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Facial Recognition as it relates to the obstruction of Holistic Processing by Partial Occlusion

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Department of Psychology

By

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ABSTRACT

Facial recognition is an important cognitive function in communication and is how we process, remember, and recall facial information. Research concerning processing styles and their effects on facial recognition accuracy is a prominent subject within the field of cognitive psychology. Holistic processing and featural processing have been experimentally manipulated in various ways with an aim to determine which of these processing styles would aid with accurate recognition. The current study is a replication of a previous study that examined the effects of masks on face information processing and recognition. This study assesses the effects of partial occlusion on face information processing and how these obstructions may affect recognition accuracy. Occlusion and orientation were manipulated in face stimuli during the learning phase of the experiment. This was followed by a test phase that presented a combination of familiar faces from the learning phase and novel faces and required an indication of whether or not those faces were recognizable. The analysis of the data indicated higher recognition accuracy scores when faces were upright than inverted, and higher accuracy scores for when faces were unoccluded than when an occluder was present. This indicated that when holistic processing is obstructed and featural processing was adopted instead, face recognition scores decreased.
Keywords: facial recognition, facial processing, holistic processing, featural processing, partial occlusion, visual attention

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Facial Recognition as it relates to the obstruction of Holistic Processing by Partial Occlusion

Facial recognition is a relatively broad term that describes the ability to retrieve familiar facial information from memory previously encoded through perception and use it to identify an individual (Bruce & Young, 1986). The ability to recognize familiar and unfamiliar faces is a vital mechanism that has ensured the survival of many different species. Facial recognition primarily depends on the brain's ability to efficiently process facial information without any obstructions and retrieve encoded information from memory (Bate et al., 2010). The importance of face-based research is explored in a variety of interdisciplinary fields such as psychology, cognitive science, neuroscience, artificial intelligence, and computer science. These research findings are often applied in industries such as law enforcement and medicine (Zhao et al., 2003). Evolutionary perspectives of facial processing and recognition research indicate the importance of facial information in survival (Burke & Sulikowski, 2013). Likewise, developmental studies indicate the importance of understanding differences in recognition patterns with aging (Nakabayashi & Liu, 2014).

For recognition to occur, initial processing and encoding of facial information are required. Like recognition, facial processing mechanisms remain a prominently researched topic, prompting the operationalization of multiple processing-related terminologies such as holistic processing and featural processing. Holistic processing, which was first identified by Galton (1883) refers to the processing of facial information globally as a complete whole, or as a gestalt (Galton, 1883; Zhao et al., 2003; Tanaka & Simonyi, 2016; de Heering et al., 2007; Richler et al., 2012). In other words, holistic processing occurs when facial information such as facial features and spatial distances are processed and encoded concurrently without a focus on individual characteristics. A variety of studies have demonstrated this phenomenon in laboratory and real-life settings and have indicated the importance of holistic processing for better facial recognition (Davidoff & Donnelly, 1990; Farah et al., 1998; Goffaux & Rossion, 2006; Hole, 1994; Homa et al., 1976; Sergent, 1984; Tanaka & Farah, 1993; Young et al., 1987). Featural processing, which is also referred to as analytic processing, componential processing, and piecemeal processing, refers to the processing of individual featural information, where individual features remain the focal point. Featural processing takes into consideration individual characteristics such as the shape and size of features, facial contours, spatial distances, and eye colors. Through the featural processing mechanism, distinct facial features may be used to aid in the retrieval and recognition of facial information (Zhao et al., 2003; Tanaka & Simonyi, 2016; de Heering et al., 2007; Richler et al., 2012).

A variety of studies have been conducted to better understand the difference between holistic and featural processing. Experimental designs focusing on holistic processing and its importance for facial recognition generally consist of the observation of manipulated and/or controlled facial stimuli followed by recognition tasks. Recognition scores of manipulated and/or controlled facial stimuli reveal how holistic processing leads to better facial recognition. For example, a study conducted by Tanaka and Farah (1993) examined how individual features, whole faces, and scrambled featured faces would influence recognition scores. Their results indicated that observing whole, uncovered faces resulted in better recognition scores than observing scrambled featured faces or individual features. Additionally, some research designs employ the composite task which involves matching two separate faces and combining them into one. By manipulating the orientation of the face or facial features, researchers have been able to assess facial processing mechanisms and recognition patterns (Tanaka & Simonyi, 2016).

Eye-tracking technologies also contribute to this research literature. The use of eye-tracking technology allows for measurements in eye movement and fixation points which reveal how faces are processed and recognized (Bombari et al., 2009). For example, Bombari et al. (2009), through their study using eye-tracking software, found that when participants processed faces holistically there was less eye movement than when they processed faces featurally.

Disruptions to Facial Processing

Artificial and natural barriers to facial processing disrupt processing mechanisms, which makes encoding and recognition of facial information challenging. Neurological conditions that prevent the observer from processing information, cultural or religious clothing that covers portions of the face, and disguises such as masks and scarves are examples of disruptions to facial processing. Recently, the use of face coverings due to COVID-19 has changed how face-to-face interactions occur which may also disrupt facial processing and recognition.

