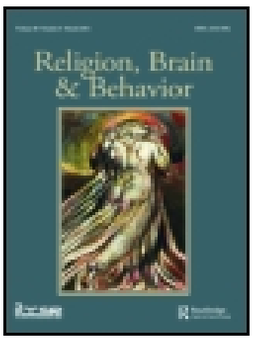

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Religion, Brain & Behavior

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rrbb20

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To cite this article: Victoria Foglia, Alyssa Mueller & M. D. Rutherford (2021): An explicit religious label impacts visual adaptation to Christian and Muslim faces, Religion, Brain & Behavior, DOI: 10.1080/2153599X.2021.1900901

To link to this article: https://doi.org/10.1080/2153599X.2021.1900901

Published online: 27 Mar 2021.

RELIGION, BRAIN & BEHAVIOR
https://doi.org/10.1080/2153599X.2021.1900901

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An explicit religious label impacts visual adaptation to Christian and Muslim faces

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ABSTRACT

Opposing aftereffects can be induced across two sets of face categories. The current literature suggests that in order to create opposing aftereffects, the two categories must (1) be perceptually distinct and (2) represent distinct meaningfully social categories. The current study was designed to test whether religion is one of the types of social categories that can support the formation of opposing aftereffects. Experiment 1 reports the creation and validation of a Christian and Muslim face set, demonstrating that the religious membership of the face images is visually identifiable. In experiment 2 we attempted to create opposing aftereffects by having adult participants fixate on Christian and Muslim faces that were expanded and contracted. Participants either heard religious membership explicit or control audio recordings. Opposing aftereffects were observed only when Christian and Muslim faces were explicitly labeled. In experiment 3, eight-year-olds were adapted to a similar paradigm, with explicit religious information provided. Opposing aftereffects were not observed. Results of these experiments suggest that for adults, religion might be the kind of meaningful social category required for the formation of opposing aftereffects, but only if religious category membership is made explicit. Eight-year-old children's understanding of religious categories may still be developing.

ARTICLE HISTORY
Received 19 October 2020
Accepted 27 February 2021

KEYWORDS
Aftereffects; opposing aftereffects; religion; religious categorization; face templates

Faces are quickly and automatically categorized by race and sex (Ito & Urland, 2003, 2005; Mouchetant-Rostaing et al., 2000; Tomelleri & Castelli, 2012). Adult face perception relies on norm-based coding (Valentine, 1991), meaning that new faces are compared to a stored representation of an average face template. Face templates are formed based on a lifetime of viewing faces, and they are malleable. When perceiving a new face, the more similar the face is to the stored template, the more attractive and normal it appears (Langlois & Roggman, 1990; Potter & Corneille, 2008; Rhodes & Tremewan, 1996; Valentine et al., 2004).

Simple aftereffects

Simple face aftereffects demonstrate the malleability of face templates (Clifford & Rhodes, 2005; Rhodes et al., 2003; Webster & Maclin, 1999). When adults are repeatedly exposed to faces distorted in a similar manner (e.g., contracted facial features) a shift in the viewers' face template occurs, resulting in other contracted faces appearing more attractive while undistorted faces appear as if

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they have expanded features (Anzures et al., 2009; Rhodes et al., 2003; Webster & Maclin, 1999). Additionally, following the adaptation of a specific face category (e.g., female) viewing an ambiguous face is perceived as belonging in the opposite category (e.g., male) (Little et al., 2005; Webster et al., 2004). Aftereffects have been observed for gender (Webster et al., 2004), race (Webster et al., 2004), emotion (Fox & Barton, 2007; Webster et al., 2004), and identity (Anderson & Wilson, 2005; Leopold et al., 2001; Rhodes & Jeffery, 2006).

Children as young as 8 years old also show evidence of face aftereffects (Nishimura et al., 2008). Anzures et al. (2009) found attractiveness aftereffects in 8-year-old children and adults. Furthermore, following similar methods, Short et al. (2011) observed simple aftereffects in 5-year-olds. While adults develop aftereffects after viewing faces distorted by 40% and 60%, this level of distortions does not induce aftereffects in children. However, when the distortion strength is increased to 70% or 90% during adaptation, aftereffects are observed in children. These results suggest that children's face templates are still developing (Anzures et al., 2009).

Opposing aftereffects

While simple aftereffects provide evidence for the malleability of prototypical face norms, opposing aftereffects can provide evidence for discrete face templates dedicated to specific social categories. Opposing aftereffects are evident if attractiveness or normality judgments shift simultaneously in opposite directions for each face category after adaptation. For opposing aftereffects to be produced, face categories must be both socially meaningful and physically distinct. Short and Mondloch (2010) explored whether social categorization alone without physical differences could evoke opposing aftereffects. Using a set of face images that were similar on the basis of race, gender, and age, the experimenters created artificial "in groups" or "outgroups" based on purported shared personality traits, but opposing aftereffects were not observed, suggesting that without a perceivable physical distinction, face categories do not evoke opposing aftereffects.

Conversely, Bestelmeyer et al. (2008) equated physical dissimilarity while manipulating categorical meaningfulness and testing for gender opposing aftereffects. By manipulating images of female faces, these authors created a set of hyper-female faces such that the physical dissimilarity was equated between a male set and a female set of face images on the one hand, and a female and a hyper-female set of face images on the other. Opposing aftereffects were observed between the male and female stimuli but not between the female and hyper-female stimuli (Bestelmeyer et al., 2008). These results suggest that in order to evoke opposing aftereffects, face sets must be (a) physically distinct from each other and (b) meaningfully social categories in the real world.

Adult observers have shown evidence of opposing aftereffects for race (Jaquet et al., 2008; Little et al., 2008), gender (Jaquet et al., 2008; Little et al., 2005), age, and species (Little et al., 2008). Opposing aftereffects have also been tested in 8-year-old (Short et al., 2011) and 5-year-old children (Short et al., 2014). Short et al. (2011) tested whether 8- and 5-year-old children can develop opposing aftereffects for Caucasian and Chinese faces. Opposing aftereffects were observed in the 8-year-old children, but not in the 5-year-olds. The predominantly Caucasian 5-year-old group adapted only to the distorted Caucasian faces. Short et al. (2014) also tested for opposing aftereffects for race, gender, and age in 5-year-olds but no opposing aftereffects were found. The authors concluded that children's face-space is undifferentiated with respect to these social categories at this age (Short et al., 2011, 2014).

Religion as a social category

Though opposing aftereffects have been observed in adults and children across race and gender categories (Jaquet et al., 2008; Little et al., 2008; Short et al., 2011, 2014), opposing aftereffects across religious categories have yet to be examined. The open question is whether social categories based on religion can fulfill the two prerequisites for the formation of opposing face aftereffects by being both (1) physically distinct and (2) socially meaningful categories. Religious groups may be represented

by one's coalitional psychology with one's own religion as an "ingroup" and other religious groups as "outgroups". Some evidence suggests that individuals' prosocial behaviors are directed towards their own religiously specific in-group, and negative attitudes are found toward religious out-groups (Johnson et al., 2012; LaBouff et al., 2012). Johnson et al. (2012) found that when Christians are primed with Christian-related words, more negative attitudes towards atheists and Muslims are evident.

