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Can Stereotype Threat and Lift Visual Messages Affect Subsequent Physical Activity? Evidence from a Controlled Experiment Using Accelerometers

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ABSTRACT

This study investigated how visual messages conveying stereotype threat or lift influenced physical activity performance. Participants ($N = 380$) were exposed to a stereotype threat, lift, or control condition image and then engaged in a running task. Accelerometers recorded forward-backward movement, upward-downward movement, and sideways balance. Stereotype threat exposure increased state anxiety relative to the control condition. In addition, forward-backward movement was linked to state anxiety and participants' sex. Moreover, women exposed to stereotype threat who experienced increased state anxiety showed reduced forward-backward movement. Men exposed to stereotype lift displayed higher forward-backward movement. Additionally, stereotype threat visual message exposure increased sideways balance activity for women but not for men. Upward-downward movement was unaffected by stereotype threat or lift. We discuss theoretical and practical implications of how exposure to visual stereotypes can influence physical activity performance.

Though the portrayals of women and men in the media have changed over time, inequalities persist. Women are underrepresented on primetime television relative to men and though some sexist stereotypes have declined others, such as portraying men as dominant and women as sexually provocative are still common (Sink & Mastro, 2017). Along these lines, video games featuring women as playable characters have increased and, at the same time, primary female characters continue to be sexualized, especially in Teen and Mature rated games (Lynch et al., 2016). In advertisement, stereotyping of women occurs mainly in relation to occupational status as women are shown in dependent and relational roles (e.g., parent, spouse, homemaker, girlfriend, sex object) instead of independent roles, such as professional, worker, narrator, or celebrity (Eisend, 2010). More specifically, visual media can perpetuate gender stereotypes in sports. Male tennis players are portrayed in newspapers as more emotional when in victory or defeat than women, whereas female tennis players are shown in dominated and helpless positions relative to men (Wanta & Leggett, 1989). Women are the main targets of negative stereotypes in sports, as they are labeled as lacking in interest, strength, and athletic ability relative to men (Chalabaev et al., 2008; Gentile et al., 2018; Stone & McWhinnie, 2008).

Stereotypical depictions of women and men in sports can cultivate a worldview that is consistent with media stereotypes (Gerbner et al., 2002) and lead to modeling and vicarious learning of media-based beliefs and behaviors, with potential consequences for individuals' self-efficacy and motivation (Bandura, 2002). For instance, sports are consistently gender-typed in western countries and these stereotypes are learned through media portrayals and peers during childhood (Riemer & Visio, 2003). Children perceive dancing and gymnastics as more feminine, swimming and tennis as more neutral, and competitive contact sports as more masculine (Riemer & Visio, 2003). More importantly, sports gender-typing may affect individuals' health and wellbeing as increased gender-typing of sports is linked to personal participation rates (Plaza et al., 2017).

In this context, *stereotype threat* theory provides a framework to examine the influence of media portrayals of members of a negatively stereotyped group (Appel & Weber, 2021). Stereotype threat refers to how raising the risk of being judged through a negative stereotype can decrease performance (Spencer et al., 1999). Stereotype threat highlights how social stimuli (e.g., images, passing remarks) can raise anxiety, self-defeating expectations, and stigmatization (Steele & Aronson, 1995). For example, women show lower math performance when reminded of negative stereotypes about their math ability (Spencer et al., 1999). Stereotype threat also decreases standardized test performance among stigmatized racial groups (Steele & Aronson, 1995). In addition, women exposed to stereotype threat show decreased working memory and math performance relative to a control group (Schmader & Johns, 2003). Several mechanisms underlie stereotype threat. Performance may suffer when attention needed to accomplish a task is redirected onto the concern of confirming a negative ingroup stereotype (Steele & Aronson, 1995). Stereotype threat can also trigger negative self-fulfilling prophecies and decrease motivation (Beilock & McConnell, 2004).