From a medical perspective, research assessing conditions such as congenital prosopagnosia and acquired prosopagnosia, which are conditions defined by a deficit in holistic processing abilities due to impairments in brain functions, indicates that those who are affected have significantly lower recognition abilities. (Le Grand et al., 2006; Lane et al., 2018). Additionally, age-macular degeneration, a condition that affects the retina and causes blurred and distorted vision, leads to a deficit in processing which impacts and decreases facial recognition abilities (Lane et al., 2018). People who have decreased facial processing and recognition abilities as a result of these conditions have a lower quality of life due to its effects on social interactions. This demonstrates that the investigation of facial recognition and processing mechanisms has real-life applications. Facial processing, whether holistic or featural, precedes facial recognition. In order to retain information that can be retrievable during recognition, undisrupted facial processing is necessary (Tanaka & Farah, 1993).

A study by Kret and De Gelder (2012) observed that cultural clothing disrupts facial processing related to emotional cue recognition. This is especially prevalent with the religious headwear of Muslim women, which correlates with a negative judgment bias. Traditionally, Muslim women wear religious clothing that covers their heads and parts of their faces, sometimes only showing their eyes. The researchers conducted a series of three experiments to assess if emotions are perceived when only the eyes are visible and if those perceptions are affected by social cues. For their first experiment, the researchers assessed the extent to which emotions would be processed and recognized when only the eyes are visible. Participants viewed full faces and faces with burkas or niqabs and attempted to recognize a variety of emotions such as happiness, sadness, fear, and anger. Through a forced-choice format, participants were required to view the stimuli and match the relevant emotions. The results indicated that participants performed better in recognizing fear and anger than they did in happiness and sadness. Also, the results indicated that it was much more difficult to recognize the emotions of those who were wearing the burkas than in the other two conditions (full faces and faces with burkas). When compared with non-religious face coverings (cap and scarf), the results indicated that religious clothing tended to be less associated with happiness, whereas it was much more associated with the scarf/cap stimuli. Although this example does not directly relate to facial processing and recognition abilities, it indicates the significant impact that disruptions such as partial occlusion can have on how facial information is processed.

Dhamecha et al. (2014) assessed how various disguises disrupted facial processing. They used disruptors such as masks, sunglasses, mustaches, scarves, turbans, and wigs to assess if those who viewed familiar partially occluded faces would have higher or lower recognition abilities than those who viewed unfamiliar partially occluded faces. They discovered that those who viewed familiar faces performed better and that disguises covering the lower areas of the face such as the chin, mouth, and nose led to much lower levels of recognition than other types of disguises. In their analysis of undisguised faces versus variously disguised faces, they found that those who viewed undisguised faces had higher recognition scores than those who viewed disguised faces. Similarly, Noyes and Jenkins (2019) assessed the impact of disguise disruptors, specifically evasion (disguising to hide one's identity) and impersonation (disguising oneself as another) on accurate facial recognition. After a series of three experiments that allowed participants to view disguised faces and complete a face-matching task, the results indicated that participants were challenged when matching disguised faces. It also indicated that the evasion technique had significantly lower recognition scores than the impersonation technique.

The above examples indicate the nature of previous research in the field of partially occluded facial processing and recognition. However, recent global events following the surge of the COVID-19 pandemic have initiated new ways of interaction for most countries around the world. Wearing face coverings such as surgical, medical, or cloth masks has become prevalent over the past year, initiating the availability of obstruction for face-to-face interactions (cdc.gov). This has led to a surge in research regarding how partial occlusion affects daily interactions, facial processing, and facial recognition (Freud et al., 2020; Carragher & Hancock, 2020). For example, Freud et al. (2020) explored this relationship and predicted that those who observe masked faces would have lower facial recognition abilities than those who observed uncovered faces. To measure facial recognition abilities, the researchers used the CFMT (Cambridge Face Memory Test), through which participants observed and recognized either whole or masked faces. This first experiment was also accompanied by the inclusion of upright and inverted faces, which was used to evaluate how the face inversion effect would impact holistic processing and facial recognition. Previous research surrounding the face inversion effect (difficulty in recognizing inverted faces) suggests that holistic processing is disrupted when faces are inverted as holistic processing is orientation sensitive (Farah et al., 1995). This disruption occurs because the mouth region of the face contributes toward holistic processing more than the eye region of the face (Freud et al., 2020). Additionally, research in this area has suggested that in the presence of inverted faces, featural processing is adopted instead of holistic processing (Freud et al., 2020). An inversion effect was detected in all conditions of the experiment suggesting the adoption of featural processing or the disruption of holistic processing led to poorer recognition scores. Their second experiment only introduced masked faces in one of the phases of the CFMT to allow participants to familiarize themselves with the stimuli. However, the results of this experiment also indicated that those who viewed masked faces had poorer recognition scores than those who viewed uncovered faces. The predictions of the researchers were supported by the results, demonstrating that partially occluded faces affect holistic processing and lead to a deficit in recognition abilities.

