to 8.64 degrees (foveal to parafoveal) the t-test results are as follows $t_9 = -2.768$, $p = .022$, $d = .785$. Next, the accuracy between 8.64 and 19.44 degrees were calculated to be $t_9 = 2.317$, $p = .046$, $d = .862$. Lastly, the 19.44 degree to 30.24 degree showed significance in accuracy with results of $t_9 = -3.401$, $p = .008$, $d = 1.07$. The gender strength association with eccentricity is exhibited in Figure 13.

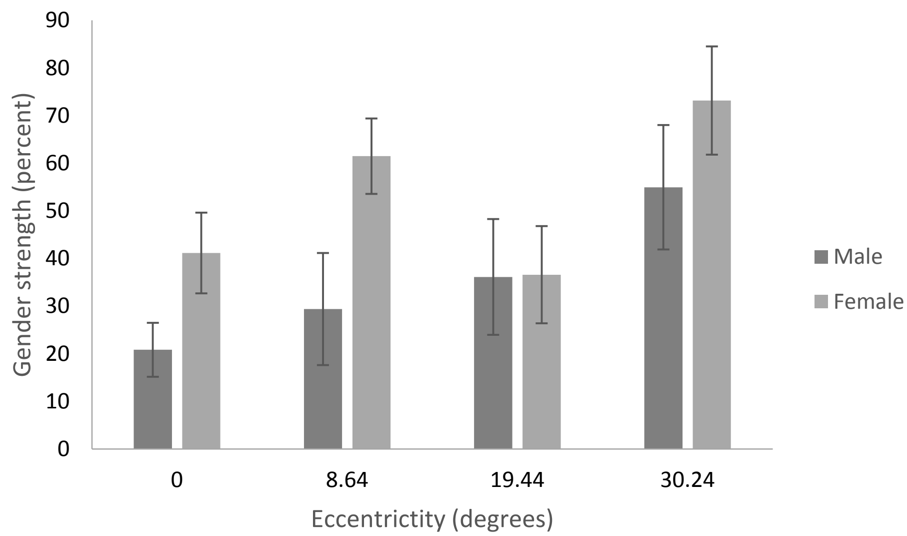

*Figure 13.. **Experiment 1a: Results***

This figure shows the average levels of accuracy in gender determination from the participants. The y-axis shows the gender strength with an 80% threshold. The increasing levels show increasing gender strength. The y-axis shows eccentricity levels.

E. Discussion

According to the Face Gender main effect calculated using the ANOVA, there is no significance between judgments between male of female faces. The average indicates that participants are equally accurate in determining the difference between the two genders. The eccentricity main effect showed significance indicating that across both genders, the accuracy between eccentricity levels does vary. The main effect calculated for face gender interacting with eccentricity showed no significance exhibiting that male vs. female faces is consistent across eccentricity levels. T-test results comparing the significance between eccentricity levels showed no significance between 0 and 8.64 degrees. In addition, the comparison between 8.64 and 19.44 degrees, also showed no significance, supporting the consistency across peripheral levels. The eccentricity levels of 19.44 and 30.24 degrees was counted significant showing the difference between both peripheral levels. As of this data we witness a decline of vision in the peripheries which has been a consistent in previous studies. We see that most stimuli in motion are accurately witnessed in the peripheries, yet spatial acuity declines (Thibos, et al. 1987). Foveal vision is required in most tasks that require a type of focus, such as reading or writing. Face perception does decline as you extend the task in the peripheries.

IV. Experiment 1b: Foveal Biases on Peripheral Face Perception

A. Overview

Foveal biases on peripheral face perception ties in directly with the face discrimination experiment. In this experiment, we are not concerned about accuracy, but more concerned on the effect that the center face has on the side faces. Since there will always be a face in fixation, this experiment is only measuring the effect in three different eccentricities. Is the appearance of a face in the periphery biased by the face we at fixation?

B. Procedure

The fixation aspect of this study is performed with 3 different conditions: foveal, parafoveal, and peripheral. In the foveal condition, there is a face in the center of the fixation cross and is surrounded by two faces on the sides which are exact copies of one another. The task asked the participant to distinguish whether the faces on the sides appear male or female. In the parafoveal setting, the faces are at 8.64 degrees from the foveal, fixation point. The peripheral conditions are at 19.44 degrees and 30.24 degrees from fixation. 30.24 degrees is considered to be an extreme version of the peripheral condition.

