Uncovering religious and occupational stereotypes using implicit face perception measures

UNCOVERING RELIGIOUS AND OCCUPATIONAL STEREOTYPES USING IMPLICIT FACE PERCEPTION MEASURES

By MAHEEN SHAKIL, B.Sc. (Hons.)

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AUTHOR: Maheen Shakil, B.Sc. (Hons.) (McMaster University)

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Lay Abstract

Stereotypes are the generalizations people make about the social groups around them. It can be difficult to study stereotypes by directly asking people about them because people do not want to appear prejudiced, so it is more effective to use indirect, or implicit, measurements instead. We conducted three studies using implicit methods to understand the stereotypes people have of religious and occupational groups. First, we showed that Christians and Muslims both have more positive stereotypes for the majority religion, Christianity, rather than both groups preferring their religious ingroup. We also showed that individuals categorize each other based on their explicitly stated religious identity and their food preferences, but not their country of origin, and this categorization impacts how faces are perceived. Finally, we demonstrated that individuals stereotype scientists as being White, male, incompetent, unsociable, and poor at communication, and these stereotypes are embedded in how scientists are pictured.

Abstract

Stereotypes refer to the generalizations individuals make about members of social categories, which can affect their thoughts and behaviours towards those who are stereotyped. Stereotypes can be difficult to assess directly. Implicit measures, which tap into attitudes without an individual's conscious awareness, are therefore useful in this area of research. In the three studies that make up this dissertation, we used implicit face perception methods to uncover stereotypes about religious and occupational groups. In the first study, we used the reverse correlation procedure to visualize and compare the mental representations Christian and Muslim individuals have for their religious ingroup and the outgroups. Our aim was to uncover their religious stereotypes and determine whether they favoured their ingroup, or instead favoured the majority group. First, a set of Christian and Muslim participants selected faces in a two-image forced choice task that resembled Christians and Muslims to them. We averaged the faces they selected to form classification images (CIs) and had a naive set of participants rate them on several demographic and valenced characteristics to reveal their stereotypes and intergroup preferences. We found that the CIs for Christian faces were consistently rated more positively on valenced characteristics than Muslim CIs were, regardless of whether the CI was made of images selected by Christian or Muslim participants. This suggests that a preference for the majority religious group exists among both Christian and Muslim adults in Canada, and this preference is not overridden by ingroup favouritism. In the next study, we tested which cues of religious identity would be effective at signalling religious group membership, leading individuals to categorize faces as members of separate groups. We used a category-contingent aftereffects paradigm, where participants viewed faces belonging Christian and Muslim individuals which were artificially contracted and expanded respectively. The identity of the faces was cued through audio that either explicitly stated their religious affiliation, or stated a food preference or country of origin that

was associated with Christianity or Islam. If the cues led to the perception of discrete groups, we would observe opposing changes in preference for Christian and Muslim faces (e.g., a preference for contracted Christian faces and expanded Muslim faces), known as a category-contingent aftereffect. We observed significant category-contingent aftereffects in the audio conditions with explicit religious labels and food preferences, but not country of origin. This suggests that the first two cues are effective at signalling group membership, enough that they act as a top-down influence on the unconscious process of face perception, and may be leading to rapid categorization and stereotyping in social interactions. In the final study, we used the reverse correlation procedure once again to study stereotypes towards scientists, rather than religious groups, and compare them to stereotypes of heroes, geniuses, and the superordinate "person" category. First we presented our participants with a two-image forced choice task where they selected images that looked like a scientist, hero, genius, and person in separate blocks. We averaged the images they selected to create CIs for each category, and then had a naive set of participants rate them on demographic and valenced traits. We found that the Scientist CI was rated as more White and male than the Person CI, which suggests that scientists are stereotyped as the most historically represented group in the sciences. The Scientist CI was also rated lower than the other CIs on some valenced traits suggesting that scientists are stereotyped as being unsociable, incompetent, and poor communicators.

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There are so many things people say it takes a village to do, and I think writing a dissertation is definitely one of them. There aren't enough words in the world to capture the gratitude I feel towards the people around me who made this possible, but anyone who knows me and my tendency for writing long messages knows I can probably find at least a few. If I shed a few tears typing all this out, well, if you know me, that's not too surprising either!

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Chapter 4

List of Abbreviations and Symbols

ANOVA, analysis of variance

CAD, Canadian dollars

CI, classification image or confidence interval

CRS, Centrality of Religiosity Scale

d, Cohen's *d*

df, degrees of freedom

F, test statistic from an analysis of variance

f, Cohen's *f*

η_p^2, partial eta-squared

IAT, Implicit Association Test

M, mean

MTurk, Amazon MTurk, an online participant recruitment tool

N, number of participants

p, p-value, probability

OSF, Open Science Framework

r, correlation coefficient

RC, reverse correlation

SD, standard deviation

t, test statistic from a *t*-test

V, test statistic from a Wilcoxon's signed rank test

χ^2, Wald's Chi-squared statistic

Declaration of Academic Achievement

Chapter 2: Dr. M.D. Rutherford and I designed the experiment. I programmed the experiment and developed all stimuli. I recruited all participants. I conducted the data analyses in collaboration with Hasan Siddiqui, a fellow PhD student in the lab at the time. I created all figures and prepared the manuscript for publication, which was edited by Dr. M.D. Rutherford.

Chapter 3: Dr. M.D. Rutherford and I designed the experiment. I programmed the experiment. Daniel Jedrzejewski, Megan Werger, Stephanie Liang, and I recruited participants. I conducted all data analyses and created all figures. I prepared the manuscript for publication, which was edited by Dr. M.D. Rutherford. Dr. M.D. Rutherford and I collaborated on revisions.

Chapter 4: Dr. M.D. Rutherford, Hasan Siddiqui, and I designed the experiment. I programmed the experiment and developed the stimuli. I collected all of the data, while Hasan Siddiqui conducted the data analyses. I created all figures. I prepared the manuscript for publication, which was edited by Hasan Siddiqui and Dr. M.D. Rutherford.

Chapter 1: Introduction

Specialized psychological processes allow humans to navigate complex social environments. When they see other people, they quickly infer age, gender, and race (Ito & Urland, 2003, 2005; Mouchetant-Rostaing et al., 2000; Tanaka, 2001). They sort others into categories based on this information, and use prior knowledge to guide their categorization. These psychological processes, while necessary for social interactions, can lead to overgeneralizations, stereotyping, and prejudice (Allport, 1979). To better understand intergroup interactions, it is necessary to understand how social categorization occurs in the mind and how it influences our perception and psychological representation of others.

Social categories – such as race, gender, age, and religion – serve as mental frameworks that help people navigate and understand their social world (Dahlgren, 1985).

Categorization

Understanding social categorization begins with understanding categorization in general. Humans have a natural tendency to classify objects, people and events into categories rather than perceiving them individually (Goldstone et al., 2018).

Psychologists have long debated how the process of categorization occurs, and how categories are mentally represented. Several key theories have emerged, with each offering a distinct perspective on how individuals classify the world around them. For instance, rule-based theories suggest that categories are defined by a list of necessary and sufficient features, much like a dictionary definition (Bruner et al., 2017; Piaget, 1974). In this framework, an entity belongs to a category if it satisfies all of the specified rules for category membership. However, one major criticism of this approach is the difficulty of defining rules that encompass all category members. A classic example of this is the category of "games" – attempts to define it with a fixed set of rules often fail (Wittgenstein, 1953), suggesting that categories may instead be based on family resemblance (Rosch, 1978a). The rules that define

categories are inconsistent both within and across subjects, making it difficult to characterize categories with consistent sets of rules (McCloskey & Glucksberg, 1978). There are also prototype theories of categorization, which are based on the aforementioned "family resemblance" approach (Mervis & Rosch, 1981; Rosch & Mervis, 1975). Here, categories are represented by idealized prototypes that embody the most frequently observed characteristics of category members. Prototypes are formed by experience with members of that category. For example, the bird category would be represented by the most prototypical bird, or by all of the common attributes and attribute values shared by birds.

Finally, exemplar theories state that categories are not defined by rules, but rather by the specific instances an individual has encountered of that category (L. Brooks, 2023; Lamberts, 2000). Under this theory, the category "bird" would include every bird an individual has actually seen, stored as unique exemplars. New objects are categorized based on their similarity to previously encountered cases of a particular category (Allen & Brooks, 1991; Brooks et al., 1991).

Categorization serves several cognitive functions. First, categories can act as units of thought, or as semantic elements – rather than thinking of or referring to single entities, individuals can reason about entire categories increasing efficiency (McNamara & Miller, 1989). Second, categories allow individuals to make inductive predictions, generalizing their knowledge of certain members of a category to other members of the same category (Rosch, 1978b). For instance, if children are told that a specific bird has a gizzard, and are later asked if a different bird has a gizzard, they tend to affirm that other birds have gizzards (Markman & Makin, 1998). Finally, it has been suggested that categorization improves cognitive economy. Storing stimuli and information about them in the form of categories, rather than as individual instances, can greatly reduce the amount of memory that is used (Goldstone et al., 2018; Rosch, 1978b). Individuals tend to retain the general sense of a category rather than its

individual members over time, which is an efficient way to store information in long-term memory (Posner & Keele, 1970). Category-level information is sufficient for individuals to efficiently navigate the world around them, according to this perspective.

Social categorization

Social categorization, or the categorization of people, can be thought of in much the same way. By grouping people into categories, individuals can quickly understand who another person is, and make predictions about how they are likely to think and behave based on prior knowledge of the categories they belong to. The social environment is complex, and social interactions become much more efficient when perception and judgements are applied to categories of people. This also allows us to reduce cognitive load during social interactions (Macrae et al., 1994). Individuals do not need to have a perfect, comprehensive understanding of others – instead, a "good enough" understanding will do (Hugenberg & Sacco, 2008). Filling in the gaps using knowledge of social categories can make gaining this "good enough" understanding much easier.

The same principles that govern object categorization apply to social categorization, or the classification of people. By grouping individuals into social categories, people can quickly predict their behaviour based on past experiences with that category. Evolutionary psychologists have posited that social categorization would have been favoured by natural selection because it would allow individuals to make inferences about the others around them (Cosmides et al., 2003). This has been argued for social categories such as race, sex, and age, which appear to be psychologically salient categories (Fiske & Neuberg, 1990; Stangor et al., 1992). However, the encoding of race, which notably lacks a biological or genetic basis unlike the other two categories, has been suggested to be a byproduct of domain-general categorization systems, or cognitive adaptations that allow for the detection of coalitions (Kurzban et al., 2001; S. E. Taylor et al., 1978). In our evolutionary past, where groups of

humans were competing for resources to survive, this was an important ability. Being able to identify someone as a member of one's own group, the ingroup, or a competing one, the outgroup, allowed individuals to cooperate with ingroup members, and be cautious and competitive around outgroup members. There were also likely smaller alliances within larger groups which were necessary to keep track of (Cosmides et al., 2003). This ability to identify ingroups and outgroups and the resulting differential treatment of them could help individuals survive and reproduce and would have been selected for.

Development of Social Categorization

Social categorization begins early in life. As early as infancy, babies prefer to look at faces that are the same gender as their primary caregiver, the race they see most often in their environment, and of other infants over adult faces (Bar-Haim et al., 2006; Kelly et al., 2005, 2007; Quinn et al., 2002). Preschool aged children are able to distinguish between people based on race, age, and sex, and make inferences about them based on their membership in these categories (Baron & Banaji, 2006; Cameron et al., 2001; Gelman et al., 1986; Hirschfeld, 1998; Kowalski & Lo, 2001; Taylor & Gelman, 1993). While babies and children attend to these three social categories much like adults, their understanding of these categories and tendency to categorize and make inferences based on them develops with age. Gender is salient for young children, and influences choices in toys and playmates for children as young as 2 to 3 years (Edelbrock & Sugawara, 1978; Jacklin & Maccoby, 1978; Ruble et al., 2006). However, race only becomes important in early childhood, as preferences for same-race playmates emerge around 4 to 5 years of age (Aboud, 2003; Aboud & Skerry, 1984). Like adults, children also categorize others based on minimal criteria such as arbitrary team assignments or shirt colours (Bigler et al., 1997; Sherif et al., 1961). Visual information is thought to be important for social categorization in adults, and it also appears to be crucial for children (Fiske, 1998). For instance, children only show ingroup preferences

in minimal groups paradigms when the group cue, such as naming two groups using colours (i.e., "blue group" and "yellow group") is paired with a visual cue (i.e., shirt colours matching the group names), and not when they are simply labelled verbally (Bigler, 1995; Bigler et al., 1997). Whether groups are differentiated by meaningful or arbitrary criteria, social categorization can have many implications for people's thoughts and behaviour.

Implications of Social Categorization

Social categorization affects people's thoughts and behaviour on both small and large scales. Ingroup-outgroup behaviour results from social categorization. Individuals behave more prosocially towards ingroup members: they share more resources with them, cooperate with them more, evaluate them more positively, and show them more empathy (Balliet et al., 2014; Brewer, 1979; Tajfel et al., 1971; Tarrant et al., 2009). They experience negative emotions when their ingroup members are harmed, and require more evidence to believe that an ingroup member behaved unjustly compared to an outgroup member (Branscombe & Miron, 2004; Dumont et al., 2003; Levine et al., 2002). This type of ingroup-outgroup behaviour can even occur for ingroups and outgroups that are formed based on minimal, sometimes arbitrary criteria. This phenomenon is demonstrated in experiments using the minimal groups paradigm (Cikara & Van Bavel, 2014; Tajfel, 1970; Tajfel et al., 1971). In these studies, participants are grouped based on arbitrary criteria, such as preferences for an artist or their accuracy in a dot estimation task, and then perform tasks that study intergroup dynamics, such as a prisoner's dilemma or resource allocation task. Participants in these experiments very quickly adopt their new identities, and will continue to identify with their group assignments until some other identity is made salient to them (Cikara & Van Bavel, 2014). They also show changes in their cognition, motivation, and behaviour, favouring their new ingroups, and disdaining their outgroups (Tajfel, 1970; Tajfel et al., 1971). These findings illustrate that individuals categorize themselves and others, even on the basis of

minor criteria, and that this categorization can influence their behaviour towards others.

It is not clear whether ingroup favouritism necessarily entails discrimination toward the outgroup. While some researchers have treated the two as reciprocal, there is a fair amount of evidence suggesting that ingroup favouritism develops first, and can exist even in the absence of negative thoughts and behaviours towards any outgroup (Balliet et al., 2014). However, under some conditions, outgroup discrimination does occur. For instance, ingroup favouritism can even be induced for minimal groups, though it appears that outgroup discrimination is more likely to occur when groups are in conflict (Abbink & Harris, 2019).

Social identity theory suggests that individuals are motivated to self-categorize to fulfill their needs for belonging and certainty(Brewer, 1991; Hogg, 2000; Tajfel & Turner, 1979). This, in turn, drives them to create distinctions between their ingroups and outgroups that favour the ingroup, bolstering their self-esteem and self-concept (Tajfel & Turner, 1979).

Many of the world's broader social conflicts can be understood through the lens of social categorization. The inferences people make within social categories can manifest as generalizations and stereotypes (Allport, 1979; Goldstone et al., 2018). Studies describing ingroup-outgroup behaviour in small groups, can be generalized to larger groups. The same factors which can lead to ingroup favouritism – the mere presence of an ingroup, in many cases – and outgroup discrimination apply to larger groups. Religious and ethnic groups, and entire nations compete for resources and differ along ideological lines that can be seen as threatening toward one's ingroup. Portraying competing groups as "the other", focusing on identity-based differences, and highlighting generalizations based on those identities are common approaches in propaganda (Reddi et al., 2023). Given that individuals are motivated to focus on group boundaries for the reasons described above, these identity propaganda campaigns can be incredibly compelling.

The stereotypes and biases individuals have towards other groups can have far-

reaching consequences across healthcare, education, employment, housing, media, the judicial system, and the workplace. In law enforcement, stereotypes may contribute to the disproportionate targeting of individuals based on race (Jones-Brown et al., 2010). In healthcare, biases can affect patient treatment and maternal health outcomes (Dehon et al., 2017; Montalmant & Ettinger, 2024). In education, they influence disciplinary actions, often leading to harsher punishment for some students while limiting their academic opportunities (Chin et al., 2020; Riddle & Sinclair, 2019). Employment discrimination persists, with certain names reducing job prospects (Cotton et al., 2008). In housing and lending, biases contribute to higher mortgage denial rates for some groups and rental discrimination, reinforcing segregation (Montalmant & Ettinger, 2024). Media representation and online algorithms shape public perceptions, perpetuating racial biases (Markina, 2019; Noble, 2018). Finally, workplace microaggressions—such as assumptions about background or abilities—foster exclusion and reinforce systemic inequalities (Smith & Griffiths, 2022).

Religious categories are prone to ingroup-outgroup bias and stereotyping. Religious stereotypes can influence how individuals unconsciously perceive and interact with people of different faiths. These biases may manifest in various ways, such as associating certain religious groups with positive or negative traits, which can affect social interactions, and even hiring decisions (Cagle, 2021; Griffin et al., 2019).

Better understanding people's attitudes towards social groups is an important first step to combating issues of prejudice and bias. However, studying these attitudes can prove challenging. Psychological research has to navigate social desirability bias, which can lead participants to give responses based on what they believe the experimenter wants to hear (Tourangeau & Yan, 2007). This is especially relevant, and problematic, for studies about sensitive topics such as politics, sexuality, religion, and racial bias.

In the wake of events like the Black Lives Matter movement, awareness of and public

discourse around social justice has shifted greatly, and people are likely to be more conscious of their biases (Dunivin et al., 2022). Speaking or behaving in an overtly offensive way is less and less acceptable – though this does not mean that observable incidents do not still occur, with hate crimes continuing to occur at high rates, and even increasing in prevalence across the globe (Department of Justice, 2023; Hambly et al., 2018; Mason, 2019; Statistics Canada, 2024). Since participants are likely to alter their responses to appear socially and politically correct, researchers cannot study issues of prejudice and bias solely through self-report. In order to address social desirability bias, the current research employs implicit measures of social category perception.

Implicit bias

The words "implicit" and "explicit" have specific meanings in the psychological literature (Brownstein, 2019). On one hand, these words can be used to describe attitudes or processes that are either accessible (explicit) or inaccessible (implicit) to consciousness (Greenwald & Banaji, 1995). On the other hand, they can be used to refer to attitudes or processes which are accessed by implicit, or indirect, measurement tools, and which may or may not be distinct from explicit attitudes. The former definition is one of the more common ways to apply the term "implicit" in the study of bias and social discrimination – to refer to a type of bias or attitude that differs from one's explicit, endorsed attitudes in some way. The idea of bias existing out of conscious awareness stems from two-process theories of cognition, which suggest that cognition can occur in controlled or automatic manners (Schneider & Shiffrin, 1977). It is thought that self-report measures capture explicit attitudes, while behavioural measures capture implicit attitudes that cannot be accessed through introspection (Bosson et al., 2000; Cunningham et al., 2004). While some researchers argue that implicit biases are entirely unconscious, others argue that individuals may have partial awareness of them and how they influence their behaviours (Brownstein & Saul, 2016;

Gawronski et al., 2006).

As noted above, another way of using the word "implicit" in "implicit bias" is to refer to biases that are evaluated using implicit measures (Holroyd et al., 2017). These measures probe attitudes using methods that involve little to no conscious awareness on the part of the participant. The aim of these methods is to work around the issue of social desirability, or conscious control of one's responses. These measures generally involve some type of behavioural or performance measurement, in contrast with direct, self-report style measures which are sometimes referred to as "explicit" bias measures. This usage of the term "implicit" can lead to the relatively conservative view that only the measures can be described as implicit, and no specific assertion can be made about the nature of the bias that is being measured (Fazio & Towles-Schwen, 1999). However, it is also possible to discuss implicit measures in conjunction with the previously described view of implicit bias as a distinct type of attitude which exists outside of consciousness. It has been suggested that the attitudes being assessed by these implicit measures are, in fact, the aforementioned implicit bias, which is distinct from explicit bias.

Regardless of how implicit bias is defined, stereotypes and biased attitudes towards social groups have real, measurable, and far-reaching consequences for the members of those groups. Understanding what stereotypes exist towards social groups and how those stereotypes are activated during social interactions and social categorization is the foundation for making positive social change. The first step towards this is determining which implicit measures can effectively measure stereotypes in the first place. The following section will outline specific measures of implicit bias, the challenges facing this area of study, and the types of implicit measures that can help address them.

Measures of implicit bias

One of the earliest measures of implicit bias is the sequential priming method (Fazio

et al., 1995). In this method, participants are exposed to social categories (e.g., faces of members of two racial groups), and are then exposed to two stereotypic categories of words (e.g., positive- and negative-valenced words). They are asked to respond to the words they are shown by completing a task such as classifying them by their valence, whether they are words or random letter strings. Their response times are measured, as it is believed that individuals respond more quickly when they are primed with categories or concepts that they associate with each other. If participants respond more quickly to stereotypic words such as "lazy" when they are primed with the "Black" racial category than the "White" category, this is interpreted as evidence that they harbour those stereotypes regarding Black individuals (Fazio et al., 1995). This basic principle – that behavioural measures such as reaction times can indicate bias – underlies many other implicit bias measures.

Perhaps the most well-known measure of implicit bias is the Implicit Association Test (IAT) (Greenwald et al., 1998). The IAT presents participants with two sets of categories: first are two social categories that individuals may have biases towards (e.g., two racial groups), which are assigned to one of two keys, and two "other" categories (e.g., "good" and "bad" words), which are paired to the same keys as the social categories. In some blocks, the social categories are paired with the other category that matches common stereotypes (e.g., "Black" and "bad" words) and in other blocks they are paired with the opposite category (e.g., "Black" and "good" words). Participants are shown target words that belong to one of the four categories on the screen and are asked to press a key to sort the target word into the correct category as quickly as possible, without making errors. By comparing reaction times and error rates between blocks that are congruent and incongruent with common stereotypes, the IAT produces a score that indicates which social category the participant favours. Participants will respond quicker and make fewer errors on trials in blocks that are consistent with their stereotypes than in trials that are inconsistent. The IAT has been used to study

stereotypes towards many social categories including race, gender, age, sexual orientation, and body image (Greenwald et al., 1998; Marini et al., 2021; Nosek et al., 2002). There are also other measures of implicit bias, such as semantic priming, the Affect Misattribution Procedure, and the Go/No-Go Association task, all of which involve similar underlying principles to the sequential priming and IAT methods (Banaji & Hardin, 1996; Nosek & Banaji, 2001; Payne et al., 2005).

There are relatively low correlations between implicit and explicit measures (Blair, 2001; C. D. Cameron et al., 2012; Dovidio et al., 2001). This has been interpreted by some as evidence of distinct implicit and explicit attitudes (Hofmann et al., 2005). If individuals harbour different attitudes than the ones they outwardly express, it would stand to reason that, when they are probed in an indirect way, their results would differ between a performance-based test and a self-report one.

The study of implicit bias can be seen as having two separate lines of inquiry. The first is to develop and use implicit measures to see what these measures correlate with. The second is to probe what constructs underlie those measures, such as unconscious, uncontrolled thoughts or behaviours. These two lines of inquiry can and should be pursued, and each informs the other, but it is not necessary to discard the first because the second still has many open questions, or vice versa. There are also many considerations that can be taken when conducting research using implicit measures, as outlined by Gawronski (2019), to ensure that studies are rigorous and that their implications are clear. For instance, researchers should carefully explain their conceptualization of implicit bias – are they referring to implicit bias as an attitude or construct outside of awareness? If so, which part of that attitude is outside of awareness – its source, its content, or its consequences? If they are conceptualizing it as an implicitly measured behaviour, that should be clearly stated. Other considerations include the temporal and contextual factors that may affect results on implicit

measures. Conducting studies on implicit bias at multiple time points in carefully controlled environments can allow for more accurate and consistent measurements. Another important step that needs to be taken in the implicit bias literature is to use a variety of implicit measures, based on different underlying mechanisms, to act as converging evidence. The previously described implicit measures, for instance, rely on priming and reaction time, and probe the associative strength between categories as a measure of bias. However, there are also methods which use face perception and categorization as the basis for implicitly probing social categories and attitudes.