Alternatively, religious people, in general, might be regarded as a social category. Evidence suggests that religious affiliation increases trust regardless of the specific religious group one belongs to. Christian participants showed increased trust following costly religious signaling regardless of whether the signaler was Christian or Muslim (Hall et al., 2015). Similarly, visible Christian religious signals have been shown to increase trust in the individuals wearing them whether the participant is Christian or non-Christian (McCullough et al., 2016).

Regardless of how positively or negatively religious groups may be viewed, it is plausible that two separate religious face groups may be perceived as separate social categories. It is unknown whether religion as a social category could evoke opposing aftereffects. If the two religious categories are meaningfully distinct, as is necessary for the formation of opposing aftereffects, opposing aftereffects may occur. However, it is also necessary for the two faces categories to be physically distinct in order to evoke opposing aftereffects. In this series of studies, we first created two sets of religious faces, Christian and Muslim, categorized by their religious identity, and tested whether they are perceptually distinct. We then tested whether explicitly labeling the two categories by religion will create the socially meaningful distinction needed to support opposing aftereffects.

Current studies

Experiment 1 reports the creation and validation of a photoset of Christian and Muslim faces. Since physical differences and a socially meaningful distinction between face categories are required to create opposing aftereffects, we wanted to ensure that the groups of models who self-identified as Christian and Muslim were perceptually distinct.

Christian and Muslim faces were selected as the religious categories of interest for several reasons. These are the two most widely practiced religions in the world (Pew Research Center, 2017), so they are likely to be recognized as separate religious categories by participants. Prejudice against Muslims is well-documented in North America and Europe (Raiya et al., 2008; Strabac & Listhaug, 2008). There has also been a recent surge of Islamophobia in North America: Muslim individuals are considered a cultural "other" to Western culture (Grosfoguel, 2012; Said & Laade, 1978), with growing intensity in hate crimes and Islamophobic biases in the years immediately after 9/11 (Bail, 2014; Peek, 2011). Recently hostility towards Muslims has become part of political discussion, with the Trump administration's travel restrictions, referred to as a "Muslim ban" (Husain, 2018) introduced in Donald Trump's first days as president of the United States. Thus, Christian and Muslim models were selected due to the likelihood of these face categories being perceived as socially meaningful categories.

The main manipulation in experiment 2 was whether Christian and Muslim faces were identified by religion, using explicit audio recordings. Half of the participants adapted to faces while hearing explicit religious information about the models, and the other half heard non-religious information about the models. If these face sets support the formation of opposing aftereffects in the condition without explicit religious labels, then it is possible that a social categorical distinction was made based on the image alone, similar to opposing race aftereffects. However, if there are opposing aftereffects only when the religious label is explicitly given, it would suggest that the images alone don't support the formation of religious opposing aftereffects.

In experiment 3 we examined whether children form opposing aftereffects for Christian and Muslim faces. Experiments 2 and 3 follow a similar design as Short et al. (2011), in which a social category was first examined for possible aftereffects in adults and then in 8-year-olds. It is not clear whether religion is the type of social category that supports the formation of opposing aftereffects in

adults and children, or how this can be affected by explicit religious information. The current studies will be the first test for evidence that adults and 8-year-olds can form opposing aftereffects for social categories defined by religion.

Experiment 1: photo stimuli validation

Experiment 1 consisted of creating and validating a set of Christian and Muslim face photographs with the intention of using the stimuli in experiments 2 and 3. As different religions are more or less prevalent in different regions of the world, individuals who practice Christianity or Islam may appear physically different. Since physical differences between face categories are required to create opposing aftereffects, we wanted to ensure that the groups of models who self-identified as Christian and Muslim are perceived as distinct. Experiment 1 examines whether the models in these two face sets can be identified as the religious category consistent with the model's self-identification.

Methods

Stimuli creation

Undergraduate students were recruited through emails and social networking groups for McMaster University as models for experiment 1. The recruitment emails asked for Christian and Muslim models and consisted of a set of demographic questions about their and their family's religious heritage. All models self-identified as Christian or Muslim. The Christian models consisted of 15 males and 21 females, and the Muslim models 15 males and 14 females (M age = 20.21, SD = 2.02, *range*: 17–27). Of the Christian models: 31 were born in Canada, 2 in Mexico, and 1 each in England, Germany, and Romania. Of the Muslim models, 14 were born in Canada, 5 were born in Pakistan, 3 in Egypt, 3 in Iran, and 1 each in Afghanistan, Bangladesh, India, and the United States (see Table 1 for additional demographic information). All models gave written consent to have their photos taken for research purposes.

Photographs were taken using a Canon Rebel T3, against a white 57.2 × 72.4 cm Bristol board. The camera was approximately 6 feet from the model. All models wore a black salon cape to cover their clothing, were asked to maintain a neutral face, and remove any glasses. After models were photographed, they answered a demographics questionnaire about their age, gender, the country they were born in, and their religious heritage. Models self-identified religious heritage-determined category membership for the validation study. Models were compensated $5 for their time.

Photo stimuli validation

The religious stimuli bank was then validated to confirm that there were observable physical differences between the Christian and Muslim models. Additionally, validating the stimuli confirms that the religion the models self-identified with matches what the participants categorize them as.

Ethics permission for experiments 1, 2 and 3 was obtained by the McMaster University Research Ethics Board. The validation study was conducted online via Gorilla.sc. During the informed consent window, participants were informed that this was a stimuli validation study designed to explore whether the models appear as either Christian or Muslim. They were informed that they would be viewing 65 images of Christian or Muslim individuals and that these individuals have self-reported their religion. After consenting to the study participants provided some demographic information about their age, gender, race, country of birth, their own religious heritage, their family's religious heritage, and their frequency of religious practice.

At the beginning of the experimental phase, instructions were displayed on the screen informing the participants that the models have self-identified their religion and that they must choose whether they think each face appears Christian or Muslim based on their first immediate choice. Participants pressed a button indicating when they were ready to move onto the experiment. Participants viewed each of the 65 images one at a time in a randomized order. Each image was displayed in the middle of the screen with 2 buttons below to select whether they thought the face

Table 1. Number and percentage of times participants misidentified each of the images ($N = 40$). Image IDs that start with M are Muslim and C are Christian, when the ID's second letter is F it is a female model and M a male model.