Similarly, Carragher and Hancock (2020) evaluated how partial occlusion affected recognition. The researchers in this study assessed the effects surgical face masks have on facial recognition through a series of face matching tasks on human facial recognition skills. They predicted that when presented with the masked condition (both stimuli masked), participants exhibited decreased abilities in recognition, as opposed to the participants in the control condition (both stimuli unmasked) and mixed condition (one stimulus masked and the other unmasked). Within this experiment, the researchers also attempted to assess the factor of familiarity and whether that would affect the participant's performance. The researchers used the Glasgow Face Matching Test (GFMT) and the Stirling Famous Face Matching Test (SFFMT), followed by a recognition test. The results indicated that impairment in face-matching existed in those who were either in the mixed or masked conditions demonstrating the implications of face coverings and how the lack of a holistic view of the face has a legitimate impact on recognition abilities.

The findings in these studies indicate that there is an established relationship between facial processing and recognition. Accurate recognition requires the processing and encoding of facial information. Disruptions, specifically those that partially occlude the face, limit facial processing, which leads to lower levels of facial recognition. In instances when featural processing is adopted due to orientation manipulations or partial occlusions to the face, recognition scores decrease indicating that holistic processing is better for accurate recognition.

How Holistic Processing is Experimentally Manipulated

The studies mentioned above demonstrate that facial recognition is better with holistic processing than featural processing. When orientation and occlusion are manipulated, and featural processing is adopted instead, recognition scores tend to decrease. Examining how experimental designs have assessed partial occlusion and its' disruption of facial processing and recognition abilities is necessary to understand the common approaches employed in this field of research. One of the most common experimental designs used in assessing disruptions to holistic processing involves the part-whole task (Richler et al., 2011). The main purpose of this methodology is to assess recognition levels of individual features in the context of either isolated features or whole faces (Tanaka & Farrah, 1993). This relates to partial occlusion in that, when isolated features are presented, it is in essence partially occluding other facial features. Another design approach is to present individual features such as the eyes, a whole face, or faces with scrambled features followed by a forced-choice recognition task. The assumption behind this method is that the recognition scores of individual features would indicate the difference in processing facial information when the whole face is presented versus when individual features are presented. Additionally, these conditions could be further manipulated. For example, Tanaka and Farrah (1993) incorporated inverted stimuli to assess if there would be differences in recognition scores depending on orientation given that the inversion effect has been associated with an obstruction to holistic processing (Farah et al., 1995). In measuring holistic and/or featural processing, researchers associate higher levels of recognition in either the whole face or individual features. If whole faces had higher recognition scores, holistic processing would be evident. If individual features had higher recognition scores, featural processing would be evident.

As mentioned, the part-whole task could be utilized for partial occlusion experiments. For example, previously explained studies by Freud et al. (2020) and Carragher and Hancock (2020) demonstrated that occluding parts of the face, which allow for only one or two features to be visible, leads to decreased recognition scores due to a lack of holistic processing. Freud et al., (2020) also utilized the inversion effect to examine if holistic processing was in fact obstructed and found results that indicated that it did. Similarly, Pellicano and Rhodes (2003) examined the differences between processing styles in children compared to adults and incorporated partial occlusion for their experiment. The manipulated facial stimuli consisted of only certain facial features being available for view as opposed to the whole face condition. They also tested the inversion effect as it relates to a decrease in holistic processing and an adoption of featural processing to examine how holistic processing would be disrupted within the context of children's recognition abilities. They found that children switch from featural processing to holistic processing at a certain age.

Another common methodology used in this field is the face composite task. As previously described, the composite task combines two halves of separate facial stimuli into one in order to create a whole stimulus (Tanaka & Simonyi, 2016). These are then manipulated in many ways depending on the goal of the researcher. For example, intact composite faces, inverted composite faces, or misaligned composite faces have been used to identify whether holistic processing occurs (Tanaka & Simonyi, 2016). By using these manipulations, researchers are able to instruct participants to ignore one half of the face and remember the other. Depending on the manipulation, researchers are able to identify if intact faces are more challenging to recognize due to the interference of holistic processing and if it is easier to recognize misaligned faces due to a lack of holistic processing (Young et al., 1987). These studies also incorporate the inversion task as it allows for a better understanding of whether or not holistic processing occurs.

The use of eye-tracking software in experimental designs has also become prevalent in recent studies to assess facial processing and recognition. For example, Bombari et al. (2009) examined the dual-code view, which refers to faces being processed both featurally and holistically depending on the context. Their study found that differences in eye movements such as saccades (rapid eye movement between fixation points) could be observed when face stimuli were manipulated in different ways (eg: blurred faces, intact whole faces, scrambled features). They also observed that depending on the type of manipulation, there were differences in fixation points on the face. When assessing how eye movements would differ according to the amount of information presented, they observed that when more information was present, as in when whole intact faces were presented, fixations tended to be on the center area of the face suggesting a more holistic approach adopted when undisrupted faces are present. They conclude that these processing mechanisms co-exist depending on the context in which we observe faces. However, it is important to note that these processing styles, both holistic and featural, differ in their ability to contribute toward accurate recognition. These findings also demonstrate the importance of eye-movement information to distinguish processing mechanisms. Similarly, Miellet et al. (2013) looked at crosscultural aspects of holistic and featural processing in relation to eye-movement tracking. Through measurements such as fixation points and saccades, researchers were able to observe cultural differences in how facial information is processed. Certain cultures tended to fixate on certain portions of the face more than others demonstrating a cultural preference for holistic vs. featural processing. This too demonstrates the benefit of utilizing eye-tracking software in research involving facial processing and recognition.