Face Perception as an Implicit Measure of Social Attitudes

Given that humans rely heavily on visual input to make sense of the world around them, and that faces are important sources of social information, face perception methods are useful to probe social attitudes. The automaticity of face perception makes tests of how individuals categorize the faces they encounter particularly useful for measuring bias without a participant's conscious awareness (Tanaka, 2001). These measures rely on the assumption that faces representing social categories and known individuals are stored mentally in a "face space" (Valentine, 1991). There are two main versions of this face space described in the literature. One is a prototype, or "norm-based", model where the centre of the face space is a prototypical face, which is formed by averaging the individual faces a person has encountered. Individual faces are stored based on their similarity or difference relative to the norm. Similar faces are located close to the norm, and dissimilar faces are located farther, along dimensions that represent different dimensions of a face (e.g., eye spacing, nose width). Faces are normally distributed along the various dimensions, though the exact number of dimensions present in face space is unknown. Novel faces are identified and categorized by comparing them to these norms – the exact number of unique norms that exist is unknown, but this can be probed using the methods described below. The other conceptualization of the

face space model is an exemplar-based one, where there is no central norm or prototype. Instead, all of the faces an individual has encountered are stored, grouped based on their similarity to each other along the various dimensions of face space. The two implicit measures described below, the category-contingent aftereffects and reverse correlation procedures, align with the prototype model of face space. These measures aim to test for the presence of these prototypes for the social categories of interest, and to visualize what these prototypes look like respectively.

Category-contingent Aftereffects

One method for studying social categories through face perception is the category-contingent aftereffects paradigm. This method can reveal whether two categories are represented with separate face templates or not. It relies on the basic phenomenon of adaptation, where repeated exposure to a particular stimulus or characteristic alters subsequent perception (Blakemore et al., 1970). Adaptation is well-documented across psychological disciplines and neuroscience, including in lower-level vision such as colour and orientation (Engel & Furmanski, 2001; Kohn, 2007; Wark et al., 2007). In studies of face perception, adaptation can lead to a "contrastive aftereffect" where viewing a specific face, or faces that are distorted in a particular way, makes novel faces appear to have the opposite features or distortions. For example, repeated viewing of contracted faces makes subsequently viewed unaltered faces appear expanded (Rhodes & Jeffery, 2006). According to the norm-based coding model described above, this occurs because the distorted faces are incorporated into the norm, which shifts in the direction of the distortion. When novel faces are compared to this updated norm, they appear distorted in the opposite direction. This simple face aftereffect phenomenon demonstrates that facial norms are malleable, as the norm-based coding model theorizes. The category-contingent aftereffects method simply applies this adaptation procedure to two different face categories to determine whether their

templates are separate or not.

In this method, faces belonging to the two categories of interest are distorted in opposite directions (e.g., faces of one category are expanded, and the others are contracted). If the two categories are mentally represented with separate norms, then adapting to these opposite distortions should lead to those norms updating separately, and aftereffects should be observed in opposite directions. Category-contingent aftereffects have been observed for many categories, such as age, race, sex, and species (Little et al., 2005, 2008). It is important to note that, for category-contingent aftereffects to occur, the two categories being studied must be physically distinct and socially meaningful. Category-contingent aftereffects cannot be produced for two artificially created groups with the same age, race, and sex characteristics, nor can they be produced for two groups that are not treated as distinct in the real world (e.g., female and hyper-female faces) (Bestelmeyer et al., 2008; Short & Mondloch, 2010).

A novel way of cueing that two groups in a category-contingent aftereffects study are meaningfully distinct is by introducing social information in the auditory domain. Foglia et al. (2021) used a category-contingent aftereffects paradigm to examine whether faces belonging to members of separate religious groups have distinct mental representations. The study consisted of faces of Christian and Muslim individuals whose religious identity was either signalled through audio character descriptions or not. Category-contingent aftereffects were observed in the condition with explicit religious audio labels, but not in the control condition. The results of this study suggest that religious faces have distinct mental representations, but that context is needed for those faces to be categorized as members of separate religious groups. These findings are novel in the category-contingent aftereffects literature, both for their use of audio cues accompanying facial stimuli, and for probing the category of religion. Religion can be a very important social category – religious

identification provides many individuals with a sense of belonging and community, but it can also be the source of intergroup conflict. Understanding how individuals categorize others on the basis of religion and how religious groups are mentally represented is an important part of understanding the roots of religious cooperation and conflict.

Reverse Correlation

While the category-contingent aftereffects paradigm reveals whether social categories are represented with separate face templates, researchers can also learn about beliefs about social categories by determining what these face templates look like. The reverse correlation (RC) procedure visualizes people's mental representations. It is typically used to visualize the face templates people have for different social categories, though it can also be used to visualize bodies or objects (Diego-Mas et al., 2022; Lick et al., 2013). In a typical RC experiment, stimuli are created by overlaying noise patterns (e.g., Gaussian or sinusoidal noise) on top of a base image, such as a face. A large set of randomly differing stimuli can be created by overlaying many noise patterns over the same base face. Participants are then shown the stimuli and asked to either rate how strongly they resemble the category of interest (if stimuli are presented one at a time) or select the stimulus that most resembles the category (if stimuli are presented in groups of two or more). The stimuli that they select are averaged to create a classification image (CI), which acts as a proxy image for the mental representation of that category. CIs can be created for individual participants, or for a group of participants. The CIs can then be analyzed in different ways to learn about the attitudes the participants have towards the social categories that are being visualized.

Many RC studies will include a second phase where a naive set of participants rates the CIs on traits of interest (e.g., valenced or demographic traits). These ratings are meant to estimate the original sample's attitudes towards the category that the CI represents. For instance, the CIs created for Moroccan faces by Dutch individuals with high anti-Moroccan

bias are rated as more criminal and less trustworthy than those created by individuals with lower anti-Moroccan bias (Dotsch et al., 2008). This method has been used to visualize mental representations for many categories, including gender, nationality, ethnicity, occupation, and religion (Brown-Iannuzzi et al., 2018; Dunham et al., 2014; Hehman et al., 2015; Imhoff et al., 2013; Tskhay & Rule, 2015). However, within these superordinate categories, there are subcategories which have not been visualized, and whose stereotypes remain to be studied using this method.

Both the category-contingent aftereffects and reverse correlation methods tap into the highly visual nature of social interactions between people to better understand how social categories are represented. The category-contingent aftereffects method is generally used to determine which categories have separate mental representations from each other. However, by manipulating the information available to participants when viewing social stimuli, it is possible to learn which cues support categorization. The reverse correlation method provides a complementary approach to studying mental representations of social categories. Using this method, the mental representations for different social categories can be visualized as CIs, and the CIs can be assessed to uncover the stereotypes individuals have about those social categories. Evidence from face perception can complement the findings obtained from priming and reaction times measures and act as converging evidence.

Current studies

Chapter 2 of this thesis examined the way people mentally represent their religious ingroups and outgroups, and what attitudes they have towards them. Reverse correlation has been used to study attitudes towards religion, such as attitudes towards atheists compared to theists, or ingroup and outgroup attitudes in Muslim and Hindu children in India (Brown-Iannuzzi et al., 2018; Dunham et al., 2014). However, the research on this social category, using this method, has been relatively sparse. Specifically, we used a two-phase reverse

correlation (RC) procedure with Christian and Muslim participants, where they selected face images from pairs of noise-altered faces that looked like Christians and Muslims. These images were averaged to create classification images (CIs) which were rated by a naive set of participants on several valenced and demographic traits. These ratings reveal the attitudes the first set of participants have towards Christians and Muslims. We found that Christian CIs were consistently rated more positively than Muslim CIs, regardless of whether the CIs were created by Christian or Muslim participants. This lends support to the literature about self-stigma and internalized prejudice in minorities (David et al., 2019).

Chapter 3 of this thesis examined the cues that individuals use to infer social category membership. To do this, we used a category-contingent aftereffects paradigm with the categories of Christian and Muslim faces, using the stimuli and methods from Foglia et al. (2021) to replicate and extend their findings. Participants were assigned to one of three audio conditions and completed three phases of a category-contingent aftereffects paradigm. In the first phase, participants saw pairs of Christian and Muslim faces, made up of a 10% expanded and 10% contracted version of the same face, and selected the face that appeared more attractive. During the next phase, participants viewed 60% contracted Christian faces and 60% expanded Muslim faces. While they viewed the faces, they heard audio that described the faces on the screen, but the audio differed by condition. Participants either heard an explicit religious label, or a food preference or country of origin associated with Christianity or Islam for each face they viewed. Next, they completed a post-adaptation phase where they selected faces from pairs in the same way they did in the first phase of the experiment. We would expect participants to subconsciously categorize the Christian and Muslim faces separately. This would cause their Christian and Muslim face templates to be updated to be more contracted and expanded respectively, consistent with the stimuli they adapted to in the second phase of the procedure. We would then expect to see an increased preference for

contracted Christian faces and expanded Muslim faces in the third phase of the experiment, which would signal that category-contingent aftereffects were induced for the two face categories. Finding significant category-contingent aftereffects would be evidence that the auditory cues support social categorization. We observed significant category-contingent aftereffects for the religious explicit and food preference audio conditions, but not for the country of origin audio condition. This suggests that explicit religious labels and food preferences can act as cues of social group membership, but country of origin does not. These findings replicated the results from Foglia et al. (2021) which suggested that Christian and Muslim faces are represented with separate mental templates. They also replicated the finding that category-contingent aftereffects can be induced by using auditory cues, highlighting the link between auditory information and visual perception using a novel method.

Finally, Chapter 4 of this thesis used the RC procedure once again but extended it to examine the way people view scientists, geniuses, heroes, and the superordinate category of a person. These are novel categories which have not been examined using the RC method – there have been some studies examining mental representations of occupations, including examining the gender stereotypes associated with them, none have specifically examined scientists (Hehman et al., 2015; Imhoff et al., 2013). Many subcategories have been visualized and contrasted with each other, but RC has not been used to visualize the broader category of what a person looks like. The procedure was structured like the one in Chapter 2, with two phases. In the first phase, participants selected faces that resembled a scientist, hero, genius, and person. The faces they selected for each category were averaged, across all participants, to create CIs for the four categories. A new, naive set of participants rated the CIs on demographic and valenced characteristics. We found that the Scientist CI was rated as more White and male in appearance than the other CIs, which aligns with stereotypes of scientists, and the demographic trends in the scientific workforce (Campbell et al., 2000;

National Science Board, National Science Foundation, 2021; Watts, 2007). The Scientist CI was also consistently rated the most negatively on valenced characteristics out of all four CIs. The valenced characteristics it was rated more negatively on can be grouped by common themes, which suggest that scientists are seen as unsociable, poor at communicating, and incompetent. This may be a reflection of stereotypes of scientists presented in the media, and of the heightened focus on scientists, their competence, and communication abilities during the COVID-19 pandemic, which occurred while this study was conducted (Salita, 2015; Sanchez & Dunning, 2021; Weingart et al., 2003; Weingart & Guenther, 2016).

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Chapter 2: Cultural majority more important than ingroup affiliation in driving positive ratings of face representations

Preface

Face perception is rapid and automatic and allows individuals to both classify others into social categories they belong to, and use this classification to infer their thoughts, beliefs, and behaviours (Ito & Urland, 2003; Tanaka, 2001). The faces that one individual encounters are thought to form category-specific mental representations that are used to make these rapid classifications in social interactions (Rhodes & Jeffery, 2006; Valentine et al., 2016). The reverse correlation procedure is an implicit method that allows researchers to visualize these mental representations, and then probe the physical and even attitudinal traits that are associated with each social category (Brinkman et al., 2017).

The reverse correlation procedure has been used to visualize mental representations of faces for social categories such as nationality, ethnicity, and gender (Dotsch et al., 2008, 2011; Imhoff et al., 2013; Mangini & Biederman, 2004). It has also been used to visualize mental representations of religious groups, including atheists, theists, and Muslims and Hindus (Brown-Iannuzzi et al., 2018; Dunham et al., 2014). The latter study aimed to implicitly assess whether Muslim and Hindu children in India showed favouritism for their religious ingroups or the majority religion. They observed that children from both religions showed a preference for their religious ingroups, which might be a protective effect for the Muslim children, who make up a religious minority in India. We wanted to expand the literature studying religious stereotypes and intergroup attitudes by using the reverse correlation procedure to study religious stereotypes held by Christian and Muslim adults in Canada.

The goals of this study were to visualize the mental representations individuals have for their religious ingroups and outgroups, to assess these visualizations to uncover their

stereotypes for these categories, and to determine whether individuals show a preference for their religious ingroup, or the majority or dominant religion. Specifically, we were interested in how Christian and Muslim individuals visualized and stereotyped Christian and Muslim faces.

In the first phase of the study, we recruited 20 Christian and 20 Muslim participants. These participants completed four blocks of a two-image forced choice task, selecting the image that resembled a Christian or a Muslim to them. The images the participants selected were averaged to create CIs approximating each group's mental representations of both religious groups.

In the second phase of the study, we recruited 252 participants to rate the CIs on valenced and demographic characteristics. The demographic characteristics would reveal what racial and gendered stereotypes the phase 1 participants had for both religious groups, while the valenced characteristics would reveal their other, attitudinal stereotypes. We compared the ratings for the various CIs using ANOVAs and Chi-squared tests of independence. We observed that CIs representing Christians were consistently rated more positively than those representing Muslims on valenced traits, with no such pattern for demographic traits. Members of both religions show a preference for the majority, or dominant, religion.

These findings reveal specific religious stereotypes held by Canadian Christians and Muslims, which contrast with the findings from a more religious society like India (Dunham et al., 2014). They also demonstrate the efficacy of the reverse correlation procedure as an implicit tool for uncovering such stereotypes for categories like religion, which may not be as physically distinct as gender or race are.

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Abstract

People store mental representations of faces for various social categories. These mental representations can reflect biases regarding social groups. This two-part study first used the reverse correlation paradigm to create images of the mental representations that Christian and Muslim Canadians have of Christian and Muslim faces. In the first part of the study, 20 Christian and 20 Muslim participants were presented with four blocks of a two-image forced choice task, where they were asked to select the face that looked Christian or Muslim. The selected images were then averaged to create classification images (CIs) which are proxy images of mental representations of Christian and Muslim faces. In the second part of the study, a new sample of naive participants rated the CIs on several valenced characteristics (e.g., happiness, trustworthiness, warmth) and several demographic characteristics (e.g., gender and ethnicity) to probe the original participants' attitudes towards Christians and Muslims. Regardless of the religious identity of the participants who generated the CI, Christian CIs were consistently rated more positively than Muslim CIs. There was no such pattern for the demographic characteristics. These results favour the idea that both Christians and Muslims have an implicit bias in favour of Christianity, the dominant religion in Canada, over ingroup bias.

Introduction

Religious discrimination has existed throughout human history, and it continues to be a major source of conflict globally, as levels of religious discrimination continue to rise (Fox, 2007). In order to understand and address prejudice and stereotyping on the basis of religion, it is necessary to understand the psychological underpinnings of religion-based discrimination.

People's inferences about others' thoughts and behaviours are influenced by social category memberships (Bodenhauden et al., 2012; Medin et al., 2003). People will treat others who share category membership with them more favourably than those who do not, a phenomenon known as ingroup-outgroup bias (Allport, 1979; Fazio et al., 1995; Hewstone, 1990; Shelton & Richeson, 2005; Tajfel, 1970; Tajfel et al., 1971; Turner et al., 1979). This phenomenon is measurable across a number of types of social categories, including religious categories (Cairns et al., 2006; Jackson & Hunsberger, 1999; Johnson et al., 2012; Preston & Ritter, 2013). The purpose of the current study is to explore the psychological basis of this social categorization.

Face perception and social categorization go hand in hand. Faces are a rich source of social information, and engender rapid inferences. In the first milliseconds of face perception, people determine the age, gender, and race of the person that they have encountered (Brewer, 1988; Fiske & Neuberg, 1990; Hewstone et al., 1991; Stangor et al., 1992; Taylor et al., 1978). It is thought that people do this by comparing new faces to a template, and which template is used depends on social categorization (Dotsch et al., 2011; Freeman & Ambady, 2014). Male faces are compared to a male template and female faces are compared to a female template, for example (Webster et al., 2004). Once a new face is compared to the relevant template, the individual perceiving that face can make inferences about what characteristics the person they are seeing has. They can infer how that person might think,

feel, and behave based on their knowledge of the categories that person belongs to. This information facilitates social interactions. Some inferences made during face perception are negative, and the broad assumptions we make about others can lead to stereotyping and prejudice. In order to understand stereotyping and prejudice towards social groups, including religion, it would help to understand how we represent the faces of the members of these groups.

Little is known about the way people perceive and mentally represent the faces of members of religious groups (Brown-Iannuzzi et al., 2018; Dunham et al., 2014). Exploring template-based perception across religious categories can be challenging. Religious identity is not necessarily connected to an individual's biology or physical characteristics, and can change. In order to visualize the mental images people have for religious groups, we employ the Reverse Correlation technique.

Reverse correlation (RC) is a technique where randomly generated noise is superimposed on stimuli (typically faces or bodies) to create a large set of unique, randomly generated stimuli (Brinkman et al., 2017). These stimuli are then presented to participants, who select or rate faces based on how well they match the category of interest. For example, participants may be asked in a 2-alternative forced-choice task to select the face that fits the category of "female". All of the selected faces can be averaged to create a classification image (CI), which is a visual proxy for the participants' mental representation of a female face. The CI can be analyzed using pixel tests to determine which regions of the face influence group membership. CIs can then be rated by naive participants on various characteristics, such as apparent age, gender, race, or personality traits. These ratings may be related to the original participant population's attitudes towards the group they selected faces to match. If the CI for female faces is rated as very warm, happy, and friendly looking, for

instance, it suggests that the participants who created the CI come from a population which has a positive perception of females.

The RC technique has been used to visualize people's mental representations for many categories, including gender, ethnicity, occupation, and religion. It has also been used to examine attitudes towards those categories. The mental representations that people have for groups they are prejudiced against tend to evoke more negative descriptions, as do those that they have for their outgroups, except in the case of caste (Dotsch et al., 2008; Dunham et al., 2014). These findings extend to religion, which has been touched on in the RC literature, though research in this area is relatively limited. Despite the growing atheist population in countries like the United States, anti-atheist prejudice is still measurable (Gervais & Najle, 2018). Atheists are stereotyped as immoral and untrustworthy, while theists are thought to be the opposite, likely because religions teach their followers to behave prosocially for fear of punishment from a higher power (Bering et al., 2005; Gervais et al., 2011). These stereotypes are reflected in the mental representations that people have for atheist and theist faces, as well. The CI for theist faces is associated with more positive attributes and is considered more likely to behave morally than the atheist CI (Brown-Iannuzzi et al., 2018).

Within the generally-favoured category of theists, there is also a preference for religious ingroups over outgroups. An RC study completed in India with Hindu and Muslim children found that the CIs created for the child participant's religious ingroups appeared warmer and more competent than those that they created for their religious outgroups (Dunham et al., 2014). This is particularly interesting in this population because Hindus are the majority religion in India, with greater political and social influence, while Muslims make up a small minority (Ansari, 2006; Census India, 2011).

Sometimes members of low-status groups either prefer the dominant outgroup over their own group or have no preference, and one would expect this trend to be represented in

the mental images they have for their ingroup and outgroups as well (Doyle et al., 1988; Newheiser et al., 2014; Newheiser & Olson, 2012). However, it seems that religion is unique in this regard. For one, religions provide frameworks that help their followers make sense of the world and its many challenges (Pargament et al., 2005; Park, 2005). This means that members of minority, or lower-status religious groups can still find solace in their religious identities, leading them to prefer their religious ingroups even when the societies they live in would encourage them not to. In a country like India, religion is woven into culture and daily life, making it a very salient social category (Silberman, 2005; Ysseldyk et al., 2010). It is possible that this ingroup bias across religious groups is particular to societies where religion is a prominent part of everyday life, and that in more secular countries, like Canada, members of religious minorities will not feel such a strong preference for their religious ingroup. However, members of minority social groups tend to be more aware of group membership, and the increased awareness of religion, even in a secular society, might make them prefer their religious ingroup.

The RC procedure has not been used to examine religious ingroup-outgroup attitudes in adults, or in a relatively secular, but still multicultural, country like Canada. The religions which have been studied using RC are also limited. Expanding the religions that have been visualized using RC, and looking at ingroup-outgroup attitudes in different populations will improve our understanding of the way religions are perceived, and where religious discrimination comes from.

Current Study

The current study aims to fill the aforementioned gap in the RC literature. It uses the reverse correlation technique to visualize Christian and Muslim individuals' mental representations of Christians and Muslims, and uses these visualizations to compare their attitudes towards their religious ingroup and the outgroup. In phase 1 of the study, Christian

and Muslim adults were recruited to participate in an RC procedure, where they selected faces that best resemble members of both religions. In phase 2, their selections were be averaged to create CIs, which were then be rated on many characteristics to determine whether their mental images are biased. We predict that the mental representations for a certain group will consistently receive more positive ratings than another. Either the mental representations for a religious ingroup (e.g., the mental representation of a Christian individual created by Christian participants) will be favoured over those for religious outgroups, similar to Dunham et al., (2014), or the mental representations for the majority group (Christianity) will consistently be rated more positively than those of the minority group (Muslims).

Phase 1: Image Creation

Methods

Participants

A total of 40 participants were recruited for phase 1: 20 Muslims (mean age = 25.9 years, male = 6) and 20 Christians (mean age = 29.8 years, male = 9). This sample size was determined using similar RC studies with approximately 20 participants per cell or condition in the image selection phase (e.g., (Dotsch et al., 2008; Dotsch & Todorov, 2012; Lick et al., 2013). Fifteen of these were undergraduate students from McMaster University who were enrolled in introductory psychology courses and were given course credit as compensation for their participation. Twelve were Canadians recruited through Amazon MTurk (11 Christians and 1 Muslim), and 13 through targeted recruitment in religious communities. External participants were paid 9.50 CAD for their participation, in accordance with minimum wage in Ontario. Of the Christian participants, 10 identified as white, 4 as Black, 3 as South Asian, 2 as East Asian, and 1 as mixed race. Of the Muslim participants, 17 identified as South Asian, and 3 identified as Black.

Procedure

Stimulus creation. Two base images, one male and one female, were generated by averaging faces from the Chicago Face Database (Ma et al., 2015) in Webmorph, the web-based version of Psychomorph (DeBruine, 2018). We created separate male and female base images because there is evidence that male and female faces are represented by discrete templates (Little et al., 2005). The male base image was created using 60 neutral male faces and the female base image was created using 60 neutral female faces. Each base image included 15 White faces, 15 Black faces, 15 Asian faces, and 15 Latino faces.

Randomly generated sinusoidal noise patterns were added to the base images using the *generate2IFCstimuli* function in the *rcicr* package in R (Brinkman et al., 2017). A total of 300 male stimuli pairs were created, where each pair included a face masked with a noise pattern, and a face with the inverse of that noise pattern. Three hundred image pairs were similarly generated using the female base image.

Image selection. Participants completed four blocks of a 2-image forced choice reverse correlation task (Brinkman et al., 2017), where they were presented with a pair of faces (faces masked with noise patterns that were the inverse of each other) and were asked to choose the face that looked like it belonged to a given category. In two of the four blocks participants were asked to select the face that looked “like a Muslim”. In one of these two blocks, the stimuli were noise-altered faces made using the female base image, and in the other, the stimuli were made using the male base image. In the remaining two blocks participants were asked to select the face that looked “like a Christian”, where one block had male stimuli, and the other had female stimuli. The four image selection blocks, and the 300 pairs of stimuli within each block, were presented in an order randomized for each participant.