ID	Religion	Country of Birth	Age	Number of participants that misidentify	Percentage of participants that misidentify
MF4142	Muslim	Iran	21	27	67.5
CM4214	Christian	Canada	20	24	60
CM4219	Christian	Canada	20	23	57.5
CM4272	Christian	Canada	19	21	52.5
CF4087	Christian	Mexico	20	19	47.5
CF4167	Christian	Mexico	20	19	47.5
MF4247	Muslim	Canada	24	19	47.5
MM4240	Muslim	Canada	20	18	45
CF4173	Christian	Canada	20	16	40
CM4198	Christian	Canada	26	16	40
MM4262	Muslim	Canada	18	16	40
CF4118	Christian	Canada	24	15	37.5
MM4259	Muslim	Canada	18	14	35
MM4267	Muslim	Canada	21	14	35
MF4230	Muslim	Iran	19	12	30
CF4150	Christian	Romania	22	11	27.5
CF4180	Christian	Canada	20	11	27.5
MF4255	Muslim	Canada	20	11	27.5
MF4256	Muslim	Afghanistan	19	11	27.5
MM4270	Muslim	India	18	11	27.5
CM4169	Christian	Canada	20	10	25
MF4228	Muslim	Canada	19	10	25
MM4191	Muslim	Canada	20	10	25
CF4098	Christian	Canada	19	7	17.5
MM4238	Muslim	Canada	19	7	17.5
CF4141	Christian	Canada	20	6	15
MM4206	Muslim	Pakistan	21	6	15
MM4257	Muslim	Egypt	18	6	15
MM4264	Muslim	Canada	18	6	15
CF4115	Christian	Canada	20	5	12.5
CF4156	Christian	Canada	20	5	12.5
CF4171	Christian	Canada	20	5	12.5
MF4133	Muslim	Canada	20	5	12.5
MM4236	Muslim	Pakistan	20	5	12.5
MM4278	Muslim	Egypt	21	5	12.5
CF4184	Christian	Canada	18	4	10
CF4203	Christian	Canada	26	4	10
CM4224	Christian	England	20	4	10
MF4211	Muslim	Iran	21	4	10
MF4231	Muslim	Bangladesh	19	4	10
CF4126	Christian	Canada	23	3	7.5
CF4175	Christian	Canada	17	3	7.5
CM4164	Christian	Canada	21	3	7.5
CM4186	Christian	Canada	20	3	7.5
CM4188	Christian	Canada	26	3	7.5
MF4208	Muslim	Canada	20	3	7.5
MF4218	Muslim	Canada	19	3	7.5
MF4226	Muslim	Canada	19	3	7.5
MM4266	Muslim	Egypt	22	3	7.5
CM4103	Christian	Canada	19	2	5
MF4196	Muslim	U.S.A.	20	2	5
MM4147	Muslim	Pakistan	20	2	5
MM4234	Muslim	Pakistan	19	2	5
CF4108	Christian	Canada	19	1	2.5
CF4123	Christian	Germany	27	1	2.5
CF4182	Christian	Canada	18	1	2.5
CM4177	Christian	Canada	20	1	2.5
CM4222	Christian	Canada	20	1	2.5
CM4253	Christian	Canada	20	1	2.5
CM4276	Christian	Canada	19	1	2.5
MF4193	Muslim	Pakistan	20	1	2.5

(*Continued*)

Table 1. Continued.

ID	Religion	Country of Birth	Age	Number of participants that misidentify	Percentage of participants that misidentify
CF4069	Christian	Canada	20	0	0
CF4092	Christian	Canada	19	0	0
CF4111	Christian	Canada	19	0	0
CM4152	Christian	Canada	20	0	0

appeared Christian or Muslim. Half of the participants viewed the Christian button on the left, the other half on the right. After completing all 65 images participants were debriefed and that study was complete. The entire session took 10–15 min.

Participants

Forty participants took part in the validation study, 30 females, 9 males, and 1 non-binary (*M* age = 19.46, *SD* = 1.75, *range*: 17–26). The average frequency of religious practice was 2.1 (*SD* = 1.35) on a 5-point scale with 5 being the most frequent (see Table 2 for additional demographic information).

Results

Of the 65 model photos categorized the average correctly identified was 81.18% of models, or 56.78 out of 65 images (*SD* = 5.13). Four of the model images were correctly identified by all participants (See Table 1 for details on misidentified images). The image that was most identifiable was sorted correctly by 62 participants, while the least identifiable image was sorted correctly by 39 participants. Of the 489/2600 misidentified trials, 249 were Christian models misidentified as Muslim, and 240 were Muslim models misidentified as Christian. A single-sample *t*-test was conducted to

Table 2. Demographics information from participants in experiment 1.

	Participants (*N* = 40)
Race	
South Asian	14
Asian	13
Caucasian	9
Black	2
Mixed-race	2
Country of birth	
Canada	21
China	8
Iraq	2
Romania	1
Taiwan	1
United Arab Emirates	1
United States	1
Sri Lanka	1
Pakistan	1
Jordan	1
Malaysia	1
Israel	1
Religious practice	
Atheist or Non-religious	14
Catholic or Christian	9
Muslim	7
Hindu	4
Sikh	2
Buddhist	1
Taoism	1
Jewish	1
Mixed-religious	1

assess if participants' ability to categorize each model image was better than chance (50%, 2 AFC task). Participants correctly categorized model faces better than chance ($t(39) = 24.99$, $p \leq 0.001$). Only 4 models were misidentified by half of the participants and were therefore not included in the pre- and post-adaptation phases in either experiment 2 or 3. Additionally, any images that were not accurately identified by over half of the participants in experiment 1 were not used in pre- and post-adaptations in experiments 2 and 3.

To test whether the country of birth was related to religious identity, a chi-square was computed to determine the association between the religious identity of the models (Christian or Muslim) and the country of birth (being born in Canada or outside of Canada). There was a significant relationship between religious identity and the country of birth, Muslim models were more likely than Christian models to be born outside of Canada (X^2 (1, $N = 65$) = 10.70, $p = .001$). Linear regression was computed to predict the model's frequency of misidentification from their age, country of birth, and religious identity. The regression model was not significant, ($F(3,61) = .407$, $p = .749$) with an R^2 of 0.020. Model's age, country of birth, and religious identity were not significant predictors of the frequency they were misidentified.

Discussion

The purpose of study 1 was to validate a novel face image set with Christian and Muslim models for use in experiments 2 and 3. We found that the Christian and Muslim models were accurately categorized as members of their self-identified religious group. This result suggests that there were perceptible physical differences between Christian and Muslim faces in this stimulus set, allowing us to proceed with experiments 2 and 3.

Experiment 2: religious opposing aftereffects in adults

Experiment 2 was designed to test whether, for adults, religion is the kind of meaningful social category that can support the formation of opposing aftereffects. In order to manipulate social significance, participants were assigned to either a religious explicit or a control condition. The religious explicit condition included audio recordings that were played during the adaptation phase and that signaled religious category membership through Christian or Muslim names and religious-relevant character descriptions. During the pre- and post-adaptation phases, face images were paired with either a Christian name or a Muslim name presented via audio recordings for the religious explicit condition. The control conditions included audio recordings of religious-neutral character descriptions, and faces were paired with religious-neutral names. If aftereffects were observed without the religious information, this would suggest that a social categorical distinction is made based on the image alone, as is the case for opposing race aftereffects (Jaquet et al., 2008; Little et al., 2008). However, if aftereffects were only observed in the conditions with religious labels, this would suggest that the images alone do not support the formation of opposing religious aftereffects, and that adaptation was influenced by the explicit social information. This is the first attempt at exploring the effect explicit religious labels have on face perception.

Methods

Materials and stimuli development

Photo editing. The 18 photos used as stimuli in experiment 2 were previously validated in experiment 1. These photos were then cropped to 1530 pixels by 1837 pixels using PhotoPad Image Editor, maintaining the aspect ratio. Following cropping, all photographs were edited using the spherize function on Adobe Photoshop CS. For experiment 2 each photograph was expanded by 60% and 10% and contracted by 60% and 10% (see Figure 1).