These studies indicate that the use of eye-trackers in experimental designs provides for a more robust examination of facial processing and recognition. Fixation points, saccades, and movement patterns can be easily distinguished using eye-tracking software in order to measure differences between processing mechanisms and recognition. A common theme amongst the findings of these studies is that when faces are holistically processed eye movements seem to fixate in the middle to lower region of the face, which is consistent with the face inversion effect as well. Additionally, studies demonstrate that there are fewer saccades with holistic processing than featural processing. When attempting to assess how holistic processing is obstructed with partially occluded faces, using eye-tracking software allows to quantitatively measure these aspects. Through this, it will be possible to distinguish if holistic processing is obstructed when faces are partially occluded and if recognition scores differ for uncovered versus partially occluded stimuli. Most eye-tracking software allows for recording reactions and behavioral patterns, which, as previously described studies indicate, allow for a vast amount of information to be collected.

The Current Study

Facial recognition and processing research contribute in many ways toward the understanding of human behavior and many other interdisciplinary fields. We learn an immense amount of information from face-to-face interactions that assist us in our daily lives. Facial recognition requires the processing and encoding of information. Facial processing and its relationship to facial recognition have been a well-researched topic that has established different styles of processing. Holistic processing and featural processing and how much it contributes to accurate facial recognition can be observed within this body of research. While debates surrounding the nature of these processing techniques persist, the common consensus is that holistic processing allows for better facial recognition. This can be observed in many real-life situations like those that affect neurological processes that disrupt holistic processing, and in other instances where facial stimuli are manipulated. Studies that involve partially occluding facial stimuli in some way have also indicated that when holistic processing is disrupted, facial recognition abilities tend to decrease. Experimental manipulations such as the composite task, inversion effect, and the part-whole task have allowed researchers to understand the relationship between holistic processing and facial recognition better. In addition, eye-tracking software has allowed researchers to understand how eye movements differ with different processing styles. Recent global events that have encouraged wearing face coverings have redefined how we interact with each other. Since communicating with partially occluded faces disrupts processing and decreases recognition abilities, assessing this phenomenon further helps researchers understand the nature of processing and recognition.

Researchers have used face-covering masks as a manipulation to assess how partial occlusion leads to disruptions in holistic processing and facial recognition in recent times. However, there remains room to assess how eye movements differ in holistic and featural processing with masked faces. Also, there are many debates surrounding the nature of face-based research involving processing and recognition and therefore a certain degree of uncertainty regarding findings. Replicating previous research to assess how partially occluded faces lead to a disruption of holistic processing, therefore, leading to a reduction in facial recognition helps add to the existing body of knowledge. The goal of this study is to assess how the presence of an occluder that blocks certain facial features affects holistic processing and if that decreases facial recognition scores. The prediction for this study is that participants will perform better at recognizing uncovered faces than partially occluded faces. Additionally, participants will perform better at recognizing faces that will be presented upright than inverted.

Method

Participants

Participants were 59 undergraduate students (22 male, 37 female) between the ages of 18-26 ($M = 21.29$, $SD = 2.49$). All participants were students enrolled in Psychology courses at Georgia Southern University. Recruitment was facilitated via a participant recruitment software (SONA). All participants received course credit upon completion of the study and all participants provided signed informed consent prior to participation.

Apparatus

To conduct this study a desktop computer connected to a Tobii TX-300 eye-tracking device was used. This allowed for the collection of eye movement and fixation point data. The desktop computer is equipped with a 22' LCD screen that records x- and y- gaze coordinates, screen to eye distances, saccades, and pupil diameter. In order to interact with this device, participants were required to sit in a cubicle within the study area. For stimulus presentation and data collection E-Prime software (Psychology Software Tools, Pittsburgh, PA) was used. Participants clicked keys on a keyboard to respond to prompts within the study.

Stimuli

The stimuli were adapted from the Chicago Face Database (Ma et al., 2015). Races found within this database include self-identified Asian, Black, Latino, White, Mixed-Race individuals collected from the US and Indian individuals collected from India. The current study made use of images of faces identified as Asian, Black, Latino, and White. Both male and female facial stimuli were used. All images had the same dimensions (2444x1718 pixels) and were of neutral facial expressions. Additionally, all individuals within the stimuli were dressed in the same neutral color and are placed before a white background. For partial occlusion trials, a black rectangular box was placed over the eyes or mouth region of the face image. Examples of these stimuli are represented in Figure 1.