Demographic questionnaire. Participants completed a demographic questionnaire, where they were asked to report their age, gender, ethnicity, and religious identity. They were also asked to complete the Centrality of Religiosity Scale-10 (CRS-10) to measure their religiosity (Huber & Huber, 2012). The CRS-10 is a 10-item iteration of the Centrality of Religiosity scale which measures religiosity across five dimensions: private practice, public practice, religious experience, ideology, and intellect. Items in the CRS-10 ask about the frequency (e.g., "How often do you pray?") and extent/importance (e.g., "How important is it to take part in religious services?") of different religious attitudes and behaviours within the five dimensions. The items are presented with either a 5-point or 7-point response scale, but all responses to 7-point scale items are re-coded so that they align with a 5-point scale. Each participant's responses were averaged to produce a Centrality of Religiosity (CRS) score, ranging from 1 to 5, with higher scores indicating greater religiosity. The guidelines for categorizing CRS scores are: 1.0 to 2.0 corresponds to not religious, 2.1 to 3.9 to religious, and 4.0 to 5.0 to highly religious. The range of CRS scores, was 2.6 to 4.9, averaging (M = 3.95, SD = 0.68) overall, (M = 3.72, SD = 0.64) for Christian participants and (M = 4.2, SD = 0.64) for Muslim participants.

Results

Classification Image creation

The images selected by the participants in this phase of the study were averaged using the *generateCI* and *autoscale* functions from the *rcicr* package in R to create 8 classification images (CIs) (Brinkman et al., 2017). A CI is the average of all of the images selected during a reverse correlation paradigm, and it acts as a visualization of the mental representation of the social group of interest. The 8 CIs created in this phase of the study are shown in Figure 1, and are described below:

1. A Christian male CI based on the selections made by Christian participants.

2. A Christian male CI by Muslim participants.
3. A Christian female CI by Christian participants.
4. A Christian female CI by Muslim participants.
5. A Muslim male CI by Christian participants.
6. A Muslim male CI by Muslim participants.
7. A Muslim female CI by Christian participants.
8. A Muslim female CI by Muslim participants.

All 8 CIs are shown in Figure 1. These 8 CIs were used as stimuli for phase 2 of the study, where they were rated by a new set of participants on several characteristics, as described below.

Phase 2: Image Rating

Methods

Participants

A sample size of 252 was deemed necessary to have 80% power to detect the effect based on a power analysis in G*power (Faul et al., 2007). We used the effect size reported in the supplemental material of Dunham et al. (2014) that represented the average differences in CI ratings across group membership. The Cohen's *d* reported by Dunham et al. (2014) was converted to Cohen's *f* via the *escalc* converter.

252 Canadian Amazon MTurk workers were recruited for this phase of the study (mean age = 35.5 years, male = 166). Participants were given 4.60 CAD as compensation for their participation, in accordance with Ontario's minimum wage. The ethnicities and religious identities of participants in this phase of the experiment were diverse. In terms of ethnicity, 157 participants identified as white, 33 as South Asian, 24 as Black, 16 as Latinx, 5 as East Asian, 2 as mixed race, and 1 as Middle Eastern. In terms of religious identity, 121 participants identified as Christian (69 Christian, 45 Catholic, 4 Protestant, and 1 each of

Methodist, Baptist, and Mormon), 32 as Hindu, 8 as Muslim, 2 as Jewish, 2 as Buddhist, 59 did not identify with a specific religion (13 Atheist, 11 Agnostic, 2 spiritual but not religious, and 33 reported no religious affiliation whatsoever).

Procedure

Rating tasks. Participants completed two blocks of a rating task. In each block, they were shown the 8 CIs generated in phase 1 of the study, one at a time, in randomized order, and asked to rate them on valenced and demographic characteristics. They rated one CI at a time on one characteristic at a time, in randomized order. The ratings were done on a 6-point Likert scale, as in Brown-Iannuzzi et al., (2018).

In the first block, participants rated the 8 CIs on 11 valenced characteristics taken from Brown-Iannuzzi et al., (2018). They rated the CIs on how religious, trustworthy, moral, competent, warm, gentle, human, hardworking, likeable, happy, and attractive they looked. These characteristics, excluding religiousness, are all considered positive, and were used to measure attitudes towards the categories the 8 CIs represented. The trials within this block were presented in a randomized order. After this rating task, participants rated the 8 CIs on their apparent gender and ethnicity. The ethnic groups included were white, Black, Latinx, East Asian, South Asian, Middle Eastern, and Indigenous Canadian. This demographics block was always presented after the valenced block in order to avoid any social desirability effects in the ratings. All participants in this phase of the experiment rated all 8 of the CIs on all of the characteristics, both valenced and demographic.

Results

Mean differences

To assess mean differences in rating scores across Classification Images (CI), a series of one-way, within-subject, ANOVAs were conducted using CI as the independent variable. ANOVAs were conducted in *RStudio* version 4.3.1. The *ez* package was used for analysis.

The data did not meet assumptions of sphericity; the Huynh-Feldt correction was used to determine new degrees of freedom and assess for significance. Due to the number of comparisons that would be involved in pairwise post-hoc tests we opted to highlight the highest and lowest rated CIs by quality. The results of all of the ANOVAs described above are reported in Tables 3 and 4.

Order effects

After graphically examining the data (see Figures 2 to 5), we were interested in testing whether certain CIs were consistently rated higher or lower than others on valenced traits. We were particularly interested in whether the CIs were rated higher or lower based on the religion of the participant (e.g., if Muslim CIs created by Muslims were rated higher than Muslim CIs created by Christians). We operationalized high and low mean ratings by "ranking" the mean ratings. In any given figure, there were four CIs whose means were visualized. If the mean rating for a CI was the highest among the four CIs for a given trait (e.g., happiness), it was counted as "first", and that CI received one observation for the "first" rank. We recorded the frequencies that the male and female CIs were first, second, third, and fourth highest on the 10 of the valenced traits (excluding religiousness, which is not necessarily positive like the others) in Tables 1 and 2. We also recorded the frequencies for the demographic ratings as a sort of control, as we would not necessarily expect specific CIs to be consistently rated higher on various gender and ethnicity categories than others like they might be on valenced traits. To examine whether the rank order of the CIs differed by the religion of the participant, we conducted four Chi-Square tests of independence. Yates' correction was applied due to the low observed frequencies. We used an adjusted alpha-level of 0.0083 for the four Chi-square tests, and the two post-hoc Wilcoxon's signed-rank tests described below.

Did valenced ratings vary by participant's religion? There was a significant association between CI and rank for the valenced traits for both male CIs ($\chi^2(9) = 74.18$, $p < 0.001$) and female CIs ($\chi^2(9) = 55.27$, $p < 0.001$). Specifically, Christian CIs were rated more positively than Muslim CIs, regardless of whether the CI was created by Christian or Muslim participants. See figures 2 and 4.

Did perception of demographic characteristics vary by participant's religion? There was no significant association between CI and rank for the demographic traits for either male ($\chi^2(9) = 5.09$, $p = 0.83$) or female CIs ($\chi^2(9) = 2.91$, $p = 0.97$). None of the CIs were more likely than the others to be consistently rated the highest on any demographic trait. See figures 3 and 5.

Was preference for the majority group or the ingroup stronger? To test if the biased distribution was due to a preference for the ingroup or a preference for the majority group, we conducted two Wilcoxon's signed-rank tests on the mean ratings for the four CI types (e.g., Christian CI by Christians, Christian CI by Muslims, etc.) across all 11 valenced characteristics. We compared ratings for the Christian CIs to Muslim CIs, and ingroup CIs to outgroup CIs. Ingroup CIs were not rated significantly higher than the outgroup CIs ($V = 667$, $p = 0.05$). However, Christian CIs were rated significantly higher than Muslim CIs were ($V = 987$, $p < 0.001$).

Discussion

The purpose of this study was to create images that depict the way Christians and Muslims mentally represent Christian and Muslim faces, and then assess attitudes towards these images. Participants revealed distinguishable mental representations for Christian and Muslim faces, visualized as CIs. Those CIs were rated in a consistent order on valenced but not demographic traits. Specifically, the majority religion's CIs were rated higher regardless

of the religion of the participants who created it, while ingroups were not favoured significantly over outgroups.

The fact that Christian CIs were consistently associated with more positive traits than Muslim CIs suggests that both Christians and Muslims view Christians more positively than they view Muslims. Rather than showing a preference for their ingroups, members of both religions gave more favourable ratings to images depicting the majority religion. This pattern mirrors findings for race and caste using the same paradigm: members of lower-status or minority groups showed a preference for the higher-status group, rather than for their ingroup. This is especially pronounced when there is conflict, or a history of conflict, between the groups in question (Newheiser et al., 2014). In recent years, Islam has been portrayed negatively in the media in many parts of the world, especially in the wake of events like 9/11. Islamophobia has been on the rise, as well, with incidents including hate crimes against Muslims increasing by 9% in Canada in 2019 (Moreau, 2021). If Muslims in Canada internalize the negative messaging surrounding Islam, they could develop an esteem for Christians and Christianity, which are viewed in a more positive light (Bettencourt et al., 2001; Rudman et al., 2002).

Such Christian favouritism would not be expected to generalize to non-Christian countries. A study using reverse correlation to examine religious ingroup-outgroup conducted in India, with Hindu and Muslim children did not find this pattern of results (Dunham et al., 2014). Religion is a far more salient category in India than it is in Canada, and even though Muslims are in the minority in both countries, Indian Muslims likely engage with their religious identity differently from Canadian Muslims. Religion tends to be a part of every aspect of life, and members of a given religion are usually taught that their religion is “right” compared to others (Pargament et al., 2005). Canadian Muslims probably engage with their religion in these ways, but given that religiosity is generally low among Canadians, and

religion is not particularly prominent in Canadian society overall, they may not be experiencing the same type of protective effect that Indian Muslims do (Cornelissen, 2021).

Our results also further illustrate how the reverse correlation technique can be used as a method to implicitly measure attitudes towards social groups. By having naive raters rate the CI face images, we were able to measure the way Christians and Muslims view themselves and each other. It also suggests that the face templates that individuals store for social categories encode more than just physical information. Biases and attitudes are reflected in face templates, such that well-liked categories have warm, friendly face templates, and disliked categories have more unpleasant face templates. It is especially interesting that this is the case for religion. Religion is a rather abstract category, not necessarily linked to physical features that would reliably cue religious identity. Religious garb or explicit statements of religious identity would be more reliable cues than facial features or apparent ethnicity. Religious group membership can also be changed much more easily than membership in other social categories. Despite this, it is clear that individuals have distinct face templates for members of different religions (see also Foglia et al., 2021) , and they encode their biases towards those religions in them.

Caveats

Our sample consisted of Canadian Christians and Muslims, and the patterns we see may be specific to these groups. Christianity is the largest religion in the world, and is the predominant religion in Canada, while Muslims make up only 3.7% of the Canadian population (Cornelissen, 2021; Vaughan, n.d.). However, Canada is a secular country where religious identity is not as salient a category as it might be in other parts of the world. Individuals from very religious societies may have stronger feelings about their religious ingroups and outgroups, and might show an ingroup preference even if they are in the minority, as seen in Indian Muslim children (Dunham et al., 2014). Future research could

apply these methods in populations where religion is more salient overall, or where Muslims are in the majority, to see if their preferences show a different pattern from the ones we observed in this study.

Conclusion

The purpose of this study was to use reverse correlation to visualize Christians' and Muslims' mental representations of their religious ingroup and outgroup, and to use those visualizations to assess their ingroup-outgroup attitudes. We found that both Christians and Muslims visualize Christians face images more positively, as indicated by raters who saw the faces without any religious labels, suggesting that they both favour Christians, the dominant religious identity, over Muslims. Our study was the first to visualize Christian and Muslim face templates in this way, and our findings reveal an interesting internalization of stigma among Canadian Muslims. Future research could examine whether Muslims from Muslim-majority countries show the same attitudes.

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Table 1

Observed frequencies for female CI means in each rank position for valenced and demographic traits

Type of rating		Christian female by Christians	Christian female by Muslims	Muslim female by Christians	Muslim female by Muslims
Valenced	First	10	0	0	0
	Second	0	8	2	0
	Third	0	1	4	5
	Fourth	0	1	4	5
Demographic	First	4	2	1	2
	Second	2	1	5	1
	Third	0	4	2	3
	Fourth	3	2	1	3

Table 2

Observed frequencies for male CI means in each rank position for valenced and demographic traits

Type of rating		Christian male by Christians	Christian male by Muslims	Muslim male by Christians	Muslim male by Muslims
Valenced	First	10	0	0	0
	Second	0	4	6	0
	Third	0	6	4	0
	Fourth	0	0	0	10
Demographic	First	2	1	3	3
	Second	3	2	2	2
	Third	3	1	3	2
	Fourth	1	5	1	2

Table 3

ANOVA results for demographic traits

Trait	df_1	df_2	F	p
Male	2.03	509.43	580.26	< 0.001
Female	1.96	491.96	582.2	< 0.001
White	5.18	1300.18	24.57	< 0.001
Black	5.50	1379.24	24.6	< 0.001
East Asian	5.48	1375.15	23.82	< 0.001
South Asian	5.26	1321.37	19.67	< 0.001
Middle Eastern	5.89	1479.62	5.58	< 0.001
Latinx	5.85	1467.89	5.78	< 0.001
Pacific Islander	5.74	1439.41	4.24	< 0.001
Indigenous Canadian	6.36	1595.44	2.52	0.02

Table 4

ANOVA results for valenced traits

Trait	df_1	df_2	F	p
Happy	6.82	1660.55	5.28	< 0.001
Religious	6.22	15.61.65	6.32	< 0.001
Trustworthy	6.57	1649.69	10.99	< 0.001
Moral	6.51	1635.02	13.66	< 0.001
Competent	6.47	1624.94	4.95	< 0.001
Warm	6.36	1596.86	12.93	< 0.001
Gentle	6.67	1673.23	11.69	< 0.001
Human	6.82	1712.54	1.53	0.15
Hardworking	6.62	1660.55	5.28	< 0.001
Likeable	6.79	1703.15	12.96	< 0.001
Attractive	6.23	1564.33	19.18	< 0.001

Figure 1

The 8 Classification Images (CIs) created using the data from phase 1

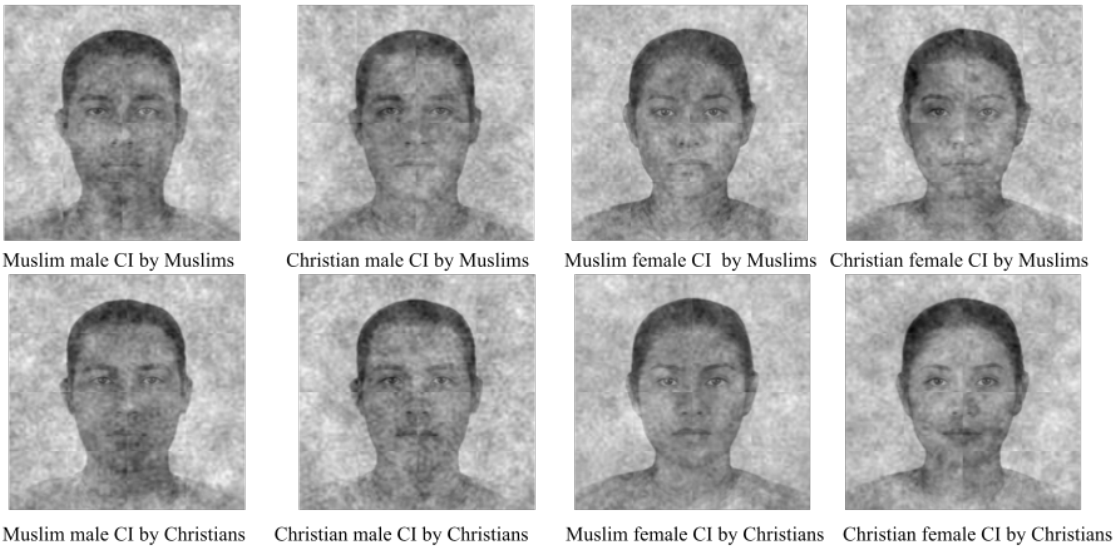


Figure 2

Mean ratings of female CIs on valenced traits. Error bars represent 95% confidence intervals.

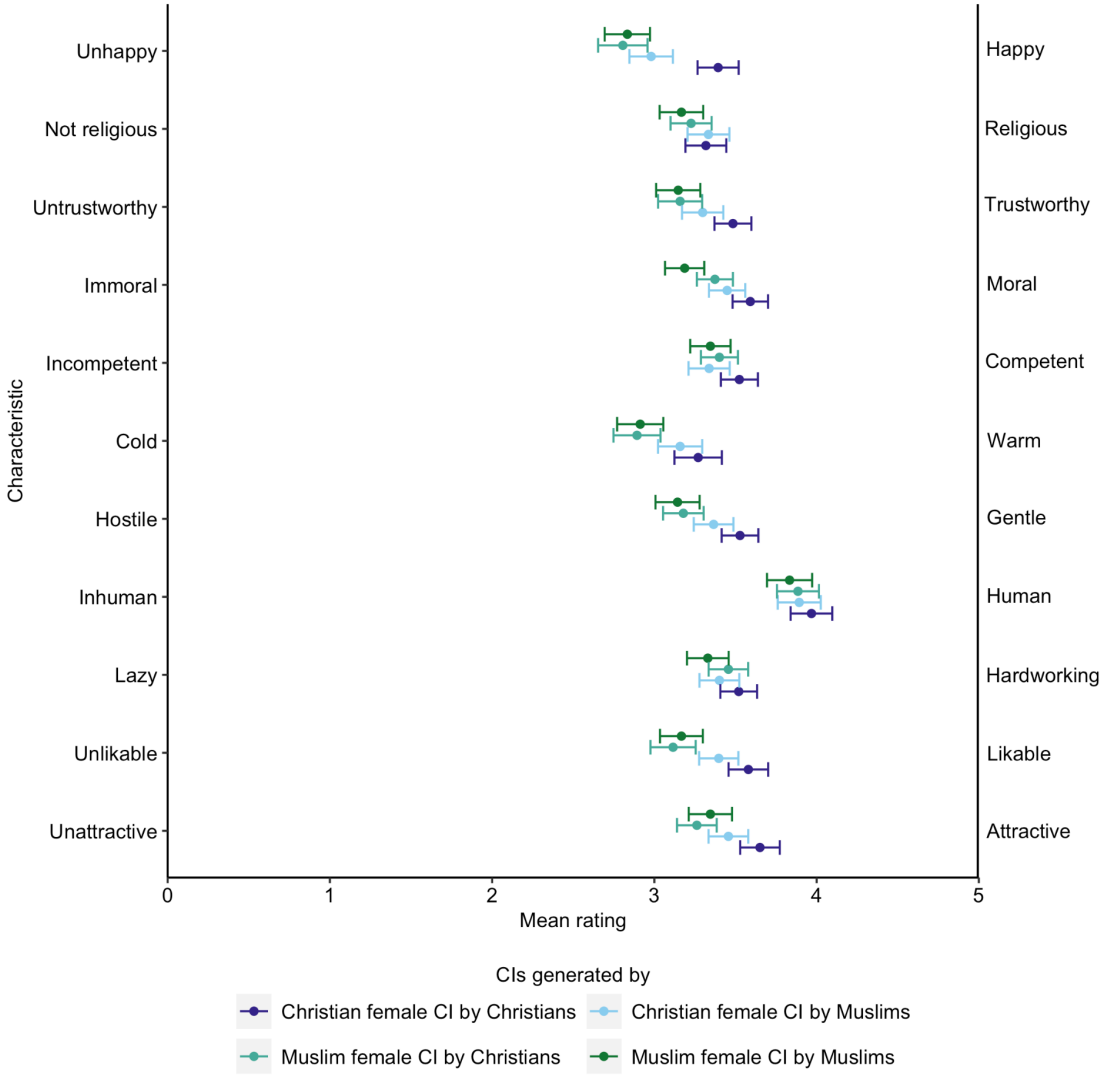


Figure 3

Mean ratings of female CIs on demographic traits. Error bars represent 95% confidence intervals.

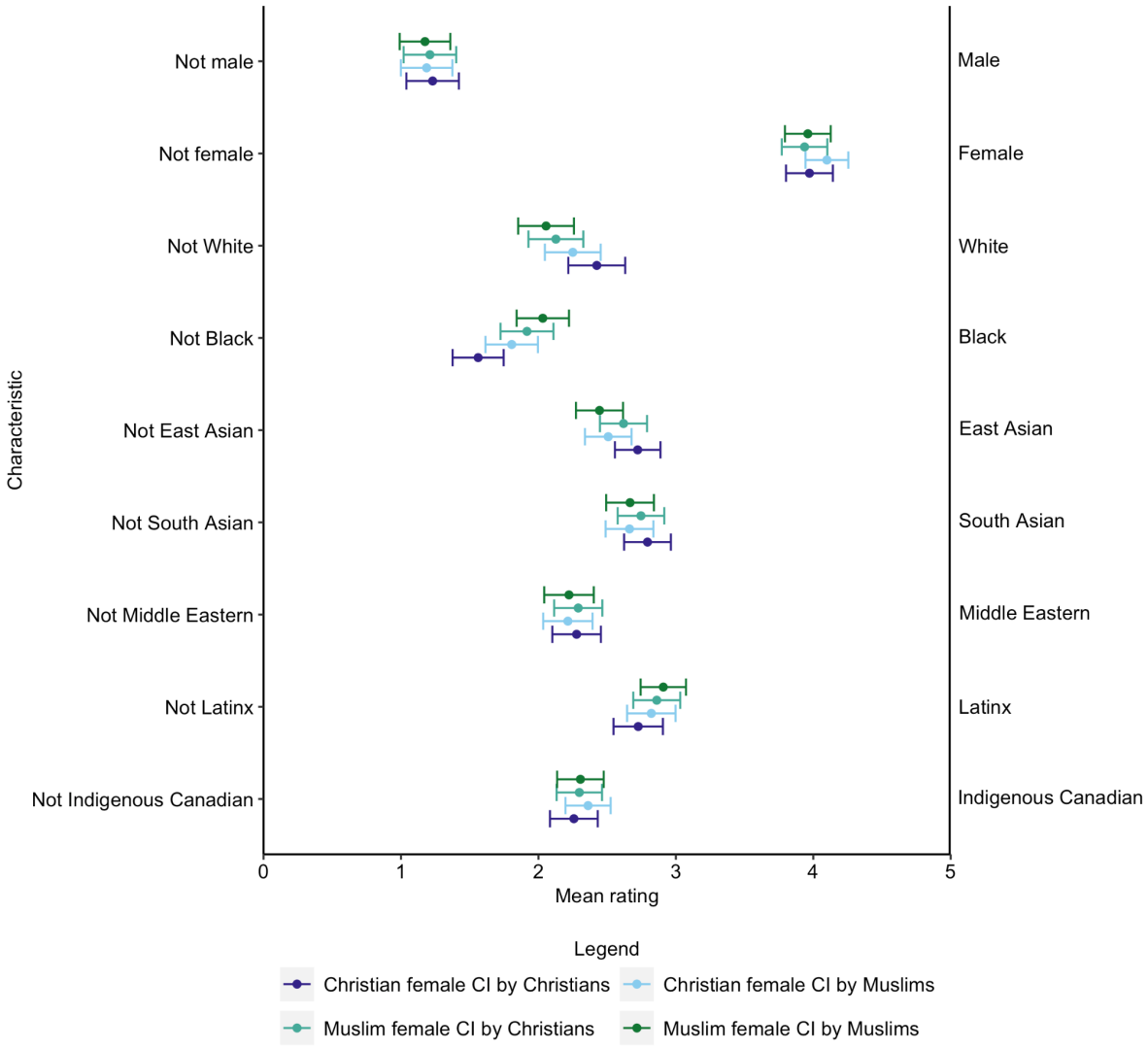


Figure 4

Mean ratings of male CIs on valenced traits. Error bars represent 95% confidence intervals.

