SEX AND SEXUAL ORIENTATION DIFFERENCES IN PERCEPTUAL AND COGNITIVE PROCESSING

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Abstract

Sex differences have been found in some visual perception and cognitive abilities, and male and female brains have been shown to have differences in functional activation. These abilities include mental rotation, face recognition and face detection. One way to measure mental rotation is by using the mental rotation task (MRT) and is one of the largest tasks to demonstrate cognitive sex differences, with males routinely outperforming females (Voyer, 2011). Face recognition and detection show robust differences favouring females (McBain et al., 2009; Brewster et al., 2012). Few studies have considered the effect sexual orientation play in visual cognition and perception. Same-sex attracted males tend to perform at the level of females in face recognition ability (Brewster et al., 2012). However, little research has focussed on same-sex attracted females and whether they also show cross-sex advantage of same-sex attracted males for tasks where males outperform females. It is possible that same-sex attracted females have a male typical advantage on mental rotation ability. This thesis seeks to further examine the effect sexual orientation has on these visual and perceptual abilities that have previously shown sex differences. The typical male advantage was found for mental rotation ability, with heterosexual males outperforming heterosexual females. However, within the same-sex attracted groups, this difference was not found, with same-sex attracted females performing at the level of same-sex attracted males. No significant differences were found for face recognition, however there was a trend for same-sex attracted males and females as well as heterosexual females to outperform heterosexual males. All groups outperformed heterosexual females on the face detection task, bringing into question whether this group truly has an advantage on this task, or whether the sample in this study did not capture the effect due to its potentially small size.

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Chapter 1: Introduction

General

For much of human history, females have been excluded from medical studies involving biological mechanisms. This has led to many adverse impacts on the health of women. For example, women of child-bearing years were excluded from clinical drug trials in the United States until 1986, on the basis that their hormonal fluctuations would be too difficult to control for (Liu et al., 2016). This resulted in many issues seen today, such as women experiencing a two-fold greater risk for adverse drug reactions than men across all drug classes. Women are also more likely to be hospitalized following an adverse drug reaction (Zucker et al., 2020). One such drug is leperiudin, an anticoagulant used to treat cardiovascular events (Petros et al., 2008). Although men and women tend to be given similar doses based on weight, leperiudin's systemic clearance in women is 25% lower than in men, meaning that it circulates in the body longer (Petros et al., 2008). This longer circulation time increases the potential of undesired bleeding, complicating the recovery of female patients (Abdel-Rahman, 2017).

Another exampling of long-standing medical intervention which did not consider that female physiology differs from males is that females tend to display different symptoms during a heart attack, such as an absence of chest-pain and less elevated biomarkers of cardiac arrest (Hochman et al., 1999; Khan et al., 2021). This causes women to be misdiagnosed and become more likely to have congestive heart failure during their hospitalizations (Hochman et al., 1999). It is clear from this example that disease presentation is not always consistent between men and women and clinicians need to be aware of sex differences in presentation when treating patients. Sex needs to be considered as a biological mechanism that could predict disease and treatment outcome. It is especially important to women's health to include females in both animal and human models to understand the underlying mechanisms of sex differences in the body and brain (Zakiniaeiz, 2016).

In recent years, the medical community has become aware that drugs that are solely tested on men may not be appropriately dosed for female physiology. The Canadian Institute of Health Research have recently appreciated these sex differences and ask researchers to include gender-based analyses (GBA) in medical studies to address potential sex differences in disease and treatment. It is necessary to study sex differences in disease prevalence as well.

Often, sex and gender are not differentiated in research settings. The sex versus gender dichotomy is extremely important in this line of research. Sex refers to biological characteristics including sex chromosomes, primary sex characteristics such as genitalia, secondary sex characteristics such as body hair placement, brain functioning and circulating hormones (Canadian Institute of Health Research, 2020). The labels for sex include female, male and intersex. Intersex individuals are those with both female and male physiological characteristics. Gender refers to culturally prescribed behaviour based on one's sex. Generally, gender refers to the behaviours, attitude, and appearance attributed to one sex or the other, based on cultural norms and expectations. The labels for gender are femininity, masculinity, and androgyny. Androgyny refers to having characteristics of both femininity and masculinity (Canadian Institute of Health Research, 2020). In this thesis, sex differences will be analyzed, meaning the differences between human females and males.

One of the most striking sex differences in medicine is the unequal prevalence of autoimmune disorders between the sexes. Women account for 80% of the patients in many autoimmune disorders including Sjogren's syndrome, autoimmune thyroid disease, and scleroderma (Whitacre, 2001). Whitacre (2001) argues that this is a result of basic immune response differences between the sexes, mostly supported by rodent research. Post immunization, female rodents tend to have heightened immune responses compared to male rodents (Eidinger et al., 1972; Weinstein et al., 1984). This work has been replicated in humans, with women showing heightened immune response after vaccinations (Amadori et al., 1995). Autoimmune disorders occur when the immune system attacks its own cells, which is why a heightened immune response could be a biomarker for autoimmune disorder risk (Smith et al., 1999). The role of hormones must also be considered when looking at sex differences in autoimmune disorder prevalence, as estrogen, progesterone and testosterone seem to mediate this sex difference (Whitacre, 2001). The reduction of symptoms of various autoimmune disorders during pregnancy is the strongest piece of evidence supporting the hormone hypothesis (Whitacre, 2001). Understanding sex differences in different contexts can help guide the research for different disorders and diseases that are sexually dimorphic.

As a result, studying sex differences is important in research settings since there are distinct differences in physiology between males and females. This sexual dimorphism also applies to the brain and its structure and function. For instance, one striking neurological sex difference is the effect of aerobic exercise on patients with mild cognitive impairment in old age. Women show marked increase in executive functioning following 6 months of aerobic exercise while men show no increase in executive functioning (Baker et al., 2010). This difference is posited to be a result of sex-based differences in the hypothalamic-pituitary-adrenal (HPA) axis response to aerobic exercise, specifically reducing cortisol for women and increasing cortisol for men (Baker et al., 2010). The HPA axis is the central control and regulatory system that connects the central nervous system with the hormonal system (Kudielka et al., 2005). The HPA axis plays an essential role in regulating cortisol levels in response to stress. This regulation seems to be supported by repeated aerobic exercise in women but not in men. However, differing HPA axis activation is not always a positive factor for women. In terms of mental illness, and the broader category of neurodivergence, the HPA axis could be the cause of the sex difference observed in the prevalence of many mental illnesses (Altemus, 2006).

Neurodivergence is defined as an atypical neurological configuration and includes developmental disorders and mental illness (Disabled World, 2011). Mental illnesses that women are twice as likely as men to suffer from include unipolar depression, dysthymia, panic disorder, post-traumatic stress disorder, generalized anxiety disorder, social anxiety disorder, and phobias (Regier et al., 1993; Kessler et al., 1994). The biological basis for this prevalence difference may be rooted in differing HPA axis responses to stress. While males tend to increase cortisol, females tend to suppress it when encountering chronic stress. Altemus (2006) argues that the suppression of cortisol may result in maladaptive responses to stress such as learned helplessness. Animal studies have shown that an increase in cortisol, after chronic stress, impairs memory performance in male rats, which is argued to be a protective measure against resulting mental illnesses (Altemus, 2006). Although more research needs to be done in this area, this sex difference in the prevalence of mental illness is another important reason why sex must be accounted for as a biological variable in research.

Neurodivergence includes developmental disorders as well as mental illnesses. One developmental disorder that has been recently reviewed for its large sex difference in prevalence is autism spectrum disorder (ASD). The ratio of males to females ranges between 4:1 for high-functioning ASD (ASD without intellectual impairment) to 2:1 for low-functioning ASD (ASD with intellectual impairment) (Kirkovski et al., 2013). More recent work has shown with new diagnostic criteria, the ratio for males to females in high-functioning ASD may be closer to 1.7:1

(Mattila et al., 2011). The large range for prevalence differences in ASD could be attributed to more misdiagnoses of girls due to cultural confounds and associated stigma (Kirkovski et al, 2013). An example of a cultural confound would be the increased social expectation placed on female children, resulting in a masking of their symptoms that are deemed socially inappropriate. However, there are biological aspects to this prevalence difference as well. There is evidence that females may need a higher genetic predisposition to present with autistic symptoms, supported by the finding that females diagnosed with ASD have more first-degree relatives diagnosed with ASD than males. Parents of females with ASD also tend to show greater social deficits than parents of affected males (Kirkovski et al, 2013). Whether the disproportion of diagnosis between males and females is due to a misdiagnosis of affected females or an altered phenotypic presentation of the disorder in affected females is yet to be determined.

Other important areas of research investigating sexual dimorphisms in the brain are cognitive and perceptual psychology. Sex differences in perceptual and cognitive processing have been studied since the late 1900s. Men tend to have better spatial ability than women, specifically the ability to mentally rotate or manipulate an object in space, which is referred to as mental rotation ability (Linn et al., 1985; Hedges et al., 1995; Voyer et al., 1995). The male advantage in mental rotation ability is the largest cognitive sex difference of any cognitive or perceptual task to date (Voyer, 2011). Men also tend to outperform women on mathematical reasoning, spatial perception, spatial visualization, and are better at route navigation in that they complete the route faster and with fewer errors than women (Kimura, 1992; McCormick et al., 1991). Mathematical reasoning tests in which men tend to outperform women include mathematical problems that involve logical problem solving (Kimura, 1992). However, women tend to outperform men in verbal fluency, category fluency, recalling landmarks, and in arithmetic calculations (Kimura, 1992; Rahman, 2003). A study measuring spatial ability and fluency found that when comparing performance across tasks, men performed significantly better on spatial tasks than fluency tasks. Women performed in the opposite direction, performing significantly better on fluency tasks than spatial task. Researchers measured spatial perception using the Spatial Relations subtest of the Differential Aptitudes Test Battery. They measured both verbal fluency and digital fluency using an animal naming tasks and a digit symbol subtest of the Wechsler Adult Intelligence scale. (McCormick et al., 1991).

Women tend to perform better than men on tasks that measure basic face detection (McBain et al., 2009) and face recognition (Brewster et al., 2012). Face detection is the ability to distinguish face from non-face objects (McBain et al., 2009) while face recognition is a measure of identity discrimination, which is the ability to perceive individual differences in facial features to distinguish identities of faces (Brewster et al., 2011).

There are the number of cognitive and perceptual tasks that show sex differences between men and women, however some of these differences between the sexes are mitigated by participant sexual orientation. Sexual orientation can be measured in a variety of manners, this thesis used a 7-point scale, the Kinsey Scale, to determine participant sexuality (Kinsey, 1948). Any participant who scored a two or higher on this scale will be referred to as same-sex attracted. However, in previous research, where those with bisexual orientations were excluded, the term homosexual is used as the participants in those groups were homosexual, analogous to a 6 on the Kinsey scale.

In the research done by McCormick et al., (1991), it was found that homosexual males performed better than heterosexual females on the cognitive tasks that measured spatial ability but performed slightly less accurately than heterosexual males. Homosexual males outperformed heterosexual males on the tasks that measured fluency but did not outperform heterosexual females. When homosexual male performance was compared across tasks, it was found that performance on spatial tasks was equal to performance on fluency tasks, showing a versatility in task performance. Homosexual females were not measured in this study. Further research on fluency showed that homosexual males outperformed heterosexual males, heterosexual females and homosexual females (Rahman, 2003), showing an cross-sex advantage on a task that typically shows a female advantage over males.

Brewster et al., (2012) found that homosexual men tend to outperform heterosexual men on measures of face recognition, showing a cross-sex advantage in this ability. Homosexual men also show verbal fluency ability that is comparable to women, outperforming heterosexual men (McCormick, 1991). Little research has been done on homosexual females and research that has been done has shown inconclusive results (Thurston et al., 2021). This could be due to sexuality being more fluid in females, resulting in a group that is more heterogeneous than same-sex attracted males (Diamond, 2009). Including sexuality as a subject variable will help to further qualify sex differences in spatial ability and face perception.

Mental Rotation Ability

Mental rotation is a spatial ability on which men tend to outperform women. Mental rotation is the ability to visualize an object and rotate that object into different orientations (Shepard et al., 1971). The standard way to measure mental rotation ability is using the Mental Rotation Task (MRT) which was created in 1971 by Shepard and Metzler. Participants were shown two articulated block designs in different orientations and were asked whether the objects differed structurally. A strong correlation between the degree of orientation shift and participant reaction time was found (Shepard et al., 1971). The greater the difference in the orientation of the two objects, the longer it took participants to accurately complete the task. This task has evolved over the decades and is most often employed in the modified Vandenburg and Kuse (VK) (1978) format of this test. This format shows the participant a target figure on the left and four figures on the right, where two of the figures on the right side are distractors and two match the target figure in structure. All the figures have differing degrees of orientation shift. An image of a typical problem set is shown in Figure 1.1 (Vandenburg, 1978).