Additionally, *stereotype lift* refers to performance increases resulting from the salience of a negative outgroup stereotype (Walton & Cohen, 2003). Stereotype lift is rooted in downward

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social comparisons relative to disparaged outgroups, especially when the abilities of outgroup members are put in question (Walton & Cohen, 2003). Stereotype lift can reduce anxiety and increase individuals' self-efficacy (Walton & Cohen, 2003). In a study examining gender stereotypes and math performance, individuals assigned to use a lone male avatar in a group with a majority of female avatars show increased math performance relative to those assigned to a lone female avatar in a group with male avatars (Lee et al., 2014). The statistical effect size of stereotype lift is about half the magnitude of stereotype threat, thus indicating that stereotype threat is more robust than stereotype lift (Walton & Cohen, 2003). Congruent with this, media portrayals conveying stereotype threat decrease the cognitive performance of those belonging to the stereotyped group ($d = -.38$) but stereotype lift effects due to media exposure are not found (Appel & Weber, 2021). Note that while cultivation and social learning theories assume that most individuals exposed to media stereotypes would be susceptible to their effects, stereotype threat and lift depend on group identification. Stereotype threat should occur for individuals who identify with a negatively stereotyped group while stereotype lift occurs when the outgroup is devalued and thus the ingroup appears to be superior (Appel & Weber, 2021).

Stereotype threat and lift effects on physical activity

Stereotype threat and lift apply to physical tasks (e.g., running) because though high-level motor tasks become routinized through practice, individuals with less practice should be more susceptible to disruptions (Beilock & McConnell, 2004). However, experienced athletes are also susceptive to stereotype threat. Expert male golfers exposed to stereotype threat show decreases in putting performance relative to a control group (Beilock et al., 2003). Further in support of stereotype threat in sports, African Americans show lower performance on a golf task when it is framed as diagnostic of "sports intelligence" but when the golf task is framed as a measure of "natural athletic ability," African Americans show increased performance compared to Caucasians (Stone et al., 1999). Additionally, women perform worse when shooting basketball free throws after stereotype threat exposure relative to a control group and also relative to men exposed to stereotype threat (Laurin, 2013). Women exposed to stereotype threat before an athletic task also perform worse relative to men (Hively & El-Alayli, 2014). Men and women display stereotype lift after exposure to negative outgroup stereotypes in a balance task (Chalabaev et al., 2008). Stereotype threat has a medium sized statistical effect on women's sport performance and the effect is higher for normatively masculine sports (Gentile et al., 2018).

Stereotypes are communicated and activated in different ways (Appel & Weber, 2021). Initial studies induced stereotype threat through subtle contextual manipulations, such as participants hearing short stereotype-inducing verbal comments made by an experimenter before performing a given task (Ratan & Sah, 2015; Schmader & Johns, 2003; Spencer et al., 1999; Steele & Aronson, 1995). Aronson et al. (1999) employ more explicit statements about the purported inferiority of the sex and race of the participants' ingroup. More recent studies examine the stereotype threat and lift effects of visual stimuli, such as avatars or digital self-representations (Chang et al., 2019; Lee et al., 2014; Li et al., 2014) and television commercials (Davies et al., 2002).

However, current research has not investigated the effect on physical activity of widely used visual messages, such as photos, memes, or magazine ads. It is important to determine how visual messages can affect physical activity as, for example, individuals share memes, photos, and fitspiration messages through social media that may convey extreme stereotypes and imagery (Araiza & Freitas, 2023). Social media posts can also convey stereotype threat on women's achievement aspirations (Walsh et al., 2022). In particular, this study focuses on stereotype threat and lift effects on running as the popularity of this activity has increased over the years due to its health benefits, high accessibility, and low cost, thus becoming one of the most common ways to exercise (Encarnación-Martínez et al., 2021).

State anxiety mediates stereotype threat and lift effects

Stereotype threat and lift effects are mediated by several factors. Spencer et al. (1999) compared the influence of state anxiety (i.e., transitory nervousness), evaluation apprehension (i.e., worry about being judged by others), and self-efficacy (i.e., perceived confidence) to find that state anxiety is a more reliable mediator of women and men's math performance relative to evaluation apprehension and self-efficacy (Spencer et al., 1999). Stereotype threat can increase state anxiety due to a fear of stigmatization and by augmenting the aversiveness of an evaluation situation (Osborne, 2007). In turn, individuals' attempt to control their anxiety may deplete cognitive resources needed for task performance (Johns et al., 2008). For example, stereotype threat raises state anxiety, which also mediates racial differences in academic performance and explains small but reliable sex differences in math achievement (Osborne, 2001, 2007). In addition, African Americans show increased arterial pressure – a physiological correlate of state anxiety – after stereotype threat exposure relative to non-threatened African Americans (Blascovich et al., 2001). African Americans under stereotype threat also show augmented arterial pressure relative to Caucasians under high or low stereotype threat (Blascovich et al., 2001).