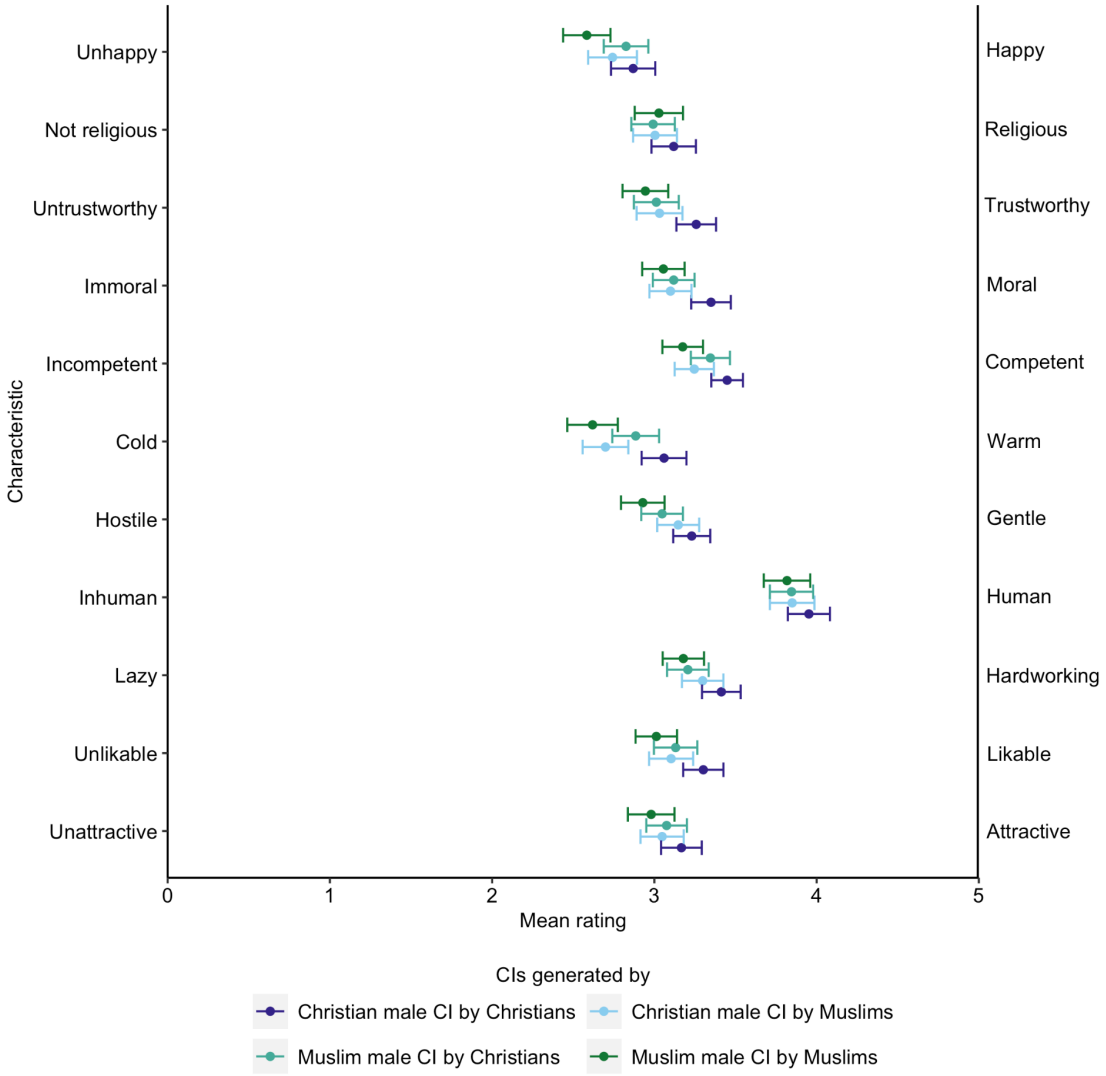
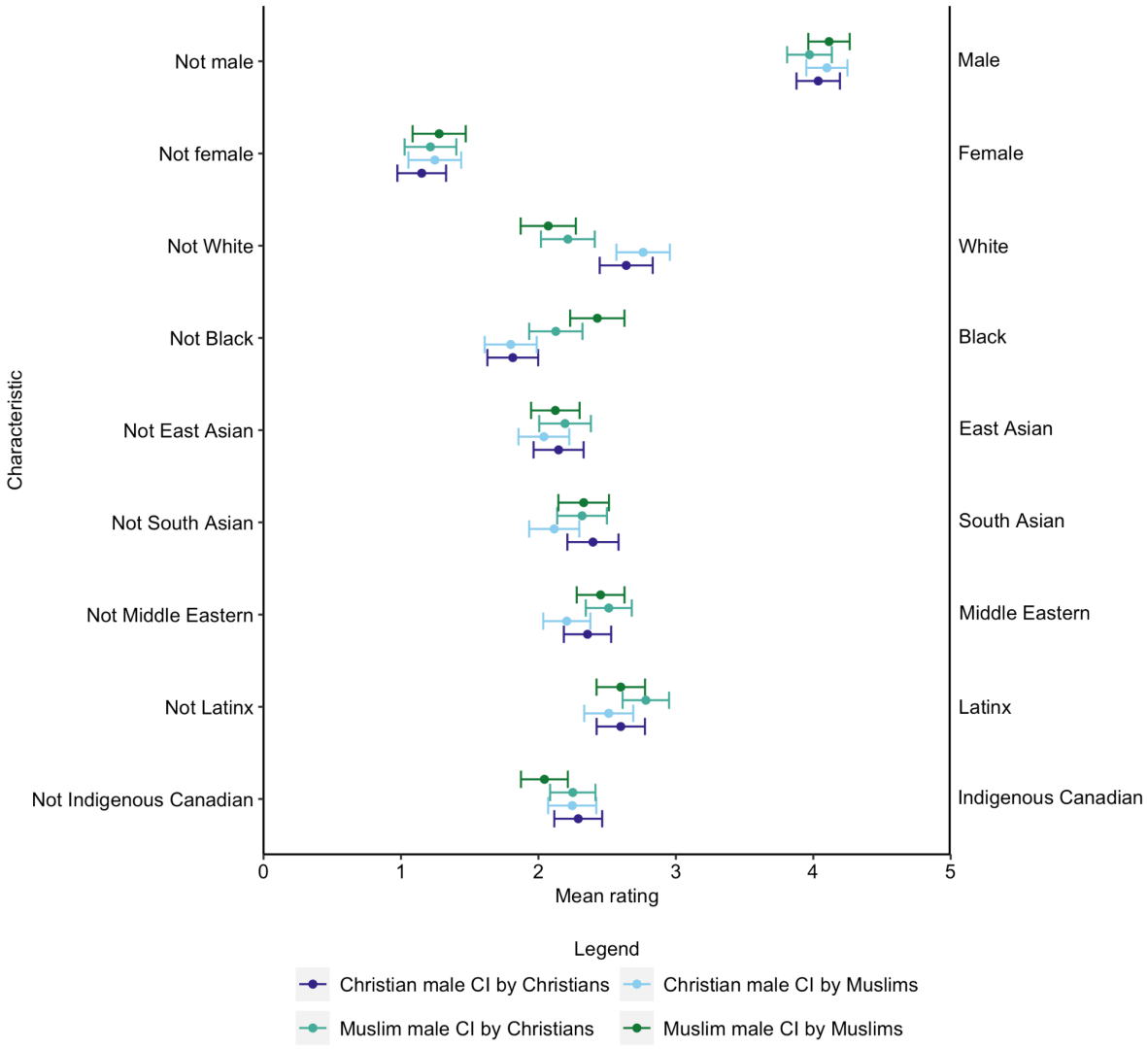


Figure 5

Mean ratings of male CIs on demographic traits. Error bars represent 95% confidence intervals.



Chapter 3: Religious labels and food preferences, but not country of origin, support opposing face aftereffects

Shakil, M., & Rutherford, M. D. (2024). Religious labels and food preferences, but not country of origin, support opposing face aftereffects. *Acta psychologica 247*, 104328. https://doi.org/10.1016/j.actpsy.2024.104328

Preface

People are able to rapidly sort the faces they encounter into different social categories such as age, sex, and race (Ito & Urland, 2003, 2005; Mouchetant-Rostaing et al., 2000; Tanaka, 2001). It is theorized that this occurs by comparing a viewed face to a mental template made up of the faces of members of that category that an individual has previously encountered (Valentine et al., 2004). Previous research using the category-contingent aftereffects method has demonstrated that, for the aforementioned categories, individuals store distinct mental templates. More recent research by Foglia et al., (2021) has used this method to show that categories like religion also have dedicated face templates. However, these templates only appear to be activated when explicit audio cues stating an individual's religious identity are present while faces are viewed.

The findings from the previous study in this dissertation used the reverse correlation procedure to visualize what these mental templates look like, in the form of CIs. In this study, we are complementing that work and providing converging evidence by applying a different implicit method to test for the presence of religious mental templates, and using that method to uncover religious stereotypes. The goals of the current study were to replicate and extend the findings from Foglia et al., (2021) which showed that individuals store separate mental templates for Christian and Muslim faces, which are only activated when religious information is provided via audio during an opposing aftereffects procedure. To extend the findings, we introduced audio conditions where the religious information was not provided

explicitly, but cued by including food preferences and countries of origin which are associated with Christianity and Islam. The aim of these conditions was to determine whether these indirect cues of religious group membership would also support category-contingent aftereffects, which would suggest that these cues lead individuals to categorize faces as members of different groups.

We first recruited 40 participants to complete a stimulus validation procedure. In this procedure, participants classified foods and countries based on whether they associated them with Christianity or Islam. We selected the three foods and countries for each religion which were associated with them the most consistently, and used them in our audio stimuli in the main experiment.

We then recruited 93 participants, who were assigned to one of three conditions to complete a category-contingent aftereffects paradigm. The conditions differed by the audio played while participants viewed faces. Participants either heard an explicit religious label, a food preference, or a country of origin while viewing expanded Muslim faces and contracted Christian faces. We assessed whether their preference for faces with these distortions changed after our procedure to determine whether category-contingent aftereffects were produced in each condition. A simultaneous increased preference for expanded Muslim faces and contracted Christian faces, would be evidence that they were categorizing the faces they viewed as members of separate social groups, and that our audio cues were effective markers of social category membership.

We observed category-contingent aftereffects in the religious explicit and food preference audio conditions, but not in the country of origin audio condition. This suggests that religious labels and food preferences are salient enough cues of social category membership to affect the way faces are perceived. This can be taken as evidence that individuals stereotype and classify others based on their explicitly-stated identity, as well as

cues like their food preferences. Also, these findings illustrate that higher-order social information affect the automatic process of face perception.

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Abstract

Face templates can be experimentally manipulated, and category-contingent aftereffects suggest discrete templates across social groups. We tested whether 1) explicit religious labels, 2) food preferences, and 3) country of origin would support religion-contingent aftereffects across Christians and Muslims face sets. While viewing face images, ninety-three participants heard audio that stated either 1) a character's religious identity, 2) preferred food, or 3) country of origin. Participants viewed contracted Christian faces and expanded Muslim faces during the training phase. To measure adaptation, before and after the training phases, participants selected the face out of a pair of expanded and contracted Christian or Muslim faces that they found more attractive. Contingent aftereffects were found in the religious explicit ($t(30) = 2.49$, $p = 0.02$, Cohen's $d = 0.58$) and food conditions ($t(30) = -3.77$, $p < 0.01$, Cohen's $d = -0.82$), but not the country condition ($t(30) = 1.64$, $p = 0.11$, Cohen's $d = 0.31$). This suggests that religious labels and food preferences create socially meaningful groups, but country of origin does not. This is evidence of an impact of social categorization on visual processing.

Keywords: Social categorization, face perception, category-contingent aftereffects, religious identity, aftereffects

Introduction

Face perception is fast and efficient. Within seconds, using conscious and unconscious processes, individuals perceive identity, race, and sex (Ito & Urland, 2003, 2005; Mouchetant-Rostaing et al., 2000; Tanaka, 2001). Identity is perceived by comparing viewed faces to existing mental face templates (Valentine et al., 2004). These face templates are the average of the faces an individual has encountered (Leopold et al., 2001). Face templates are malleable: when individuals view new faces, existing templates are updated (Hurlbert, 2001).

Aftereffects can be experimentally induced when the participant adapts to faces that are distorted along a particular stimulus dimension (Anzures et al., 2009), and they provide evidence of the template's malleability. When participants see a set of faces that are distorted in one direction (e.g., eyes set close together), a subsequently presented undistorted face will appear distorted in the opposite direction (e.g., eyes set wide; Webster & Maclin, 1999). Such aftereffects have been induced across identity, race, age, sex, and emotion (Hurlbert, 2001; Kaping et al., 2010; O'Neil & Webster, 2011; Webster et al., 2004). It is possible to test whether categories are represented using separate face templates through higher-level, category-contingent aftereffects.

Category-contingent aftereffects occur when individuals simultaneously adapt to distortions in opposite directions for two different social categories. For instance, category-contingent aftereffects could occur if participants simultaneously adapted to men with expanded features and women with contracted features. Repeated exposure to such distortions will shift the respective norms in the direction of the distortion, making similarly distorted faces from those categories appear more normal or attractive. Thus, aAdaptation can be measured by asking participants to rate faces which are distorted in the direction of the adaptation or the opposite, based on how normal or attractive they appear – similar results

have been found using either probe (Little et al., 2005; Rhodes et al., 2003). If participants have adapted, faces with the viewed distortion should appear more normal or attractive, because they resemble the updated norm (Leopold et al., 2001; Rhodes et al., 2003). In the previous example, where participants adapt simultaneously to men with expanded features and women with contracted features, they will rate expanded male faces and contracted female faces as more attractive than they did before the adaptation occurred. In a category-contingent aftereffects paradigm, the adaptation occurs in opposite directions for the two categories of interest. If there were only a single template being impacted by the opposing adaptation procedure, the opposite distortions would cancel each other, leaving no measurable adaptation. Thus, when category-contingent aftereffects occur, this is evidence that the two categories are represented using separate mental templates. However, certain factors such as the presentation time for each face can affect whether aftereffects occur (Gao et al., 2022). Social categories must be perceptually distinct (Short & Mondloch, 2010) and socially relevant (Bestelmeyer et al., 2008) in order to support category-contingent aftereffects. Category-contingent aftereffects have been observed for race, sex, age, and species (Little et al., 2005, 2008), and for religious categories (Foglia et al., 2021).

While Foglia et al (2021) found that Christian and Muslim faces have separate templates, category-contingent aftereffects were only found when faces were presented with auditory information explicitly labelling the face model's religion. The current study tested whether implicit religious cues support the formation of religion-contingent aftereffects. A person's national identity, for instance, could imply their religious affiliation (Barro & McCleary, 2005). Another potential cue for religious identity is food preference (Johnson et al., 2011), as many religions have food restrictions or use specific foods in religious rituals and celebrations (Fieldhouse, 2017).

The current study

The current study aimed to further examine religious category-contingent aftereffects. First, we replicated Foglia et al. (2021)'s second study, which found that explicit religious audio labels induce category-contingent aftereffects in adults for Christian and Muslim faces. We also introduced country of origin and food preference as implicit religious cues. In both of these conditions, participants viewed Christian and Muslim face models in a category-contingent aftereffects paradigm, but heard audio labels that described countries of origin or food preferences that were associated with Christianity and Islam. If food preferences and country of origin support category-contingent aftereffects, then these are the types of information that are perceived as discrete social categories.

Methods: Stimulus Validation

For the religious condition, audio recordings were created by re-recording the audio from the religious condition in Foglia et al., (2021). Audio was re-recorded to make the voice consistent with the audio recordings in the new food preference and country of origin conditions. The original audio recordings were sets of three-sentence character descriptions: three describing Muslim face models, and three describing Christian face models. Two of the sentences described the face model's studies and hobbies, and one sentence explicitly stated that the character was a Muslim and worshipped at a mosque, or that they were a Christian and worshipped at a church.

To create audio recordings for the food and country conditions of the aftereffects paradigm, foods and countries that were reliably associated with Christianity and Islam were needed. A stimulus validation study was conducted for this purpose. Preliminary lists of foods and countries associated with Christianity and Islam were developed. The lists consisted of 17 Christian foods, 15 Muslim foods, 13 Christian countries, and 10 Muslim countries. The full lists are provided in Tables 1 and 2.

Participants

40 undergraduate students (Female = 36, Male = 3, Non-binary = 1, *M* age = 18.13, *SD* = 0.88) were recruited, and were granted course credit for their participation in the experiment. Fourteen of the participants identified as white, eight as East Asian, six as South Asian, seven as Middle Eastern, three as mixed race (East Asian and white), one as Latin American, and one as Indigenous Canadian. In terms of religion, fourteen participants identified as Catholic, six as Christian, seven as Muslim, two as Hindu, one as Jewish, one as Sikh, one as Atheist, and five did not identify with any religious identity. The study was conducted online using Gorilla.sc (Anwyl-Irvine et al., 2020).

Procedure

Informed consent was obtained at the beginning of the session. Participants were shown text in 24-point font naming the foods and countries, one at a time, in random order at the center of their computer screen. Underneath the word, there were two buttons they could click on using the mouse to indicate whether the food or country was related to Christianity or Islam.

After the study was complete, participants completed a demographic questionnaire. They were asked to provide their age, gender, ethnicity, family's religious heritage, and frequency of religious practice. Participants reported frequency of religious practice on a scale from 1 ("Very frequent, one or more times a week") to 5 ("Very infrequent or never"). Half of the participants reported that they practiced very infrequently or never, with the average frequency of religious practice being 3.48 (*SD* = 1.74).

Results: Stimulus Validation

We calculated the proportion of participants who misidentified the religion for each food and each country (See Tables 1 and 2). For each religion, we included the 3 foods and 3 countries with the lowest proportion of misidentification as stimuli in the category-contingent

aftereffects paradigm. If multiple foods or countries had the same proportion of misidentification, one was randomly selected to complete the set of three stimuli for each religion. This was done to select one of the Christian foods and two of the Muslim foods. These were shepherd's pie (0% misidentified), spaghetti and meatballs (0%), and hamburgers (2.5%) as foods for the Christian character descriptions, and shawarma (2.5%) , tabouleh salad (2.5%), and kebabs (5%) as foods for the Muslim character descriptions. For countries, England (0%), Italy (0%), and Scotland (0%) were selected for the Christian character descriptions, and Pakistan (0%), Iraq (0%), and Afghanistan (0%) were selected for the Muslim character descriptions.

Methods: Category-contingent aftereffects paradigm

Participants

93 undergraduate students (Male = 22, *M* age = 18.43 years, *SD* = 1.34) were recruited and granted course credit for their participation. The sample size of 93 participants was determined using a power analysis based on the effect size reported for the Christian contracted/Muslim expanded main effect in Foglia et al. (2021). Cohen's *d* was converted to Cohen's *f* and the power analysis was conducted in GPower 3.1.9.7 for a one-way, omnibus ANOVA for 2 groups. This statistical calculation suggested that a sample size of 93 participants would give us 95% power to detect the effect at alpha = 0.05. Study 2 was completed using a between-subjects design, and each participant was randomly assigned to one of three audio conditions – religious explicit, country of origin, or food preference audio. Audio labels were used, as in Foglia et al. (2021)'s study, so that participants could focus on scanning the faces during the aftereffects procedure, rather than reading written information about the face on the screen. 31 participants participated in each of the conditions.

Twenty-five participants identified as white, 24 as East Asian, 21 as South Asian, 10 as Middle Eastern, three as Latin American, three as African, two as West Indian, and three

as mixed race (White and South Asian, White and Afro-Caribbean, and White and East Asian). Nineteen of the participants identified as Muslim, 14 as Catholic, 12 as Christian, 13 as Hindu, three as Buddhist, one as Sikh, one as Jehovah's Witness, nine as agnostic or questioning, eight as atheist, and 20 did not identify with any religious identity. The majority of participants reported that they practiced their religion infrequently or never, with the average frequency of religious practice being 3.34 (SD = 1.50).

Procedure

The procedure consists of three phases, described below, and also illustrated in Figure 2. All participants completed the experiment on a 15-inch ASUS laptop, and were positioned such that their eyes were approximately 60 cm away from the screen. Participants were randomly assigned to one of three audio conditions: religious explicit, country of origin, and food preference. Informed consent was obtained at the beginning of the session.

Pre-Adaptation phase

Participants viewed 12 pairs of faces, four times each, in random order. There were six pairs of Christian faces and six pairs of Muslim faces. Each pair consisted of two images of the same model. One image was 10% expanded, and the other was 10% contracted. The two images were presented side by side, at a resolution of 814 x 1217 pixels each (10.582° × 19.222° of visual angle). Participants viewed the faces for 2 seconds, and were allowed to freely scan the faces during this time. They were then asked to press a key on the keyboard to indicate which of the images they found more attractive (the F key was pressed for the left image, and the J key for the right image). After each response, and before the next face pair was shown, a fixation cross was displayed for 1 second. While they viewed the faces, the participants heard the name of the character. In the religious explicit condition, participants heard a Christian or Muslim name while they viewed the face pairs (e.g., "Mohammad" or

"Matthew"). In the food and country conditions, participants heard a neutral name: one that could plausibly belong to a Christian or Muslim individual (e.g., "Sophia" or "Adam").

Adaptation phase

Participants viewed six faces one at a time, three times each, in random order. Three of the faces were 60% contracted Christian faces, while the other three were 60% expanded Muslim faces. Each face was shown for 7 seconds at the center of the screen at a resolution of 1063 x 1588 pixels (9.077° × 13.580° of visual angle), with a 500-millisecond interval between faces. Participants were able to freely scan faces when they were shown. Each time the face was viewed, participants heard one sentence out of a three-sentence character description. In the religious explicit condition, the character description included a religious name, and an explicit statement about the character's religious identity and place of worship. In the country and food conditions, the character description included a neutral name, and a statement about the character's country of origin or food preference.

Post-adaptation phase

The post-adaptation phase was the same as the pre-adaptation phase. The only difference was the addition of top-up faces, three 60% contracted Christian faces and three 60% expanded Muslim faces, which were shown for 1 second each after each attractiveness selection was made – in total the 6 top-up faces were shown for 6 seconds. The top-up faces were presented at a resolution of 1063 x 1588 pixels (9.077° × 13.580° of visual angle). The top-up faces were added to ensure that the adaptation developed in the previous phase was maintained. Participants were able to freely scan all face pairs and top-up faces when they were shown.

Demographic questionnaire

Participants completed the same demographic questionnaire that was provided to the participants in the stimulus validation study.

Post-study stimulus check

After the category-contingent aftereffects paradigm was complete, participants in the food and country conditions completed a form where they rated the foods and countries from the adaptation condition on a scale from 1 ("Strongly Christian") to 5 ("Strongly Muslim"). This scale was used to determine how strongly they associated the foods and countries they heard with the religions they were meant to cue.

Visual Stimuli

The stimuli used in this study were the same as those used in Foglia et al., (2021). A total of 18 photos of models were used. Half of the images were of Christian models (5 of the 9 images were of female faces), and the other half were of Muslim models (5 of the 9 images were of female faces). The images were expanded by 10% and 60%, and contracted by 10% and 60% using the spherize function in Adobe Photoshop CS. The 10% distorted stimuli were used in the pre- and post-adaptation phases, and the 60% distorted stimuli were used in the adaptation and post-adaptation phases. Sample stimuli are shown in Figure 1.