This task is normally a pencil-and-paper task; however, some work has been done in a virtual reality paradigm. While men routinely outperform women on both pencil-and-paper (Voyer, 2011) and virtual reality versions (Jacobs et al., under review), women's scores tend to increase when participants receive training on the task (Casey et al., 1992) and sex differences tend to diminish when there are no time constraints (Peters, 2005). However, a sex difference is still found when women receive training and there are no time constraints, with men outperforming women.

It is unclear whether the male advantage in spatial mental rotation ability arises from biological or environmental factors. Some biological components playing a role in mental rotation ability include handedness and familial handedness (Casey, 1990; Casey, 1996). There is a subgroup of females that perform in the male fashion on the MRT and have higher spatial abilities in general (Casey, 1996). These females have a genetic advantage for spatial abilities known as the heterozygotic advantage. They are females who are right-handed but have non-right-handed family members, resulting in a mixed gene containing an allele for a right-handed shift and an allele for a left-handed shift (Casey 1996). Though the right-handed shift is the dominant allele and results in these females being right-handed, it is theorized by Casey (1996) that this heterozygotic pairing results in the left-hemisphere to not be as dominate in language processing, allowing this subgroup to rely less on purely verbal problem-solving strategies, leading to a potential for better spatial skills.

In a test done on this subgroup, it was found that these females outperformed their homozygotic counterparts in tests of spatial ability, including the MRT (Casey, 1999). Casey (1995) also found that females showed a significant relationship between mental rotation skills and math aptitude. Additionally, Albaret and Aubert (1996) found that females in sciences, technologies, engineering, and maths programs had superior mental rotation skills compared to females in humanities and social studies. These findings lend support to the theory that women with a predisposition to heightened spatial abilities seek out opportunities to strengthen those abilities. Sherman (1978) formalizes this theory in her "bent-twig" model that posits male children are drawn to spatial tasks such as block play. Sherman theorizes male children are drawn to spatial tasks because they have a predisposition for better spatial skills and experiences with these tasks strengthen spatial abilities in male children. This theory could be applied to the subgroup of heterozygotic females who also possess a predisposition for good spatial abilities.

Other researchers have found sociocultural factors in the development of spatial abilities. Parents have different expectations for their male and female children on the MRT, even when gender-traditional beliefs, such as male children must play with Legos and female children must play with dolls, are controlled for. This suggests parents who reject gender-traditionalist views still stereotype their children based on their biological sex (Meunks et al., 2019). The environment children are exposed to are often affected by parental beliefs. Those with female children may provide fewer opportunities to utilize their spatial skills than those with male children, so even if female children are genetically inclined to good spatial skills, they are denied the opportunity to strengthen them.

The role of sociocultural factors in mental rotation ability is challenged by a series of studies that have indicated a sex difference in mental rotation abilities found in infants. Infants tend to spend more time looking at novel images than learned images in the habituation paradigm (Quinn et al., 2008). Using a habituation paradigm, Quinn and Liben (2008) found that male infants preferred mirror images to images of a habituated object rotated 120° while female infants did not show a difference in preference between the mirror images and the images of a habituated objected rotated to a new orientation. This implies male infants view the mirror images as novel but not the rotated images, while female infants view both the mirror images and the rotated images as novel. This shows a sex difference in mental rotation ability in infancy, implying a biological basis.

There appears to be a dedicated underling neural structure involved in mental rotation ability. Functional neuroimaging has shown increased activation in the posterior parietal lobule (PPL) when completing a mental rotation task (Champod et al., 2007). The PPL plays a key role in working memory and general intellectual functioning. Further analysis has shown the inferior parietal lobule (IPL) is specifically activated during the mental rotation task, with males showing increased activation compared to females (Hoppe et al., 2012).

There is also a difference in the neurological correlates recruited during the mental rotation task seen in fMRI studies. Men tend to show increased activation in inferior parietal lobule compared to women, while women showed increased activation in the frontal lobe and fusiform areas (Jordan et al., 2002). This increase in activation may be greater inputs received by the brain area, a greater degree of processing taking place in the brain area, and/or a greater number of outputs from the brain area (Harris et al., 2000). Another study suggests that parietal lobe activation is similar across the sexes, but the main difference is female activation of the frontal lobe (Hugdahl et al., 2006). This sex difference in spatial abilities is not purely behavioural but has underlying neural correlates as well.

This study investigates sexual orientation as a contributing factor for mental rotation ability. Another brain area associated with spatial ability is the anterior hypothalamus (Rahman et al., 2017). Same-sex attracted women show heterosexual male typical activation of the anterior hypothalamus when completing spatial tasks (Swaab, 2008). It is posited that sexual orientation may influence females' accuracy on this task. Previous work in this field studying same-sex attracted individual performance in tasks that produce reliable sex differences supports this theory. We found that same-sex attracted males tend to show female typical success on face perception tasks and posit same-sex attracted females will display this cross-sex advantage in mental rotation ability. In accordance with previous literature, we posit a male advantage in accuracy on the mental rotation task will be found within the heterosexual samples.

Another ability that shows marked sex and sexual orientation differences is face perception. Face perception also has a dedicated underlying neural structure that has been studied extensively. Face perception includes the abilities to distinguish a face from non-face objects and to recognize individual differences between faces. It is a fundamental ability that allows humans to interact with, identify, and distinguish faces and facial expressions. It is also an ability that is sexually dimorphic, with females outperforming males on basic face detection, the ability to recognize a face as a face, (McBain et al., 2009) and face recognition, the ability to distinguish one face from another or identify previously seen faces (Brewster et al., 2012). It is important to understand sex differences in face perception as it is an integral part of social life and humans need social connections to lead happy and healthy lives.

The core system consists of the occipitotemporal (OT) regions in the extrastriate visual cortex (EVC). Three bilateral regions within the OT EVC that show preferential activation for face processing include the inferior occipital gyri (occipital face area), the lateral fusiform gyri (fusiform face area) and the superior temporal sulci (STS) (Haxby et al., 2000). Gauthier (2000) argues the occipital face area (OFA) shows face selectivity but is not category-specific, as it is an earlier visual area, meaning it is important for the process of face detection but not necessarily face recognition. However, this notion is controversial as work with prosopagnosia patients P.S. and D.F. has shown when the OFA is structurally or functionally damaged, while the FFA remains intact, higher level face processing does not occur (Roisson et al., 2003; Steeves et al., 2006). The fusiform face area (FFA) shows face selectivity, is category-specific, and appears to be involved in the perceptual processing of visual information that is important for individual level processing (Gauthier, 2000). This points to the FFA being important for face recognition. While FFA is important for face recognition, evidence from a patient with prosopagnosia, an inability to recognize faces, and who has bilateral lesions overlapping the OFA, shows activation in the FFA when viewing faces, but cannot recognize these faces. This suggests that this region is not sufficient for higher level face processing (Steeves et al., 2006). The FFA is necessary but not sufficient for face processing, pointing to the necessity of the OFA.

It has been argued that the FFA is not a specialized system in the brain specifically for faces, rather it is in an area that specializes in categorization. Neural signatures of face-specific areas are found when viewing non-face objects by experts, specifically categorizing birds in bird watchers (Gauthier et al., 2001). However, these systems are necessary for face perception, even if they are used for other types of categorizations as well. Whether these areas develop through usage of them or are specifically encoded from genetics, remains to be discovered.

It has been posited that face perception has two distinct processes: one accounts for invariant facial features that are specific to individuals, such as the eyes, mouth, and nose, and facilitates face recognition. Invariant features are structural features of the face that do not change when expression changes or when the eyes and mouth move (Haxby et al., 2000). Invariant facial processing mainly occurs in the FFA (Puce et al., 1998; Hoffman et al., 2000). Invariant facial perception can be measured using both a facial recognition task and a facial detection task. Facial recognition involves being able to discriminate facial identities and remembering facial identities (Brewster et al., 2012). Face detection involves being able to decipher the difference between a face and a non-face object (Mcbain et al., 2009)

Bruce et al., (1986) found that recognition of identity and expression seem to occur independently. Familiarity and repetition priming have been shown to facilitate performance on face perception tasks involving facial identity but not in tasks that involve facial expression. Repetition priming is when subjects are shown the same exact stimulus repeatedly after an initial occurrence (Wagner et al., 2002). This work points to invariant and variant facial processing to be two distinct systems.

Variant facial processing accounts for changeable facial features, such as gaze and expression, which facilitate social interaction (Haxby et al., 2000). The STS is an important neural correlate in the perception of expression and gaze (Engell et al., 2007). Hasselmo et al., (1989) used macaque monkeys as an animal model to measure the role of expression and identity in face-selective responses of single neurons. Neurons tuned differentially to expression were found in the STS (Hasselmo et al., 1989).

One important aspect of the face processing network is that it seems to be sexually dimorphic in humans. Some studies suggest face processing is right hemisphere dominant

(Kanwisher et al., 1997; Rossion et al., 2012), however it has been found that face perception is typically bilaterally processed in adult females compared to males who are more right hemisphere dominant (Proverbio, 2010). This is consistent with evidence that females also have an advantage in face processing, with better face recognition and detection skills (Brewster et al., 2012; McBain et al., 2009). Face recognition differences appear in infancy, with infant girls attending more to images of faces than infant boys, who prefer non-face images (Connellan et al., 2000). This suggests that face processing differences emerge early in life. The female advantage of better and more consistent face detection and recognition is seen in adults but is more variable when neural development is still ongoing (McClure, 2000).

Women tend to show an own-gender bias when processing faces, while men do not (Herlitz et al., 2013). This own-gender bias is seen in other-ethnicity faces as well. Caucasian women show an own-gender bias when viewing faces of African American peoples (Slone et al., 2000). However, given this own-gender bias, women still outperform men on recognition of male faces (Herlitz et al., 2013). This could be due in part to the finding that, anatomically, women and girls have larger fusiform face areas than boys and men, when controlling for overall brain volume (Tahmasebi et al., 2012). It has also been shown that women have higher effective connectivity than men between the fusiform face area and the insula, which is part of the extended face network (Mather et al., 2010). In summation, the behavioural sex differences are supported by structural and functional sex differences in the underlying brain regions that support face processing.

There are also functional and structural differences observed based on sexual orientation. Homosexual males have been shown to have a larger isthmus – a posterior region of the corpus callosum, connecting parietotemporal cortical regions – than heterosexual males (Witleson, 2007). Homosexual males also tend to have increased bihemispheric representation of language when compared to heterosexual males (Witlseson, 2007). The thalamus and precentral gyrus in heterosexual men tend to have more dense gray matter volume when compared to homosexual men, while homosexual men tend to have more dense gray matter volume in the putamen (Votinov, 2021). Gay males and heterosexual women tend to show more widespread connections from left to right amydala while lesbians and heterosexual men show a more widespread connection from the right amygdala (Savic & Lindstrom, 2008).

An effect of sexual orientation has been demonstrated for face recognition ability. Homosexual males outperform heterosexual males on face recognition, giving homosexual males a cross-sex advantage (Brewster et al., 2012). It could be posited that face processing strategies may differ across the sexes but also within the sexes across sexual orientations. The female advantage may be a result of the bilateral activation seen in face processing areas, allowing females to recruit more neural correlates when detecting and recognizing faces. It could also be the result of women and girls having larger FFAs and higher effective connectivity in the extended face network. Same-sex attracted males may show female-typical bilateral activation in response to viewing faces, giving them a female-typical advantage in face processing abilities.

For this thesis, sex and sexual orientation differences in mental rotation and face perception abilities will be investigated. Using the mental rotation task to measure mental rotation ability, and a face recognition and a face detection task to measure face perception ability, the aim is to uncover whether sex differences in these perceptual tasks translate to same-sex attracted populations. Whether same-sex attracted males retain the male advantage in mental rotation ability and show a female-typical advantage in face perception abilities are two outcomes to be studied. Whether same-sex attracted females retain the female advantage in face perception and show a male-typical advantage in mental rotation ability will also be investigated.

Hypotheses

1. Mental Rotation Ability: We expect heterosexual males to outperform heterosexual females in terms of accuracy on the mental rotation task. We posit that there may be a complementary cross-sex advantage for same-sex attracted females in mental rotation ability, with higher accuracy than heterosexual females, performing in a male-typical fashion. We expect same-sex attracted males to retain the male advantage in mental rotation ability.
2. Face Recognition: We expect heterosexual and same-sex attracted females to outperform heterosexual males in terms of accuracy on the face recognition task. We also expect same-sex attracted males with show a cross-sex advantage, outperforming heterosexual males in terms of accuracy on the face recognition task.
3. Face Detection: We expect heterosexual and same-sex attracted females to outperform heterosexual males in terms of accuracy on the face detection task. We also expect same-sex attracted males with show a cross-sex advantage, outperforming heterosexual males in terms of accuracy on the face detection task.

Chapter 2: Methods

Participants

Eighty-nine participants between the ages of 18 and 65 years were recruited to participate in this study. Based on sexual orientation identification, there were 19 same-sex attracted females (mean age = 25 years, SD = 9.29 years, range = 19 – 55 years), 17 same-sex attracted males (mean age = 20 years, SD = 12.29 years, range = 18 – 58 years), 28 heterosexual females (mean age = 25 years, SD = 10.54 years, range = 18 – 64 years), and 25 heterosexual males (mean age = 25 years, SD = 4.20 years, range = 19 – 35 years). Participants were recruited using the York Undergraduate Research Participant Pool and a snowballing recruitment technique. This research has been approved by the York University Office of Research Ethics. All participants gave informed consent. Participant recruitment lasted 6 months.