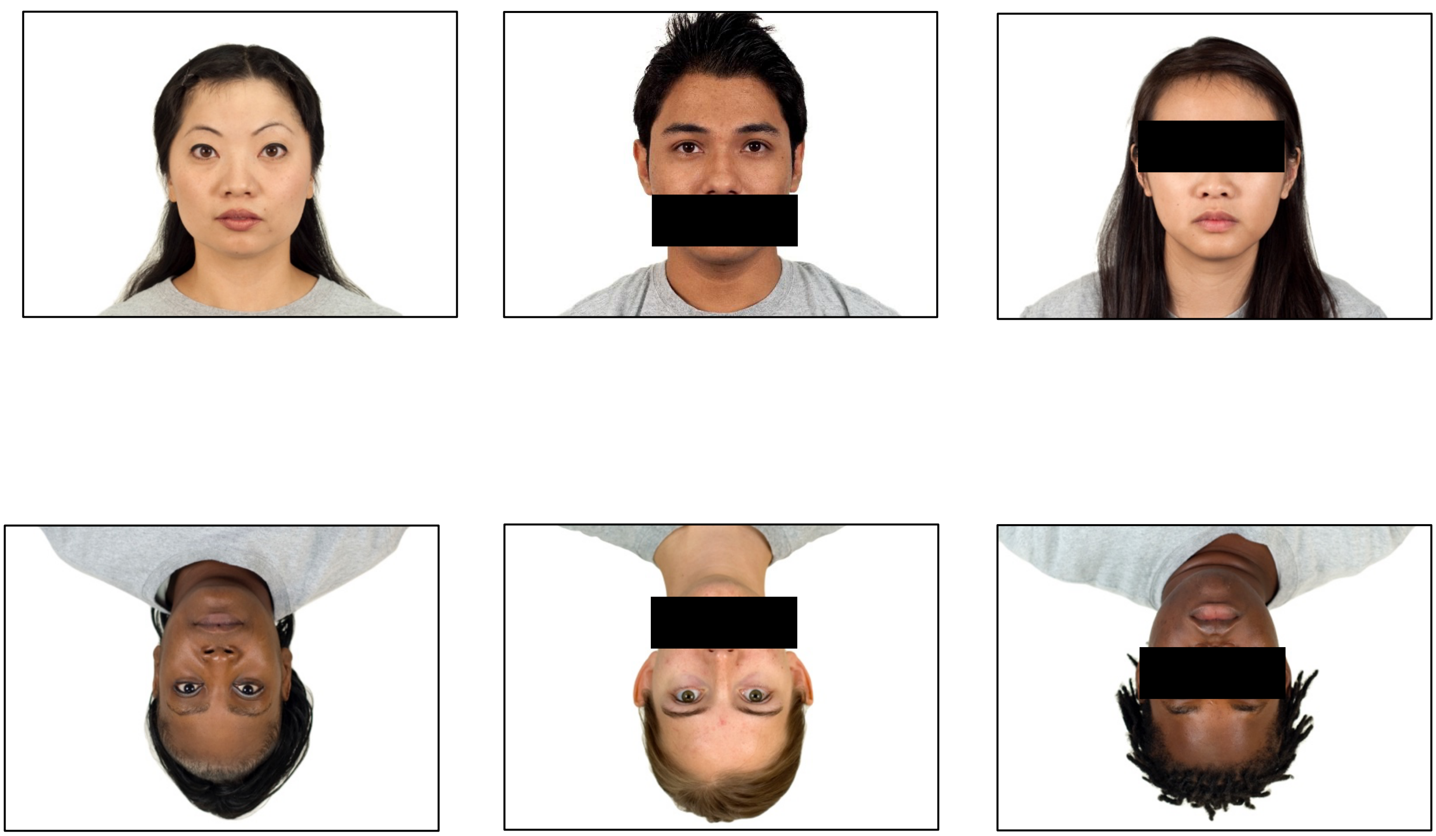
Procedure

Upon entering the research lab, participants were notified that they would be participating in a computerized study conducted in front of an eye-tracking device while responding to certain prompts using keys on a keyboard. After being seated at an appropriate distance from the eye-tracking monitor, the eye-tracking system was calibrated to their eyes. Calibration involved following the movements of a red circle around the computer screen. Following calibration, participants were given instructions about the experiment and were told that they would be completing a practice trial in order to familiarize themselves with the nature of the experiment. The practice trial involved a learning phase which was a sequential display of two cartoon characters for five seconds each followed by a brief break of five seconds which was then followed by a test phase. The test phase consisted of the display of the cartoon characters shown during the learning phase and two other novel cartoon character faces, which appeared on the screen one after the other. Participants were required to press 1 on the keyboard if they recognized the face from the learning phase and 2 if they did not. The responses were not time-restricted. Upon completion of the practice trials, participants proceeded to the learning phase of the first block of trials.

Participants completed two blocks of two types of learning phase trials; two blocks where the face image stimuli were presented in an upright orientation and two blocks where the face image stimuli were presented in a vertically inverted orientation. Participants were randomly assigned to complete these blocks of trials in one of two sequential orders, either upright-inverted-inverted-upright (ABBA) or inverted-upright-upright-inverted (BAAB). For each block, the face image stimuli presented during the test phase were always upright. Order group was a between-groups manipulation, while orientation and occlusion were within-groups manipulations. During the learning phase, participants were presented with a series of 9 faces for five seconds each for each of the four blocks, with the stimuli presented upright or inverted as described above. Within each block of upright and inverted trials of the learning phase, an occluding box overlaid the mouth region on three randomly selected trials and the eye region on three randomly selected trials. Following the learning phase within each block, participants took a 10-second break, which was followed by the test phase. The test phase displayed a total of 18 faces that included the faces displayed during the learning phase as well as nine novel faces that had not been presented during the learning phase. Upon the display of each face, participants were required to indicate whether or not they recognized the face by pressing the keys ‘1’ if they recognized or ‘2’ if they did not. There was no time limit imposed during the test phase. After completion of all four blocks, participants were debriefed and the intentions and nature of the study were explained to them.