Audio Stimuli

Audio stimuli were recorded using the Samsung Voice Recorder application on a Samsung S20+ phone. The same female voice was used to narrate all of the audio stimuli described below. For the pre- and post-adaptation phases, 24 names were recorded (six Christian, six Muslim, and 12 religiously neutral). For the adaptation phase, 18 three-sentence character descriptions were recorded. There were six character descriptions for each of the three conditions in the study. The character descriptions consisted of a sentence describing the character's area of study (e.g., "Sarah is in school to be a doctor."), a sentence describing their hobby (e.g., "Sarah likes to play soccer"), and a third sentence that varied depending on the experimental condition. In the religious explicit phase, the third sentence described the character's religious identity and place of worship (e.g., "Hasan is Muslim and worships at a

mosque"). In the country of origin condition, the sentence described the character's country of origin (e.g., "Adam is from Pakistan"), and in the food preference condition, the sentence described the character's preferred food (e.g., "Nadia's favourite food is shepherd's pie."). A full script is available in the Supplementary Materials.

Neither of the studies in this manuscript were preregistered. The data and code used for analysis are publicly available; see 10.17605/OSF.IO/234HS. The materials used in the study are not publicly available, and requests to access them should be directed to the first author.

Results: Category-contingent aftereffects Paradigm

Pre-adaptation attractiveness selections

First, we analyzed the attractiveness selections participants made in the pre-adaptation phase. We conducted a 2 (model religion: Christian or Muslim) by 3 (audio condition: religious explicit, food preference, or country of origin) mixed ANOVA. The dependent variable was the number of contracted faces selected as more attractive during the pre-adaptation testing. We found a significant main effect of religion ($F(1, 180) = 8.79$, $p < 0.01$, $\eta_p^2 = 0.05$). Participants selected more contracted faces as attractive in the Muslim face pairs ($M = 17.1$ out of 24 Muslim face pairs, $SD = 4.25$) than they did in the Christian face pairs ($M = 14.3$ out of 24 Christian face pairs, $SD = 4.62$). There was no significant effect of condition ($F(2, 180) = 0.01$, $p = 0.92$) and no condition by religion interaction ($F(2, 180) = 0.03$, $p = 0.86$). Since there was no interaction, and no difference in attractiveness selections across conditions, we used the pre-adaptation scores to calculate change scores for our subsequent analyses.

Comparing the three audio conditions

To examine the effect of audio condition on the change in attractiveness selections, we conducted a 2 (model religion: Christian or Muslim) by 3 (condition: religious explicit,

food preference, or country of origin) mixed ANOVA. The dependent variable was a change score, which was calculated by subtracting the number of contracted faces selected in the pre-adaptation phase from the number of contracted faces selected in the post-adaptation phase. The change score was, therefore, the change in preference for contracted faces after undergoing the adaptation phase. There was no significant effect of religion ($F(1, 180) = 2.99$, $p = 0.85$) or condition ($F(2, 180) = 1.30$, $p = 0.26$) and no condition by religion interaction ($F(2, 180) = 0.57$, $p = 0.45$).

Religious explicit condition

To determine whether religion-contingent aftereffects were induced in the religious explicit audio condition, we conducted a two-sample *t*-test comparing the change scores for Christian and Muslim stimuli (See Figure 3). We observed significant religion-contingent aftereffects ($t(30) = 2.49$, $p = 0.02$, Cohen's $d = 0.58$). The change in preference for contracted Christian faces ($M = 2.39$, $SD = 4.46$) was significantly greater than the change in preference for contracted Muslim faces ($M = 0.16$, $SD = 3.16$).

Food preference condition

We tested for religion-contingent aftereffects in the food preference condition by conducting a two-sample *t*-test comparing the change scores for Christian and Muslim stimuli. We observed significant religion-contingent aftereffects in this condition ($t(30) = 3.77$, $p < 0.01$, Cohen's $d = 0.82$). Participants showed an increased preference for contracted Christian faces after the adaptation ($M = 2.39$, $SD = 2.75$), and a decreased preference for contracted Muslim faces ($M = -0.19$, $SD = 3.50$), which was a statistically significant difference.

Country of origin condition

To determine whether the country condition induced religion-contingent aftereffects, we conducted a two-sample *t*-test comparing the change scores for the Christian and Muslim

stimuli. We did not observe significant religion-contingent aftereffects in this condition ($t(30) = 1.64$, $p = 0.11$, Cohen's $d = 0.31$). The increased preference for contracted Christian faces ($M = 2.65$, $SD = 4.21$), and contracted Muslim faces ($M = 1.42$, $SD = 3.78$) did not differ significantly.

Discussion

Previous work suggests that religious categories can support the formation of category-contingent aftereffects if category membership is made explicit (Foglia et al., 2021). The purpose of this study was to test whether religious categories can support the formation of religion-contingent aftereffects when other religious cues are provided via audio. We found that explicit religious labels and preferred foods both supported the formation of religion-contingent aftereffects, but country of origin did not.

Religion-contingent aftereffects were found in the food preference condition. When audio was played stating a preference for a typically Christian or Muslim food in the adaptation phase, participants showed evidence of religion-specific adaptation in the post-adaptation phase even though religion was not mentioned. This suggests that faces were categorized as Christian or Muslim, and participants' templates for the two groups adapted independently during the adaptation phase. Food preference appears to be a cue of religious group membership that engages the relevant psychology to lead to the categorization of faces as Christian or Muslim, allowing for religion-contingent aftereffects to occur. However, it is important to note that, while the data support the presence of religion-contingent aftereffects, it is possible that the two face categories were categorized based on ethnicity, as the foods could be associated with particular ethnic groups and cultures, or based on food preferences themselves.

Food plays a role in human sociality. The acquisition, preparation, and consumption of food can involve social interaction (Rozin, 2006). Individuals may work together to acquire

food, and often learn methods of preparing food from others (Bietti et al., 2019; Cosmides & Tooby, 1992). In early humans, the use of fire to cook food would have involved many individuals cooperating to maintain large hearths. Food could be shared and gathering to cook and eat around fires could make social bonding occur more efficiently (Dunbar, 2014). This means that food can play a role in forming and maintaining strong bonds within groups, and distinguishing from out-groups (Dunbar, 2014; Kaplan et al., 2005).

Religious groups can be associated with specific food practices. Food can play a role in religious rituals, such as communion, making offerings to deities or ancestors, and the slaughter and distribution of meat by Muslims for Eid ul-Adha (Bradshaw, 2007; Maqsood, 2003; McCreery, 1990). Religions can also impose food restrictions: Jewish individuals eat Kosher, Muslims cannot eat pork or drink alcohol, Hindus do not consume beef, and members of many faiths engage in periodic fasting (Dugan, 1995; Persynaki et al., 2017; Regenstein, 2020; Sarkar & Sarkar, 2016). A person's adherence to religious dietary rulings can indicate their religiosity as well (Johnson et al., 2011) and serve as an effective method for distinguishing members of a given religion from those outside the religion (Rozin, 2006).

Food restrictions can also ensure that individuals understand the distinctions between their religious group and others. When people cannot share food, they cannot socialize with other groups, and the potential for leaving one's religion to join another may be reduced (Fieldhouse, 2017; Pinker, 1997).

Individuals can infer an individual's religious identity based on the foods that they do and do not eat, and we believe that this thinking led participants to associate the foods in our category-contingent aftereffects paradigm with the religion of the character they were viewing. The presence of religion-contingent aftereffects suggests that religion and food are psychologically associated, and that the food one chooses to eat can lead others to infer their religious identity.

Religion-contingent aftereffects were also observed in the audio condition with explicit religious labels, replicating the findings in Foglia et al. (2021). This provides further support for the existence of distinct templates for Christian and Muslim faces. It also demonstrates again that auditory information affects visual processing. While individuals can categorize faces based on visual information, information provided in the auditory domain can also play a role in identifying which groups a given face belongs to. This suggests that the visual perception of faces has top-down influences. Research on other areas of face processing support this. In emotional face recognition, providing auditory cues like affective sounds and speech can improve the identification of emotions (Wieser & Brosch, 2012). Voice and face recognition regions of the cortex show high connectivity, suggesting that they might exchange information to maximize person recognition (Blank et al., 2011). Our findings, and the findings in Foglia et al. (2021) indicate that auditory information can influence the categorization of faces by religion.

We did not observe religion-contingent aftereffects in the country of origin condition. Perhaps the country of origin as an implicit cue of religion did not support the formation of two socially meaningful categories. One possible explanation for the lack of religion-contingent aftereffects in the country of origin condition is that the audio labels used person-first language ("Adam is from Pakistan") rather than using the noun-label for their nationality ("Adam is Pakistani"). Person-first phrases may make national identity seem less central to one's identity than if the noun-label was used. If this is the case, participants may not make the connection between the national identities presented in the adaptation phase and the religious groups they were associated with. Research on other categories suggests that this may be the case. Using generic language to describe members of a group (e.g., "Zarpies like to eat flowers" rather than "this Zarpy likes to eat flowers) can lead to higher essentialist thinking about that group (Rhodes et al., 2012). Noun-labels for mental illnesses (e.g., "He is

a schizophrenic" rather than "He has schizophrenia") are more likely to be endorsed by individuals who are essentialist in their thinking about those illnesses (Williams et al., 2022). For our purposes, to cue a religious identity that may be identified with a given nationality, using noun-labels may be more useful.

Another possible explanation for this null result might be the lack of geographic knowledge within our sample. Geographic literacy is low among Canadian students: they rank seventh out of nine countries surveyed by the National Geographic Society, and score low on tests of geographic knowledge (averaging between 53 and 64 percent) (National Geographic Society, 2006; Sharpe, 2005; Vajoczki, 2009). If participants lack geographic knowledge about the countries we used, they may not know the religious demographics of those countries. Although our stimulus validation showed no misidentification, it was a 2-alternative forced choice task, and participants may not make those associations spontaneously. As a result, they may have failed to correctly classify the faces as Christian and Muslim.

Caveats and limitations

Our sample consisted of undergraduates from the Greater Toronto Area in Canada. While this is a very diverse area in terms of cultures, ethnicities, and religions, it is possible that the knowledge our participants had of the religious groups we were testing is specific to this population (Jansen & Lam, 2003). Perhaps each of our conditions would support the formation of religion-contingent aftereffects in participants from more religiously inclined regions. For participants from less diverse regions, who may lack knowledge about the religious groups and their associated foods and countries of origin, the cues may be less effective overall. Future studies could examine religion-contingent aftereffects in areas with different levels of religious diversity, or compare samples with varying religiosity.

It is also worth noting that the religion-contingent aftereffects that were observed in the religious explicit and food preference audio conditions did not show "opposite" aftereffects. There was an increased preference for contracted Christian faces, which matched the direction of the adaptation, but there was approximately no change in the preference for contracted Muslim faces. We refer to our observed effect as religion-contingent aftereffects because there was a significant difference in the change scores for the two face categories, which differ by religion. However, it is possible that there was only a significant change for the Christian faces because they are perceived as the default category, while the Muslim faces are a marked, other category. This is likely because our sample has more experience with Christians than Muslims, and if this experiment were repeated with a sample from a Muslim-majority country, perhaps an opposite or attenuated would be observed.

Another characteristic of our sample is that it consisted mostly of females. There are many reported sex differences in face processing, such as superior face and emotion recognition abilities in females, especially for female faces (Guillem & Mograss, 2005; Thayer & Johnsen, 2000; Sommer et al., 2013). Women also tend to evaluate faces more positively than men (Proverbio, 2017). It is possible that our findings were affected by the gender of the majority of our participants, and they may generalize to the general population better had the sample been more evenly split in terms of gender.

It is possible that our results were affected by the way responses were bound to specific keys. In the pre-adaptation and post-adaptation phases of the experiment, participants pressed the J key, on the right of the keyboard, to select the right face as more attractive, and pressed the F key, on the left side, to select the left face. This was done to make the response straightforward, to prevent error if participants had to press a "mismatched" key. However, there is evidence that the way individuals conceptualize space and respond to specific arrangements of stimuli is not random. For instance, the Simon effect refers to the fact that

participants will respond more quickly when the stimulus location is congruent with the location of the response key (Simon & Rudell, 1967). There also appears to be a link between how much agency a social category is thought to have and where it is represented in space, which is described by the Spatial Agency Bias model (Chatterjee, 2002). For instance, males are typically viewed as more agentic than females, and categories that are thought to have greater agency are typically represented in the left side of space. On the other hand, there can be spatial bias where negative concepts are associated with the left side of space, and positive concepts are associated with the right side of space (Casasanto, 2009; 2011). Our design does not involve direct comparisons between genders or religious or ethnic groups – attractiveness selections are done between two versions of the same image. However, participants' likelihood of choosing an image may be based in part on their spatial bias (e.g., selecting the left image when a male face pair is on the screen, based on perceived agency). Future studies could account for this, or examine the effect of these phenomena on this procedure, by including conditions where participants input responses using the opposite keys.

Another caveat is that we do not know the strength of the association between a given stimulus and its respective religion. The stimuli were validated in a two-option forced-choice task. This allowed us to select the foods and countries that were consistently associated with Christianity or Islam. If the stimuli were rated on a Likert scale, for instance, participants could indicate the strength of the association. Stimuli chosen on that basis may cue religious identity more effectively. The more similar the stimulus validation is to the category-contingent aftereffects paradigm, the more representative the stimuli will be.

Conclusion

The purpose of this study was to determine the cues that signal religious identity strongly enough to induce religion-contingent aftereffects. With respect to religion-contingent aftereffects, religious group labels and food preferences are effective cues of religious

identity, but country of origin is not. This shows that 1) faces are categorized based on religion, and 2) top-down information provided in the auditory domain influences face processing. It also demonstrates that religious identity can be signalled through direct and indirect cues, which adds to our understanding of social categorization and the roots of stereotyping and prejudice. Future studies may examine other indirect cues which may signal religious identity, examine the impact of the participant's religious identity and religiosity on the effectiveness of these cues, and study other religious identities to extend these findings.

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Table 1

Preliminary list of Christian and Muslim foods and percentage of participants who misidentified their associated religions (N = 40)

Stimulus	Religion	Percentage of participants who misidentified
Spaghetti and meatballs	Christianity	0
Shepherd's pie	Christianity	0
Hamburger	Christianity	2.5
Shawarma	Islam	2.5
Tabouleh salad	Islam	2.5
Apple pie	Christianity	2.5
Hot dogs	Christianity	2.5
Caesar salad	Christianity	2.5
Kebab	Islam	5
Casserole	Christianity	5
Macaroni and cheese	Christianity	5
Pizza	Christianity	5
Fish and chips	Christianity	5
Fattoush salad	Islam	5
Sausages	Christianity	7.5
Baida roti	Islam	7.5
Pasta	Christianity	7.5
Ham	Christianity	7.5
Falafel	Islam	7.5
Tandoori chicken	Islam	7.5
Garlic bread	Christianity	10
Chicken biryani	Islam	10

Table 1

Continued

Stimulus	Religion	Percentage of participants who misidentified
Lasagna	Christianity	10
Bacon	Christianity	12.5
Stuffed turkey	Christianity	12.5
Samosa	Islam	15
Baklava	Islam	15
Chicken curry	Islam	20
Butter chicken	Islam	25
Hummus	Islam	32.5
Dates	Islam	40
Chicken on the rocks	Islam	55

Table 2

Preliminary list of Christian and Muslim countries and percentage of participants who misidentified their associated religions (N = 40)

Stimulus	Religion	Percentage of participants who misidentified
England	Christianity	0
Italy	Christianity	0
Scotland	Christianity	0
Iraq	Islam	0
Afghanistan	Islam	0
Pakistan	Islam	0
New Zealand	Christianity	2.5
Syria	Islam	2.5
Saudi Arabia	Islam	2.5
Iran	Islam	2.5
Germany	Christianity	5
United States	Christianity	5
Ireland	Christianity	5
Lebanon	Islam	7.5
Palestine	Islam	7.5
Canada	Christianity	10
Russia	Christianity	10
Greece	Christianity	10
Egypt	Islam	12.5
Spain	Christianity	12.5
Brazil	Christianity	15
Philippines	Christianity	32.5

Table 2

Continued

Stimulus	Religion	Percentage of participants who misidentified
Jordan	Islam	35

Figure 1

Sample stimuli used in the category-contingent aftereffects paradigm

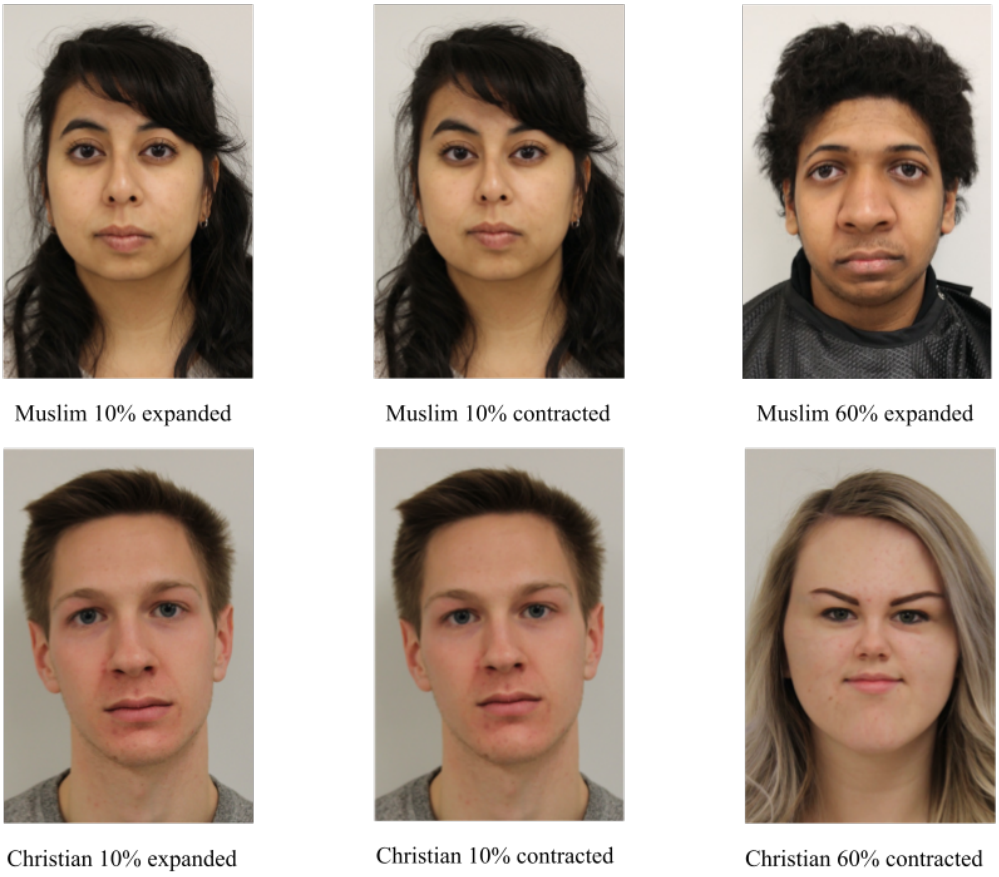


Figure 2

Illustration of the category-contingent aftereffects procedure used in this study. Participants in all three conditions underwent all three phases of the procedure. In the pre-adaptation phase (1), participants viewed pairs of Christian and Muslim faces that were expanded and contracted by 10% for 2 seconds, and selected the face that was more attractive with a key press. The response was followed by a 1 second fixation cross. They heard religiously neutral names when viewing the face pairs. In the adaptation phase (2), participants viewed 60% expanded Muslim faces and 60% contracted Christian faces while hearing three-sentence character descriptions that contained either an explicit religious label, a food preference, or country of origin. The post-adaptation phase (3) was the same as the pre-adaptation phase, with the addition of 6 60% distorted top-up faces, presented for 1 second in total, between the fixation cross and the next face pair.

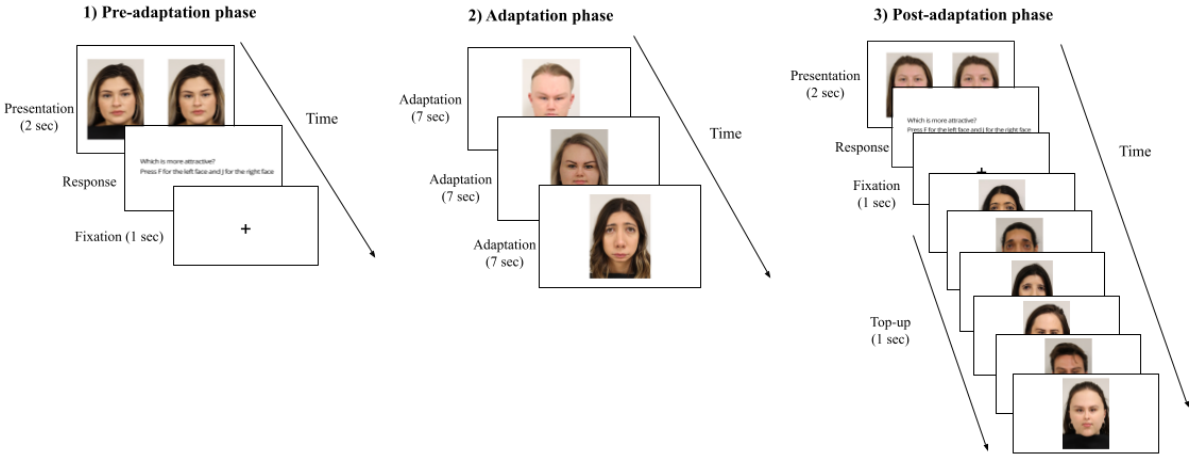
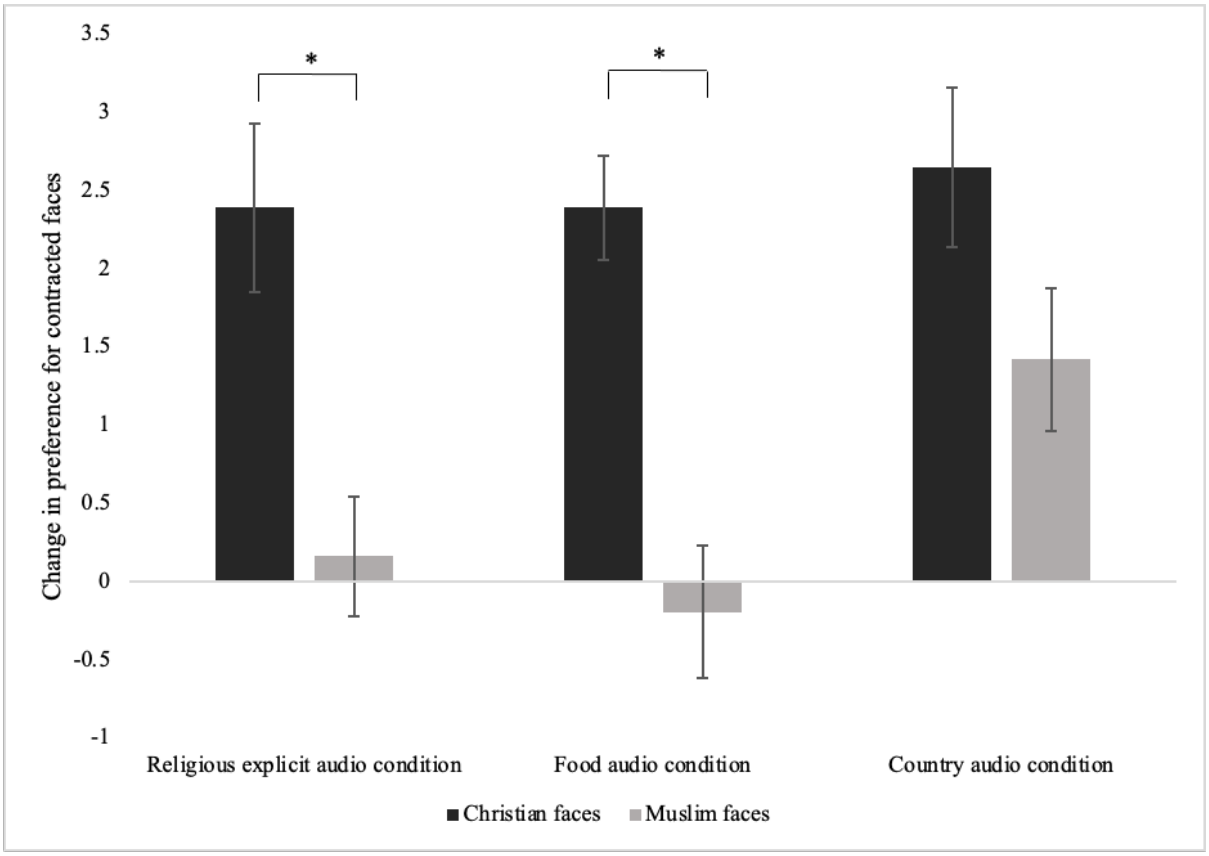


Figure 3

Mean change in preference for contracted faces in the three audio conditions. Error bars represent standard error. Significant religion-contingent aftereffects were observed in the religious explicit and food preference conditions.