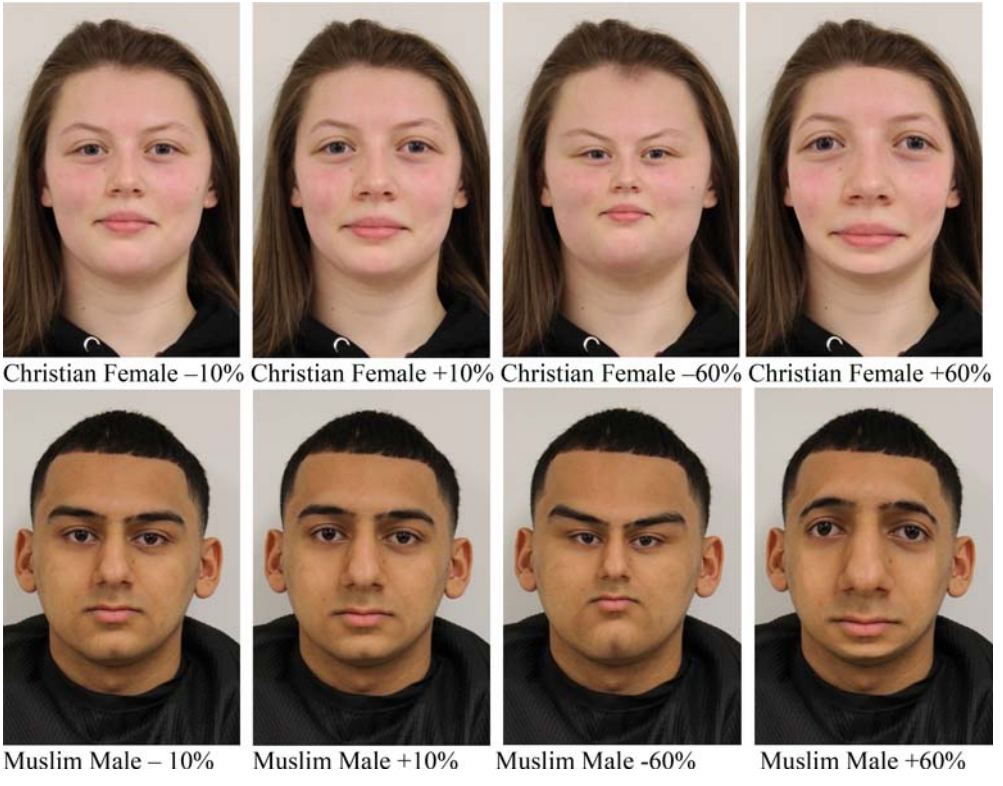

Figure 1. Stimuli samples of the Christian and Muslim faces used in experiment 2. Pre and post adaptation phases consisted of presenting ±10% Christian and Muslim faces. Adaptation consisted of ±60% Christian and Muslim faces.

Audio stimuli. All audio recordings for the religious explicit and control conditions were created via iPhone application Voice Recorder Audio Editor. Recordings used in the pre- and post-adaptation phases included 12 Christian and Muslim names for the religious explicit condition and 12 religious neutral names for the control condition. Four additional sentences were recorded as character descriptions in the adaptation phase. The sentences either indicated the individuals place where they practiced their faith, their favorite food, what they are studying in school, and what their plans for the summer were.

Participants

One hundred and twenty-four McMaster University students participated (19 male). This sample size was determined using a power analysis with average effect sizes from the literature ($k = 4$, $f = 0.30$, $\beta = 0.8$, $\alpha = 0.05$) interaction effects (Little et al., 2008; Short et al., 2011). Data from one male and one female participant were excluded due to a computer error. The one hundred and twenty-two participants' ages were analyzed (17–41 years old, $M = 18.81$, $SD = 2.88$). Participants received course credit for their time. Informed consent was obtained from all participants.

Procedure

The paradigm consisted of a pre-adaptation, adaptation, and post-adaptation phase. Participants were assigned to one of four conditions. Conditions differed by the audio recordings presented (religious explicit or control) and the direction of face distortions (Christian expanded, and Muslim contracted, or Muslim expanded and Christian contracted). Each of the religious explicit and control conditions consisted of one condition where participants were adapted to contracted Christian

and expanded Muslim faces and one condition where participants were adapted to expanded Christian and contracted Muslim faces.

Audio recordings played with face stimuli during the adaptation phase. For the religious explicit condition, one of the three-character description sentences mentioned where the character practiced their faith (e.g., "Leah's family is Catholic, and they spend their Sundays at church" or "Hasan's family is Muslim, and they worship at a mosque"). The two other audio recordings indicated the character's favorite food (e.g., "Leah's favorite food is pizza") and what they are studying in school (e.g., "Hasan is in school to become a psychologist"). Control audio recordings used neutral names and consisted of sentences about the stimuli's favorite food, what they are studying in school, and what their plans for the summer are (e.g., "Warren is planning to take a trip to Europe in the summer").

Pre-adaptation phase. Participants viewed 12 pairs of faces, 4 times each, in a randomized order. Each pair consisted of the same model, with one face expanded by 10% and the other contracted by 10%. Six of the face pairs were Christian and 6 were Muslim. Across the 4 presentations, the expanded face was presented on the left twice, and on the right twice. An audio recording played along with each face pair presented stating the name of the face. Each pair was presented for 2 s, followed by a prompt screen instructing the participants to select via keypress which face they found more attractive. An attractiveness selection was obtained for all 48 pairs of faces.

Adaptation phase. Throughout the adaptation phase participants observed distorted faces that were either Christian or Muslim, depending on condition. All participants viewed 3 Christian faces and 3 Muslim faces one at a time, 3 times each. Faces were presented in a randomized order for 7 s per face with a 500-millisecond inter-stimulus interval. Each face was paired with a character description via audio recording.

Post-adaptation phase

The post-adaptation phase was identical to the pre-adaptation phase, except for the addition of 6 top-up faces after each attractiveness selection in order to maintain the adaptation gained from the previous phase. Top-up faces are commonly used to maintain the adaptation from the adaptation phase throughout the post-adaptation trials in which the faces presented are less distorted than those in adaptation. Top-up faces were distorted consistent with the adaptation direction for each condition at -/+ 60%. The top-up faces were randomly generated from the same stimuli set used during the adaptation phase. Each top-up face was shown for 1 s before the next pair of faces was presented.

Questionnaires

Following the three phases, participants completed a demographics questionnaire that asked about their age, gender, the country in which they were born, ethnicity, family's religious heritage, and religion that they practiced. A religiosity scale was completed, asking participants to rate how often they practice their religion on a scale from 1 to 5. The religion practiced by the participants was diverse: with 48 Christian/Catholic, 40 non-practicing, 21 Islam, 4 Hindu, 4 Jewish, 3 Sikh, 1 Jain, and 1 mixed.

Results

Examining pre-adaptation selections

As change scores are influenced by pre-adaptation selections for attractiveness, we first examined whether there were differences in the pre-adaptation attractiveness selections. A 4 (adaptation condition: religion explicit or control condition) by 2 (religion: Christian or Muslim model) mixed

ANOVA was conducted. For the pre-adaptation attractiveness ratings there was a main effect of religion, ($F(1,119) = 39.153$, $p \leq 0.01$), more Muslim contracted faces were selected as most attractive when Muslim face pairs were presented with one expanded and one contracted side by side ($M = 16.62$ out of 24 Muslim face pairs) than contracted Christian faces when participants viewed Christian face pairs selected as more attractive ($M = 14.59$ out of 24 Christian face pairs). However, there was no main effect of condition ($F(3,119) = 0.481$, $p = 0.696$), and no condition by religion interaction ($F(3,119) = 1.425$, $p = 0.239$). Since attractiveness selections did not differ across conditions, we continued to use the pre-adaptation scores to calculate the change in attractiveness scores.