Software

Participants completed the mental rotation task and the face perception tasks hosted online on Pavlovia (Pierce et al., 2019). This task was created by the Perceptual Neuroscience Laboratory using a graphic user interface (GUI) called Psychopy (Pierce et al., 2019).

Questionnaires, Scales and Quotients

Participants completed a series of scales, questionnaires and one quotient in an online format. All scales, questionnaires and quotients are listed in the appendix. Our lab created a personal background questionnaire that asked participants their age, sex, ethnicity, level of education, familial handedness, and lingual status. We measured handedness using the Edinburgh Shortened Handedness Questionnaire (Veale, 2013), sexual orientation using the Kinsey Scale (Kinsey, 1948), the Traditional Masculinity Femininity (TMF) Scale to measure gender identity (Kachel, 2016), and the Autism-Quotient (AQ) was used to measure levels of autism in a research setting

(Baron-Cohen et al., 2001). All questionnaires, scales and quotients were completed on Qualtrics (Qualtrics, Provo, UT), a website that hosts surveys that can be formulated by the researcher and shared anonymously with participants.

Edinburgh Handedness

We used the 4-item Edinburgh Handedness Inventory to measure the degree of handedness in participants. The 4-item scale, despite being brief, has good reliability and validity for measuring handedness in participants (Veale, 2013). The scale asked participants whether they use their left or right hand or both equally when throwing, using a spoon, writing, and using a toothbrush. Scores of 60+ determine the participant is right-handed, -60 to -100 determine left-handedness, and scores between 60 and -60 determine ambidexterity (Veale, 2013). The scales brevity also makes it ideal for use in an online environment. We want to measure handedness because it seems to mitigate a disadvantage for females in the MRT and an advantage for males on face recognition (Brewster et al., 2012; Bourne, 2008; Casey et al., 1992; Li et al., 2003). Participants were also asked about familial handedness in a background questionnaire.

Kinsey Scale

The Kinsey Scale was first utilized by Alfred Kinsey in 1948 when measuring sexual behaviour in the human male (Drucker et al., 2012). It is a seven-point Likert scale measuring sexual orientation, zero being completely heterosexual, six being completely homosexual, with degrees of hetero and homosexuality in between (Kinsey, 1948). The Kinsey Scale has been used in an online environment and it is typically easy to interpret without the help of a researcher (Drucker et al., 2012). This is one of the reasons we chose to employ the scale in our experiment. The scale also measures sexual orientation across a variety of dimensions including sexual fantasies, thoughts, emotions, romantic feelings, dreams, and frequency of sexual activity (Kinsey, 1948). This multidimension measures gives us a better understanding of participant sexuality compared to a binary choice. Participants who scored a one on the Kinsey Scale were excluded from the analysis as they could not be placed within the heterosexual or same-sex attracted groups in a reliable fashion.

Traditional Masculinity-Femininity Scale

The traditional masculinity-femininity (TMF) scale was developed to create a scale that measures self-ascribed aspects of masculinity and femininity (Kachel et al., 2016). Allowing participants to use their own concepts of masculinity and femininity to complete the scale allows it to be utilized across cultures. Its traditional use is to provide a methodology for research into gender stereotypes (Kachel et al., 2016). We plan to use it as a proxy for self-identified sex and sexual orientation. Including this additional variable will allow us to assess the relationship between sex, gender, sexual orientation, and skill level on the MRT and face perception tasks. The scale has been validated in both heterosexual and same-sex attracted males and females (Kachel et al., 2016) making it a valuable tool in measuring gender identity in these groups.

Autism Quotient

The autism quotient (AQ) is a research tool that measures the degree of autistic traits in individuals with normal intelligence and was validated in 2001 by Baron-Cohen and his team (Baron-Cohen, 2001). They found that 80% of high-functioning individuals with autism scored higher than a 32 (out of 50) on the quotient. Men tended to score higher than women, even within the control group (Baron-Cohen, 2001), indicating a possible male-typical bias in the quotient. However, autism seems to affect males more often than females in the general population (Werling et al., 2013). It has been debated as to whether this is because females present differing symptoms than males or if males have a natural predisposition towards autistic traits. Participants who scored higher than 32 on the AQ were excluded from the analysis. These participants were excluded from the analysis as those with higher rates of ASD traits are more likely to have issues pertaining to face perception. Those with predispositions towards poor facial perception skills were excluded to allow for clear analysis of sex and sexual orientations differences in face perception. Five participants, two heterosexual females and three same-sex attracted females, were excluded from the final analysis due to having scored higher than 32 on the AQ.

Stimuli – Mental Rotation Task

The problem set used in this experiment is a mental rotation task designed by Vandenburg and Kuse in 1978. The target figure appeared on the left-hand side of the screen and four exemplars appeared on the right-hand side (see Figure 3.1). Two figures are distractors and two match the target figure in structure but are presented in a different orientation.

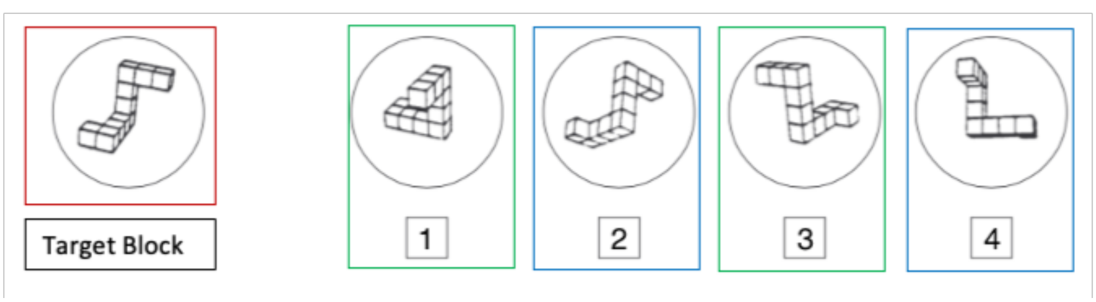


Figure 1.1. An example trial. The leftmost block figure is the target image. The participant is asked which two of the four exemplars to its right are the same as the target image. Blocks one and three, outlined in green match the target block in structure while blocks two and four, outlined in blue, are the distractors. (Adapted from Albaret et al., 1996).

Procedure – Mental Rotation Task

The task consisted of 20 problems that participants had a total of 15 minutes to answer (approximately 45 seconds for each problem). Participants were given instructions on the task and were prompted to complete it as quickly and accurately as possible. After a training phase of three trials, they were instructed to press the spacebar to continue to the test trials. Below the block arrays was text indicating to participants to input their first response. Once the participant inputted their first response, the same problem was shown with text telling participants to input their second response. The separation of inputs was due to programming restraints on psychopy. This procedure repeated for each of the 20 problems (see Figure 3.2 for schematic).

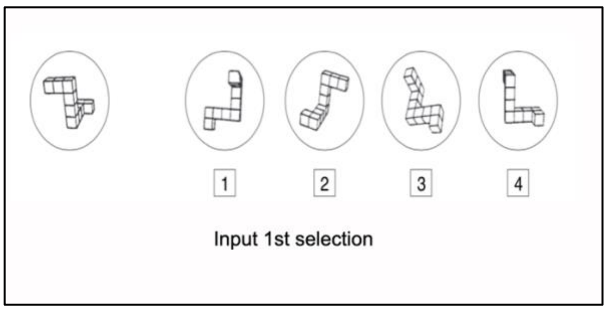


Figure 1.2a. The first screen participants viewed when solving the mental rotation task problem sets.

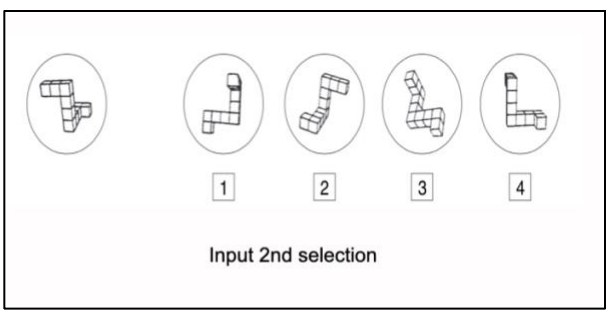


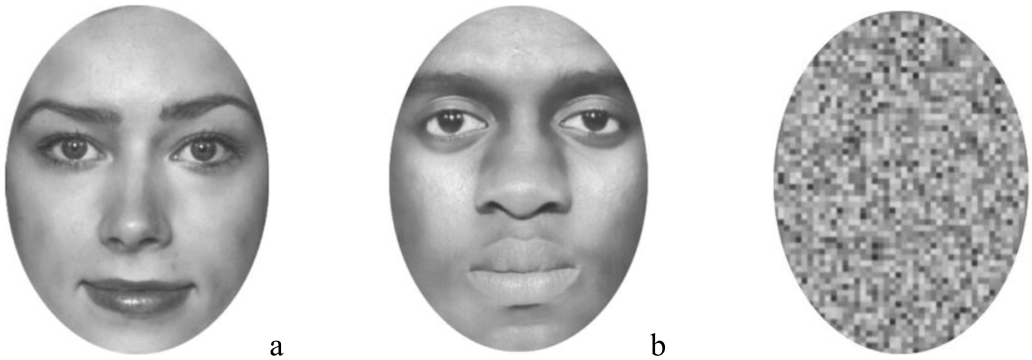
Figure 1.2b. The second screen participants viewed when solving the mental rotation task problem sets.

Stimuli – Face Recognition Task

In the face recognition task all face stimuli are rendered in gray scale and cropped in an oval to eliminate non-face information such as hair (see Figure 2.1.). An equal number of female and male faces were presented to participants. Additionally, an equal number of different ethnic groups are represented within the face stimuli. Participants were asked to learn 10 faces, 5 male and 5 female. A fixation cross rendered on Psychopy was shown between trials.

Procedure – Face Recognition Task

There was a learning phase and a testing phase for this experiment. During the learning phase each participant were presented with the ten target faces two times for ten seconds each for a total of 20 seconds exposure for learning. Before and after each target face is presented, a central fixation cross appears for 500ms. Following the learning phase, participants will be asked to discriminate these learned faces from 30 novel faces, 15 male and 15 female. During the testing phase, participants were shown a series of 50 faces in total, 30 of which were novel faces. Each trial began with a fixation cross for 500ms, followed by a face image for 250ms, followed by a noise mask for 250ms, generated using a PDF editor. The participants were asked to use the "f" key on their keyboard to indicate if the face was a learned face that they had seen before and to use "j" to indicate if the face was a new face. Participants were asked to complete the task as quickly and accurately as possible. This task followed the same procedure as previous research done in the laboratory investigating the relationship between sexual orientation, handedness, and task accuracy (Brewster et al., 2012).



a b c

Figure 2.1. a) An example of a novel female and b) male face. c) The noisemask used in the testing phase.

Stimuli – Face Detection Task

Stimuli for the face detection task consist of four quadrants of line drawings, one is a face and the other three are distractors, scrambled non-face images (see Figure 4.2). The task runs in two blocks, one featuring faces and the other trees, with the duration of stimulus presentation changing throughout the blocks showing for 100ms for the long presentation condition and for 33ms for the short presentation condition.

Procedure – Face Detection Task

Each block had a total of 240 trials for a total of 480 trials. Using either the "f" key or "j" on their keyboards, participants were asked to respond as quickly and accurately as possible to whether the face line drawing is presented on the left or right side of the screen. The stimulus shows on the screen for either 33ms or 100ms, followed by a central fixation cross for 250ms. The short and long conditions were included to see if there was a specific presentation time where there was an effect of participant sex and sexual orientation on proportion correct or whether it was an overarching effect that did not depend on stimuli presentation time.

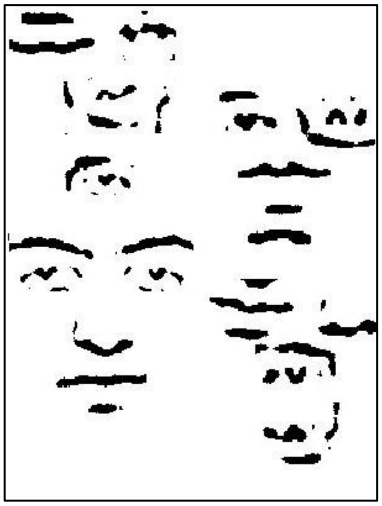


Figure 2.2. Example of line drawing of a face on the bottom left with distractors in the other three positions (McBain et al., 2009).

Stimuli – Tree Detection Task

Stimuli for the tree detection task consists of four quadrants of line drawings, one is a line drawing of a tree and the other were distractors, non-tree images (see Figure 4.3). This task was the second block following the face detection task, the duration of stimulus presentation changed throughout the blocks, presented for 33ms in the short prestation condition and 100ms for the long presentation condition.