Chapter 4: Picture a Scientist: Classification Images of Scientists are seen as White, Male, and Socially Inept

Preface

Occupational stereotypes impact individuals across sectors, including the sciences. Historically, there has been discrimination in scientific education and hiring, with women and other minorities making up a minority of the scientific workforce (Huang et al., 2020; National Science Board, National Science Foundation, 2021). While there have been some improvements in this area, there are still challenges for women and minorities pursuing the sciences today. To better address these challenges, it is necessary to understand how individuals conceptualize scientists – what stereotypes do they hold, and are they stored as deeply as an individual's mental representations of that group?

We applied the reverse correlation procedure, which allows us to visualize mental representations, to implicitly access stereotypes towards scientists. The goals of this study were two: first to visualize the mental representations individuals have for the categories of scientist, genius, hero, and the superordinate category of a person, and second, to use these visualizations to uncover the stereotypes individuals have towards scientists compared to the other three categories.

We first recruited 20 participants to select images that would be used to create the CIs representing the four categories of interest. The participants completed four blocks of a two-image forced choice task where they selected the face out of a pair that most resembled the stated category to them. We averaged the images that all 20 participants selected for each category to create 4 CIs.

Next, we recruited 251 participants to rate the CIs on demographic and valenced characteristics. The valenced characteristics were selected from a database containing gendered terms used to describe science professors(Schmidt, n.d.), to determine whether

scientists were rated higher on more male-associated traits than the other CIs were. We compared the mean ratings of the four CIs on the demographic and valenced traits, and uncovered several stereotypes about scientists. We found that the Scientist CI was rated as more White and male in appearance compared to the superordinate Person CI. This aligns with historical and current trends in the scientific workforce (Huang et al., 2020; National Science Board, National Science Foundation, 2021). In terms of valenced ratings, the Scientist CI was not rated higher on male-associated traits, but it was rated higher on traits associated with incompetence, unsociability, and poor communication skills. Some of these stereotypes align with the way scientists are portrayed in the media and in fiction as unsociable individuals who may be poor at communicating with the population at large (Fiske & Dupree, 2014; Fujiwara et al., 2022). Other findings are more surprising, such as the perceived lack of competence, which might be influenced by the overlap between this study and the occurrence of the COVID-19 pandemic, which brought heightened scrutiny to scientists (Sanchez & Dunning, 2021; Van Dooren & Noordegraaf, 2020).

These findings all further demonstrate the ability of the reverse correlation procedure to implicitly assess stereotypes towards novel categories. In the previous studies in this dissertation, the implicit methods, including reverse correlation, were used to capture religious stereotypes. In this study, we complemented those findings by studying other occupations as socially meaningful categories plus the superordinate "person" category, and showed that these methods can apply to them as well. Once again, we demonstrated that top-down influences, such as the category cues in the first phase of a reverse correlation paradigm, can affect how faces are perceived. We also demonstrated that stereotypes are embedded in our psychology in ways we may not be consciously aware of, but that implicit methods like reverse correlation can help uncover them.

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%2C%22her%20kids%22%5D%2C%22department__id%22%3A%7B%22%24lte%22%3A25%7D%7D%2C%22aesthetic%22%3A%7B%22x%22%3A%22WordsPerMillion%22%2C%22y%22%3A%22department%22%2C%22color%22%3A%22gender%22%7D%2C%22counttype%22%3A%5B%22WordCount%22%2C%22TotalWords%22%5D%2C%22groups%22%3A%5B%22unigram%22%5D%2C%22testGroup%22%3A%22C%22%7D

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Abstract

Stereotypes and biases towards social categories are often reflected in mental representations of faces. The current study used a two-phase reverse correlation procedure to visualize mental representations of the face of a Scientist, a Hero, a Genius, and a Person. In the first phase, 20 participants completed four blocks of a two-image forced-choice task. In each block, they selected which face out of a pair looked like one of the four categories. The images they selected were averaged to create classification images (CIs) which are proxy images for their mental representations of the four categories. In the second phase of the study, 251 naive participants rated the CIs on a number of valenced and demographic characteristics. We found that the scientist image was rated as the most White and male, which reflects stereotypes about who pursues scientific careers. The scientist image was also rated more negatively than the other CIs on several characteristics, which might reflect negative biases towards scientists as unsociable, poor communicators, and incompetent authority figures, especially during the COVID-19 pandemic. These findings extend our understanding of the way social categories are represented, and how the classification image method can be used to uncover stereotypes and attitudes regarding these social categories.

Introduction

Picture a scientist. What type of person comes to mind? One's mental image of a scientist reflects stereotypes associated with the profession, including sex, race, and age. For the last five decades, developmental psychologists have employed "Draw a Scientist" tests to assess children's stereotypes of scientists. Although gender diversity has increased somewhat over the decades, most children draw a White man when asked to draw a scientist (Miller et al., 2018). This bias likely reflects the children's observations: Historically, scientists have mostly been represented as White men (Watts, 2007). In North America, women and minorities have struggled to make a place in science and be recognized for their work (Campbell et al., 2000). While the proportion of women and other minorities in the sciences has increased, the majority of scientists are still White and male. In the United States, as of 2019, men made up 66% of the workforce in STEM, compared to 48% in non-STEM fields. White workers make up 64% of the STEM workforce in the United States, compared to the 61% share they make up of the overall workforce (National Science Board, National Science Foundation, 2021).

Even when women manage to join the scientific workforce, there are struggles. Men publish more papers, achieve more senior positions in academia, and apply for more grants than women (Huang et al., 2020; Larivière et al., 2013; Ley & Hamilton, 2008). There are multiple explanations that have been suggested for this disparity, including parental care, biases in review processes and resource allocation, and work culture (Borsuk et al., 2009; Bronstein & Farnsworth, 1998; Cameron et al., 2016; Duch et al., 2012; Stack, 2004). The stereotypes about scientists likely exacerbate the barriers women and minorities face in the sciences, as well as barriers to entering the field. The 2020 documentary *Picture a Scientist* told the story of three female scientists and the struggles they dealt with as women in STEM

(Shattuck & Cheney, 2020). Women's struggles to achieve in science can, in turn, reinforce stereotypes of scientists.

One way to understand stereotypes is by visualizing people's mental representation of a social category of interest, like the category of scientists. Mental representations are formed through experience with a given category (Valentine et al., 2004). It is theorized that individuals identify each other's social category membership by matching their faces to their mental representations of those social categories (Freeman & Ambady, 2014). This process occurs rapidly for social categories like race, gender, and age (Ito & Urland, 2003, 2005; Mouchetant-Rostaing et al., 2000; Tanaka, 2001). Individuals also classify others based on categories without clear perceptual markers, such as political affiliation, social class, and religious identity, better than would be expected by chance (Andrzejewski et al., 2009; Bjornsdottir & Rule, 2017; Olivola et al., 2012; Rule & Ambady, 2010). This suggests that individuals store distinct mental representations for such categories, and occupation may also be one. This rapid process of social categorization not only activates mental representations for a given social category but also activates the stereotype content associated with them (Freeman & Ambady, 2009; Hugenberg & Bodenhausen, 2003). The immediate impressions formed about an individual's face have significant consequences in the real world, including employment, political, financial, and judicial outcomes (Rule et al., 2016; Olivola & Todorov, 2010; Rule & Ambady, 2011; Todorov et al., 2005; Zebrowitz & McDonald, 1991). The stereotypes individuals have towards scientists – regarding their demographic traits and their other characteristics – could be revealed by their mental representations. The reverse correlation method allows us to create an image that depicts someone's mental representation of a scientist.

Reverse correlation (RC) is a technique that is used to create a visual image of mental representations, particularly of different faces (Brinkman et al., 2017). Randomly generated

noise patterns are superimposed over face images to create large sets of varied stimuli, and participants rate or select the stimuli that most resemble the category of interest. For instance, when visualizing female face representations, participants might select which of two noise-altered faces looks more female, or rate how female a given noise-altered face looks. These selections are then averaged to create a classification image (CI) that is a proxy for their mental representation of female faces. Reverse correlation has been used to visualize representations of faces of different genders, occupations, ethnicities, religions, degrees of sickness, and more (Brown-Iannuzzi et al., 2018; Dotsch et al., 2008; Dunham et al., 2014; Hehman et al., 2015; Imhoff et al., 2013; Mangini & Biederman, 2004; Ojeda et al., 2022). It has also been used to visualize bodies, and objects such as cars (Diego-Mas et al., 2022; Lick et al., 2013; Maister et al., 2021).

Many RC studies will include a rating task, where the CIs are rated by a naive sample of participants on various traits of interest. These ratings can reveal information about stereotypes and attitudes towards the categories represented by the CIs. The biases the first participant group had towards the categories of interest are reflected in the CIs their image selections created, and the ratings from the second set of participants are meant to reveal those biases. The benefit of the RC method, then, is its ability to implicitly assess attitudes towards social categories. Studies using this paradigm have shown, for instance, that individuals with implicit bias against Moroccans visualize faces generated to represent Moroccans as criminal and untrustworthy, and that atheists are perceived negatively compared to theists (Brown-Iannuzzi et al., 2018; Dotsch et al., 2008). CIs can also reflect an individual's assumptions of how members of a social group will behave. For instance, CIs representing theists are expected to behave more morally than those representing atheists (Brown-Iannuzzi et al., 2018). This suggests that mental images can store stereotypes and also reinforce them. Visualizing the way people mentally represent scientists can thus shed

light on the stereotypes associated with them, especially those which individuals may not be aware of, or wish to explicitly endorse due to social desirability bias (Tourangeau & Yan, 2007).

While RC has been used to study a variety of social categories, it has not been extended to studying the category of scientists. Of interest is how stereotypes of scientists contrast with stereotypes of other categories. Scientists are characterized as intelligent, as are "geniuses". Unlike scientists, geniuses may be more likely to be seen as innately gifted, and may be more easily thought of as being of any gender or ethnicity. Unlike scientists, they are also not necessarily professionals–one can be a genius in any number of areas. Scientists' roles as professionals can also be the basis for distrust. They may be seen as out of touch from the general population, occupied by their work in their "ivory tower" (Locke, 1999; Stilgoe et al., 2014). The longstanding issues in the realm of scientific communication can also exacerbate this perception (Koswatta et al., 2023). A "hero" and a scientist may share traits such as competence and helpfulness, but they may contrast on other traits given the specificity of the scientist label. A hero would not have the same training, and could be labelled a hero based on a unique, spontaneous event such as saving a child from a river. Heroes are also more likely to be seen as altruistic and kind, while scientists are often stereotyped as cold and aloof (Fiske & Dupree, 2014; Fujiwara et al., 2022). Determining whether scientists, geniuses, and heroes have distinct mental face templates would expand our understanding of the types of categories that are represented distinctly in the mind.

Finally, another category which should have a corresponding mental representation is a superordinate one: "person". Most RC studies select specific social categories, such as genders, ethnicities, and professions, and examine their mental representations. To our knowledge, no one has yet studied how individuals represent a person in general. This representation would also serve as an interesting contrast to categories like scientist, genius,

and hero, as a person should encompass all possible traits, while the others might have particular characteristics based on stereotypes.

The current study

The purpose of the current study is to use an RC paradigm to visualize mental representations of a scientist, and compare that representation to that of a genius, a hero, and a person. In the first phase of the study, participants selected face images in a two-image forced choice task that resemble each of the four categories we are testing. The stimuli they selected were averaged to create CIs, which were then rated on several valenced and demographic characteristics by a naive set of participants. These ratings revealed whether these four categories are viewed positively or negatively, and which traits differed across categories. Ratings also revealed whether these categories are associated with specific genders and ethnicities, highlighting any demographic biases and stereotypes about these categories. We predicted that the scientist CI would be rated as White and male in contrast to the other CIs. We also predicted that it would have similar ratings to the genius for traits related to intelligence, and to the hero for traits related to competence. The CI for the category of person was expected to be neutral on valenced and demographic traits, as it represents a superordinate category.

Phase 1: Image selection

Methods

Participants

Twenty participants (mean age = 18.35 years, male = 4) were recruited for the first phase of the experiment. This sample size was based on sample sizes reported in past reverse correlation research (e.g., Dotsch & Todorov, 2012). Participants were undergraduate students at McMaster University, and received course credit for participation. Five

participants identified as South Asian, 5 as East Asian, 4 as White, 3 as South East Asian, 1 as Black, and 1 as mixed-race (South Asian and East Asian).

Procedure

Stimulus creation. A base image was created by averaging 30 neutral faces (15 male and 15 female) from the following ethnic groups: White, Black, Asian, and Latinx. The faces were taken from the Chicago Face Database (Ma et al., 2015). The average was generated in Webmorph, the web-based version of Psychomorph (DeBruine, 2018). Randomly generated sinusoidal noise patterns were overlaid on the base image using the *generateStimuli2IFC* function in the *rcicr* package in R version 4.2.1. Three hundred stimulus pairs were created, with each pair consisting of the base image with a randomly generated noise pattern and the base image with the inverse noise pattern overlaid, such that the dark pixels in one image corresponded to light pixels in the other.

Image selection. Participants completed four blocks of a two-image forced choice reverse correlation task. In each block, participants were asked to select, by clicking on one of the images, the face that most resembled the category label. In one block, they selected the face that looked like a scientist. In another block, they selected the face that looked like a hero, in another the face that looked like a genius, and in another the face that looked like a person. Each block consisted of 300 trials, presented in an order randomized for each participant. The order of the blocks was randomized for each participant.

Demographic questionnaire. Participants were asked to report their age, gender, ethnicity, nationality, religious identity, and socioeconomic status prior to the study.

Results

Classification image creation

The images selected in each of the four blocks were averaged using the *generateCI2IFC* function in the *rcicr* package in R version 4.2.1 (Brinkman et al., 2017). The

resulting averages for each block were the four Classification Images (CIs), and these are taken to be proxy images for mental representations of the categories of interest. Thus, this process yielded CIs that represent what a scientist, hero, genius, and person look like (see Figure 1).

Phase 2: Image rating

Methods

Participants

Two hundred and fifty-one participants (mean age = 35.04 years, male = 136) were recruited from Amazon MTurk and were paid 4.60 CAD as compensation for their participation in accordance with Ontario's minimum wage. A sample size of 251 was deemed necessary to have 80% power to detect differences in CI ratings across groups, based on the effect size reported in the supplemental material of Dunham et al. (2014). The power analysis was conducted using *G*power* 3.1. In terms of ethnicity, 154 participants identified as White, 33 as South Asian, 27 as East Asian, 10 as Middle Eastern, 7 as South East Asian, 4 as Latinx, 4 as Black, 2 as Indigenous North American, and 6 identified as mixed-race (2 White and East Asian, 1 White and South Asian, 1 White and Latinx, 1 White and Black, 1 unspecified).

Selecting valenced characteristics

One block of the rating task involved rating the CIs from phase 1 on valenced characteristics. We were interested in using valenced ratings that examined characteristics that were relevant to scientists and that could reveal potential gender biases. To do this, we gathered data from Ben Schmidt's "Gendered Language in Teaching Evaluations"' database on January 12th, 2022 (Schmidt, n.d.). This database collects and displays terms used to describe professors on Ratemyprofessor.com, split by gender. For our purposes, we retrieved terms that were used to describe professors in the sciences. We selected terms with the

greatest disparity in how they were used to describe male versus female professors. Ten male-gendered terms and 9 female-gendered terms were selected, and antonyms for each term were generated to use as labels for the rating scale endpoints. The term "clear" that was taken from the database was changed to "well-spoken" to prevent participants from rating the image on visual clarity. The terms are shown in Table 1.

Procedure

Rating tasks. Participants completed two blocks of a rating task. In the first block, participants rated the four CIs on 19 valenced characteristics. In the second block, participants rated the four CIs on 10 demographic characteristics (gender and ethnicity). The demographic characteristics were: male, female, White, Black, Latinx, East Asian, South Asian, Middle Eastern, Pacific Islander, and Indigenous Canadian. The two blocks were presented in this fixed order to prevent social desirability effects on responses. During the rating task, participants saw one of the CIs on the computer screen with a slider representing a 6-point Likert scale below it. Participants clicked on the slider to indicate how much the CI fit the characteristic. Each participant rated all four CIs on all of the characteristics. The trials within each block were presented in randomized order across participants, but the order of the blocks was set such that all participants completed the valenced ratings before the demographic ratings.

Demographic questionnaire. Participants in phase 2 of the experiment completed the same demographic questionnaire as the participants in phase 1.

Data availability statement

All of the study materials and raw data for both phases of this experiment are openly available on OSF at https://osf.io/ycnzg/?view_only=57a646052c2d49fcb0b948355b10b562.

Results

Findings: Demographic Traits

We conducted a within-subjects ANOVA using Rating scores as the dependent variable[1]. Independent variables included Classification Image (CI; Scientist vs. Hero vs. Person vs. Genius) and Trait (10 levels, see Figure 2). We found a significant main effect of CI ($F(3, 738) = 5.72$, $p < 0.001$, Cohen's $f = 0.14$, 95% CI [0.07, 0.22]). We also found a main effect of Trait ($F(9, 2214) = 72.54$, $p < 0.001$, Cohen's $f = 0.54$, 95% CI [0.49, 0.58]). Critically, we found a significant CI x Trait interaction ($F(27, 6642) = 22.09$, $p < 0.001$, Cohen's $f = 0.29$, 95% CI [0.27, 0.32]).

At this stage, we conducted one-way within-subject ANOVAs using CI as the within-subject independent variable. We found a significant effect of CI on "Female" Ratings ($F(3, 738) = 54.85$, $p < 0.001$, Cohen's $f = 0.47$, 95% CI [0.39, 0.54]). Post-hoc tests revealed that the Person CI was rated as significantly more female than the remaining CIs (ps < 0.001). We also found a significant effect of CI on "Male" Ratings ($F(3, 738) = 58.47$, $p < 0.001$, Cohen's $f = 0.48$, 95% CI [0.41, 0.56]). Post-hoc tests revealed that the Person CI was rated as significantly less male than the other CIs (ps < 0.001). Next, we examined the effect of CI on race demographic ratings. We found a significant effect of CI on "White" Ratings ($F(3, 738) = 11.05$, $p < 0.001$, Cohen's $f = 0.20$, 95% CI [0.13, 0.28]). Conducting post-hoc analyses, the Scientist CI was rated as significantly more White than the remaining CIs (ps < 0.05). We also conducted a one-way ANOVA investigating the effect of CI on Black ratings. We found a significant effect of CI on Black ratings ($F(3, 738) = 3.81$, $p = 0.01$, Cohen's $f =$

[1] We conducted within-subject ANOVAs to mimic analyses conducted in previous reverse correlation studies using social categories (e.g., Dunham et al., 2014). However, to account for the nested nature of the data, mixed-effects linear models were conducted to mimic the analyses presented here. The results of the mixed-effects linear models can be found in Appendix A.

0.11, 95% CI [0.03, 0.19]). For Black ratings, the Scientist CI was rated significantly less Black than the Hero CI ($p = 0.02$), but no other post-hoc comparisons reached significance.

Findings: Valenced Traits

As with the demographic traits, we first conducted a within-subjects ANOVA on Rating scores with CI (Scientist vs. Hero vs. Person vs. Genius) and Trait (19 levels, see Table 1) as independent variables, as well as the interaction between them. We found a significant main effect of CI ($F(3, 738) = 52.99$, $p < 0.001$, Cohen's $f = 0.46$, 95% CI [0.38, 0.54]). Post-hoc analyses revealed that the Scientist CI received significantly lower scores (were rated more negatively) than the other CIs (ps < 0.001; see Figure 2). We also found a significant main effect of Trait ($F(18, 4428) = 45.05$, $p < 0.001$, Cohen's $f = 0.42$, 95% CI [0.39, 0.45]). Critically, we again found a significant CI x Trait interaction ($F(54, 13\ 284) = 6.62$, $p < 0.001$, Cohen's $f = 0.15$, 95% CI [0.13, 0.17]).

At this stage, we conducted one-way within-subjects ANOVAs with CI as the independent variable. All one-way within-subjects ANOVAs unveiled a significant main effect of CI, but we report only the findings where the corresponding post-hoc comparisons were significant after a Bonferroni correction. We found a significant effect of CI on Warm ($F(3, 738) = 17.24$, $p < 0.001$) ratings. The Hero CI was rated as more Warm (ps < 0.005) than the remaining CIs, while the Person CI was rated as more Warm than the Scientist. We found a significant effect of CI on Sweet/Harsh ratings ($F(3, 738) = 15.17$, $p < 0.001$, Cohen's $f = 0.24$, 95% CI [0.17, 0.32]). Again, the Hero was rated as more Sweet (ps < 0.005) than the remaining CIs. We found a significant effect of CI on Strict/Lenient ($F(3, 738) = 6.34$, $p < 0.001$, Cohen's $f = 0.15$, 95% CI [0.08, 0.23]) and Mean/King ($F(3, 738) = 7.79$, $p < 0.001$, Cohen's $f = 0.17$, 95% CI [0.09, 0.24]) ratings. In this case, the Hero CI was rated as less Strict (ps < 0.05) than the remaining CIs, and the Scientist was more Mean than the Hero CI ($p < 0.001$).

There were various characteristics where the Scientist CI was rated the lowest among the four CIs. In the cases of Funny/Dull ($F(3, 738) = 23.54$, $p < 0.001$, $f = 0.31$), Engaging/Tedious ($F(3, 738) = 19.78$, $p < 0.001$, $f = 0.28$), Cool/Awkward ($F(3, 738) = 11.33$, $p < 0.001$, $f = 0.21$), and Brilliant/Dim ($F(3, 738) = 10.50$, $p < 0.001$, $f = 0.20$) ratings, all CIs were rated more positively than the Scientist CI (ps < 0.001). Similarly, all CIs were rated as more Entertaining ($F(3, 738) = 14.02$, $p < 0.001$, $f = 0.24$) and more Chill (less Uptight) ($F(3, 738)$, = 13.78, $p < 0.001$, $f = 0.24$) than the Scientist (ps < 0.002). The Scientist was also rated as the lowest on Charismatic/Uncharismatic ratings ($F(3, 738) = 10.81$, $p < 0.001$, $f = 0.21$); specifically, they were rated significantly worse than the Person and the Hero CI (ps < 0.001). The Scientist was also rated as the lowest on Competent/Incompetent ratings ($F(3, 738) = 8.81$, $p < 0.001$, $f = 0.19$); specifically, the Scientist was rated less competent than the Genius and Person (ps < 0.002). The Scientist was also rated the lowest on Smart/Dumb ratings ($F(3, 738) = 8.80$, $p < 0.001$, $f = 0.19$); specifically, the Scientist was rated as less Smart than the Genius and the Person CIs (ps < 0.001). Again, the Scientist was rated lowest on the Personable/Irritating ratings ($F(3, 738) = 6.29$, $p < 0.001$, $f = 0.16$); specifically, the Scientist was rated lower than the Genius and the Hero (ps < 0.01). Finally, the Scientist was rated as less Intelligent (more Obtuse) ($F(3, 738) = 8.05$, $p < 0.001$, $f = 0.18$) and less Well-Spoken (more Ineloquent) ($F(3, 738) = 7.38$, $p < 0.001$, $f = 0.17$) than the Person ($p < 0.001$).