Differences between the religious explicit and control adaptation conditions

In order to examine whether the adaptation conditions influenced attractiveness ratings' overall adaptation conditions and whether the religious explicit and control conditions differed, a 4 (all adaptation conditions: 2 religious explicit conditions and 2 control conditions) by 2 (religion: Christian or Muslim face) mixed ANOVA was conducted. Change scores were the dependent variable, all adaptation conditions were the between-subjects factor and religion the within-subjects factor. The dependent measure was the change in the number of contracted faces selected as more attractive from the pre- versus the post-adaptation phases as a change in attractiveness selections would be reflective of whether adaptation was obtained for both face categories independently. A significant main effect for religion ($F(1, 119) = 6.03$, $p = 0.02$, $\eta_p^2 = 0.048$) was observed: there was a greater change in the number of contracted Christian faces selected as more attractive ($M = 1.63$, $SD = 4.363$) compared to Muslim faces ($M = 0.72$, $SD = 4.23$), ($t(122) = 2.29$, $p = 0.02$, Cohen's $d = 0.21$). A significant interaction between all adaptation conditions and religion ($F(3, 119) = 4.60$, $p = 0.004$, $\eta_p^2 = 0.10$) was also observed, though the main effect of the conditions was not ($F(1, 119) = 1.61$, $p = 0.19$). This interaction was further examined by exploring the religious explicit and control conditions separately.

Religious explicit conditions

A 2 (adaptation condition: adapted to expanded Christian/contracted Muslim or contracted Christian/expanded Muslim faces) by 2 (religion: Christian or Muslim face) mixed ANOVA was conducted for the two religious explicit conditions. The change scores were the dependent variable and adaptation condition was the between subjects' factor and religion the within subjects' factor. A significant main effect for religion was found ($F(1, 58) = 9.63$, $p = 0.003$, $\eta_p^2 = 0.14$): There was a greater change for Christian ($M = 1.40$, $SD = 2.86$) compared to Muslim faces ($M = -0.18$, $SD = 4.12$), ($t(59) = 2.86$, $p = 0.006$, Cohen's $d = 0.45$). A significant interaction was found between adaptation condition and religion ($F(1, 58) = 11.32$, $p = 0.001$, $\eta_p^2 = 0.16$), though no main effect of adaptation condition was found ($F(1, 58) = 0.11$, $p = 0.74$).

Aftereffects were assessed through paired t-tests for each adaptation condition separately to determine if the change of preference for contracted faces consistent with the direction of adaptation for the Christian and Muslim faces presented. For the contracted Christian/expanded Muslim adaptation condition, significant aftereffects were observed ($t(29) = 4.36$, $p \leq 0.001$, Cohen's $d = 0.663$), with more change in preference when contracted Christian faces were adapted to ($M = 2.43$, $SD = 5.74$) than when expanded Muslim faces were adapted to ($M = -0.87$, $SD = 4.08$), consistent with the direction in which the faces were presented during adaptation. However, there was no difference in change in preference for contracted faces in the expanded Christian/contracted Muslim condition ($t(29) = -0.20$, $p = 0.85$). Thus, opposing aftereffects were significant for the Christian contracted/Muslim expanded condition (see Figure 2).

Control condition

A 2 (adaptation condition: adapted to expanded Christian/contracted Muslim or contracted Christian/expanded Muslim) by 2 (religion: Christian or Muslim face) mixed ANOVA was conducted

with the two control conditions pooled. The was no main effect of religion ($F(1,61) = 0.24$, $p = 0.62$) or adaptation condition ($F(1,61) = 2.35$, $p = 0.13$) or interaction between adaptation condition and the religion ($F(1,61) = 0.70$, $p = 0.45$). No aftereffects were observed for either control conditions (see Figure 2).

Adaptation to categorically ambiguous models

In order to test whether the adaptation in Christian contracted/Muslim expanded faces in the Religious explicit condition was implanted by the explicit religious labels, adaptation to the two most misidentified Christian and Muslim female faces from Experiment 1 was further explored. We tested whether these two most ambiguous models face show evidence of adaptation using a one-sample *t*-test comparing change scores for both faces to 0. If the change score from pre- to post-adaptation was 0 it would indicate no evidence of adaptation. Change scores were different from 0, ($t(59) = 4.45$, $p \leq .001$) indicating adaptation for the most ambiguous faces when religious labels were present in the direction predicted by the model's category membership.

Additionally, participants' change scores to these two faces were examined for opposing aftereffects through directional expectant, one-tailed paired *t*-tests. For the contracted Christian/expanded Muslim adaptation condition, significant aftereffects were observed ($t(29) = 2.036$, $p = 0.025$), with more change in perception for Christian faces ($M = .42$, $SD = 1.38$), compared to Muslim faces were adapted to ($M = -0.13$, $SD = 1.17$), consistent with the direction in which the faces were presented during adaptation. However, there was no difference in the change in preference for contracted faces for the same faces in the control condition when religious labels were not provided ($t(29) = 1.07$, $p = 0.15$).

Effect of explicit religious labels

Change scores were compared across religious explicit trials and control trials for both the adaptation conditions (contracted Christian/expanded Muslim and expanded Christian/contracted Muslim) using paired *t*-tests. This contrast tested the effect of explicit religious information on face adaptation. There was no significant difference between change scores for the Christian faces when a religious label was given ($t(48.40) = -0.38$, $p = 0.71$, Cohen's $d = 0.04$). However,

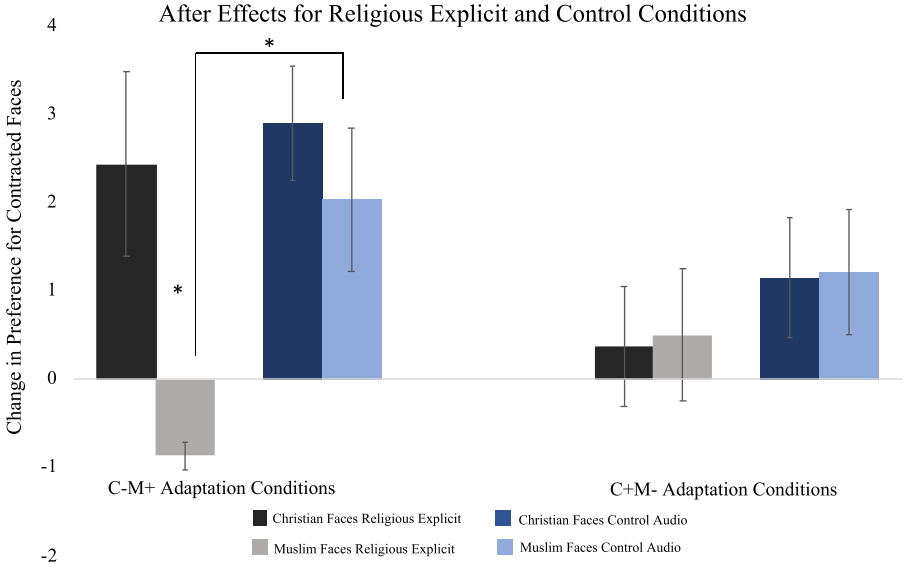

Figure 2. Mean change in preference for contracted faces selected from pre to post adaption for all adaptation conditions in experiment 2. Significant aftereffects are observed for the C-M+ religious explicit condition.

there was a significant difference for Muslim faces ($t(57.57) = -2.70$, $p = 0.01$, Cohen's $d = 0.65$) when a religious label was given. Change scores in reaction to Muslim faces were in the predicted direction only in the religious explicit condition ($M = -0.87$, $SD = 4.45$), but changed in appearance in the same direction as Christian faces in the control condition ($M = 2.03$, $SD = 4.45$). Thus, for Muslim faces, viewing faces paired with the religious labels reversed the adaption compared to the control condition.