Procedure – Tree Detection Task

Each block had a total of 240 trials for a total of 480 trials. Using either the “f” key or “j” on their keyboards, participants were asked to respond as quickly and accurately as possible to whether the tree line drawing is presented on the left or right side of the screen. The stimulus appeared on the screen for either 2 or 4 frame refreshes per second, followed by a central fixation cross for 250ms. The tree detection task was used as an attentional control in this study. If participants scored lower than chance, 50%, on the tree detection task, their data was not included in the analysis. Approximately 25 participants were excluded due to this criterion.

Figure 2.3. Example of line drawing of face on the bottom left with distractors in the other three positions.

Chapter 3: Results

Mental Rotation Task

Data were analysed using a between-participants 2x7 analysis of variance (ANOVA) of proportion correct responses with Sex x Kinsey Score as factors. Welch's independent samples t-test post-hoc pairwise comparisons with Bonferroni corrections were used to account for unequal group sizes. All assumptions of ANOVA testing were met with this data set.

There was a significant main effect of sex, $F(1,85) = 7.509$, ($p = 0.007$). There was no interaction effect of sex and Kinsey score $F(1, 85) = 1.406$, ($p = 0.239$). Post-hoc pairwise comparisons revealed a significant difference in proportion correct responses between heterosexual males and heterosexual females, with a large effect size $t(45) = -3.3$, $p = 0.002$ ($d = 0.914$). Heterosexual males had higher proportion correct mental rotation scores compared to heterosexual females. Post-hoc pairwise comparisons for proportion correct responses were not significantly different between same-sex attracted males and same-sex attracted females $t(33) = -0.11$, $p = 0.911$, between same-sex attracted males and heterosexual males $t(38) = -1.4$, $p = 0.168$, between same-sex attracted males and heterosexual females $t(33) = 1.7$, $p = 0.094$, between same-sex attracted females and heterosexual females $t(41) = -1.8$, $p = 0.065$, nor between same-sex attracted females and heterosexual males $t(41) = 1.3$, $p = 0.197$. For a graphical representation of these data, see Figure 3.3a.

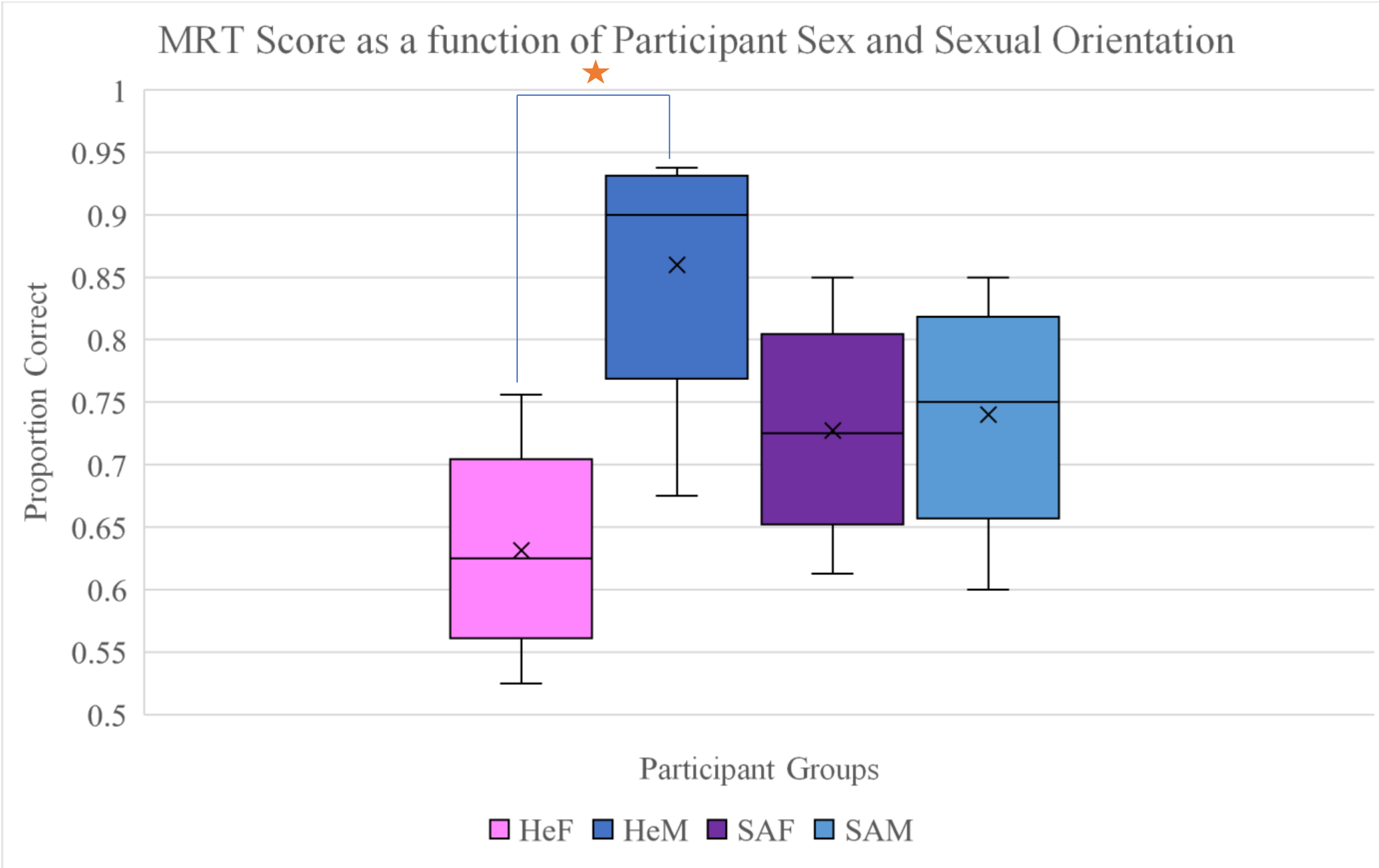


Figure 3.1a. A significant difference was found between heterosexual females and heterosexual males on this task, shown in boxplot where the x axis represents participant group, and the y axis represents proportion correct on the mental rotation task. Error bars represent the standard error of the mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue) represents same-sex attracted males. The star represents a significant difference between group means.

A post-hoc 2x7 ANOVA on proportion correct was performed with participant group sample size equalized at 17 per group. The method used to pare down the participant count was using the first 17 data sets that were acquired during recruitment for each group for a total of 68 participants.

There was a significant There was a significant main effect of sex, $F(1,64) = 4.871$, ($p = 0.031$). There was no interaction effect of sex and Kinsey score $F(1, 64) = 0.878$, ($p = 0.352$). Post-hoc pairwise comparisons revealed a significant difference in proportion correct responses between heterosexual males and heterosexual females, with males having higher scores compared to females, with a large effect size $t(30) = -2.5$, $p = 0.016$ ($d = 0.871$). Post-hoc pairwise comparisons for proportion correct responses were not significantly different between same-sex attracted males and same-sex attracted females $t(30) = -0.11$, $p = 0.911$, between same-sex attracted males and heterosexual males $t(30) = -0.9$, $p = 0.353$, between same-sex attracted males and heterosexual females $t(32) = 1.8$, $p = 0.075$, between same-sex attracted females and heterosexual females $t(30) = -1.1$, $p = 0.301$, nor between same-sex attracted females and heterosexual males $t(31) = 1.4$, $p = 0.179$. For a graphical representation of these data, see Figure 3.3b.

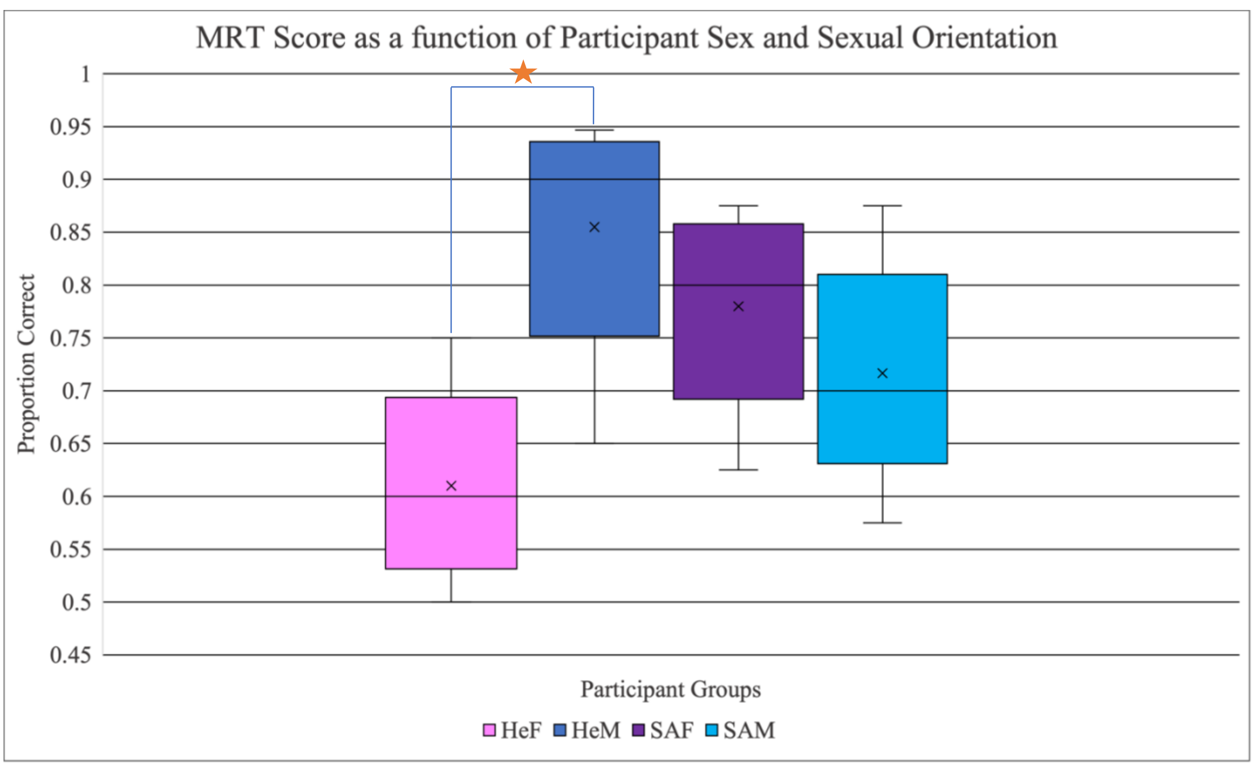


Figure 3.1b. A significant difference was found between heterosexual females and heterosexual males on this task, shown in boxplot where the x axis represents participant group, and the y axis represents proportion correct on the mental rotation task. Error bars represent the standard error of the mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue) represents same-sex attracted males. The star represents a significant difference between group means.

A power analysis was completed for this experiment. For a large effect size (d = 0.9), there would need to be 5 participants in each group to achieve statistical power of 0.8. To achieve statistical power of 0.99, there would need to be 9 participants in each group. This analysis ensures this experiment was properly powered to elucidate this effect.

Face Recognition

Data were analyzed using a between-participants 2 x 7 analysis of variance (ANOVA) on proportion correct responses with Sex x Kinsey Score as factors. All assumptions of ANOVA testing were met with this data set. There was no main effect of participant Sex $F(1,93) = 1.422$, ($p = 0.236$) or participant Kinsey Score $F(1,93) = 0.395$ ($p = 0.531$) nor an interaction effect $F(1,93) = 0.266$, ($p = 0.607$). See figure 4.4a for a graphical representation of these data.

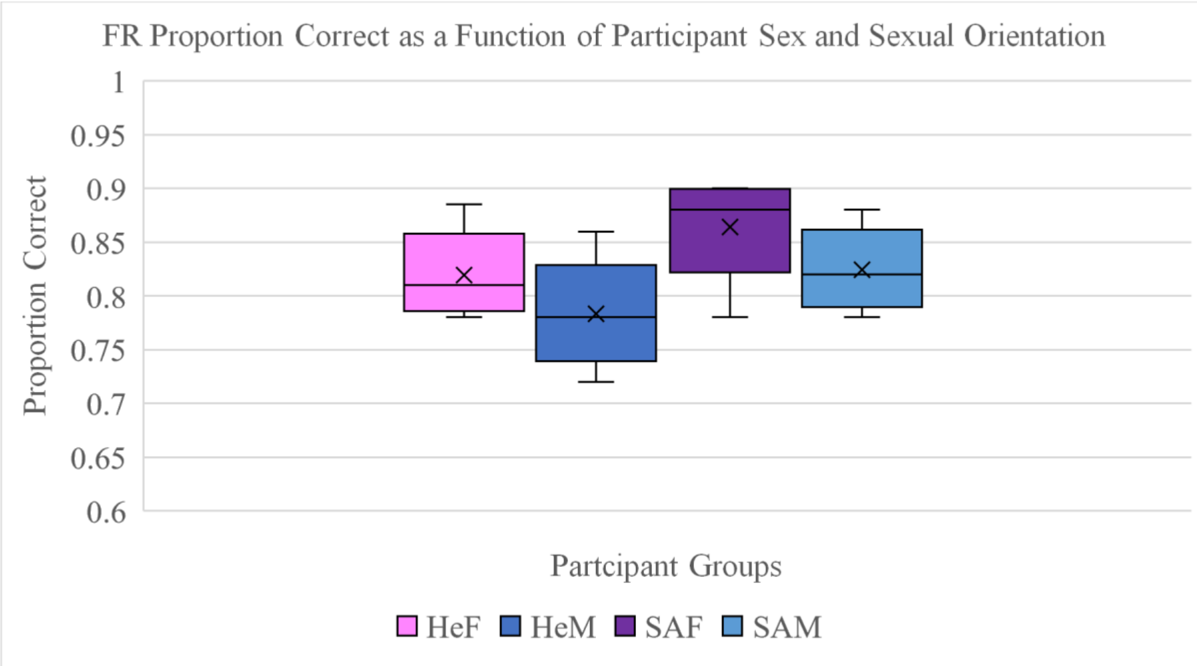


Fig 4.1a. No significant differences were found between any of the groups as shown in boxplot of participant proportion correct for face recognition as a function of participant sex and sexual orientation. Error bars represent standard error of the mean for each group. “x” represents the mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue box) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue box) represents same-sex attracted males.