However, there is also mixed support for the mediating role of self-reported state anxiety (Smith, 2004). Somatic anxiety has a mediating effect on motor task performance among women exposed to stereotype threat but, contrary to expectations, it enhances basketball free throw performance (Laurin, 2013). Cognitive and somatic anxiety did not mediate the effects of stereotype threat and lift on motor performance but, among men, higher self-confidence and task involvement are reliable mediators (Chalabaev et al., 2008). Mixed results may be due to inadequate timing of state anxiety measurement, study participants being unaware of their own anxiety, and state anxiety failing to operate as a mediator under defined conditions (Steele et al., 2002). Considering these mixed results, this study seeks to establish how state anxiety mediates the effects of visual messages conveying stereotype threat and lift on running activity.

Sex differences in stereotype threat and lift effects

Stereotype threat and lift can affect men and women performance differently. For instance, men perform better at solving math problems after exposure to stereotype threat relative to stereotype lift and control conditions, whereas women's math performance increases in stereotype lift and control conditions relative to a threat condition (Johnson et al., 2012). Sex differences may yield unexpected results. Women exposed to stereotype threat perform better on an easy math test and worse on a difficult math test in comparison to women in a control group (O'Brien & Crandall, 2003). Along these lines, women perform better in a muscular endurance task after stereotype threat exposure relative to women exposed to a nullified stereotype or no stereotype (Deshayes et al., 2020). However, men display stereotype lift and thus perform better after exposure to a message that targeted women's athletic ability (Deshayes et al., 2020). In addition, the activation of sex roles linked to specific sports raises stereotype threat and moderates stereotype threat and lift effects among men and women (Chalabaev et al., 2013). Considering these unanticipated results, we examine how sex differences moderate the effects of stereotype threat and lift visual messages on running activity.

The present study

This experiment compares the effects of stereotype threat and lift visual messages on individuals' subsequent running performance relative to a control condition. It also examines the mediation effect of state anxiety and the moderation effect of individual's sex. Instead of relying on self-reports, we deploy accelerometers that objectively recorded physical activity while running after exposure to visual messages conveying stereotype threat and lift. Based on the above, we examine the following hypotheses and research question:

H1 *Relative to a control condition, individuals who are exposed to a stereotype threat visual message that conveys negative stereotypes about the physical prowess of the ingroup will show less physical activity.*

H2 *Relative to a control condition, individuals who are exposed to a stereotype lift visual message that conveys negative stereotypes about the physical prowess of the outgroup will show more physical activity.*

H3 *Individuals' state anxiety will mediate and reduce the relationship between stereotype threat vs. control visual message exposure and physical activity.*

H4 *Individuals' state anxiety will mediate and increase the relationship between stereotype lift vs. control visual message exposure and physical activity.*

RQ *Does participants' sex influence the direct effects of stereotype threat and lift visual message exposure and the mediation effects of state anxiety (moderated mediation effects), such that men experience less anxiety and show a smaller performance decrease relative to women?*

Method

Participants and design

Participants ($N = 392$, with 224 women and 168 men) were students recruited from a large public university in the US West Coast using a research participation system. For an experimental design using a fixed model linear regression with three predictors, one outcome variable, a mediator, a moderator, and a covariate with power of 80% expecting a small effect size close to alpha = .15, we needed a 119 participants per experimental cell (Faul et al., 2007). Average participant age was 19.57 years ($SD = 1.99$). 46.9% of the participants were Asian/Pacific Islander, 23.2% were Latino/Hispanic, 22.2% were Caucasian/White, 2.3% were African American/Black, .8% were American Indian or Alaska Native, and 4.6% were of Other racial background. Participant body mass index (BMI) fell into the "normal" category (between 18.5–25) of 22.83 on average ($SD = 4.21$) (Centers for Disease Control and Prevention, 2022). Participants were randomly assigned to a 3(visual message: stereotype threat vs. stereotype lift vs. control) x 2(sex: female vs. male) between-subjects design. The stereotype threat visual message conveyed negative stereotypes about the physical prowess of the ingroup, whereas the stereotype lift visual message communicated negative stereotypes about the physical prowess of the outgroup. The control condition entailed exposure to an abstract painting, which was consistent with control conditions in the literature in which no explicit gender stereotypes were made salient prior to task performance (Beilock et al., 2007; Spencer et al., 1999; Stone et al., 1999). The control condition choice was also consistent with visual stimuli controls which exposed participants to empty walls in virtual reality (Abdou & Fingerhut, 2014) or to television commercials featuring inanimate objects instead of depicting humans (Davies et al., 2002, 2005). The study's hypotheses and data analysis plan were pre-registered https://osf.io/d4gxc/?view_only=745084f099204da8b05e6a98b295d5aa. The analyses presented below are exploratory as they integrate the preregistered hypotheses within a more comprehensive moderated-mediation analysis. This study was approved by the university's institutional review board and participants received extra credit for their participation. Data collection took place between October 2019 and March 2020. The data underlying this article are available in OSF.