Discussion

The purpose of study 2 was to test whether adults adapt differently to Christian and Muslim religious faces when religious labels are explicit compared to when they are absent. Opposing aftereffects were observed in the religious explicit conditions but not in the control conditions. When given religious labels for each face model via audio recordings, the perception of faces shifted, consistent with the expected adaptation. When religion was not made explicit, opposing aftereffects were not observed. This was the first exploration of the effect that religious labels can have on the formation of opposing aftereffects to Christian and Muslim faces.

Experiment 3: religious opposing aftereffects in 8-year-old's

Experiment 3 investigated whether, for 8-year-old children, religion is the kind of meaningful social category that can support the formation of opposing aftereffects as with adults. It was hypothesized that children may be able to adapt to religious social categories, similar to previous findings for race opposing aftereffects in children (Short et al., 2011, 2014), though other social factors such as how immersed the child is in their religion may affect how early religious categorization in children emerges (Takriti et al., 2006; Waillet & Roskam, 2012). A between-subjects paradigm was used: half of the children adapted to a storybook consisting of Christian expanded and Muslim contracted faces, and the other half adapted to images distorted in the opposite direction. We modified the methods of experiment 2 to be child-friendly, like previous studies that have successfully observed simple and opposing aftereffects in children of this age (Anzures et al., 2009; Short et al., 2011, 2014). Children rated the attractiveness of faces along a 5-point cup scale. Faces rated pre- and post-adaptation had stronger intensities than in experiment 2 (±70% compared to ±10%). The adaptation phase was presented to children in the form of an electronic storybook. Finally, the faces observed during adaptation were stronger than those used for the adult's adaptation phase in experiment 2 (±90% compared to -/+ 60%) (Anzures et al., 2009).

Method

Materials

Adaptation storybook. Children were adapted to expanded and contracted Christian and Muslim faces (90%) within the context of a 5-minute electronic storybook. There were two versions of the storybook, one with Christian expanded/Muslim contracted faces, and the other with Christian contracted/Muslim expanded faces as adaptation stimuli. The two storybook versions were identical except for the direction of distortion. The storybook pages were shown electronically while the experimenter read the story out loud and "flipped pages" via keypress. Children were asked to continuously view and listen. Each page contained between one and seven faces and the size and location of the faces varied. Male and female, and Christian and Muslim faces were balanced throughout the story. Only one religious category was presented on each page and is alternated from page to page.

The story consisted of a Christian boy named Matthew and a Muslim boy named Omar's separate birthday parties. To introduce the two religions throughout the storybook the characters were defined as being either friends with Matthew from church or friends with Omar from Mosque. On

pages in which it was Matthew's birthday, all of the characters had Christian names and on pages in which it was Omar's birthday, the characters had Muslim names. The story began with Matthew and Omar waiting for their guests to arrive. When their guests arrived, they began their separate parties. Throughout the stories, the characters played board games, card games, video games, and watched movies, ate popcorn and pizza, opened presents, and blew out candles on their cakes.

Stimuli distortions. The 28 photos used as stimuli in experiment 3 were previously validated in experiment 1. All photographs were edited using the spherize function on Adobe Photoshop CS. Each photograph was then expanded by 70% and contracted by 70% for the pre- and post-adaptation stimuli. Pre and post adaptation stimuli consisted of 12 adult faces: 6 Christian and 6 Muslim. The faces were divided into two separate sets of 6 face identities each. Each set consisted of an undistorted, expanded (+70%) and contracted (−70%) Christian and Muslim face. Faces from one set were shown pre-adaptation and faces from the other set were shown post-adaptation. The order was counterbalanced across participants.

Sixteen different faces (8 Christian, 8 Muslim) were used as adaptation stimuli. Adaptation stimuli were distorted by ±90%. All faces were edited to only display the head of the individual. See Figure 3(a) for an example of pre- and post-adaptation stimuli and Figure 3(b) for examples of the electronic storybook pages.

Participants

A total of forty-six 8-year-olds participated in this experiment (±6 months of age, 21 males, M = 7.83 years, SD = 0.38, *range*: 7 years and 7 months—8 years and 3 months). Sample size was determined based on a previous opposing aftereffect experiment with children as participants (Short et al., 2011). Parents provided written consent and children provided verbal consent. Parents completed a demographic questionnaire about their child's ethnicity, religious heritage, and frequency of religious practice on a scale from 1 to 5. Two female participants' data were removed from analyses upon the parent's request. Analyses included 26 Christian or Catholic and 2 Muslim children and 16 children whose parents responded non-religious/not applicable. Participants were compensated with $10.

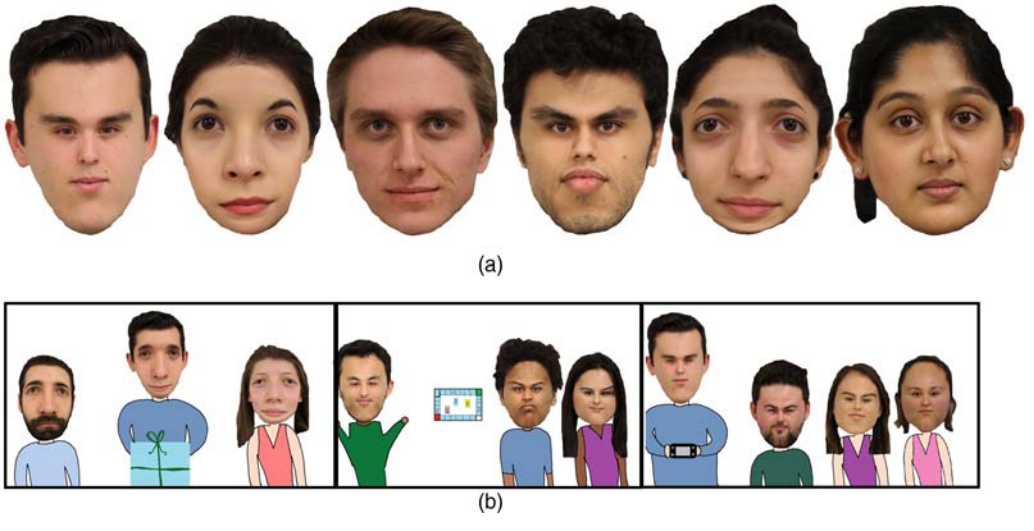

Figure 3. (a) Pre and post adaptation stimuli examples, Experiment 2: (Left-Right) Christian Male 70% contracted, Christian Female 70% expanded, Christian unaltered, Muslim Male 70% contracted, Muslim female 70% expanded, Muslim unaltered. (b) Stimuli examples of the electronic storybook. Faces are altered at ±90%.