In order to analyze and compare results for both fixation and surround experiments, the Points of Subject Equality (PSE) are analyzed in the data. The Points of Subject equality indicates when the stimulus presented from the study is equivalent to the standard stimuli used as a reference. The Points of Subject Equality are also used for the surround experiment since they are presented with background faces. The higher the percentage of PSE indicates that there is a greater contribution from the female face in order for the participant to see it as androgynous.

C. Stimuli

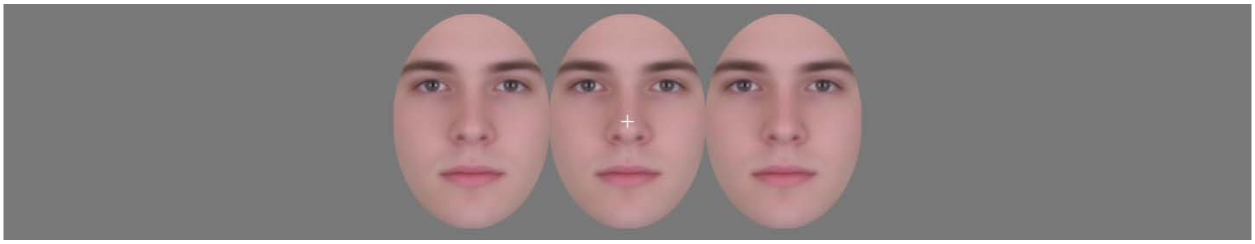

Figure 14. ***Experiment 1b: Male Faces in the Parafoveal Eccentricity***

The fixation experiment requires analysis of 3 different eccentricities. This image exhibits the parafoveal eccentricity with a standard male face at fixation, and two copies of the standard male face in the surround.

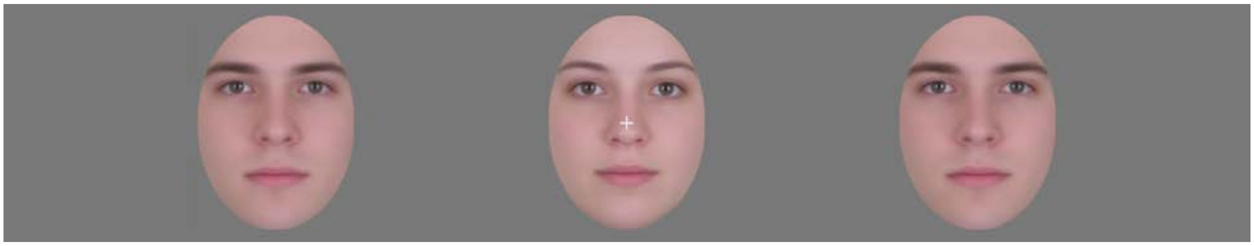

Figure 15. ***Experiment 1b: Female Face at Fixation with Male Faces in the Periphery***

This image shows a female face at fixation, and two male faces in the peripheral eccentricity.

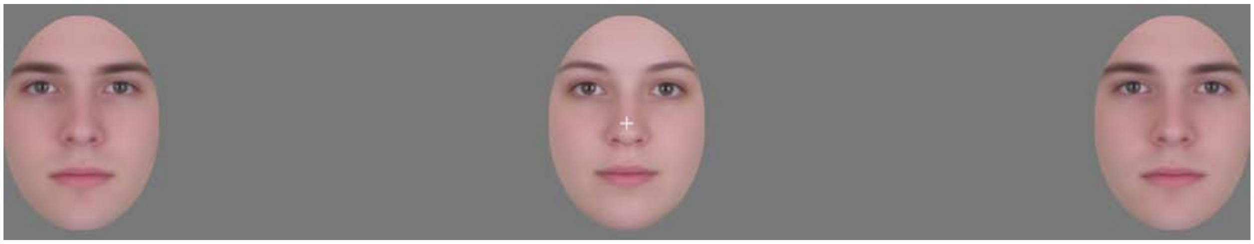

Figure 16. ***Experiment 1b: Female Face at Fixation with Male Faces in the Far Periphery***

This image is the most extreme condition in this experiment. It shows a female face at fixation and two male faces in the far periphery.