A post-hoc 2x7 ANOVA on proportion correct was performed with participant group sample size equalized at 17 per group. The method used to pare down the participant count was using the first 17 data sets that were acquired during recruitment for each group for a total of 68 participants. There was no main effect of participant Sex $F(1,64) = 0.513$, ($p = 0.476$) or participant Sexual Orientation $F(1,64) = 0.833$ (p = 0.0.365) nor an interaction effect $F(1,64) = 0.522$, ($p = 0.473$). See Figure 4.4b for a graphical representation of these data.

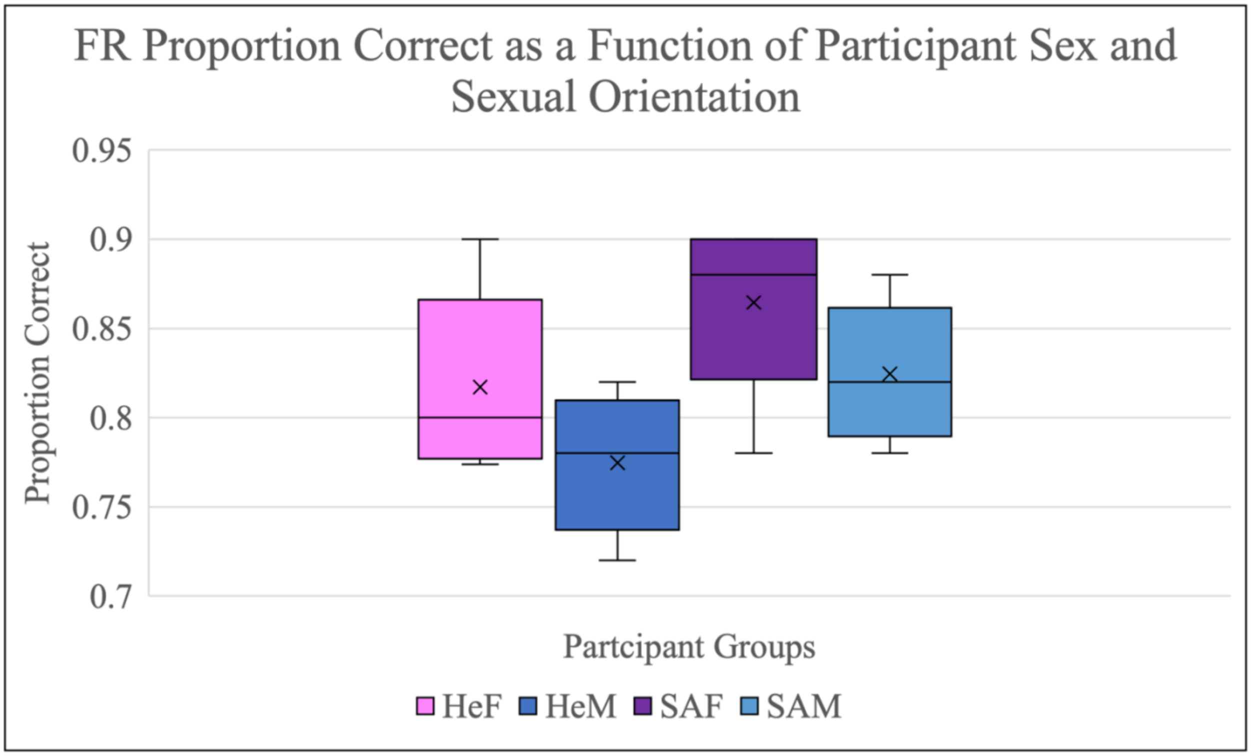


Fig 4.1b. No significant differences were found between any of the groups as shown in boxplot of participant proportion correct for face recognition as a function of participant sex and sexual orientation. Error bars represent standard error of the mean for each group. "x" represents the mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue box) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue box) represents same-sex attracted males.

A power analysis was completed for this experiment. For a small effect size (d = 0.2), there would need to be 70 participants in each group to achieve statistical power of 0.8. To achieve This analysis reveals this experiment was most likely underpowered and unable to detect the effect due to small group sizes.

Face Detection Long Duration

Data were analyzed using a between-participants 2 x 7 analysis of variance (ANOVA) for Sex x Kinsey Score on proportion correct with Bonferroni corrected post-hoc pairwise Welch's t-test comparisons to account for unequal group sizes. All assumptions for ANOVA testing were met with this data set.

The main effects of participant sex and Kinsey score were non-significant, $F(1,93) = 1.286$, ($p = 0.260$) and $F(1,93) = 0.723$, ($p = 0.397$), respectively. The interaction effect of Sex and Kinsey Score was approaching significance, $F(1,93) = 3.027$ ($p = 0.091$). The Bonferroni corrected post-hoc pairwise comparisons revealed a significantly higher proportion correct scores for heterosexual males compared to heterosexual females, with a moderate effect size, $t(45) = -2.8$, $p = 0.008$ ($d = 0.742$) and for same-sex attracted females compared to heterosexual females, with a moderate effect size, $t(45) = -2.4$, $p = 0.019$, ($d = 0.626$). The Bonferroni corrected post-hoc pairwise comparisons did not show a significant different between heterosexual males and same-sex attracted males, $t(23) = -1.4$, $p = 0.188$, between heterosexual males and same-sex attracted females, $t(50) = -0.5$, $p = 0.649$, between heterosexual females and same-sex attracted males, $t(32) = 10.7$, $p = 0.474$, nor between same-sex attracted females and same-sex attracted males, $t(22) = 1.1$, $p = 0.286$. A graphical representation of these data can be seen in Figure 4.5a.

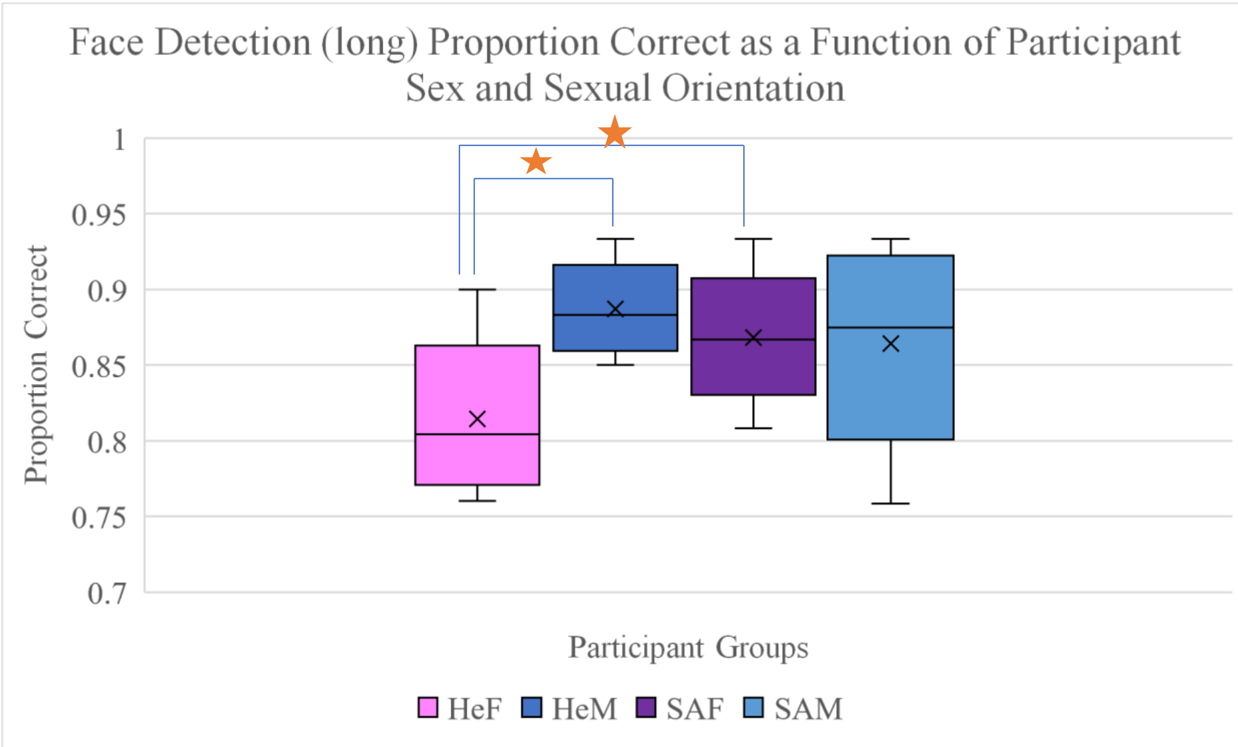


Figure 4.2a. A significant difference was found between heterosexual females and heterosexual males, and between heterosexual females and same-sex attracted females shown on this boxplot of participant proportion correct on the face detection task with a longer duration as a function of participant sex and sexual orientation. Error bars represent standard error for each group. "x" represents mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue box) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue box) represents same-sex attracted males. The star represents a significant difference between group means.

A post-hoc 2x7 ANOVA on proportion correct was performed with participant group sample size equalized at 17 per group. The method used to pare down the participant count was using the first 17 data sets that were acquired during recruitment for each group for a total of 68 participants. The main effects of participant sex and Kinsey score were non-significant, $F(1,64) = 2.099$, ($p = 0.152$) and $F(1,64) = 0.601$, ($p = 0.441$), respectively. The interaction effect between participant sex and Kinsey score was also non-significant however it was approaching significance, $F(1,64) = 3.275$, ($p = 0.071$).

Bonferroni corrected Welch's T-test pairwise comparisons were done to analyze the differences between groups. These pairwise comparisons were corrected to mitigate the family-wise error rate. Heterosexual males had significantly higher proportion correct scores than heterosexual females on this task, $t(27) = -2.7$, $p = 0.014$, with a moderate effect size ($d = 0.75$). There were no significant differences between heterosexual females and same-sex attracted females, $t(26) = -1.9$, $p = 0.075$, between heterosexual females and same-sex attracted males, $t(31) = -1.0$, $p = 0.317$, between heterosexual males and same-sex attracted females, $t(31) = -1.2$, $p = 0.259$, between heterosexual males and same-sex attracted males, $t(27) = 1.4$, $p = 0.146$, nor between same-sex attracted females and same-sex attracted males, $t(26) = 0.7$, $p = 0.527$. A visualization of these data can be seen in figure 4.5b.