Figure 1

Examples of face stimuli presented during the learning phase of the trials.



Results

Mixed Model ANOVA

The primary analysis was a 2 x 2 x 3 mixed model Analysis of Variance (ANOVA) with order group analyzed as a between-subjects factor, and stimulus orientation (Upright, Inverted) and occlusion (Mouth, Eyes, None) analyzed as repeated-measures. The analysis revealed a significant main effect for orientation, $F(1{,}56) = 63.59$, $p < .001$, $\eta_p^2 = .53$, with participants more accurately recognizing faces that had been presented upright during the learning phase ($M = .90$, $SEM = .01$) than those that had been presented inverted during the learning phase ($M = .74$, $SEM = .02$). The analysis also revealed a significant effect for occlusion, $F(2{,}112) = 20.91$, $p < .001$, $\eta_p^2 = .27$. Pairwise comparisons indicated that participants more accurately recognized faces (both $p < .001$) that had not been occluded during the learning phase ($M = .89$, $SEM = .01$) than when the mouth had been occluded ($M = .78$, $SEM = .02$) or the eyes had been occluded ($M = .78$, $SEM = .02$). There was no difference ($p = .77$) in recognition of faces that had been presented with an occluder over the mouth and those that had been presented with an occluder over the eyes. Additionally, the analysis indicated no significant effect for order group, $F(1{,}56) = .60$, $p = .442$, $\eta_p^2 = .01$, exhibiting no order effect. The analysis revealed a marginally significant interaction between orientation and order group, $F(1{,}56) = 3.78$, $p = .057$, $\eta_p^2 = .06$, which pairwise comparisons revealed was due to a slightly smaller difference in accuracy when stimuli were presented upright ($M = .89$, $SEM = .02$) than when inverted ($M = .77$, $SEM = .03$) for those in the ABBA order group, and a slightly larger difference in recognition accuracy between stimuli presented upright ($M = .90$, $SEM = .02$) and inverted ($M = .71$, $SEM = .03$) for those in the BAAB order group.

There were also no interactions between occlusion and order group $F(2{,}56) = .21$, $p = .80$, $\eta_p^2 = .00$, orientation and occlusion, $F(2{,}56) = .03$, $p = .97$, $\eta_p^2 = .00$, or orientation, occlusion, and order group, $F(2{,}56) = 1.08$, $p = .34$, $\eta_p^2 = .02$.

A secondary 2 x 2 x 2 mixed model ANOVA with order group analyzed between-subjects and stimulus orientation (Upright, Inverted) and type of test phase stimulus (Novel, Familiar) as repeated-measures was conducted to examine whether participants varied in their abilities to recognize faces they had seen during the learning phase and to reject faces that they had not. The analysis revealed a significant main effect for orientation, $F(1{,}56) = 64.33$, $p < .001$, $\eta_p^2 = .54$, with participants more accurately recognizing familiar faces and rejecting novel faces in blocks in which the faces had been presented upright during the learning phase ($M = .89$, $SEM = .01$) than when they had been presented inverted during the learning phase ($M = .79$, $SEM = .79$). The analysis also revealed a significant main effect for type of test phase stimulus, $F(1{,}56) = 7.79$, $p = .007$, $\eta_p^2 = .12$, with participants more accurately rejecting faces that were novel (introduced during the testing phase only) ($M = .87$, $SEM = .01$) than accurately recognizing faces that were familiar (presented during the learning phase and again during the test phase) ($M = .82$, $SEM = .02$) exhibiting a lack of recognition bias. Additionally, the analysis indicated no significant effect for order group, $F(1{,}56) = .05$, $p = .817$, $\eta_p^2 = .00$. There was a significant interactions between orientation and type of test phase stimulus, $F(1{,}56) = 22.03$, $p < .001$, $\eta_p^2 = .28$. In blocks where the faces were inverted during the learning phase, participants more accurately rejected novel faces ($M = .85$, $SEM = .01$) than they recognized familiar faces ($M = .74$, $SEM = .02$); however, in blocks where the faces were upright during the learning phase, they performed similarly in recognizing familiar faces (*M* = .90, *SEM* = .01) and rejecting novel faces (*M* = .90, *SEM* = .01). The analysis also revealed a significant interaction between orientation, order group, and accuracy, $F(1,56) = 6.18$, $p = .016$, $\eta_p^2 = .10$, which pairwise comparisons suggest was due to a unique significant difference ($p < .001$) between familiar face recognition (*M* = .71, *SEM* = .31) and novel face rejection (*M* = .86, *SEM* = .02) in participants in the BAAB order group and when the faces were inverted during the learning phase. The complexity of this interaction suggests caution should be used in its interpretation. The analysis did not reveal a significant interaction between orientation and order group, $F(1,56) = .43$, $p = .515$, $\eta_p^2 = .01$, or accuracy and order group, $F(1,56) = 1.11$, $p = .296$, $\eta_p^2 = .02$.