Correlational Analysis

For each of our valenced traits, other than "Well-Spoken" (a term we created) we calculated the ratio of usage to describe male professors compared to female professors in reviews on RatemyProfessor.com. Higher ratios mean that the word was used more often to describe male professors than female professors. For example, the word arrogant had a ratio value of 3.38, meaning that the word arrogant is used 3.38 times more often to describe male

professors than female professors. We correlated these ratios with the corresponding mean rating for each valenced trait for the Scientist CI. There was a significant negative correlation between male-to-female ratio and mean responses ($r(18) = -0.57$, 95% CI [-0.82, -0.14], $p = 0.01$), suggesting more positive ratings for more masculine traits.

Order effect

When graphically observing the data (see Figure 3), it appeared that the Scientist CI was consistently rated the lowest across all personality traits. To assess if this was true, we conducted a Chi-square test of independence to test the null hypothesis that there was no relationship between Classification Image and valence ranking. A significant Chi-square test would indicate that certain CIs received the same ranking (e.g., highest, lowest, etc.) across multiple characteristics. We operationalized high and low mean ratings by "ranking" the mean ratings. In Figure 3, there were four CIs whose means were visualized. If the mean rating for a CI was the highest among the four CIs for a given trait (e.g., happiness), it was counted as "first", and that CI received one observation for the "first" rank. We recorded the frequencies that the CIs were first, second, third, and fourth highest on the 19 valenced characteristics in Table 2. The Chi-square test was significant ($X^2(9) = 75.58$, $p < 0.001$). The Scientist CI was ranked the lowest more often than would be expected by chance.

Discussion

The purpose of this study was to visualize participants' mental representations of scientists, heroes, geniuses, and people, and to test whether demographic and valenced characteristics were associated with these mental representations. Using a reverse correlation paradigm, we created images representing each category, and collected demographic and valenced ratings of each image. We found that the Scientist image was rated as more male and more White than the other three categories, and had the most negative ratings overall. Specifically, the Scientist was rated lower on traits associated with sociability,

communication skills, and competence. The Hero image was rated as warm and kind, and the Person was rated as the most female in appearance.

The generation of four unique CIs in this study illustrates the utility of the reverse correlation method. We were able to create face images that reflect the mental representations of our participants. Further, we have extended previous research that has used reverse correlation to visualize individuals with certain occupations (Hehman et al., 2015; Imhoff et al., 2013). Similar to these studies, we found that people have representations of the faces of people in specific occupations, even though occupation is a flexible, chosen identity. Since stereotypes about occupations are reflected in these mental representations, reverse correlation can be used to reveal stereotypes. This is especially useful given that reverse correlation is an implicit method – this allows us to capture more spontaneous responses, with less response biases than are present in methods that directly ask about stereotypes. Heroes and geniuses are even more nebulous categories than scientists, but participants revealed distinct representations that reflect stereotypes for these categories as well. The reverse correlation method lends itself to exploring attitudes and stereotypes about various social categories and labels that have not been examined before.

The fact that the scientist CI was perceived as more male and more White than other categories suggests that there is a stereotypical image of a scientist, and this image is relatively White and male. This result is consistent with the idea that mental representations of faces are based on all of the faces one has encountered. In the United States, White males traditionally pursue careers in the sciences more than women or people of colour do (Campbell et al., 2000). This would lead to the formation of a White masculine mental representation of a scientist, as it reflects the characteristics of the scientists that people have seen.

The way scientists are represented in the media may also contribute to people's mental representations. News stories about scientists differ by gender. While typically masculine and feminine traits (e.g., drive and collaboration respectively) are attributed to scientists of all genders, female scientists' personal lives and work-life-balance are given more attention (Mitchell & McKinnon, 2019). This perpetuates the idea that science is something men can perform without having to balance anything else while women are expected to balance priorities.

The Scientist, Hero, and Genius were all rated as more male in appearance than the Person. As discussed above, men outnumber women in the sciences. Heroes may also be male-coded: Fictional male superheroes often outnumber their female counterparts, and tend to have stereotypically masculine traits, whereas female superheroes are often feminine and sexualised (Anderson & Cavallaro, 2002; Cocca, 2014; Harriger et al., 2022). Geniuses may be seen as more male given the associations between intelligence and maleness. Intelligence, in the West, is conceptualized as a rational, logical trait, which are considered to be masculine traits (Räty & Snellman, 1992; Sternberg, 1985; Sternberg et al., 1981). Compared to these three categories, the superordinate category of Person would appear less masculine.

The Scientist CI consistently received the least favourable ratings of any of the four CIs across all of the valenced characteristics. Specifically, it was rated significantly lower than other CIs on characteristics that can be grouped into three "themes," that reflect perceptions individuals have of scientists. First, the Scientist CI was seen as less sociable, and was rated significantly more dull, tedious, awkward, and irritating. The Scientist CI was seen as a poor communicator, and was rated less engaging, charismatic, entertaining, and well-spoken. Finally, the Scientist CI was even seen as less capable academically, and was rated less brilliant, competent, smart, and intelligent. Some of these findings reflect broad stereotypes around scientists, and others can be understood by comparing the connotations of

being a scientist, versus a hero, genius, or a regular person. When compared to the Hero and Genius, the authority associated with the role of a scientist might explain their relatively negative perception. Heroes are, by definition, altruistic and use their abilities for the greater good. Scientists do not necessarily do so, and their portrayals in fiction perpetuate this idea. In contrast, scientists and geniuses share the connotation of intelligence and competence, but scientists are professionals, often in roles of authority. Distrust towards authorities and attitudes towards scientific guidance around issues like climate change, vaccines, and more recently, the COVID-19 pandemic, might mean scientists are viewed as less competent and poorer at communicating.

Heroes are viewed as more powerful and competent than the population at large, and this allows them to save others and lead them through difficulties (Kinsella et al., 2015a, 2015b). They are seen as altruistic and likeable (Fradkin et al., 2016; Muller et al., 2020). This applies to heroes in real life (e.g., Volodymyr Zelenskyy's leadership during the invasion of Ukraine) and in fiction. In theory, scientists are also thought to be competent in their area of expertise, setting them apart from the general population. These two categories can overlap: some scientists are seen as heroes for their ground-breaking contributions to science and the betterment of society, such as Alan Turing's code-breaking in World War II, or Katherine Johnson's contributions to NASA's first manned space flight (Bullynck et al., 2015; Malcom, 2020). However, not all scientists are viewed this way.

The Hero was rated as warmer and kinder than the Scientist, and the Scientist was also rated lower on other traits associated with sociability, perhaps due to the stereotypical image of scientists as cold, clinical, and calculating (Fiske & Dupree, 2014; Fujiwara et al., 2022). While the ability to be objective and thorough is useful for research, it does not make scientists appear approachable or likeable. The Western conception of logical intelligence being separate from social and emotional intelligence may also feed the perception of

scientists as logical individuals who are not socially adept (Sternberg, 1985; Sternberg et al., 1981). However, it is important for scientists to gain not only the respect, but also the trust of the general public by projecting warmth and competence, to effectively communicate and enact their findings (Fiske & Dupree, 2014).

Unfortunately, distrust of scientists is prevalent, and appears to be increasing, especially regarding issues like climate change and vaccines, and this may have contributed to the surprising finding that individuals perceive scientists as incompetent (Dixon & Jones, 2015; Kabat, 2017; Peters, 2013; Pittinsky, 2015; Rutjens et al., 2018a; Rutjens et al., 2018b). . Some of this lack of trust is related to individuals' ideologies and political views and whether these views align with those of scientific authorities. For instance, there is growing distrust in scientists among right-wing individuals in the United States due to their perception that scientific institutions are growing increasingly more liberal (Cofnas et al., 2018). This also applies to COVID-specific distrust towards scientists, with right-wing individuals being less trusting of scientists and vaccine mandates than during the pandemic (Kossowska et al., 2021). The recommendations scientists made around social distancing, mask wearing, and vaccination, were viewed by many as measures that were part of a larger agenda. This sentiment has only increased with the emergence of the COVID-19 pandemic, which coincided with the time this study was run (Sanchez & Dunning, 2021). During this time, scientists became an important authority, informing communication about and responses to the pandemic (Grundmann, 2021; Van Dooren & Noordegraaf, 2020). There were many who felt that scientists were overstating the risks associated with COVID-19, or that guidelines were infringing on their personal freedoms. Updates to guidelines could be perceived as mixed messages, and may have exacerbated the view among the general public that scientists are incompetent, and that they struggle to communicate information clearly. While scientific findings and guidelines are the products of rigorous study, the gap between the work and the

public's understanding of it, especially when information is presented differently by various outlets – scientists, journalists, governments, et cetera – can lead to the perception that scientists are out of touch, and do not know what they are doing (Salita, 2015; Weingart & Guenther, 2016). Negative messaging in the media also likely contributed to a lack of trust in scientists and their competence. News outlets in parts of the world position scientists as members of the corrupt elite in contrast to the general population (Kulas, 2018). In the United States, President Donald Trump, and right-wing media outlets, downplayed the expertise of scientific authorities including the World Health Organization and leading scientists in America, including Dr. Anthony Fauci (Froese Raihl, 2023; Rutledge, 2020). There is some research suggesting that President Trump's messaging did not have a direct effect on individuals' attitudes towards scientists and their competence in the United States (Evans & Hargittai, 2020). Instead, their social group membership — political alignment, race, religion, and socioeconomic status — seems to be a better predictor. However, it is important to note that this research was conducted using self-report measures, whereas the current study used an implicit measure. Even individuals who outwardly express belief in scientists' competence may implicitly believe the opposite, and this may explain our pattern of findings. While there are many possible explanations for feelings of distrust and negativity towards scientists, it is possible that the context of the COVID-19 pandemic contributed in some way to the sentiments reflected in the scientist CI and its ratings.

A great deal of distrust in science comes from conspiracy-like beliefs, where individuals believe that others are secretly working towards nefarious ends (Douglas et al., 2017). In these cases, individuals fear that scientists are not acting objectively, and are instead working under the influence of some other power, or corporation (Dixon & Jones, 2015). These sentiments likely increased negative sentiments towards scientists, leading individuals to select colder, less friendly looking faces when completing the scientist image

selection task. These attitudes may be exacerbated by real cases of unethical research such as the Tuskegee Syphilis Study, where researchers studying the advancement of syphilis withheld life-saving treatment from the hundreds of Black men in the study (Brandt, 1978). Fictional representations of scientists can also be negative. Consider the trope of the "mad scientist" (Weingart et al., 2003). It is very common for scientists to be portrayed as villains in fiction – consider characters such as Dr. Jekyll, Dr. Frankenstein, and the geneticists in *Jurassic Park*. Fictional scientific organizations include Aperture Science in the *Portal* series of video games and the Umbrella Corporation in the *Resident Evil* series of games. These scientists are typically shown experimenting, often in secret, with the human body and human nature, and creating things that are harmful to our health (Weingart et al., 2003). As such, even scientists who do their job well may be associated with different traits than heroes, geniuses, and ordinary people are.

There are caveats to consider when interpreting the results of this study. First, it is possible that the negative results regarding scientists are the result of this study's context: the COVID-19 pandemic. Doing a similar study during a different time, or with different populations, with more and less exposure to scientific information and scientific involvement in pandemic-related regulations might yield different results. Studying individuals who are not science undergraduate students, or who have particularly strong feelings about science, might also lead to different results, and would be interesting to study in future research. Our sample may have also influenced the characteristics seen in the CIs: specifically, the Person which appeared more female than the other three CIs. Our sample consisted of more females than males, and they may have a more feminine representation of a typical person, perhaps because they have more interaction with other females. Future studies using undergraduate participants could also collect information about participants' majors, or recruit students from

specific majors (e.g., science and non-science students) to see how their area of study influences their view of scientists.

The impacts of the base images on the resulting CIs are not quantified but are likely to be substantial. In our study, the base images that were used to create the stimuli included male and female faces of various ethnicities. Many reverse correlation studies create their stimuli solely using Caucasian male faces (e.g., Dotsch et al., 2008). It may be that the characteristics of a CI, especially its perceived gender and ethnicity, are constrained or influenced by the gender and ethnicity of the base images. Future studies could explore this issue and determine what, if any, impact the starting point has on the end product in a reverse correlation study.

The specific two-phase reverse correlation method also has certain caveats. Recent studies have shown that when CIs are created by aggregating the images selected by all participants, and those CIs are presented to new participants for rating, the differences between those CIs can be overestimated, and this can lead to an inflated Type I error rate (Cone et al., 2021). As such, it is possible that the findings in the current study were significant, or that differences between CIs appeared larger because of the way the CIs were generated. To address this, we included effect sizes, with confidence intervals, for all main effects and interactions, and only reported on *post-hoc* comparisons that remained significant after correction. Often, in cases where Type I error rates are likely, significant *p*-values are associated with weak effect sizes with confidence intervals that cross zero (e.g., Rothman, 2010). In our study, no effect sizes were associated with confidence intervals that crossed zero. This increases confidence that the effects observed in our study were not merely Type I errors (Rothman 2010). Additionally, we included non-parametric analyses to support the conclusion that there were systematic differences in how CIs were rated. With this in mind, future studies could generate CIs for each individual participant in the first phase of the

experiment and collect ratings, or calculate informational value for the CIs to assess stereotypes with a lower Type I error rate.

Finally, the current work may have benefitted from the use of factor analysis to combine our valenced traits into fewer factors. Doing so would have reduced the number of *post-hoc* comparisons necessary across CIs. Due to the repeated measures nature of our data, a *post-hoc* exploratory factor analysis would not have been suitable (Newsom, 2023). Participants responded to the same valenced question multiple times, and those responses could not be combined or correlated as they differed systematically by CI (Newsom, 2023). However, future research would benefit from *a priori* confirmatory factor analysis. Prior research with the Stereotype Content Model indicates that many our valenced traits may have combined into factors such as Warmth or Competence (see Cuddy et al., 2008). As such, future research using similar traits could use the Stereotype Content Model to support the theoretical development of factors to reduce the number of *post-hoc* comparisons.

Conclusion

The aim of this study was to visualize the mental representations of scientists, geniuses, heroes, and people, and to measure the demographic and valenced traits that are associated with each category. We found that scientists are perceived as relatively White and male, reflecting stereotypes of who works in the sciences as well as media and fictional portrayals that exaggerate the extent to which White men dominate science. Scientists are also rated low on characteristics associated with sociability, competence, and communication abilities. This might reflect negative stereotypes associated with scientists as authority figures, especially when they are the face of issues like the COVID-19 pandemic. Future research can explore other occupations, even within the sciences, to learn the stereotypes and attitudes that are held towards these groups.

Ethics Statement:

This project was approved by the McMaster Research Ethics Board, Project 4945.

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Table 1

Traits selected for valenced ratings in phase 2 of the study, with frequencies (in words per million) and male-to-female ratios. Traits were collected from data for science professors in the Gendered Language in Teaching Evaluations Database.

Trait	Male frequency	Female frequency	Male to female ratio	Female to male ratio
Arrogant	119.9	35.4	3.39	0.30
Charismatic	9.6	3.6	2.67	0.38
Entertaining	252	113	2.23	0.45
Funny	1538	719	2.14	0.47
Brilliant	117	69	1.70	0.59
Cool	581	350	1.66	0.60
Chill	37	25	1.48	0.68
Smart	517	355	1.46	0.69
Engaging	90	65	1.38	0.72
Intelligent	256	186	1.38	0.73
Clear	977	1150	0.85	1.18
Nice	2285	2702	0.85	1.18
Personable	48	57	0.84	1.19
Competent	9.06	11.15	0.81	1.23
Mean	186	233	0.80	1.25

Professional	51	64	0.80	1.25
Organized	208	299	0.70	1.44
Strict	74	112	0.66	1.51
Warm	11.3	18.7	0.60	1.65
Sweet	126	342	0.37	2.7

Figure 1

The 4 Classification images (CIs) created using data from phase 1.

Figure 2

Mean ratings of CIs on demographic traits. Error bars represent 95% confidence intervals.

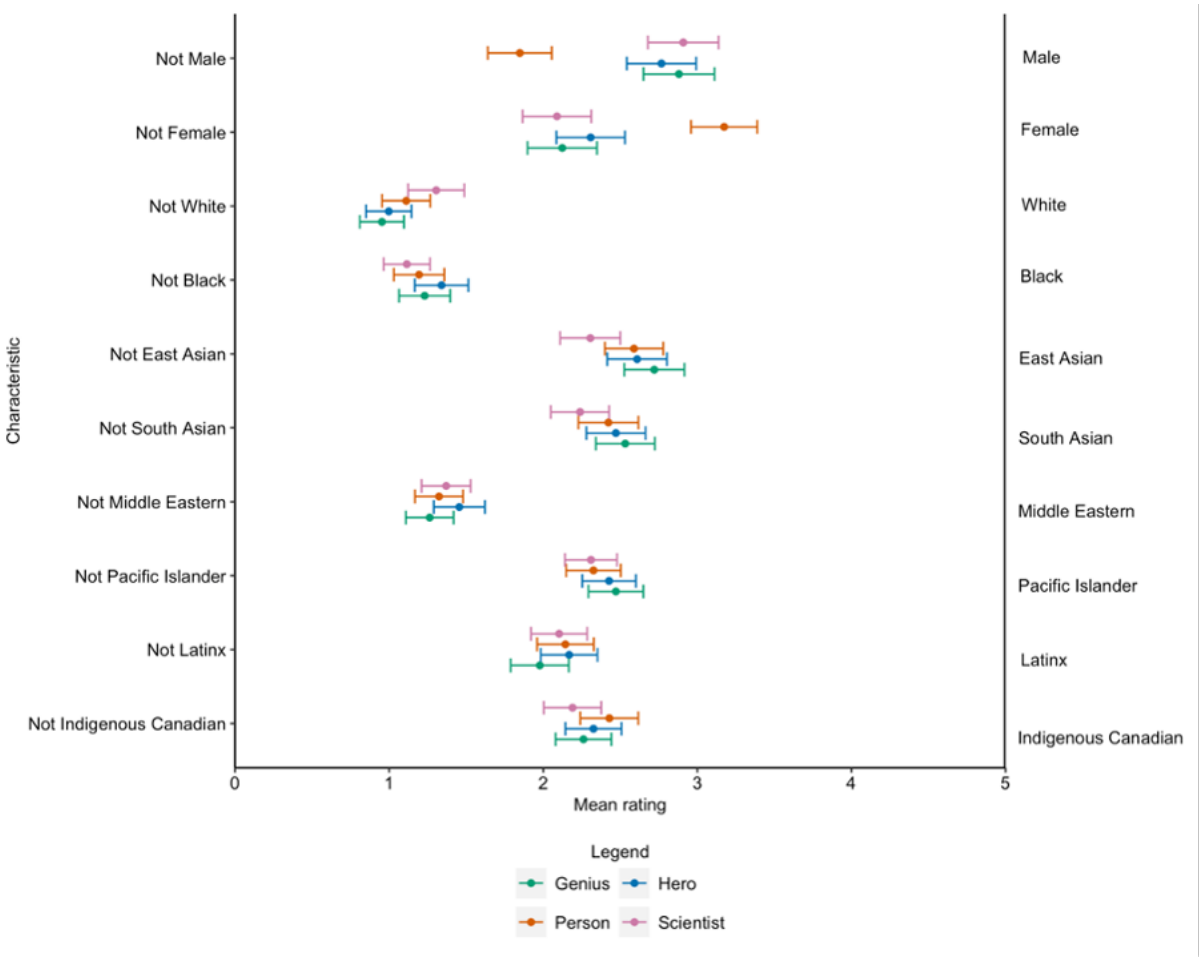
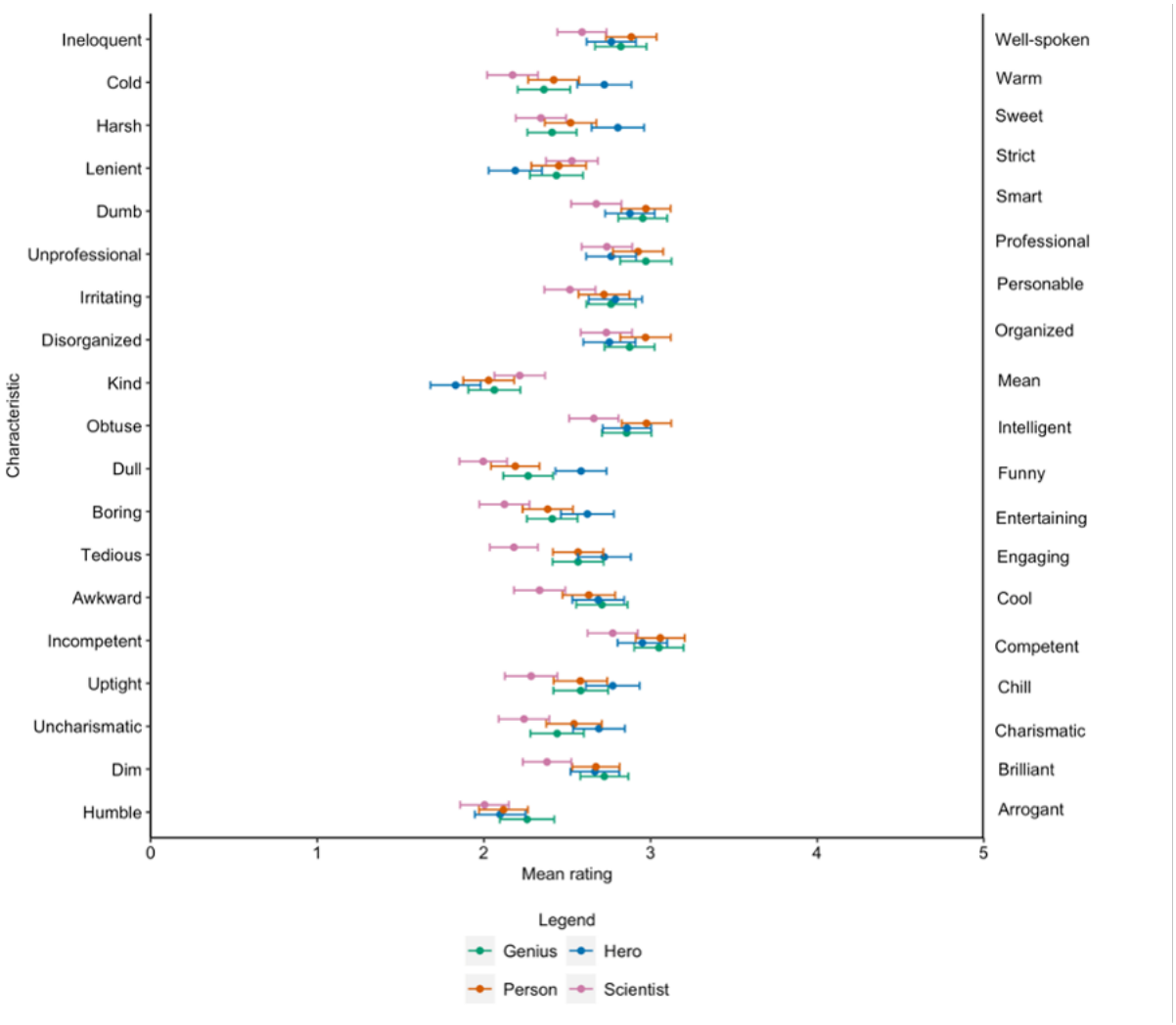


Figure 3

Mean ratings of CIs on valenced traits. Error bars represent 95% confidence intervals.