D. Results

In order to examine data collected from the fixation experiment, a 2x3 ANOVA was used to calculate the variables of face gender and eccentricity. With regards to the face gender, across eccentricity levels, there is no significance in gender fixation. This translates to the lack of an effect of the central (foveal) face at fixation towards the peripheral faces. The data observed for this effect are as follows: $F_{1,9}$ = 2.888, p = .123, ηρ² = .243. The eccentricity effect was also proven insignificant showing that there is no particular bias with participants deciding whether a face is male or female, regardless of what the gender is of the central face. When face gender and eccentricity interact, there also is no significance in the accuracy for male faces compared to female faces in all eccentricity levels as concluded from the data $F_{2,8}$ = 1.169, p = .359, ηρ² = .226. After a three planned pairwise comparison, in terms of the critical alpha of .017, a 2 tailed t-test was used to further analyse the significance between eccentricities. At the eccentricity of 8.64 degrees, or parafoveal vision, there is no significance on perceived gender at this eccentricity level due to the fact that the p value is not below the alpha value of .017 t_9 = .466, p = .652, d = .189. Furthermore, the eccentricity value of 19.44 degrees is also insignificant since there is a consistency with judgment of fixation gender across eccentricity levels. Lastly, the eccentricity level of 30.24 degrees shows significance for fixation of gender. Participants showed that there is an effect on perceived gender at this eccentricity level.

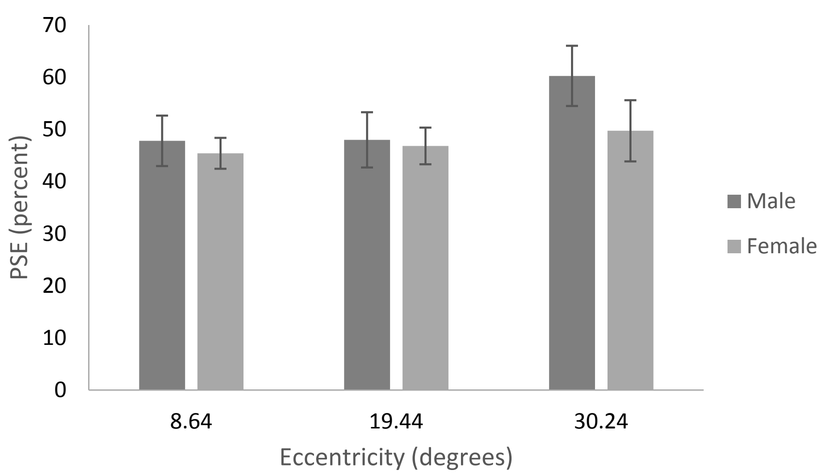

Figure 17. **Experiment 1b: Results**

These results exhibit the mean Point of Subject Equality (PSE) for the faces at various eccentricity levels. The y-axis shows the contribution from the female face in order for the face to appear androgynous. The X-axis shows the three eccentricities.

E. Discussion

After determining face gender main effect in the fixation section of the study, the calculations showed no particular significance. We see that across all eccentricity levels there is no fixation effect. Gender does not have a particular effect, whether the center face is male or female, on the perceived gender of the outside faces. The insignificance of the eccentricity main effect exhibits that there is no bias between the judgment of a face being male of female, regardless of fixation across eccentricity levels. Between face gender and eccentricity, the interaction also showed no significance further exhibiting the consistency for determining male vs female across all eccentricity levels.

The t-test results for each of the eccentricity levels 8.64, 19.44, and 30.24 (parafoveal, peripheral, far-peripheral). The first eccentricity level of 8.64 showed no significance showing that there is no effect on the perceived gender of faces at this level. Next, the eccentricity level of 19.44 also showed no significance of fixation gender in this level. Lastly, the last eccentricity level of 30.24 showed a significant effect on the perceived gender.