Materials

The study took place in a communication research lab with a waiting room and experimenter room. A 50" plasma screen in the waiting room was used to display the stereotype threat and lift visual messages in the format of a meme (i.e., image with short punchline text). Participants in the control condition were exposed to an abstract painting by Jackson Pollock. After exposure to either of these images, participants ran in place while in front of a Kinect motion-sensing camera that

tracked their movements and displayed them back using an avatar projected on a large 150 × 150 cm computer screen. The avatar mimicked the participant's head, arm, and leg movements, and was in a synthetic environment resembling a running trail. This setup was used to increase engagement while running in place (Navarro et al., 2020). The avatar matched the gender of the participant. Actigraph accelerometers (the GT3X and GT9X) and heart rate monitors recorded participants' physical activity (Sasaki et al., 2016). The GT3X and GT9X were placed at the hip and on the participants' dominant ankle, respectively. The heart rate monitor, which made skin contact with participants, was placed at the chest (ActiGraph Software Department, 2012).

Procedure

Participants filled out a motivation for physical activity scale (BREQ-2) with 19 items presented as a 1 to 5 Likert-type scale (Cronbach's $\alpha = .76$, $M = 3.05$, $SD = .48$). This scale was treated as a statistical covariate in the analyses below, which was consistent with attempts in the stereotype threat literature to control for the effects of preexisting performance and motivation. For example, Steele and Aronson (1995) used SAT scores as a covariate to control for the effects of this factor on test performance of African-Americans and Caucasians. SAT scores were used when comparing stereotype threat effects among Latinos and Caucasians (Gonzales et al., 2002). Educational attainment, chronological sex, and baseline memory test performance were used as covariates in a study testing the link between stereotype threat and cognitive decline assessments (Barber et al., 2015). Upon arrival at the lab, each participant was randomly assigned to an experimental condition using a list created with a random number generator with values between 1–3. Participants were asked to silence and put away their cellphones and then filled out a long decoy survey that measured motivation to exercise and enjoyment. Trained research assistants videocasted the images (3 different conditions) from a computer in the experimenter room to a large screen television housed in the waiting room in which participants were placed. To ensure exposure to the experimental manipulations, participants were left alone in the waiting room for exactly 10 minutes while a 50" plasma screen video displayed the image corresponding to their assigned exposure condition. Each casted video representing an experimental condition featured the threat, lift, or control image alternated with an image of a mountain trail every five seconds to draw the attention of participants. Research assistants refrained from mentioning the images displayed in the waiting room. Research assistants were blind to the content or intended effect of the manipulations. To increase experimental consistency, the stereotype threat message shown to women was also used in the stereotype lift condition for men. Conversely, the stereotype lift message shown to women was used in the stereotype threat condition for men (Figure 1).

Figure 1. Experimental visual messages.

Next, participants were moved to a separate room, were furnished with three accelerometers, and then performed a physical activity task that consisted in running the longest possible distance for 10 minutes (Cooper, 1968). To increase engagement while participants ran in place on top of a cushioned mat, a motion-sensing video game displayed an avatar of the participant onscreen. In all conditions, the avatar was dressed in sports clothes and displayed the participant's face (Navarro et al., 2020). Following this, they filled out a manipulation check and post-exposure scales, such as state anxiety (Marteau & Bekker, 1992), avatar identification (Van Looy et al., 2012), and task motivation (Lee et al., 2014). After

the post-exposure survey was completed, participant's height and weight were recorded with a measuring tape and scale. Participants were then debriefed and thanked for their participation.

Manipulation check

After completing the 10-minute running task, participants identified what image they remember seeing in the waiting room before performing the running task. 334 participants (87.89%) identified the correct image they were exposed to. Thus, all participants were retained as they may have implicitly instead of explicitly remembered what visual message they were exposed to and eliminating them would have resulted in a 12.11% attrition rate. Consider that explicit memory entails conscious remembering of previous events, whereas implicit memory refers to influences of prior episodes on current behavior without conscious retrieval or conscious recollection of previous events (Graf & Schacter, 1985). Sensitivity tests comparing the full sample relative to the results of participants who passed the manipulation check reaffirmed the findings presented below though had decreased statistical power due to having fewer cases. The sensitivity analysis showed that majority of the effects retained the same direction though decreasing the number of participants decreased statistical power. The results of the sensitivity analysis can be found in the OSF link provided above.