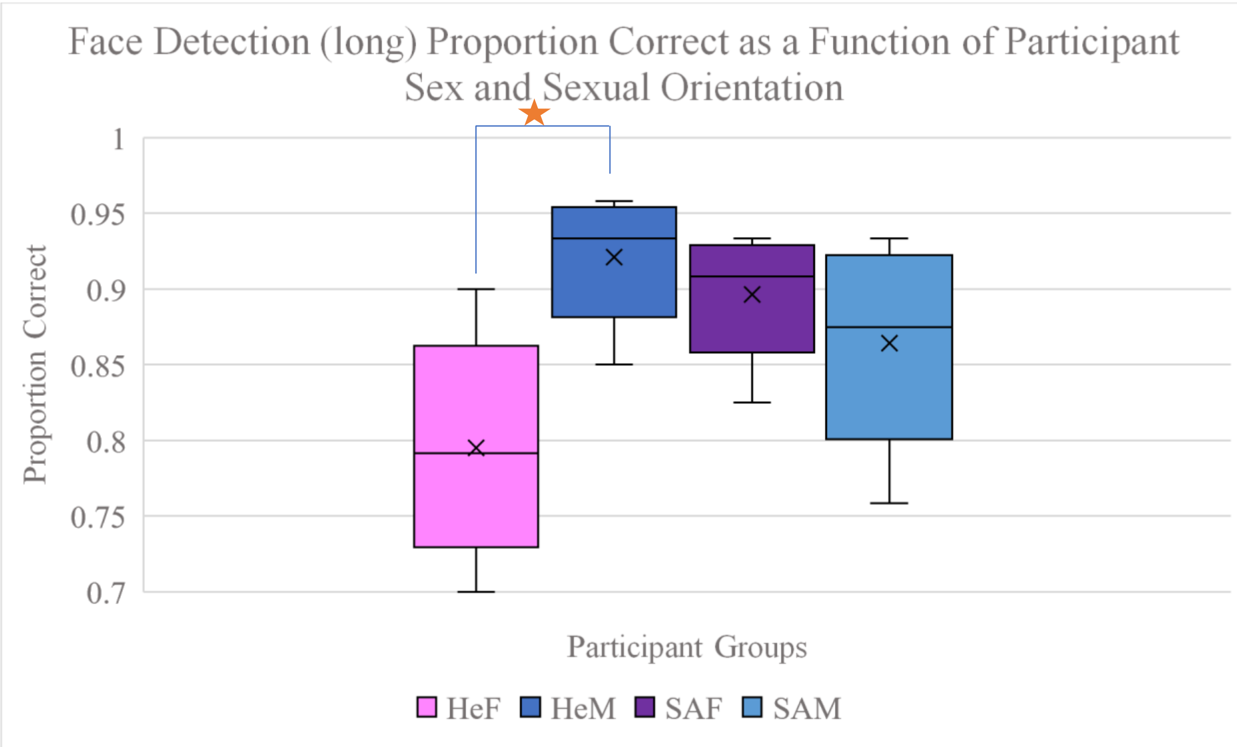


Figure 4.2b. A significance difference for proportion correct between heterosexual females and heterosexual males was found, as shown on this boxplot of participant proportion correct on the face detection task with a longer duration as a function of participant sex and sexual orientation. Error bars represent standard error for each group. “x” represents mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue box) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue box) represents same-sex attracted males. The star represents a significant difference between group means.

A power analysis was completed for this experiment. For a moderate effect size (d = 0.5), there would need to be 12 participants in each group to achieve statistical power of 0.8. To achieve statistical power of 0.99, there would need to be 25 participants in each group. This analysis shows that this studied had a statistical power between 0.8 and 0.99, however this leaves room for a type B error, meaning there is a possibility that there was an effect that was not shown in these data analyses.

Face Detection Short Duration

Data were analyzed using a between-participants 2 x 7 ANOVA with Sex x Kinsey Score as factors for proportion correct. Neither main effects of Sex, $F(1,93) = 1.920$, ($p = 0.169$), nor Kinsey Score, $F(1,93) = 0.490$, ($p = 0.486$), were significant. The interaction effect between Sex and Kinsey Score was also non-significant, $F(1,93) = 1.995$, ($p = 0.1611$). However, when further tested using Welch's t-test with Bonferroni correction post-hoc pairwise comparisons, it was revealed that heterosexual males performed significantly better on proportion correct scores than heterosexual females, with a moderate effect size, $t(51) = -2.0$, $p = 0.047$, ($d = 0.556$), same-sex attracted females also outperformed heterosexual females on this task, with a moderate effect size, $t(49) = -2.6$, $p = 0.012$, ($d = 0.672$), and between heterosexual females and same-sex attracted males, with a moderate effect size, $t(36) = -2.1$, $p = 0.045$, ($d = 0.624$). There were no significant differences between heterosexual males and same-sex attracted males, $t(34) = -0.3$, $p = 0.789$, between heterosexual males and same-sex attracted females, $t(47) = -0.4$, $p = 0.706$, nor between same-sex attracted males and same-sex attracted females $t(29) = 0.04$, $p = 0.972$. For a graphical representation of these data, see Figure 4.6a.

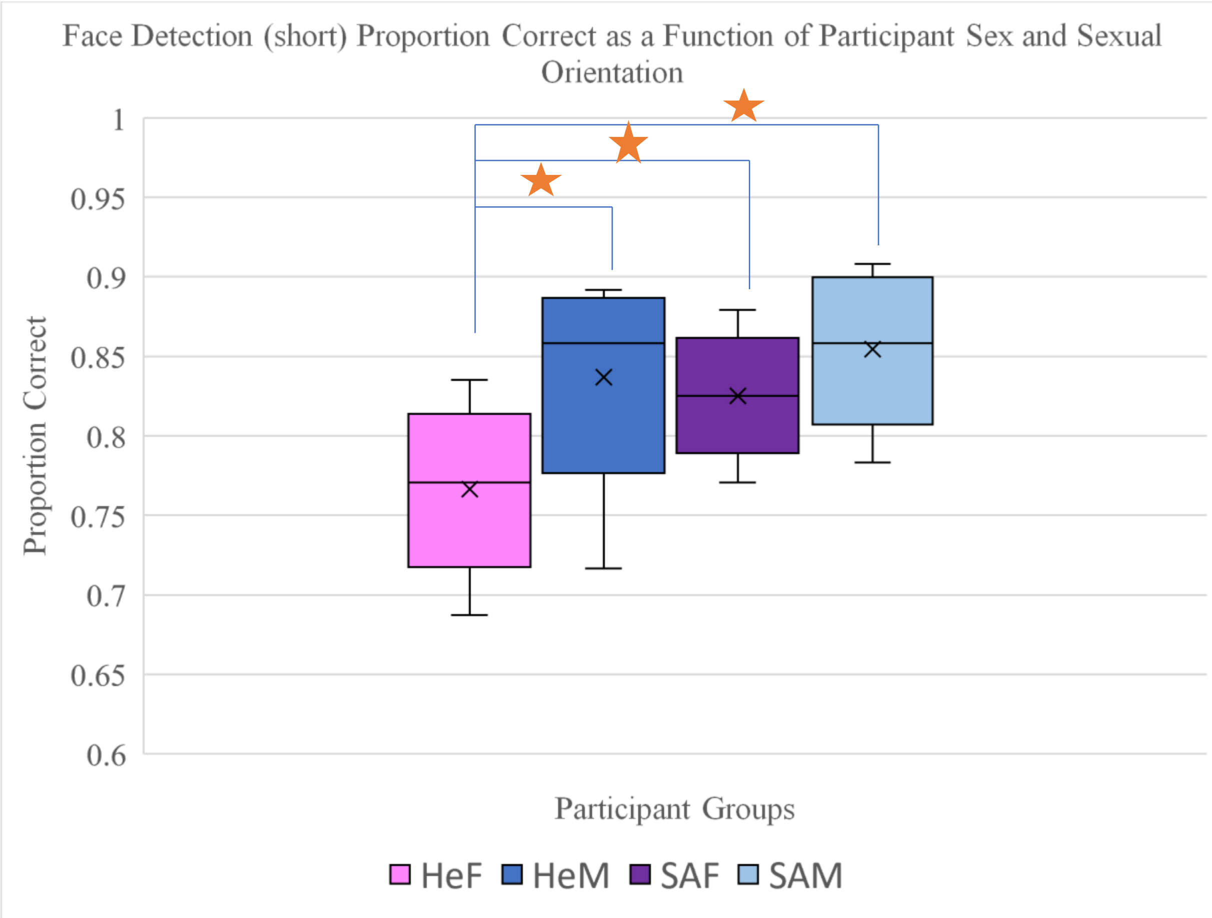


Figure 4.3a. A significant difference in proportion correct between heterosexual females and all other groups was found, shown in this boxplot of participant proportion correct on the face detection task with a longer duration as a function of participant sex and sexual orientation. Error bars represent standard error for each group. "x" represents mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue box) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue box) represents same-sex attracted males. The star represents a significant difference between group means.

A post-hoc 2x7 ANOVA on proportion correct was performed with participant group sample size equalized at 17 per group. The method used to pare down the participant count was using the first 17 data sets that were acquired during recruitment for each group for a total of 68 participants. The main effects of participant sex and Kinsey score were non-significant, $F(1,64) = 3.702$, ($p = 0.059$) and $F(1,64) = 0.162$, ($p = 0.0862$), respectively. However, the main effect of sex was approaching significance. The interaction effect between participant sex and Kinsey score was also non-significant, $F(1,64) = 3.036$, ($p = 0.086$).

Welch's T-tests with Bonferroni corrections were performed to look at pairwise relationships between groups. There were significant differences between heterosexual females and heterosexual males with heterosexual males outperforming heterosexual females on proportion correct scores, $t(30) = -2.3$, $p = 0.030$, and same-sex attracted males significantly outperforming heterosexual females on this task, $t(31) = -2.1$, $p = 0.046$. There were no significant differences between heterosexual females and same-sex attracted females, $t(29) = -1.9$, $p = 0.068$, between heterosexual males and same-sex attracted females, $t(31) = 0.5$, $p = 0.609$, between heterosexual males and same-sex attracted males, $t(31) = 0.2$, $p = 0.866$, nor between same-sex attracted males and same-sex attracted females $t(32) = -0.3$, $p = 0.748$. A graphical representation of these data can be seen in figure 4.6b.

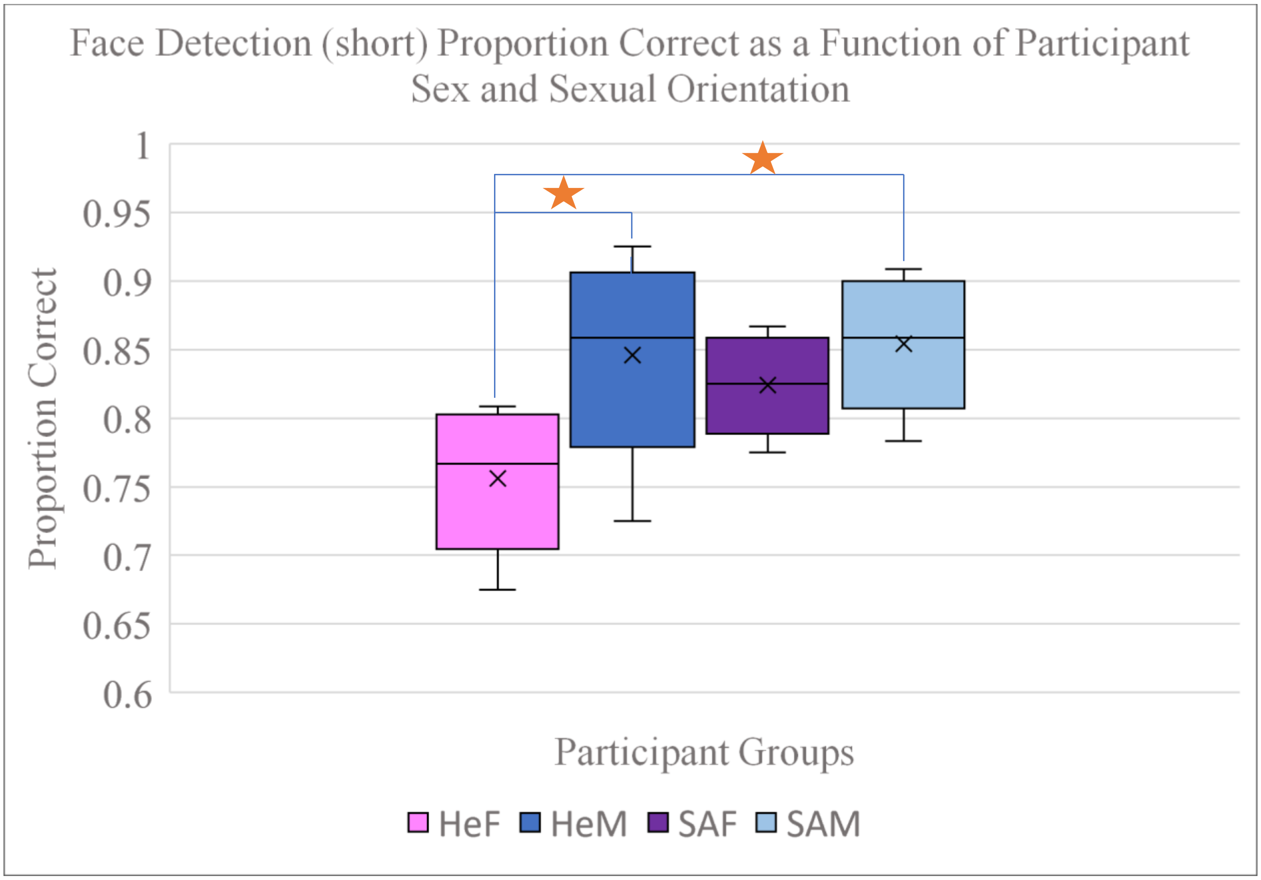


Figure 4.3b. A significant difference was found between heterosexual females and heterosexual males and between heterosexual females and same-sex attracted males on proportion correct. These relationships are shown in this boxplot of participant proportion correct on the face detection task with a longer duration as a function of participant sex and sexual orientation. Error bars represent standard error for each group. “x” represents mean for each group. HeF (pink box) represents heterosexual females, HeM (dark blue box) represents heterosexual males, SAF (purple box) represents same-sex attracted females, and SAM (light blue box) represents same-sex attracted males. The star represents a significant difference between group means.

A power analysis was completed for this experiment. For a moderate effect size (d = 0.5), there would need to be 12 participants in each group to achieve statistical power of 0.8. To achieve statistical power of 0.99, there would need to be 25 participants in each group. This analysis shows that this studied had a statistical power between 0.8 and 0.99, however this leaves room for a type B error, meaning there is a possibility that there was an effect that was not shown in these data analyses.