The results indicate that vision is not an exact record of acquired findings or data collection. Vision fluctuates depending on surrounding stimuli and possible distractions that can affect the view of an object. It is an active process that can be supported by the idea of the contrasts effect similar to the Ebbinghaus illusion (Roberts et. al., 2004). Any aspect of the visual field can affect the perception of another in that same visual field. Face perception, more specifically, is also an active process due to the collection of features that is integrated into the brain for processing. A stimulus in the foveal point of view can be given a lot of importance as opposed to the periphery, which in turn shows that a higher level of brain processing is required for facial perception. The face in the fovea is quite clear which influences outside faces to look similar and assimilate themselves to the outside faces.

V. Experiment 2: Simultaneous Contrast or Assimilation in Face Perception

A. Overview

As discussed in the previous sections, we see that contrast and assimilation effects may influence the appearance of faces. It's important to see how the background can affect the face at fixation (center). In this experiment, we did not measure the accuracy in which the participant was able to identify the gender of the face at fixation, rather we want to see how the surrounding faces affects their decision in deciding if it's male or female. Is the face you are fixating on affected by the characteristics of the surrounding faces or vice versa?

B. Procedure

The surround condition is presented with one face at fixation and 8 surrounding faces that are strictly copies of one another. These faces are always showed constantly in the foveal 0 degrees of fixation for about 1-2 seconds. These faces will eventually become androgynous depending on the responses of participants. The Points of Subject Equality was also taken into account in order to compare the responses from the original "average" stimuli.

C. Stimuli

The stimuli for Experiment 2: Simultaneous Contrast or Assimilation in Face Perception consisted of the standard faces artificially created on the FaceGen program. There is a face at fixation and 8 different faces in the surround. Multiple combinations can result in this formatting. For instance, you may have an androgynous face in the center, while it is surrounded by male faces (Figure 18). You may also have an androgynous face with a female surround as shown in Figure 19.

Figure 18. ***Experiment 2: Male Surround***

This image shows an androgynous face in the center, while surrounded by male faces.

Figure 19. ***Experiment 2: Female Surround***

This image is an example of an androgynous face at fixation, surrounded by female faces.

D. Results

After conducting a 2 tailed t-test for the samples the gender of the surrounding faces did not show any significance. The face that appeared in the foveal vision at fixation does not affect the response for the gender of the surrounding faces as shown in the data set $t_9 = .785$, $p = .453$, $d = .454$. The p-value for this set must be less than or equal to p=.05 in order to be significant.

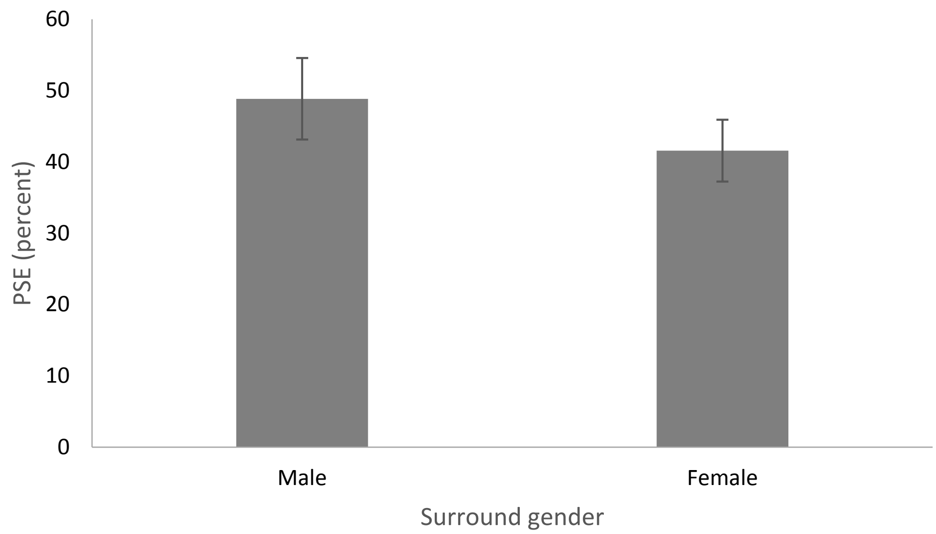

Figure 20. ***Experiment 2: Results***

These results show the mean of responses for the surround condition which tests for the gender at fixation. The y-axis indicates the PSE values, which show the contribution for female face to appear androgynous. X-axis is for surround gender.