Dependent variables

State anxiety

Six items from a Likert-type state anxiety scale measured how participants felt after image exposure and running (Marteau & Bekker, 1992). The scale ranged from 1 = *disagree a lot* to 5 = *agree a lot*. Items included "I am worried" and "I feel upset." The scale's reliability was acceptable (Cronbach's α = .78, M = 2.04, SD = .71).

Physical activity

Triaxial accelerometers can quantify the multidirectional features of human movement during walking and running (Bouten et al., 1994; Butte et al., 2012; Rowlands et al., 2004). When walking on treadmills, *forward-backward movement* has increased predictive ability relative to the remaining axes because such physical activity task is aligned in the direction of horizontal movement (Vathsangam et al., 2011). In particular, ankle movement along the forward-backward axis indicates more postural control (Blanchet et al., 2019). In addition, *upward-downward movement* is associated with exercise intensity (John et al., 2012) and ground force impact (Vanwanseele et al., 2020). For example, elite runners display smaller vertical magnitudes relative to non-elite runners (Williams & Cavanagh, 1987). Elite runners are more "light-footed" and thus show less impact velocity and better running economy (Williams & Cavanagh, 1987). *Sideways movement* acceleration or sway may indicate lack of muscle strength and fatigue among soccer players (Fischer et al., 2016) and imbalance among elderly patients (Chou et al., 2003). Increases in sideways movement is also associated with decreases in balance control (Kavanagh & Menz, 2008; Kavanagh et al., 2005; Kim et al., 2019; Yang & Hsu, 2010). Thus, normal movement patterns can be deduced from upward-downward and forward-backward movement, which also coincide with step frequency, while sideways movement is useful to detect gait abnormalities, such as increased sway (Butte et al., 2012).

The accelerometers provided accumulated activity count data along a Cartesian x, y, z plane per measurement period of one minute, for a total of 10 measurements per axis. Activity counts from the ankle accelerometer were considered in the analysis as step movement occurs closer to the ankle than the wrist (Rhudy & Mahoney, 2018). When walking and running, leg muscles fulfill three functions, including generating support by opposing the downward gravity pull, propelling the body forward or backward, and controlling sideways movement in each step (Pandy et al., 2010). The y-axis provided vertical body acceleration data accumulated per measurement period (upward-downward movement). The x-axis provided accumulated anteroposterior bodily acceleration data (forward-backward movement). The z-axis provided accumulated mediolateral bodily acceleration data per measurement period (sideways movement). The accelerometers used counts as a unit of measurement, which are defined as activity that causes an acceleration signal to exceed a threshold (ActiGraph Software Department, 2012). Counts were utilized instead of velocity because collected data is not numerically integrated per measurement period; instead, individual samples are summed over each one-minute measurement period. Each of the 10 measurements were averaged to create a composite measure across each axis. Extreme outliers were identified and excluded from the analysis after applying Tukey's 1.5 interquartile range criterion (Hoaglin et al., 1986). Four state anxiety and activity count univariate outliers were eliminated from the tests reported below. This resulted in N = 388 (221 women and 167 men), with n = 129 in the stereotype threat, n = 133 in the stereotype lift, and n = 126 in the control conditions. Thus, the study had sufficient statistical power to test its hypotheses as it had more than 119 participants per cell. Accelerometer data for eight participants was missing, which resulted in N = 380 for the statistical tests presented below. Physical activity outcome variables were not strongly correlated. The correlation between forward-backward movement and sideways movement was non-significant, $r(380) = -.07$, $p = .18$ (two-tailed). The association between upward-downward and forward-backward movement was $r(380) = .22$, $p = .001$ (two-tailed). The correlation between upward-downward movement and sideways movement was $r(380) = .21$, $p = .001$ (two-tailed).