Across Task Performance

A final post-hoc analysis was done to examine whether performance across tasks were correlated. Using Pearson's correlation coefficient to determine the degree of a linear relationship each task had with one another, it was discovered that mental rotation performance and face recognition performance were weakly correlated both when using the entire sample of 97 participants and in the reduced sample with equal group sizes. Mental rotation performance and face detection performance were moderately correlated in both analyses. Face recognition performance and face detection performance were weakly correlated. Finally, there was a moderate to strong correlation present between the two face detection conditions. For a table with the exact correlation coefficients for each analysis please refer to Table 1 and Table 2.

Table 1 Pearson's Correlation Coefficient across tasks for the sample of 97 participants

Task Name	Mental Rotation	Face Recognition	Face Detection (S)	Face Detection (L)
Mental Rotation	1	0.0428	0.4117	0.4187
Face Recognition	0.0428	1	0.3016	0.2762
Face Detection (S)	0.4117	0.3016	1	0.7881
Face Detection (L)	0.4187	0.2762	0.7881	1

Table 2 Pearson's Correlation Coefficient across tasks for the sample of 68 participants

Task Name	Mental Rotation	Face Recognition	Face Detection (S)	Face Detection (L)
Mental Rotation	1	0.0871	0.4329	0.4286
Face Recognition	0.0871	1	0.2878	0.3221
Face Detection (S)	0.4329	0.2878	1	0.8395
Face Detection (L)	0.4286	0.3221	0.8395	1

Chapter 4: Discussion

Mental Rotation

Consistent with previous literature (Voyer, 2011) and as predicted, heterosexual males outperformed heterosexual females on mental rotation. Mental rotation is one of the most frequently used measures of spatial ability (Carroll, 1993) and consistently demonstrates that heterosexual males are more accurate in their ability to mentalize the spatial rotation of the block designs compared to heterosexual females. There was no significant difference between same-sex attracted females and same-sex attracted males nor between same-sex attracted females and heterosexual males. In other words, while not significantly different from heterosexual females, these two same-sex attracted groups did not perform significantly lower than heterosexual males. This suggests that the male advantage in spatial abilities may not be present in same-sex attracted groups.

These data show a sex difference in accuracy between heterosexual males and heterosexual females consistent with previous literature. The sex difference in the pencil-and-paper mental rotation task is one of the largest sex differences described to date (Voyer, 2011). The present study employed a digitized analog of the pencil-and-paper mental rotation task. As expected, heterosexual males outperformed heterosexual females on the mental rotation task, pointing to a male advantage for mental rotation ability. This could be a result of differing neural recruitments between males and females or different strategic processing (Champod et al., 2007; Harris et al., 2000; Hoppe et al., 2012; Jordan et al., 2002). Understanding which subject variables correlate with mental rotation ability is an important first step in determining what can be done to help facilitate more women to join STEM fields because mental rotation ability is an important spatial ability that predicts performance in STEM fields (Maeda, 2013).

Although it was presumed that same-sex attracted men and women would outperform heterosexual women – with same-sex attracted men retaining the sex advantage and same-sex attracted women showing a cross-sex advantage, this was not supported by the data. Nonetheless, it can be inferred that sexual orientation plays some role in mental rotation ability as a difference between same-sex attracted males and females was not found. This supports the hypothesis that sexual orientation is an important variable to consider as there is no male advantage present in the same-sex attracted sample. The lack of difference between same-sex attracted women and men could be explained by the following. It is possible that same-sex attracted females recruit similar neurological correlates to males when completing visuospatial tasks, nullifying the difference usually found between males and females in mental rotation ability. This is supported by the finding that same-sex attracted women did not perform significantly differently from either same-sex attracted men nor heterosexual men.

It has been shown that heterosexual men had faster search latencies during spatial learning than heterosexual women and gay men, but not same-sex attracted women (Rahman et al., 2017), indicating a similar performance between heterosexual men and same-sex attracted women. Furthermore, the anterior hypothalamus, found to be important in spatial memory (Rahman et al., 2017) was found to be sex-atypical in same-sex attracted men and women (Swaab, 2008), with same-sex attracted women showing a heterosexual male typical activation of the anterior hypothalamus during spatial tasks. It could be that these groups recruit the same neural correlates as heterosexual males or use similar strategies to complete mental rotation problems.

Future research should examine neural correlates associated with this behavioural task and compare across sex and sexual orientation statuses of participants. Men tend to have more activation in the inferior parietal lobule when performing spatial tasks, while women tend to have increased activation in the frontal lobule (Jordan et al., 2003). However, these studies have primary been done with participants who are heterosexual, or sexuality was not considered. Adding sexuality as a factor in an fMRI study for this task would elucidate the role sexuality and sex play in visuospatial perception.

This study had a few limitations, the first being an unequal amount of right-handed versus left-handed individuals, making statistical analysis of this variable unattainable. Another issue was the presentation of 3D block designs on a 2D plane, this leaves the interpretation open that this task may not be measuring 3D mental rotation ability. However, a recent study showed that sex differences in mental rotation ability persist in a virtual reality paradigm, further validating the mental rotation task (Jacobs et al., under review).

In summary, mental rotation shows a large heterosexual sex difference in accuracy, with heterosexual men outperforming heterosexual women. In addition, this difference is also dependent on subject sexual orientation as it is not found the same-sex attracted population. These data have shown that heterosexual men significantly outperform heterosexual women but there is no significant difference when comparing heterosexual men to same-sex attracted women nor when comparing same-sex attracted men to same-sex attracted women. This could be a result of same-sex attracted women tending to show a male-typical advantage on this task, where they do not perform less accurately than males. Perhaps same-sex attraction is another factor that can predict better spatial abilities in females. Since same-sex attracted males did not differ significantly from heterosexual males, it can be inferred that they tend to retain the male advantage on the mental rotation task. Further research in this area will contribute to our understanding of the effect sexual orientation has on mental rotation ability and whether the behavioural differences in this task are supported by underlying neurological differences.

Face Recognition and Face Detection

Overall, these data show that there is a trend for heterosexual and same-sex attracted females and same-sex attracted males to outperform heterosexual males in face recognition. Females and same-sex attracted males had higher mean accuracy scores on the face recognition task. However, this was only a trend and most likely due to the study being under powered with too few participants. As previous face recognition work (Brewster et al., 2012) was not replicated here, these results come as a surprise. Due to the experiment lacking the regular controls a laboratory setting provides, there are many variables that could not be controlled for as it was performed in an online setting. These variables include not being able to control precise stimuli presentation time as researchers have no control over what computer processors are used to complete an online study. Future research should include larger group sizes to encompass the full effect of this difference and to minimize potentially error in the samples.

Both face detection tasks showed a significant difference between heterosexual females and heterosexual males; however, in the opposite direction of one study in the prevailing literature – with heterosexual males outperforming heterosexual females. Both tasks also showed a significant difference between same-sex attracted females and heterosexual females, with same-sex attracted females outperforming heterosexual females on proportion correct. In the short duration face detection task, there was a significant difference between same-sex attracted males and heterosexual females, with same-sex attracted males outperforming heterosexual females. However, when the group sizes were equalized, the same-sex attracted female group no longer had a significant advantage over the heterosexual female group on the short duration face detection task. There were a long and short duration conditions of this task to elucidate whether the stimuli presentation time influenced performance on the task. A longer stimuli presentation time allows for further cognitive processing of stimuli, and we wanted to see if this further cognitive processing resulted in a nullification of the sex difference usually observed in this task – females outperforming males on proportion correct (McBain et al., 2009).

These results suggest that females tend to excel at face recognition, but face detection skills may be more equal than previously thought. Although this experiment was not a direct replication of the previous work done by McBain et al., (2008), it used the same stimuli and the same presentation time, so it is surprising the results are so vastly different. Due to these tasks being attributed to differing brain areas, following Gauthier's theory of face perception – the FFA supporting face recognition and the OFA supporting face detection, one could argue that these data suggest the FFA is sexually dimorphic while more basic processing in the OFA is not. However, this theory does not grasp the complexity of FFA and OFA function. Work with prosopagnosia patients P.S. and D.F. has shown when the OFA is structurally or functionally damaged, while the FFA remains intact, higher level face processing does not occur (Roisson et al., 2003; Steeves et al., 2006). While FFA is important for face recognition, evidence from a patient with prosopagnosia, an inability to recognize faces, and who has bilateral lesions overlapping the OFA, shows activation in the FFA when viewing faces, but cannot recognize these faces. This suggests that this region is not sufficient for higher level face processing (Steeves et al., 2006). The FFA is necessary but not sufficient for face processing, pointing to the necessity of the OFA. Follow-up studies should examine these behavioural tasks coupled with neuroimaging techniques to get a clearer picture of the neural processing involved when completing these face perception tasks.

This could also be the result of a sample size that was too small to elucidate the true population effect on this task. It could also point to there not being an effect, and McBain et al., may have found an artefact in their study rather than a true effect. More research must be done to fully understand sex and sexual orientation differences in face detection.

Sex differences in face perception are important to study due to the presence of sexually dimorphic rates of face processing dysfunction. For example, when a male and female suffer the same lesions, males are more likely to suffer from prosopagnosia than females (Mazzucchi et al., 1983). This phenomenon can be explained, in part, by the finding that females tend to process face images bilaterally while males tend to process them only the right hemisphere (Proverbio, 2010). This is a protective feature of face processing in females.

Behaviourally, same-sex attracted men tend to perform at the levels of heterosexual women on face recognition tasks (Brewster el al., 2012). These results this experiment were not significant but trend in this direction, with women and same-sex attracted men having higher average accuracy on this task than heterosexual men. Sexual orientation is also an important variable to consider when doing face perception work due to this difference.

In summation, while the face recognition task did not produce data with significant differences between the groups, females and same-sex attracted males had higher mean accuracy scores than heterosexual males. Both the long and short presentation duration versions of the face detection tasks showed heterosexual males and same-sex attracted females outperforming heterosexual females. The short version showed same-sex attracted males outperforming heterosexual females. More work must be done to elucidate the true effect between these groups for face recognition and face detection skills.

Across Task Correlations

There was a weak correlation between mental rotation performance and face recognition performance. This is not a surprising finding as spatial abilities and face perception are related only in that they are both visual tasks, but the cognitive mechanisms and neural correlates used to complete these tasks are very different. Mental rotation ability and face detection had a moderate correlation which was a surprising finding as mentioned previously they recruit different cognitive and neural correlates. However, we saw heterosexual men outperform the other groups on this task and perhaps those outperformances are driving this correlation. Surprisingly, face recognition and face detection only had a moderate correlation, considering they are both face perception tasks. However, they target different cognitive abilities with face recognition targeting the participants ability to recall previously seen faces while face detection targets participant ability to notice a face within a line drawing. Finally, there was a strong correlation between the two face detection conditions, which is expected as they use the same stimuli and target the same cognitive process, only differing in presentation time.

General Discussion

Studying sex differences is very important because for much of the history of the scientific method, female subjects have been left out. Science has been male-centric and to remedy this, researchers must consider sex differences in behaviour and neurological function. This will allow a clearer picture of human behaviour and the human brain as there are some fundamental differences between males and females that must be accounted for. Studies have shown that men and women respond differently to treatments for illnesses and experience disease differently (Mostertz et al., 2010; Kokras et al., 2014; Zhou et al., 2016; Bawor et al., 2014). There are also sex differences in ASD, with prevalence ratios ranging from 4:1, male to female, to 2:1, male to female (Kirkovski et al., 2013). Understanding the biological and behavioural mechanisms behind these differences could assist in understanding why certain diseases and dysfunctions are sexually dimorphic.

One way to gain understanding in sexually dimorphic behavioural patterns is to run experiments using tasks that consistently show sex differences. Some such tasks include mental rotation, face recognition and face detection. These tasks have been used to detect sex differences but only in the last ten years have researchers begun to look at sexual orientation differences as well. This project serves to fill the gap in the literature on whether sexual orientation is a factor that should be considered when studying tasks that produce consistent sex differences.

The first task, the mental rotation task, was originally produced by Shepard and Metzler (1971) and gained traction due to their finding that reaction time was significantly related to the amount one block differed in orientation from the second block. Sex differences favouring men on the mental rotation task have been well documented since the 1980s and it continues to be one of the largest cognitive sex differences observed in the literature (Voyer, 2011). Understanding this sex difference is important because performance on the mental rotation task can be a predictor variable for how well an individual will fair in STEM fields (Maeda, 2013). It is also important to note that training on mental rotation helps diminish sex differences (Casey et al 1996).

Whether this is sex difference is due to sociocultural influences or biological mechanisms is yet to be determined, however it is most likely a combination of the two. While infant studies have shown sex differences favouring males in mental rotation ability at 3 months of age (Quinn et al., 2008), other work has theorized that male children are more likely to train their spatial skills throughout childhood through block play (Casey et al., 1996). There is a subset of females who have a genetic predisposition to better spatial skills, which points to a biological underpinning, however there is still a favourable sex difference towards males when compared to this subset (Casey et al., 1996).