Figure 2

Mean recognition accuracy for orientation and occlusion conditions

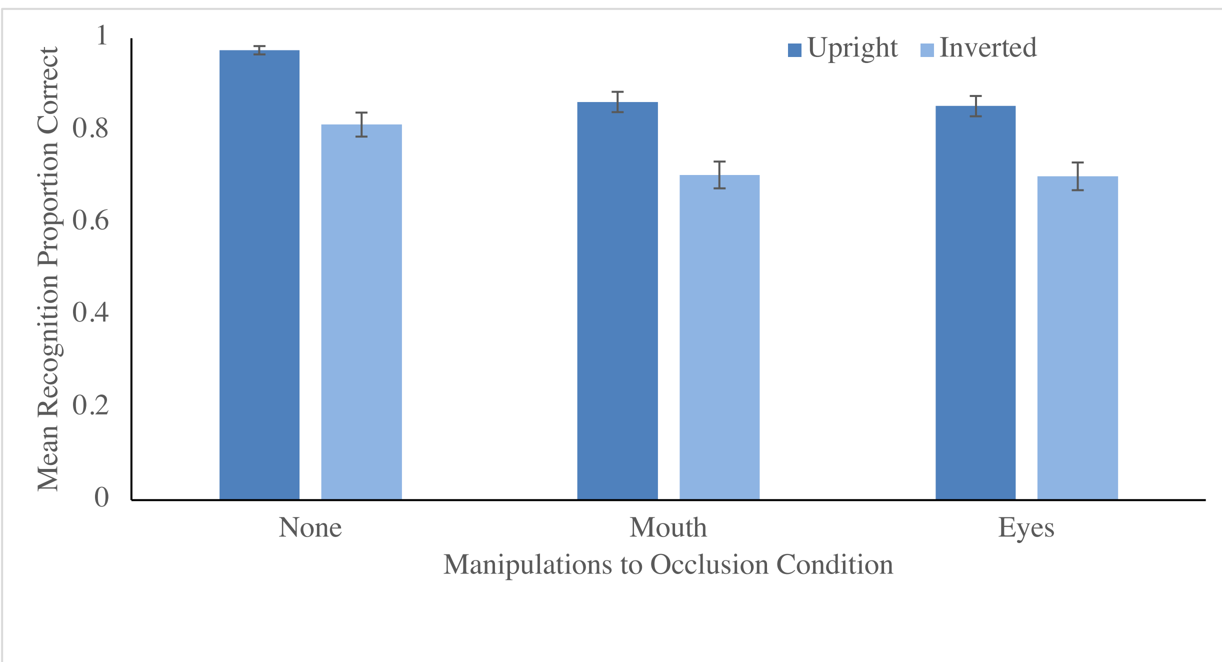
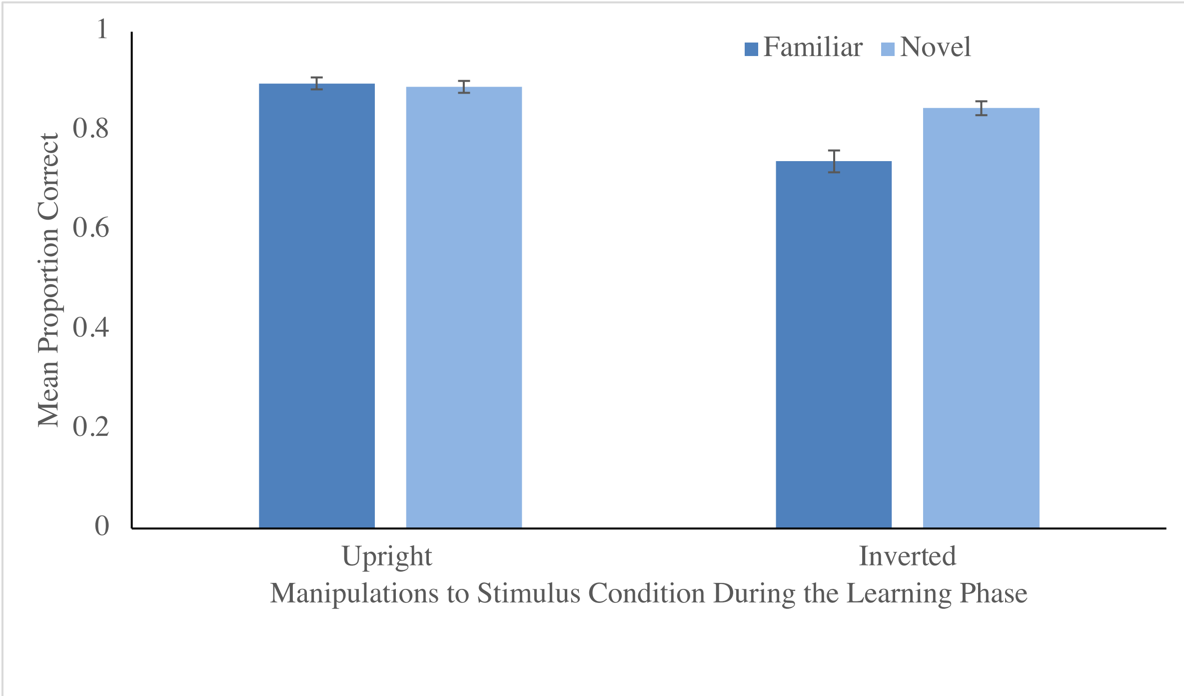