Results

The results were analyzed with the PROCESS model 59 macro for moderated mediation analysis with multicategorical predictors using indicator coding to test for the effects of participants' sex on all of the legs of the model (Hayes & Montoya, 2017). The control condition was the reference group for all indicator coding comparisons. State anxiety was the mediator and mean activity counts for the y, x, and z axes were set as outcome variables. White's test for all outcome variables were

non-significant, thus indicating that the homoscedasticity assumption was met. HC3 was employed for further protection from data heteroscedasticity. Mean centering was applied to all variables that define products. Each model had 20,000 bootstrapped samples to account for violation of normal distribution assumptions in mediator and outcome variables. Sex was set as a statistical moderator for all mediation and direct effect paths. BREQ-2 scores representing participants' preexisting motivation to exercise was used as covariate. BMI did not significantly correlate with any of the three measures of physical activity, $r_{upward\text{-}downward\ movement}$ (380) = .05, p = .33, $r_{forward\text{-}backward\ movement}$ (380) = .01, p = .88, $r_{sideways\ movement}$ (380) = .06, p = .29. Thus, BMI was not further considered in the analyses below.

The hypotheses stated that stereotype threat exposure would decrease physical activity relative to the control and stereotype lift conditions. Stereotype lift was expected to increase physical activity relative to the control and stereotype threat conditions. In addition, increased state anxiety should mediate the link between stereotype threat exposure and physical activity. Participants' sex was expected to moderate the results. Descriptive statistics appear in Table 1.

Participants who were exposed to a stereotype threat visual message had increased state anxiety relative to those in the control condition (see Table 2 and Figures 2–4). The stereotype lift visual message did not influence state anxiety scores relative to the control condition. Participants' sex did not influence state anxiety scores. Further analysis of the

Table 1. Means and standard deviations of threat, lift, and control manipulations between sexes for state anxiety and physical activity measures.

	Threat				Lift				Control			
	Female		Male		Female		Male		Female		Male	
Variable	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
State Anxiety	2.25	.79	2.08	.79	2.09	.65	1.94	.63	1.98	.72	1.91	.58
Side to Side	4219.29	2440.18	4570.68	2451.24	3820.23	2192.20	3344.06	2056.88	3465.82	2014.43	3704.77	2381.36
Vertical	7547.91	3427.24	9288.16	3843.86	6568.75	3047.19	9824.77	4706.24	6908.30	3137.75	9236.50	3963.16
Forward Backward	3575.64	2424.53	3428.5	2590.87	3432.63	2193.64	4302.45	2839.25	3697.82	2791.70	3177.31	2580.55

Table 2. Effects of stereotype threat and lift manipulations, sex, interaction effects, and BREQ-2 scores on upward-downward activity counts.

			95% CI		
Variable	*B*	*SE(HC3)*	*LL*	*UL*	*p*
Constant	4855.98	1606.83	1696.34	8015.62	.00
Stereotype threat[1]	675.04	546.24	−399.07	1749.16	.22
Stereotype lift[2]	−387.07	538.48	−1445.94	671.79	.47
State anxiety	−115.96	306.42	−718.49	486.57	.71
Participants' sex[3]	2552.63	1342.37	−86.97	5192.23	.06
Stereotype threat*Sex	−279.29	972.94	−2192.47	1633.89	.77
Stereotype lift*Sex	1360.79	1001.89	−609.30	3330.89	.18
State anxiety*Sex	−183.22	607.25	−1377.31	1010.87	.76
BREQ-2	757.51	440.48	−108.63	1623.66	.09

CI = confidence interval; *LL* = lower limit; *UL* = upper limit.
BREQ-2 = motivation to exercise. [1] Threat condition = 1, Control condition = 0.
[2]Lift condition = 2, Control condition = 0. The multi-categorical analysis was conducted with the control condition as the reference group. [3] Female = 0, Male = 1.