The data for this mental rotation experiment followed the trend of the literature with heterosexual males outperforming heterosexual females. However, same sex attracted groups were sampled as well and, in this sample, there was no between same-sex attracted males and same-sex attracted females. This is a compelling finding as it suggests that the sex difference in this long-studied task may be dependent on participant sexual orientation. Same sex attracted females tend to recruit similar neurological correlates to heterosexual males when completing visuospatial tasks (Swaab, 2008). This could explain the above findings pointing to a cross-sex advantage in this task. There is some neurological evidence for this assertion; the anterior hypothalamus, found to be important in spatial memory (Rahman et al., 2017) was found to be sex-atypical in same-sex attracted men and women (Swaab, 2008).

The implications of this research include the possibility of another subset of females who have a predisposition to have better spatial skills than the average female population – females with some degree of same-sex attraction. Further testing must be done using sexual orientation as a subject variable to further understand the relationship between female sexual orientation and mental rotation ability. Mental rotation is not the only task that shows a sex difference that is dependent on participant sexual orientation.

Previous studies on face recognition have shown that same-sex attracted males seem to have a cross-sex advantage at this task, meaning they perform at the level of females (Brewster et al., 2012). Both groups tend to outperform heterosexual males. The current study shows data trending in the same direction, with both females and same sex attracted males having higher scores on accuracy, however this difference does not reach significance.

Face perception is a fundamental ability that facilitates socialization in human populations. Being able to recognize, identify and interact with faces is a very important aspect of fostering positive social relationships. Positive social relationships are important for both physical and mental health. Understanding the differences between males and females in face perception can help researchers create treatments for dysfunctions in face perception that sexually dimorphic such as autism spectrum disorder and prosopagnosia.

Another important aspect of face perception is face detection – the ability to recognize a face as a face. One study has shown that females tend to outperform males on measures of face detection (McBain et al., 2009) however, the data in this study have shown the opposite effect. Heterosexual men performed significantly better than heterosexual women on the face detection task. This could point to a subset of heterosexual men that have better face detection skills than most heterosexual men. Same-sex attracted men and women outperformed heterosexual women on the short version of the face detection task. These findings could indicate that this sample was unable to uncover the effect McBain et al. found, or it could be due to the uncertainty of stimuli presentation time due to the online setting of this research. Another possible explanation is that the McBain et al. study found an artefact of the data rather than a true sex difference between males and females on face detection ability.

Limitations

There were some limitations to these experiments, the first being that they were performed in an online setting. Researchers had less control over the setting in which participants performed the tasks, meaning differences could have arisen based on what type of monitor participants used, how far or close to the screen they were positioned, and/or less focus from not being in a laboratory setting. There is also an increased likelihood of participants not paying attention as there are external distractors in a home or library setting that are not present in the laboratory setting such as family members interrupting the participant, the use of a cellphone while doing an experiment, and background noise that is not present in a laboratory. Another issue with the online format is the researcher is not present to help the participant understand the task guidelines and/or ensure the guidelines are read in full.

Another limitation is the sample size, it is small and uneven. This results in a less representative sample as well as difficulty in group comparisons due to unequal sample sizes. However, an analysis was performed with a reduced sample that allowed for equal sample sizes and the results remained the same except on the short face detection task, there was no longer a significant difference between heterosexual females and same-sex attracted females. This analysis still had the issue of a small overall sample size. Time constraints made it difficult to collect more participants to raise the power of the experiment.

Future Directions

Mental rotation

It would be interesting to repeat the same experiment in a laboratory setting to see how the online results would compare. Another follow-up would be looking at the neural correlates of this task and comparing them across groups. Men tend to have more activation in the inferior parietal lobule when performing spatial tasks, while women tend to have increased activation in the frontal lobule (Jordan et al., 2003). However, these studies have primarily been done with participants who are heterosexual, or sexuality was not considered. Adding sexuality as a factor in an fMRI study for this task would elucidate the role sexuality and sex play in visuospatial perception.

Face perception

Again, it would be valuable to do the same tasks in a laboratory setting to compare with the online data. This would allow researchers to test the validity of the online experiment. Examining the neurological correlates of these tasks would be helpful as well. Specifically, focussing on the lateral fusiform area, the occipital face area, and the superior temporal gyri, which make up the extended face network (Haxby et al., 2000). Many studies suggest face processing is right hemisphere dominant (Rossion et al., 2012), however it has been found that face perception is bilaterally processed in adult females (Proverbio, 2010). It would be interesting to see how same-sex attracted males brain activation may differ from heterosexual males, especially since they seem to have a cross-sex advantage in the face perception domain (Brewster et al., 2012).

Another line of research that could follow these experiments is to examine differences in these tasks between individuals with high rates of autistic traits compared to those with lower rates. This would help elucidate the relationship between autistic traits in clinically neurotypical participants and face perception abilities.

Conclusion

Sex and sexual orientation differences are important to study. Abilities that traditionally show sex differences include spatial abilities and face perception skills. Given the results, sexual orientation is clearly a variable that must be included in studies looking at sex differences as the significant results were dependent on participant sexual orientation as well as participant sex.

Mental rotation data showed the typical male advantage over females but only in the heterosexual groups, implying that same-sex attracted groups do not show this differentiation. This was an important finding because it adds to the literature that shows sexuality is a factor that most likely has a biological underpinning. The sex difference that is found between heterosexual groups is not seen in the same-sex attracted groups, pointing to the cognitive difference seen between heterosexual groups not being present between same-sex attracted males and females. Face recognition data trended in the direction of the literature, with females and same-sex attracted males having higher mean accuracy scores on the task, however these results did not meet significance. This was most likely due to an underpowered study design with too few participants. Face detection data showed the opposite result of one study, with heterosexual men outperforming heterosexual women, bringing into question the reliability of the McBain et al. study.

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Appendix

Edinburgh Handedness Inventory – Short Form

Edinburgh Handedness Inventory - Short Form

Please indicate your preferences in the use of hands in the following activities or objects:

	Always right	Usually right	Both equally	Usually left	Always left
Writing					
Throwing					
Toothbrush					
Spoon					

Scoring:

For each item: Always right = 100; Usually right = 50; Both equally = 0; Usually left = -50; Always
left = -100

To calculate the Laterality Quotient add the scores for the four items in the scale and divide this by four:

Writing score	
Throwing score	
Toothbrush score	
Spoon score	
Total	
Total ÷ 4 (Laterality Quotient)	

Classification:	Laterality Quotient score:
Left handers	-100 to -61
Mixed handers	-60 to 60
Right handers	61 to 100

Kinsey Scale

Please consider the following when deciding your ranking: fantasies, thoughts, emotional/romantic feelings, dreams, and frequency of sexual activity.

Please select below which statement you most identify with.

Please select the best representation of your sexual orientation:

- Exclusively heterosexual
- Predominately heterosexual, incidentally homosexual
- Predominately heterosexual, more than incidentally homosexual
- Equally homosexual and heterosexual
- Predominately homosexual, more than incidentally heterosexual
- Predominately homosexual, incidentally heterosexual
- Exclusively homosexual

Traditional Masculinity-Femininity Scale

The Traditional Masculinity-Femininity Scale (TMF) in English translation [with original German wording]

1. I consider myself as…
   [Ich empfinde mich selbst als…]
2. Ideally, I would like to be…
   [Idealerweise wäre ich gern…]
3. Traditionally, my interests would be considered as…
   [Traditionellerweise würden meine Interessen angesehen werden als…]
4. Traditionally, my attitudes and beliefs would be considered as…
   [Traditionellerweise würden meine Einstellungen und Ansichten angesehen werden als…]
5. Traditionally, my behavior would be considered as…

[Traditionellerweise würde mein Verhalten angesehen werden als…]

6. Traditionally, my outer appearance would be considered as…
[Traditionellerweise würde meine äußere Erscheinung angesehen werden als…]

Scales ranged from 1 (*not at all masculine*) to 7 (*totally masculine*) and from 1 (*not at all feminine*) to 7 (*totally feminine*) in Study 1 and from 1 (*totally masculine*) to 7 (*totally feminine*).

Autism Quotient

The Adult Autism Spectrum Quotient (AQ)

Ages 16+

SPECIMEN, FOR RESEARCH USE ONLY.

For full details, please see:

S. Baron-Cohen, S. Wheelwright, R. Skinner, J. Martin and E. Clubley, (2001)
The Autism Spectrum Quotient (AQ) : Evidence from Asperger Syndrome/High Functioning Autism, Males and Females, Scientists and Mathematicians
Journal of Autism and Developmental Disorders 31:5-17

Name:.. Sex:...

Date of birth:.................................. Today's Date................................

How to fill out the questionnaire

Below are a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree with it by circling your answer.

DO NOT MISS ANY STATEMENT OUT.

Examples

E1. I am willing to take risks.	definitely agree	slightly agree	slightly disagree	definitely disagree
E2. I like playing board games.	definitely agree	slightly agree	slightly disagree	definitely disagree
E3. I find learning to play musical instruments easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
E4. I am fascinated by other cultures.	definitely agree	slightly agree	slightly disagree	definitely disagree

1. I prefer to do things with others rather than on my own.	definitely agree	slightly agree	slightly disagree	definitely disagree
2. I prefer to do things the same way over and over again.	definitely agree	slightly agree	slightly disagree	definitely disagree
3. If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	slightly disagree	definitely disagree
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	slightly disagree	definitely disagree
5. I often notice small sounds when others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
6. I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	slightly disagree	definitely disagree
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	slightly disagree	definitely disagree
8. When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	slightly disagree	definitely disagree
9. I am fascinated by dates.	definitely agree	slightly agree	slightly disagree	definitely disagree
10. In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	slightly disagree	definitely disagree
11. I find social situations easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
12. I tend to notice details that others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
13. I would rather go to a library than a party.	definitely agree	slightly agree	slightly disagree	definitely disagree
14. I find making up stories easy.	definitely agree	slightly agree	slightly disagree	definitely disagree

15. I find myself drawn more strongly to people than to things.	definitely agree / slightly agree / slightly disagree / definitely disagree
16. I tend to have very strong interests which I get upset about if I can't pursue.	definitely agree / slightly agree / slightly disagree / definitely disagree
17. I enjoy social chit-chat.	definitely agree / slightly agree / slightly disagree / definitely disagree
18. When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree / slightly agree / slightly disagree / definitely disagree
19. I am fascinated by numbers.	definitely agree / slightly agree / slightly disagree / definitely disagree
20. When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree / slightly agree / slightly disagree / definitely disagree
21. I don't particularly enjoy reading fiction.	definitely agree / slightly agree / slightly disagree / definitely disagree
22. I find it hard to make new friends.	definitely agree / slightly agree / slightly disagree / definitely disagree
23. I notice patterns in things all the time.	definitely agree / slightly agree / slightly disagree / definitely disagree
24. I would rather go to the theatre than a museum.	definitely agree / slightly agree / slightly disagree / definitely disagree
25. It does not upset me if my daily routine is disturbed.	definitely agree / slightly agree / slightly disagree / definitely disagree
26. I frequently find that I don't know how to keep a conversation going.	definitely agree / slightly agree / slightly disagree / definitely disagree
27. I find it easy to "read between the lines" when someone is talking to me.	definitely agree / slightly agree / slightly disagree / definitely disagree
28. I usually concentrate more on the whole picture, rather than the small details.	definitely agree / slightly agree / slightly disagree / definitely disagree
29. I am not very good at remembering phone numbers.	definitely agree / slightly agree / slightly disagree / definitely disagree
30. I don't usually notice small changes in a situation, or a person's appearance.	definitely agree / slightly agree / slightly disagree / definitely disagree
31. I know how to tell if someone listening to me is getting bored.	definitely agree / slightly agree / slightly disagree / definitely disagree

32. I find it easy to do more than one thing at once.	definitely agree	slightly agree	slightly disagree	definitely disagree
33. When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree
34. I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35. I am often the last to understand the point of a joke.	definitely agree	slightly agree	slightly disagree	definitely disagree
36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree
37. If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38. I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39. People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40. When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46. New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people.	definitely agree	slightly agree	slightly disagree	definitely disagree
48. I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree

50. I find it very easy to play games with children that involve pretending.	definitely agree / slightly agree / slightly disagree / definitely disagree

Developed by:
The Autism Research Centre
University of Cambridge

Participant Background Questionnaire

When is your birthday? (YYYY/MM/DD)

What is your biological sex?

- Male
- Female
- Intersex

What is your Ethnicity? (Please specify)

Are any of your immediate family members left-handed?

- Yes
- No

What is your level of education?

Highschool

Post-secondary

Graduate school

If "post-secondary" or higher, what is/are your field(s) of study?

Input "N/A" if you selected "Highschool" in previous question.

[ ]

Please enter your primary language:
("Primary" referring to most utilized language in your everyday experience)

[ ]

Is English your first language?

Yes

No

Do you speak any additional languages?

Yes

No

If you answered "Yes" in the above question, please specify languages spoken.
Input "N/A" if you selected "No" in previous question.