Figure 3

Comparisons of means of accuracy scores within-trial conditions



Discussion

This study examined the effects of partial occlusion on facial information processing and recognition based on the study conducted by Freud et al. (2020) that suggest that holistic processing is a better aid for accurate recognition. Based on their findings we predicted that the presence of an occluder will reduce recognition abilities. Further, we also predicted that manipulating the orientation of the stimuli would affect recognition scores, which according to previous studies (Farah et al., 1995, Freud et al., 2020) indicate disruptions to holistic processing. The findings supported these hypotheses. The analyses indicated main effects for both occlusion and orientation, which is consistent with previous research (Freud et al., 2020). Further investigation into the analysis indicates that the mean recognition scores for faces that were unoccluded were significantly higher than when an occluder was present. This indicates that when forced to focus on specific facial features and a holistic approach to facial information processing is disrupted, recognition accuracy decreases. However, the difference between recognition scores of mouth occlusions and eye occlusions was not significant, with the mean of recognition scores when the mouth was occluded being only slightly higher than when the eyes were occluded. The lack of a significant difference between mouth and eye occlusions, and higher recognition scores when faces were unoccluded are consistent with the main study by Freud et al., (2020).

The orientation main effect indicated within the analysis was also consistent with previous studies. The difference between recognition scores of upright faces and inverted faces was significant with the mean of upright faces being higher than the mean of inverted faces. Previous research exploring the inversion effect suggests that holistic processing is orientation sensitive associating the difficulty in recognizing inverted faces with disruption to holistic processing. In this instance, when inverted faces are presented, featural processing is adopted instead. Higher recognition scores for upright faces then suggest that holistic processing, which is adopted when faces are presented upright is a better aid for accurate recognition than featural processing. The analysis did not indicate a significant effect for order group which ensured that the experiment was counterbalanced and internally valid. The primary mixed model analysis did not indicate any significant interactions between manipulations (orientation, occlusion, or order group) suggesting that these conditions did not affect each other or their effects on recognition scores. There was a subtle orientation by order group interaction. Participants in both conditions showed a fairly typical inversion effect (i.e., higher recognition accuracy for stimuli that had been upright during learning than for those that had been inverted), although this effect was slightly larger for those in the BAAB than those in the ABBA order group, suggesting perhaps that beginning the experiment with inverted faces (as those in the BAAB condition did) was especially challenging. The secondary mixed model analysis was mainly conducted to examine if a recognition or 'yes' bias was present. In order to confirm this, the results should have to indicate that participants have accurately rejected novel faces by pressing 'no' when a novel face was presented during the test face at a higher rate than accurately recognizing faces that were familiar by pressing 'yes'. Since the mean recognition scores for novel faces presented upright were significantly lower than when novel faces were presented (upright and inverted) the lack of a recognition bias can be confirmed. This is further observed within the significant interaction that was present between orientation, novel/familiarity of stimulus, and order group. The mean for when participants who accurately recognized familiar stimuli that were inverted and in BAAB order was lower than those who accurately rejected novel stimuli that were inverted and in BAAB order. Accurate rejection for novel stimuli indicates that participants did not press 'yes' at every instance a stimulus was presented during the test phase which would have exhibited a recognition bias.

Limitations

This study aimed to utilize eye-tracking data to further analyze gaze patterns and their relationship to face perception and processing. For example, previous research in this area has suggested that certain gaze patterns such as focusing primarily on the middle region of the face is related to holistic processing (Bombari et al., 2009). Eye-tracking data is being used in face perception and recognition studies more frequently due to the important information it can contribute to understanding this field better. Although we aimed to do the same, due to technical difficulties and time constraints, this was a limitation. Additionally, a higher number of participants would have been preferred. Initially, we attempted to recruit at least 100 participants following the direction of the Freud et al. (2020) study. However, due to the nature of the study being in-person, and time constraints only 59 participants were able to be recruited.

Conclusion

The current study examined the nature of facial processing and how this might be disrupted in the presence of partial occlusion and its relationship to recognition. Overall, our hypotheses were supported. Partial occlusion disrupted facial information processing which led to a decrease in recognition scores. This was observed in the means of the no occlusion condition being significantly higher than when occluders were present. Similarly, an inversion effect was also observed in which participants' recognition accuracy decreased when inverted faces were presented as opposed to when upright faces were presented further supporting the notion that when holistic processing is disrupted, recognition is poorer. Future research should incorporate eye-tracking data, and a larger sample size in order to further explore the relationship between facial processing and recognition, and how these cognitive functions might be disrupted in the presence of occlusions. This study adds to the body of research that explores the cognitive functions of face information and processing and recognition, highlighting the importance of face-based research and its real-life applications of it.

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