E. Discussion

The results show that there is no significance with the surrounding faces affecting the gender of the central face. The face at fixation does not necessarily influence the judgment of each participant regardless of whether the central face is male or female. It's interesting to witness the lack of significance since simultaneous contrast effects have been studied vigorously. Most stimuli show a clear effect, but with regards to faces the lack of significance is particularly interesting. As with the contrast effects of fixation, we can conclude that face processing requires a higher level of recognition, which could generally be a reason why these contrast effects do not occur in facial perception (Kanwisher et. Al., 2006).

VI. Conclusion

Face perception is open to influences and can vary depending on different contexts. The experiment showed that face perception is influenced by contexts in the surround. As discussed in the introduction, face perception is also open to extraneous influences. The instability of facial perception further supports the idea the complexity of facial perception in human brain processing. Although we did not see a contrast effect, we did witness that faces are able to become assimilated into a new background. Furthermore, holistic processing impacts the identification of faces since the entire face is analyzed prior to making a decision. Assimilation effects suggests that these areas comprise a different set of underlying mechanisms.

Face perception varies depending on where your vision is fixated. In Experiment 1a: Face Discrimination in the Fovea vs. Periphery, we witnessed an effect in eccentricity levels. The eccentricity level significance supports the idea that visual acuity declines in the peripheries, and this is also evident in facial perception. From the data, we can conclude that facial perception is not strictly a foveal task. Individuals are still able to recognize faces in the periphery, yet there is a decline in visual acuity. The data from Experiment 2 shows us that faces lack contrast effects. The lack of contrast effects distinguishes faces from any other visual stimuli, discussed in the introduction. This further supports the idea that there is a unique brain processing involved in facial perception.

There are certain limitations to this study that could have been improved in order to receive accurate and/or significant results. It’s possible to get a new significance if the participant size was increased. In addition, the trial set of 60 images could have been reduced in order to receive better feedback. Most participants found experiment 1 very long and felt that their eyes grew weary in the middle of the experiment.

Future research that can be developed from this experiment is the use of a another variable, aside from gender. This experiment can be duplicated with the use of age or even ethnicity. Facial perception is crucial in analyzing brain function and as well as social concepts. We use facial recognition on a daily basis in order to communicate with one another. Perception of faces in the peripheries also play a role in eyewitness accounts in certain court cases or crimes. The complexity of facial perception, if analyzed, can be completely mastered with future research and the development of new technology.

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Experiment Description

Overview

"This experiment will show computer generated faces and you will be asked to judge whether they are male or female. The experiment will take approximately an hour and will not have any risks beyond what watching television would be associated with. If you decide to participate, you may withdraw from further participation in the research at any time without reason or consequence."

Full Experiment Instructions

Experiment 1a: Face Discrimination in the Fovea vs Periphery

"There will be a fixation cross in the center of the screen with either a face directly behind it or two faces on both sides. These faces are simply copies of one another. The faces will flash on the screen for one second and you are to judge whether they appear male or female. Using the mouse, you will click left for male and right for female. In order for the response to register, you must wait until after the faces disappear, until you make your decisions. The faces will become difficult as you progress trials. The gender of the face will become less obvious. It's important to stay focus and avoid moving your gaze to the side faces. We will do 4 trials with 60 faces per trial. Do you have any questions?"

Experiment 1b: Foveal Biases on Peripheral Face Perception

"In this experiment, you must focus your attention and gaze to the fixation cross in the center of the screen. There will be a face in the center of the fixation cross, as well as two faces next to the central face. These faces are copies of one another. The faces will flash on the screen for one second. You must focus your gaze on the center of the screen, but judge the faces next to the central face. If the side faces appear male, click the left mouse button. If they look female, you must click the right. Respond immediately after the faces have left the screen. If the screen goes blank, click again with the same response. There will be eight trials that are going to be 3 minutes each. Do you have any questions?"

Experiment 2: Simultaneous Contrast or Assimilation in Face Perception

"This experiment will have a fixation cross in the center of the screen with a face behind it. There will be 8 faces surrounding the central face. These faces will flash up on the screen together, for 1 second. You must judge whether the central face is male or female. Click the left button if it looks male. Click the right button if it looks female. Wait until the faces disappear to make your response. The face gender will eventually become less obvious in the later trials. Focus your gaze on the center face and avoid looking at the surrounding faces. Do you have any questions?