Appendix A: Mixed-Effects Linear Models

This Appendix includes alternate analyses to those presented in the main article. For brevity, we will focus on the interaction effects which comprised the major analyses of the main article. All analyses were conducted in *R* 4.2.2. Mixed-effects linear models were conducted using the *lmer* package, while marginal means were calculated using the *emmeans* package.

Demographic Traits

We conducted a mixed-effects linear model. The model included two fixed effects: Classification Image (CI; Scientist vs. Hero vs. Genius vs. Person) and Trait (10 traits; see Table 1 in the main article). The model also included a random effect for Participant. We found a significant CI x Trait interaction (Wald χ^2 (27) = 448.79, $p < 0.001$). We next calculated marginal means. All significant contrasts can be found in Table A1.

Valenced Traits

Similar to the demographic traits, a mixed-effects linear model was conducted. The model included two fixed effects: Classification Image (Scientist vs. Hero vs. Genius vs. Person) and Trait (19 traits; see Table 1). The model also included a random effect for Participant. We found a significant CI x Trait interaction (Wald χ^2 (54) = 371.35, $p < 0.001$). We next calculated marginal means. All significant contrasts can be found in Table A2.

Table A1

All significant contrasts comparing Classification Images on the valenced traits

Trait	Comparison	*b*	*SE*	*p*-value
East Asian	Genius CI - Scientist CI	0.41	0.09	< 0.001
Female	Genius CI - Person CI	-1.05	0.09	< 0.001
Female	Hero CI - Person CI	-0.87	0.09	< 0.001
Female	Person CI - Scientist CI	1.09	0.09	< 0.001
Male	Genius CI - Person CI	1.03	0.09	< 0.001
Male	Hero CI - Person CI	0.92	0.09	< 0.001
Male	Person CI - Scientist CI	-1.06	0.09	< 0.001
White	Genius CI - Scientist CI	-0.35	0.09	0.02

Table A2

All significant contrasts comparing Classification Images on the Valenced Traits

Trait	Comparison	*b*	*SE*	*p*-value
Brilliant	Genius CI - Scientist CI	0.34	0.07	< 0.001
Brilliant	Hero CI - Scientist CI	0.29	0.07	0.03
Brilliant	Person CI - Scientist CI	0.29	0.07	0.02
Charismatic	Hero CI - Scientist CI	0.45	0.07	< 0.001
Charismatic	Person CI - Scientist CI	0.30	0.07	0.01
Chill	Genius CI - Scientist CI	0.30	0.07	0.02
Chill	Hero CI - Scientist CI	0.49	0.07	< 0.001
Chill	Person CI - Scientist CI	0.30	0.07	0.02
Competent	Person CI - Scientist CI	0.29	0.07	0.04
Cool	Genius CI - Scientist CI	0.37	0.07	< 0.001
Cool	Hero CI - Scientist CI	0.35	0.07	< 0.001
Cool	Person CI - Scientist CI	0.30	0.07	0.02
Engaging	Genius CI - Scientist CI	0.38	0.07	< 0.001
Engaging	Hero CI - Scientist CI	0.54	0.07	< 0.001
Engaging	Person CI - Scientist CI	0.38	0.07	< 0.001
Entertaining	Genius CI - Scientist CI	0.29	0.07	0.03
Entertaining	Hero CI - Scientist CI	0.50	0.07	< 0.001
Funny	Genius CI - Hero CI	-0.32	0.07	0.004
Funny	Hero CI - Person CI	0.39	0.07	< 0.001
Funny	Hero CI - Scientist CI	0.59	0.07	< 0.001
Intelligent	Person CI - Scientist CI	0.32	0.07	0.005
Mean	Hero CI - Scientist CI	-0.38	0.07	< 0.001
Smart	Person CI - Scientist CI	0.30	0.07	0.02
Strict	Hero CI - Scientist CI	-0.34	0.07	< 0.001
Sweet	Genius CI - Hero CI	-0.39	0.07	< 0.001
Sweet	Hero CI - Person CI	0.28	0.07	0.04
Sweet	Hero CI - Scientist CI	0.46	0.07	< 0.001

Table A2

Continued

Trait	Comparison	*b*	*SE*	*p*-value
Warm	Genius CI - Hero CI	-0.36	0.07	< 0.001
Warm	Hero CI - Person CI	0.30	0.07	0.01
Warm	Hero CI - Scientist CI	0.55	0.07	< 0.001
Well-spoken	Person CI - Scientist CI	0.295546559	0.069986429	0.02

Chapter 5: General Discussion

The three studies in this thesis all use implicit methods to examine the impact of stereotypes about social categories, namely religion and occupation. Implicit measures can provide insight into stereotypes and their effects that might otherwise be hidden through conscious control. Such methods are increasingly useful as social awareness increases. While implicit methods vary in their underlying theories and psychological processes, the implicit methods used in these three studies are all based on theories of face perception. They each involve probing mental representations, either by visualizing them to reveal embedded stereotypes through reverse correlation, or manipulating them to determine how they are activated during social categorization through category-contingent aftereffects. In Chapter 2, we visualized participants' mental representations of their religious ingroups and outgroups to uncover their associated stereotypes and determine whether their impressions favoured their ingroup or the majority group. In Chapter 3, we further studied stereotypes towards religious groups and found that seemingly unrelated, higher-order information about food preferences impacted social categorization. We also demonstrated that social category membership can impact face perception. In Chapter 4, we extended our use of the reverse correlation paradigm to uncover stereotypes towards scientists, and contrast them with other social categories, including the superordinate category "human".

Chapter 2: Using mental representations to reveal religious stereotypes

In Chapter 2, we examined stereotypes about religious categories – specifically Christian and Muslim – by having Christian and Muslim participants complete a two-phase reverse correlation procedure. This procedure allowed us to visualize their mental representations of the two religious groups in the form of CIs, and to have a naïve group rate those mental representations to discover what stereotypes are embedded in them. We were particularly interested in whether the CIs would reveal an ingroup preference, or instead, a

preference for the majority religious group.

Rather than showing an ingroup preference, it appears that members of both religious groups favour the majority group. CIs representing Christian faces were consistently rated higher than CIs representing Muslim faces, regardless of the religion of the participants who made the CI. This leads to the inference that a preference for the majority group is stronger than an ingroup preference for the Muslim participants. This aligns with other literature that demonstrates that members of minority groups may internalize stigma towards their ingroups, and view the majority or dominant group more positively (Doyle et al., 1988; Newheiser et al., 2014; Newheiser & Olson, 2012). This is particularly likely when there is a history of conflict between the majority and minority groups (Newheiser et al., 2014). In some cases, members of minority groups do show a preference for the ingroup – the ingroup CIs created by Indian Muslim children, who are members of an often persecuted minority, are perceived as warmer and more competent than the CIs for Hindus, the majority religion in India (Dunham et al., 2014). However, in our case, it is likely that the Muslim participants have internalized the existing, and growing, negativity towards Muslims and Islam in many parts of the world, including Canada. In the wake of events such as 9/11, there has been growing hostility towards Muslims, who are often portrayed negatively in the media (Al Atom, 2014). Islamophobic attitudes and hate crimes have been on the rise, increasing by 9% in Canada in 2019, and there have been many prominent attacks on Muslims, such as the 2017 Quebec mosque shooting and the 2021 attack on the Afzaal family in Ontario, which received extensive media coverage (Jamil, 2022; Jiwani & Bernard-Brind'Amour, 2023; Moreau, 2021). Muslims living in Canada may be internalizing this negative view of their religious community, and developing a more positive view of the normalized, accepted majority religion of Christianity.

It is also important to note that religiosity is relatively low in Canada overall

(Cornelissen, 2021). Religion often permeates all aspects of an individual's life, and members of religious groups are often taught that their religion is the "correct" one (Pargament et al., 2005). While Canadian Muslims likely also engage with religion in this way, Muslim youth may have a less strong sense of, and pride in, their religious identity given their low religiosity and the challenges that Canadian Muslim youth face when forming their identities while integrating into Canadian society (Jamal et al., 2022). This may help explain why our results are consistent with the idea that Canadian Muslims respond to negative attitudes by incorporating them, rather than developing an opposing, protective view of their religious ingroup. It should be noted that it is not possible to say, based on the data in this study, whether the Christian participants were demonstrating an ingroup preference, a preference for the majority, or some combination of the two.

The findings from this study contribute to our understanding of the implicit measurement of stereotyping in several ways. First, we demonstrated that the reverse correlation paradigm can be used to visualize the mental representations of Christian and Muslim faces, which are novel social categories for this literature. By visualizing unique mental representations for these two religious groups, we were able to lend more concrete support to the idea that individuals store mental representations of the members of different religious groups, and that these mental representations store attitudinal information as well as physical information. This is especially interesting given that religion is not necessarily tied to physical features in the same way as race and gender (though religious and ethnic identity can be associated with each other). We were also able to demonstrate that this method can be used to probe the attitudes that participants have towards members of various religions.

Limitations and Future Directions

The findings from Chapter 2 add to our understanding of religious stereotypes, and how reverse correlation can be used to implicitly uncover them, but they may be specific to

the cultural context in which the study was conducted. The participants in both phases of the study were Canadian, and Canada is a secular nation where Christians make up a larger proportion of the population than Muslims do. It is possible that the pattern of results would be different if this study were conducted in a non-secular Christian or Muslim nation. This might also be true if it were conducted in a country with a primarily Muslim population – in this context, perhaps the pattern of results would be the opposite of those observed in the current study, and members of both religions would show a preference for Muslims. It is also possible, depending on the level of conflict between the two religious groups in that country, that there would be an ingroup preference shown by members of both religions instead.

There are many avenues for future research based on the study described in Chapter 2. First, this method could be used to visualize the mental representations and probe stereotypes of other religious groups. It could also be adapted for use with children, to examine how mental representations of religious groups develop, and how the developmental trajectories might differ between children from religious and non-religious upbringings. This study could also be replicated with a sample of the general Canadian population, not solely Christian and Muslims, to understand how the rest of the Canadian population stereotypes members of both religions and whether the preference for the majority religion generalizes to them, as well.

Chapter 3: Determining the cues used to assume religious group membership

In Chapter 3, we examined the perception of members of religious categories using a different implicit method, the category-contingent aftereffects paradigm. Using this method, we sought to replicate the findings from Foglia et al. (2021), to test whether Christian and Muslim faces have separate mental templates. We also wanted to extend those previous findings by testing whether the implicit or indirect religious cues of food preferences and country of origin can support category-contingent aftereffects. This would help us better understand religious stereotyping by determining which cues are used to categorize

individuals into social groups.

Of the two cues we used, only food preferences were able to support category-contingent aftereffects. The findings from the food preference audio condition suggest that individuals categorize others into groups based on the foods they like to eat, and this social categorization impacts face perception. The foods that we used as stimuli were those which were associated with Christianity and Islam in our validation study. It is possible that the participants were inferring religious identity from the characters' food preferences or that they were grouping the characters together by some other identity, such as ethnicity or culture, instead.

There are many reasons why food would be an effective cue of social category membership. In our ancestral past, gathering, preparing, and eating food around hearths was likely done in groups, which would facilitate social bonding and the distinction of ingroups and outgroups (Dunbar, 2014; Kaplan et al., 2005). Food continues to play an important role in human social interactions. Across cultures, individuals learn methods for acquiring and cooking food from others, and consume food together. Foods, food preparation, and consumption methods tend to be culture-specific, which makes food an important marker of group identity (Bietti et al., 2019; Cosmides & Tooby, 1992; Rozin, 2006).

Many religions have specific food practices, which create an association between food and religious identity. For instance, many religions use foods in religious rituals and celebrations, such as offerings to deities and ancestors, or rituals such as communion (Bradshaw, 2007; McCreery, 1990). Many religions also have dietary restrictions, and practices such as fasting, which can make a clear association between the foods an individual chooses to eat and their religious identity (Dugan, 1995; Persynaki et al., 2017; Regenstein, 2020; Sarkar & Sarkar, 2016). These dietary restrictions may also prevent individuals from eating, and therefore socializing, with members of religious outgroups (Fieldhouse, 2017;

Pinker, 1997). This can, in turn, decrease the likelihood that people will leave their religious group to join another.

We replicated the findings of Foglia et al. (2021), who found that category-contingent aftereffects were observed for Christian and Muslim faces, but only when religion was explicitly labelled via audio. This supports the finding that Christian and Muslim faces can be processed by separate mental templates, which are activated and updated when viewing faces belonging to presumed members of those religious groups. This also demonstrates that individuals use information from across sensory modalities – visual and auditory – when processing and categorizing faces. This is supported by, and connects to, findings from across the literature that show that auditory information plays an important role in face processing. For instance, auditory cues and speech can improve emotion recognition, and there is a high degree of connectivity between the regions of the brain responsible for recognizing voices and faces (Blank et al., 2011; Wieser & Brosch, 2012).

We did not find category-contingent aftereffects when country of origin was used as a cue to religious identity. We believe that there are several possible reasons for this. One reason might be the use of person-first language ("Sarah is from Scotland.") rather than noun-labels ("Sarah is Scottish.") to describe the characters' countries of origin. Noun-labels are linked to higher essentialist thinking about social groups (Rhodes et al., 2012; Williams et al., 2022). Using noun-labels might create less psychological distance between the characters and their countries of origin, which may make it easier for participants to link the character, country, and religious identity to each other. Future research could compare conditions with these two types of phrasing to determine whether that has an effect on participants' abilities to categorize the faces into two different groups.

Another possible explanation for this null result is a lack of geographic knowledge on the part of our participants. Canadian students rank relatively low on international surveys of

geographic literacy, and tend to score poorly on geographic knowledge tests (National Geographic Society, 2006; Sharpe, 2005; Vajoczki, 2009). A lack of geographic knowledge in general might imply a lack of knowledge about the religious demographics of the countries being used as stimuli. This would make it difficult for them to use the countries of origin described in the audio to infer the character's religious identity.

The findings from this study provide interesting new information about the implicit measurement of stereotypes. First, the category-contingent aftereffects paradigm can be used to test whether two social categories have separate mental templates or representations, specifically religious categories in our study. As noted in the discussion for Chapter 2, religions do not necessarily have associated physical traits like genders and ethnicities do, and religious identities can often be changed, which makes it even more interesting that individuals do store mental templates of what members of different religions look like. The category-contingent aftereffects method complements the findings from Chapter 2 which relied on the reverse correlation paradigm, another implicit measure. This method allows you to test whether there are different mental representations at all, reverse correlation allows you to visualize what they look like.

By using audio cues we can examine how top-down influences are exerted on social categorization. Specifically, by manipulating the information presented in the cues, we can learn which types of information lead to social categorization, and which do not. Cues which successfully support category-contingent aftereffects suggest that individuals stereotype each other based on that type of information. In the case of the results presented in Chapter 3, individuals appear to perceive religious identity based on food preferences. This method could be used to implicitly test for other such cues, for any number of other social categories. As such, the category-contingent aftereffects paradigm could provide valuable converging evidence to our overall understanding of person perception.

Limitations and Future Directions

It is possible that the results observed in this study were influenced by the sample, which consisted of undergraduate students from the Greater Toronto Area in Canada. As noted in the discussion for Chapter 2, Canada is a secular country with low religiosity, and religions like Islam make up a small minority of the population. While this part of Canada is diverse, the participants may have a different understanding of religious identities than a sample from a more religious nation might. If the study were replicated with such a sample, the pattern of results may differ, and it is possible that all three audio cues would support category-contingent aftereffects. On the other hand, a sample with extremely limited contact with Christians and Muslims might not demonstrate category-contingent aftereffects with these stimuli at all.

The religious makeup of our sample might also explain why we did not observe a clear aftereffect for the Muslim stimuli – the aftereffect only clearly occurred for Christian faces. We believe that this might be because individuals view the Christian faces as a default category, while Muslim faces are a marked "other" category that may not be sensitive to our experimental manipulation in the same way in this paradigm. This could be tested by comparing the results of the current study to a study using a sample from a location where Christianity is not the majority religion.

Our sample also consisted mostly of female participants, and given that females tend to have better face recognition abilities than males, especially when viewing female faces, and evaluate faces more positively, the results may differ if the study were repeated with a sample with an equal number of males and females (Guillem & Mograss, 2005; Proverbio, 2017; Sommer et al., 2013; Thayer & Johnsen, 2000).

The methods used in this study could be used to determine whether other religious groups, which have not been studied in this literature, are represented with separate mental

representations. They could also be used to study more superordinate religious categories, such as atheists and theists. Previous research using the reverse correlation paradigm has visualized unique mental representations for atheists and theists, which reflect stereotypes towards them (Brown-Iannuzzi et al., 2018). The category-contingent aftereffects paradigm could be used to test for evidence supporting these results, and, as was the case in our study, could also be used to determine whether implicit or indirect cues signal category membership for these categories as well.

Chapter 4: Revealing occupational stereotypes using mental representations

In Chapter 4, we used the reverse correlation paradigm to explore stereotypes about scientists, and the contrasting categories of hero, genius, and the superordinate category of a person. We were able to visualize distinct mental representations for all four categories, and observed stereotypes that map onto findings from studies using other methods, and stereotypical representations of these categories.

In terms of demographic ratings, we observed that the Scientist CI was rated more White and more male in appearance than was superordinate Person CI. This finding aligns with stereotypical portrayals of scientists, and with observed demographic trends in the scientific workforce, where White men are the predominant group, and are represented as scientists more than are women and minorities (Campbell et al., 2000; National Science Board, National Science Foundation, 2021; Watts, 2007). The Hero and Genius were also rated as appearing more male than the Person, which is likely a reflection of the association between masculinity and heroism and intelligence (Anderson & Cavallaro, 2002; Cocca, 2014; Harriger et al., 2022; Räty & Snellman, 1992; Sternberg, 1985; Sternberg et al., 1981).

In terms of valenced ratings, the Scientist CI was rated significantly more negatively than the other three CIs across the traits, and not only on female-associated traits. Through post-hoc tests, we found that scientists were rated significantly lower than the other CIs on

traits that can be grouped into three main themes. Scientists are seen as unsociable, as they are rated as significantly less personable, funny, cool, and chill than other CIs. They are seen as poor communicators, as they are rated as significantly less well-spoken, entertaining, engaging, charismatic. They are also seen as incompetent, as they are rated as significantly less smart, intelligent, competent, and brilliant than the other CIs. These findings reflect some common stereotypes of scientists, such as the unsociability and poor communication abilities, and some surprising ones, including a lack of intelligence and competence. The stereotypes we uncovered generally make sense when compared to the stereotypes of heroes and geniuses, and especially in the context of the COVID-19 pandemic, which occurred while this study was conducted.

Where heroes are typically seen as altruistic and likeable, scientists are not necessarily associated with these traits (Fradkin et al., 2016; Muller et al., 2020). Geniuses and scientists should both, in theory, be seen as intelligent, but the position scientists hold as authority figures may carry a negative connotation compared to geniuses. Scientists are often portrayed as being cold and calculating in fictional media, and the cold, logical thinking associated with science means they are also perceived as such in real life (Fiske & Neuberg, 1990; Fujiwara et al., 2022). There is also a growing distrust in scientists, with individuals holding conspiracy-like beliefs that scientists are conducting research and influencing policy as part of a greater, hidden agenda (Dixon & Jones, 2015; Kabat, 2017; Peters, 2013). This type of thinking was especially prominent during the COVID-19 pandemic, when scientists were at the forefront of conducting research, communicating their findings, and informing policy – all of which had a large impact on people's lives (Grundmann, 2021; Sanchez & Dunning, 2021; Van Dooren & Noordegraaf, 2020). A lack of clarity in scientific communication and changing guidelines based on updated research could all lead the public to view scientists as being incompetent at research and communication, and out of touch with the feelings of the

general population (Salita, 2015; Weingart & Guenther, 2016). These sentiments are also present in other scientific issues which predate COVID-19, such as climate change and vaccination (Dixon & Jones, 2015; Sanchez & Dunning, 2021).

Limitations and Future Directions

All reverse correlation studies begin with a base image, but what this base image consists of – whether it is a collection of White male faces, or a mix of genders and ethnicities as in our study – is not standard across experiments. Our study demonstrated that using a demographically mixed set of faces to produce a base image can still lead to the creation of CIs that are perceived as having different genders and ethnicities. Future studies, however, could explore the impact of the composition of the base image on the demographic ratings of the resulting CIs.

It should be noted that the two-phase reverse correlation procedure risks having a high Type-I error rate when CIs are created by averaging selections across all participants (Cone et al., 2021, p. 2). The error rate can be reduced by, instead, creating CIs for each individual participant in the first phase of the study. Future studies using this method, such as the ones suggested below, could use this slightly adjusted method.

There are several avenues for future research based on the study described in Chapter 4. First, it would be interesting to compare the mental representations and embedded stereotypes of scientists held by science undergraduate students, who participated in the current study, to other populations. For instance, future studies could examine the stereotypes held by graduate students and academics in the sciences, undergraduate students majoring in programs outside of science, and members of the general public. Making comparisons between how individuals of different genders and ethnicities view scientists may also be revealing, given that our current study uncovered clear demographic stereotypes of scientists.

Another interesting avenue for future research would be to follow this study up in the

present day, or in the future, now that several years have passed since the onset of the COVID-19 pandemic and guidelines such as lockdowns, masking, and vaccine mandates are no longer being enforced as strictly.

Final Conclusions

In this dissertation, we made several interesting findings about face perception and the implicit measurement of stereotypes. The implications of the studies described above for face perception are incredibly interesting. As noted previously in this dissertation, face perception is an evolutionarily ancient process, and one that occurs automatically during social interactions (Ito & Urland, 2003, 2005; Mouchetant-Rostaing et al., 2000; Tanaka, 2001). However, the findings from all three studies illustrate that face perception is influenced by social information. The social category an individual or model is believed to belong to affects how that face is processed – an entirely different mental template can be activated and updated with physical and attitudinal information depending on what social cues are presented to an individual. Vision can occur, and is often studied, as a low-level, bottom-up process, occurring mainly in the visual cortex. However, it is clear that there are top-down influences, especially from higher-level social concepts, that can affect this automatic process of visual perception.

We also demonstrated that implicit, theory-informed measures can be used to uncover stereotypes about social categories. We specifically showed that these implicit measures can be applied to social categories where category membership is not fixed or reliant on the presence of unchanging, physical traits, namely religion (Chapters 2 and 3) and occupation (Chapter 4). While there has been prior research into stereotypes for both of these categories, it has been relatively limited, especially using the specific measures we used in this dissertation (Miller et al., 2018). In our increasingly socially aware world, where individuals are more motivated than ever to mask their prejudice and respond in politically correct ways,

it is becoming more difficult to study stereotyping. Some previously useful methods may not be as effective as they once were. In the face of these challenges, implicit measures provide a valuable means of accessing attitudes and stereotypes that are unaffected by conscious efforts to provide socially desirable responses.

However, the implicit bias literature is not a monolith, and should not rely upon a single implicit measure or theoretical framework to make conclusions about stereotypes and prejudice. Instead, researchers should use theory informed measures to create a body of converging evidence. In this thesis, we specifically used methods based on face perception, and demonstrated that mental representations can act as an indirect means of accessing people's stereotypes towards social groups. In Chapters 2 and 4, we used reverse correlation to test whether mental representations include the physical and attitudinal stereotypes individuals have for religious and occupational categories. In Chapter 3, we used category-contingent aftereffects and manipulated the information provided about social categories, and thus mental templates, to reveal the ways individuals infer others' category membership. The results of these studies demonstrate that stereotypes are embedded deep in our psychology, within our unconsciously-formed mental representations of social groups, even ones where category membership is not fixed or reliant on specific physical traits. This key finding, and the methods we used to uncover it, can help guide future research about stereotyping and eventually help us develop ways of combatting it.

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