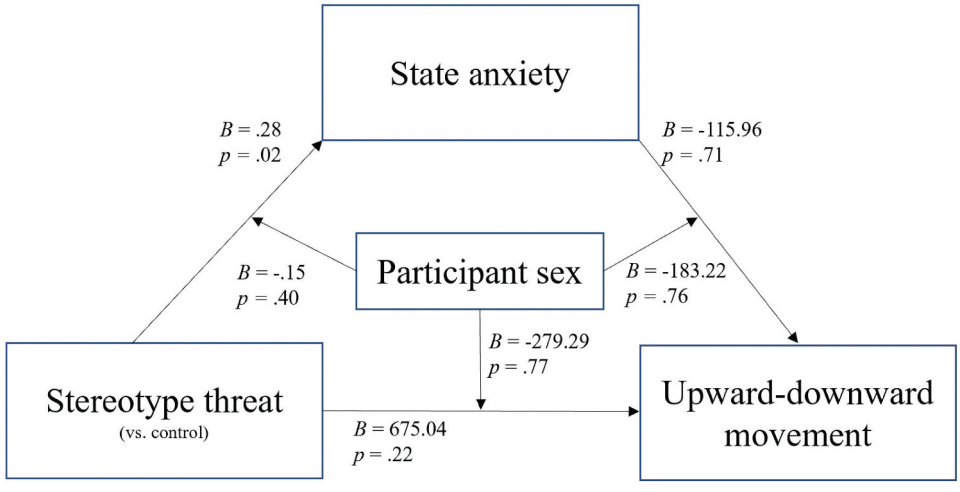

Figure 2. Mediation effects of state anxiety on the association between stereotype threat on upward-downward activity counts as moderated by participant sex.

interactions between the experimental conditions and participants' sex found no difference between the threat and lift images relative to the control condition. BREQ-2 scores were negatively related to state anxiety.

Effects on state anxiety and upward-downward movement

Stereotype threat exposure did not influence upward-downward movement relative to the control condition (see Table 2 and Figure 2). Additionally, stereotype lift exposure did not influence upward-downward movement relative to the control condition. State anxiety, participants' sex, and BREQ-2 scores were unrelated to upward-downward movement. The interactions between participants' sex and the experimental conditions revealed no conditional effects between the threat vs. control and lift vs. control conditions (change in $R^2 = .01$, $p = .25$). Further mediation and moderated mediation tests were non-significant for the threat vs. control condition comparisons (Index of moderated mediation = −6.01, 95% CIs [−331.74, 234.07]) and lift vs. control condition comparisons (Index of moderated mediation = 21.58, 95% CIs [−144.36, 216.04]). H1-H4 were disconfirmed in relation to upward-downward movement.

Effects on forward-backward movement

In addition, stereotype threat exposure did not influence forward-backward movement relative to the control condition (see Table 3 and Figure 3). There were no differences between the lift relative to the control condition. H1 and H2 were disconfirmed in relation to forward-backward movement. BREQ-2 scores were not linked to forward-backward movement. State anxiety and participants' sex both influenced forward-backward movement. Additionally, there was a significant interaction between the lift condition and participants' sex but there was no interaction between the threat condition and participants' sex. More specifically, men showed stereotype lift relative to the control condition, $B = 1145.51$, $SE = 502.55$, $t(380) = 2.28$, $p = .02$, 95% CIs [157.30, 2133.72] but women did not display such stereotype lift, $B = -252.92$, $SE = 436.80$, $t(380) = -.58$, $p = .56$, 95% CIs [−1111.85, 606.00]. This finding pertained to the research question regarding potential sex differences linked to stereotype lift and forward-backward movement. Women with increased state anxiety also showed decreased forward-backward movement compared to men. Adding the mediator by moderator interaction term to the model revealed significant group differences (change in $R^2 = .01$, $p = .01$). There were significant differences between the

Table 3. Effects of stereotype threat and lift manipulations, sex, interaction effects, and BREQ-2 scores on forward-backward movement activity counts.

			95% CI		
Variable	*B*	*SE(HC3)*	*LL*	*UL*	*p*
Constant	4127.76	1011.43	2138.92	6116.61	.00
Stereotype threat[1]	19.09	450.15	−866.08	904.25	.97
Stereotype lift[2]	−252.92	436.80	−1111.85	606.00	.56
State anxiety	−636.80	219.65	−1068.71	−204.89	.00
Participants' sex[3]	−2409.86	903.95	−4187.38	−632.35	.01
Stereotype threat*Sex	72.33	687.55	−1279.65	1424.31	.92
Stereotype lift*Sex	1398.44	668.74	83.44	2713.44	.04
State anxiety*Sex	957.92	375.72	219.11	1696.73	.01
BREQ-2	295.48	283.42	−261.82	852.78	.30

CI = confidence interval; *LL* = lower limit; *UL* = upper limit.
BREQ-2 = motivation to exercise. [1] Threat condition = 1, Control condition = 0.
[2]Lift condition = 2, Control condition = 0. The multi-categorical analysis was conducted with the control condition as the reference group. [3] Female = 0, Male = 1.