Procedure

All trials were conducted on an ASUS 15-inch laptop and children sat 70 cm away from the screen in a laboratory setting. Children were assigned to one of two adaptation conditions: Christian expanded/Muslim contracted faces, or Christian contracted/Muslim expanded faces.

Practice trials. A cup scale was used to elicit the children's attractiveness ratings. Practice trials introduced the child to the 5-point cup scale and how to use it in the upcoming trials. Children rated three presents and three balloons that varied in attractiveness. They were shown each present individually, in a randomized order, and had unlimited time to view and rate each present. The same methods were followed for the balloons. For this and all subsequent trials, the largest cup meant very, very attractive and the smallest cup meant not attractive at all.

Pre-adaptation phase. Children were told that they were going to see pictures of children who would be attending a birthday party and that their job was to rate how attractive each face was. Each child viewed 6 faces (3 Muslim and 3 Christian) at each level of distortion. The first 2 faces presented were always undistorted, and the following faces were randomized. Each face appeared on the screen for 3 s. After 3 s the face disappeared, and the cup scale appeared. Children had unlimited time to select their answers via keypress.

Adaptation phase. Participants were asked to view and listen to the electronic story about the birthday parties of Matthew and Omar. The storybook was read out loud by the experimenter. Throughout the story, children viewed Christian and Muslim faces that had been distorted by 90%. The entire story was 5 min.

Post adaptation phase. At the end of the storybook, participants were told that 6 guests had arrived late. Participants were shown an additional six faces from the second face set and asked to rate the faces using the same methodology in the pre-adaptation trial. After rating each face two top-up faces were presented. Top-up faces were distorted consistent with the adaptation direction for each condition. The first top-up face matched the religion of the previous trial, and the second matched the religion of the next trial. Top-up faces were paired with an encouraging voice, the first top-up face said, "Great job!" and the second said, "I think so too!".

Results

Mean attractiveness ratings were calculated for all distorted faces (+70% and −70%, Christian and Muslim) pre- and post-adaptation, and change scores were calculated by subtracting the rating of pre-adaptation from the rating from post adaptation.

As change scores are influenced by pre-adaptation ratings, we first examined whether there were differences in the pre-adaptation ratings for either of the distortion levels or adaptation conditions. A 2 (adaptation condition: expanded Christian/contracted Muslim or contracted Christian/expanded Muslim) by 2 (distortion: +70% or −70%) repeated-measures ANOVA for the pre-adaptation ratings revealed no main effect of distortion ($F(1,42) = 0.27$, $p = 0.605$), adaptation condition ($F(1,42) = 0.90$, $p = 0.35$), or condition by distortion interaction ($F(1,42) = 0.38$, $p = 0.55$).

Examination of both adaptation conditions

For the main analysis, a 2 (religion: Muslim or Christian) by 2 (distortion: +70% or −70%) by 2 (adaptation condition: expanded Christian/contracted Muslim or contracted Christian/expanded Muslim) mixed ANOVA with adaptation condition as the between subject's variable and mean change scores as the dependent variable was conducted to determine if opposing aftereffects were present. There was no main effect of adaptation condition ($F(1, 42) = 1.92$, $p = 0.17$), distortion ($F(1, 42) = 1.68$, $p = 0.20$), or religion ($F(1,42) = 0.55$, $p = 0.46$). There was a significant religion by

distortion interaction ($F(1,42) = 9.67$, $p = 0.003$, $\eta_p^2 = 0.19$), but no significant interaction of condition and distortion ($F(1,42) = 0.79$, $p = 0.38$), condition and religion ($F(1,42) = 0.10$, $p = 0.76$) or condition, distortion and religion ($F(1,42) = 1.80$, $p = 0.19$). Opposing aftereffects were not observed as change scores did not differ based on condition, distortion, and religion.

Paired *t*-tests examined the distortion by religion interaction. After correcting for multiple comparisons, the alpha level was set at 0.0083. Contracted Christian faces ($M = 1.36$, $SD = 1.62$) resulted in significantly more change in attractiveness ratings than contracted Muslim faces ($M = 0.32$, $SD = 1.33$), ($t(43) = 3.07$, $p = 0.004$, Cohen's $d = 0.70$) over both adaptation conditions. All other pairings were not significant ($ps > 0.012$). See Figure 4.

Discussion

The purpose of experiment 3 was to test whether for 8-year-old children religion is the kind of meaningful social category that can support the formation of opposing aftereffects as found in adults in experiment 2. In contrast to adults, religion-based opposing aftereffects were not observed in 8-year-olds.

General discussion

In experiment 2, participants who adapted to Christian contracted and Muslim expanded faces paired with audio recordings that made religious membership explicit showed evidence of opposing aftereffects: the preference for contracted Christian faces increased after adaptation, and preference for Muslim-contracted faces decreased. Even when data from the 2 most misidentified female models viewed were examined individually, opposing aftereffects were observed. This is the first evidence we know of opposing aftereffects across religious-based categories, and the first time that information delivered via audio recordings has been shown to impact whether opposing

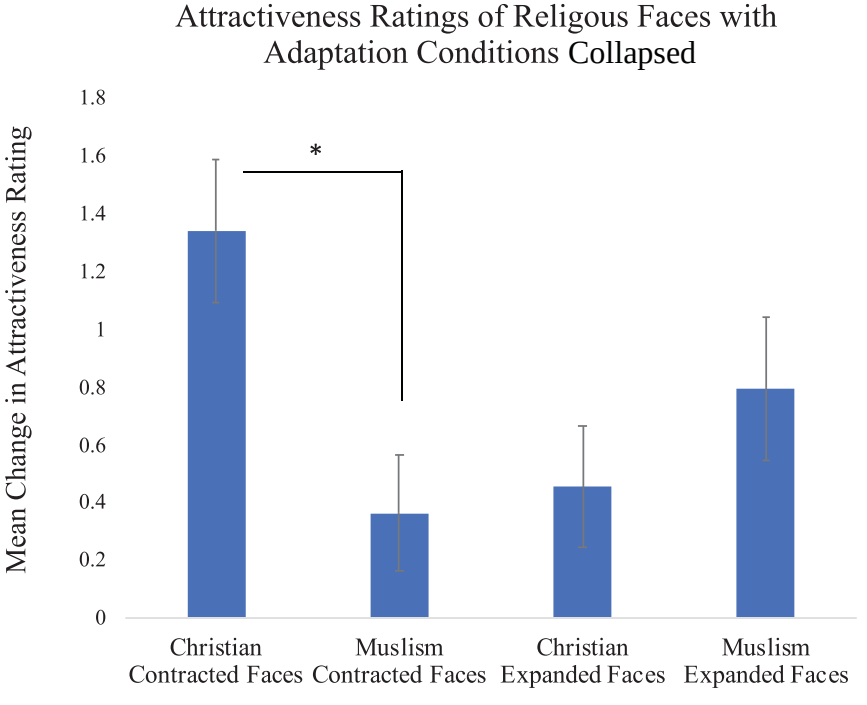

Figure 4. Mean change in attractiveness ratings for experiment 3, collapsed across adaptation order.

aftereffects form. Religious categories may serve as the kind of meaningful social category necessary for the formation of opposing aftereffects, but only if such category membership is made explicitly.

Others have reported opposing aftereffects in adults across race and gender categories without the use of audio labels to enhance the meaning of the faces presented (Jaquet et al., 2008; Little et al., 2005, 2008). The current results differ markedly because the opposing aftereffects were induced only among participants who heard religious labels and explicit religious descriptions. As the control trials resulted in no aftereffects, whatever physical similarities the two sets of images shared based on race, ethnicity, or country of birth, were not distinct enough to evoke an aftereffect on their own. Studies showing opposing aftereffects across race and gender categories have induced these aftereffects without making explicit the race or gender of the models (Jaquet et al., 2008; Little et al., 2005, 2008). This suggests that race and gender were both physically distinct and socially meaningful enough based on visual information available in the faces alone. A clear conclusion is that the categories of race and religion are not psychologically equivalent. The difference may be that, although our image sets were correctly sorted in Experiment 1, religious categories may lack a visually perceivable social distinction until the social information is explicitly labeled.

One important implication of these results is that information presented in the auditory domain appears to impact visual processing. In the control condition, fixating on faces that had been manipulated differently depending on the model's religious category did not result in opposing aftereffects. In the experimental condition, religious information was introduced only in the auditory domain. This implies a top-down visual perception of the face stimuli.

Previous research suggests that two arbitrary categories alone cannot support the formation of opposing aftereffects. Apparently, two categories have to be sufficiently socially meaningful to enable the formation of opposing aftereffects (Short & Mondloch, 2010). Results from the current study suggest that religion is the type of social category that can support the formation of opposing aftereffects, but not that religion is unique in this respect. It is highly possible that numerous other social categories might also be the type of social categories that could support the formation of opposing aftereffects. For example, would opposing aftereffects result if explicit labels described ethnicity, nation-of-origin, or preference for a regionally specific cuisine? This study was not designed to distinguish between religion and other types of social categories, but future research could shed light on other social categories that support the formation of opposing aftereffects.

Children's developing understanding of religion

In experiment 3, opposing aftereffects for religion were not observed in 8-year-olds, suggesting immaturity either in the development of religious face templates or in the participants' understanding of religion. Unlike adults, 8-year-olds did not show evidence of opposing aftereffects even when the religion of the faces is made explicit. Our predominantly Caucasian sample only showed evidence of adapting to Christian faces. These results are similar to Short et al. (2014)'s examination of race aftereffects in 5-year-olds, in which their predominantly Caucasian sample only adapted to Caucasian faces. Results from experiment 3 suggest that the opposing aftereffects observed in adults in experiment 2 may not develop until after the age of 8.

It is not clear when children come to view religious groups as social categories. Some researchers suggest that children begin to understand differences between religions around 8 or 9 years of age (Elkind, 1964; Quintana, 1998). How immersed a child is in their own religion, and how aware they are of other types of religions impacts a child's understanding of the religious groups we examined (Waillet & Roskam, 2012). If a child does not recognize the religious groups presented in this experiment, aftereffects would not be predicted.

Children's face space is still developing at 8 years of age, and it is possible that as with race, (Short et al., 2014), religious opposing aftereffects across religious categories will not be evident until later. It also is possible that the physical differences between the Christian and the Muslim faces were not

perceived as categorically distinct at this age. If the face sets are not perceptually distinct to the observer, opposing aftereffects would not be predicted. Furthermore, although the relationship between religion and coalitional psychology was presented with stark contrast for the sake of the experimental design, how children view religious "out-groups" may vary based on where they are raised, and their perception of these "outgroups" could still be developing.

Influence of physical distinctiveness and social meaning

In order to evoke aftereffects, faces must be physically distinct across categories (Armann et al., 2011; Short & Mondloch, 2010). The purpose of experiment 1 was to ensure that the Christian and Muslim faces could be accurately categorized based on the model's self-identified religion. Over 80% of the faces were accurately categorized, and only 4 faces were misidentified by half of the participants. These 4 were the most miscategorized faces and were not included in test trials in experiment 2 and 3, ensuring that the stimuli consisted of face sets which could be categorized by religion based on visual cues in experiment 2.

Limitations

Previous studies have suggested that some computer distorted stimuli may be perceived as less perceptually distorted than others (Robbins et al., 2007; Robbins et al., 2012). In experiment 2, it is possible that the Christian expanded and Muslim contracted stimuli may have been perceived as less distinct or distorted than the Christian contracted and Muslim expanded faces stimuli, resulting in weaker aftereffects. Additionally, in experiment 2, the Muslim contracted faces were perceived differently than Christian contracted faces, possibly affecting the Christian expanded Muslim contracted adaptation condition. This condition did not yield opposing aftereffects when faces were paired with religious explicit audio. The potential perceptual difference between viewing Muslim contracted faces and Christian contracted faces further explains the differences in opposing aftereffects for both of the religious explicit adaptation conditions.

In experiment 3, children perceived Christian contracted faces as more attractive than the Muslim contracted faces. It is possible that the Muslim contracted faces were seen as less distorted than the Christian contracted faces. Similar results have been observed in 10-year-old children who perceived inverted distorted faces as less distorted than up-right distorted faces (Robbins et al., 2012), whereas adults were capable of simultaneously adapting to opposing aftereffects for inverted faces (Rhodes et al., 2004; Robbins et al., 2012; Watson & Clifford, 2006). The majority of our sample in experiment 3 consisted of self-identified Christian, Catholic or non-practicing children. It is possible that Christian and Muslim children who are exposed to multiple religions might show differing results than the children in our sample as the religious categories may be more socially meaningful. Future research should examine both Christian and Muslim children and children who have a broad religious education.

Future directions

This project is an early step towards understanding the relationship between face perception and religious-based social categorization. The current study suggests that religious social groups are, in fact, meaningful enough to evoke opposing aftereffects when relevant social information is provided. Experiment 2 provides evidence that religious categorization impacts face perception, because opposing aftereffects are evident only in trials in which the model's religion is made evident via audio labels and not in trials in which the same models are not described in religious terms. It does not, however, allow us to infer whether these faces would be perceived categorically in the absence of any audio stimuli. It is unclear whether the religious audio label enhanced adaptation or if the control audio impeded adaptation. Future studies could re-test these models with no

accompanying audio information, in order to estimate a "baseline" adaptation for comparison for the purpose of disambiguating the direction of the effect.

Future examination could also explore a perceptually ambiguous face set and manipulate the religious labels between subjects via audio labels. By adapting one set of participants to faces labeled Christian and another set labeled Muslim, one could further explore this effect of social labeling Christian and Muslim faces independent of perceptual cues. Additionally, the same faces as in the current study could be explored with the use of other labels, like an ethnic label, or a nationality, or preferred foods, to determine if adaptation occurs with and without these social labels.

Conclusion

The purpose of this study was to examine whether opposing religious aftereffects across Christian and Muslim face sets could be induced in adults and children. Experiment 2 was the first study to demonstrate opposing aftereffects for Christian and Muslim faces. Opposing aftereffects were observed when religious categories were made explicit via audio descriptions. In experiment 3, 8-year-old children showed no evidence of opposing aftereffects for Christian and Muslim faces. Eight-year-olds may be immature with respect to face template development or to an understanding of religion as a social category.

Acknowledgements

This research was funded by a Social Sciences and Humanities Council (Canada) grant to MDR. The authors thank Eiman Malik for her assistance in data collection.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Social Sciences and Humanities Research Council of Canada.

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