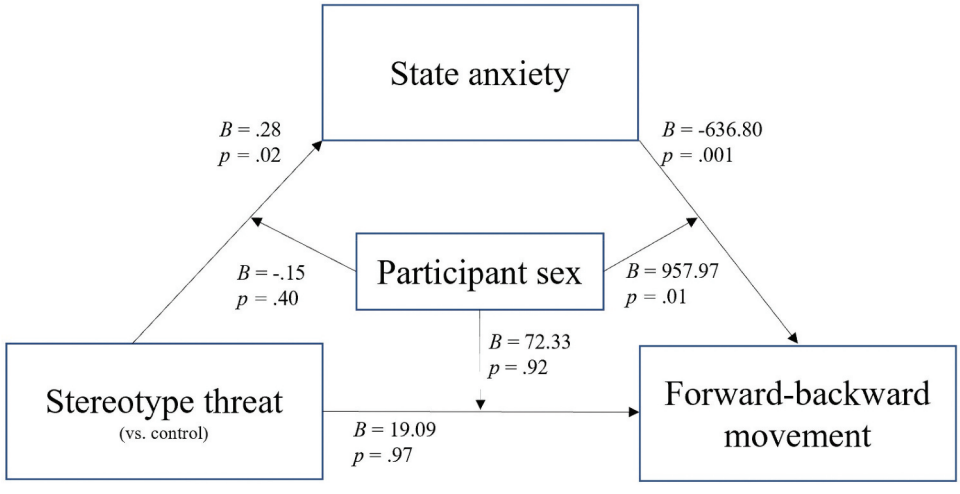

Figure 3. Mediation effects of state anxiety on the association between stereotype threat on forward-backward activity counts as moderated by participant sex.

threat and control conditions (Index of moderated mediation = 218.58, 95% CIs [16.02, 482.64]). The mediated model was significant for women, $B = -177.44$, 95% CIs [−399.30, −24.16] but not for men, $B = 41.13$, 95% CIs [−77.04, 212.34]. H3 was confirmed regarding forward-backward movement. This moderated mediation result addressed the research question regarding sex differences linked to stereotype threat and forward-backward movement. However, the comparison between the lift vs. control conditions was non-significant (Index of moderated mediation = 93.01, 95% CIs [−81.09, 295.87]). H4 was disconfirmed regarding forward-backward movement.

Effects on sideways movement

Additionally, stereotype threat exposure directly influenced sideways movement relative to the control condition (Table 4 and Figure 4). H1 was confirmed with regards to sideways movement. However, there was no difference between the lift and the control conditions. Thus, H2 was not confirmed for sideways movement. State anxiety, participants' sex, and BREQ-2 scores did not influence sideways movement (Table 4). For the threat vs. control condition comparison, women showed a significant increase in sideways movement $B = 809.06$, $SE = 386.80$, $t(380) = 2.09$, $p = .04$, 95% CIs [48.46, 1569.66] but men did not display such effect, $B = 605.48$, $SE = 585.69$, $t(380) = 1.03$, $p = .30$, 95% CIs [−546.20, 1757.16]. This result addressed the research question regarding sex differences linked to stereotype threat and sideways movement. Results of the index of moderated mediation was non-significant between the threat and control conditions (Index = −19.94, 95% CI [−210.94; 180.18]) and the lift and control conditions (Index = 2.68, 95% CI [−120.45; 123.99]). H3 and H4 were disconfirmed regarding sideways movement.

Discussion

Stereotypic depictions of women and men in sports cultivate stereotype-consistent attitudes and foster observational learning of beliefs and behaviors transmitted by media, with potential negative consequences for individuals' self-efficacy and motivation to maintain personal health and wellbeing through physical exercise. In this context, the present study built on stereotype threat as a framework to investigate the exposure effects of negative visual messages that undermined ingroup members' physical prowess before performing a running activity. Stereotype threat exposure increased participants' state

Table 4. Effects of stereotype threat and lift manipulations, sex, interaction effects, and BREQ-2 scores on sideways movement activity counts.

			95% CI		
Variable	*B*	*SE(HC3)*	*LL*	*UL*	*p*
Constant	2021.17	1023.23	9.10	4033.23	.05
Stereotype threat[1]	809.06	386.80	48.46	1569.66	.04
Stereotype lift[2]	537.45	389.11	−227.69	1302.59	.17
State anxiety	−3.66	231.50	−458.88	451.55	.99
Participants' sex[3]	992.14	955.54	−886.81	2871.09	.30
Stereotype threat*Sex	−203.58	702.52	−1585.00	1177.84	.77
Stereotype lift*Sex	−1199.29	657.82	−2492.82	94.24	.07
State anxiety*Sex	−160.00	414.81	−975.68	655.69	.70
BREQ-2	478.14	297.47	−106.79	1063.08	.11

CI = confidence interval; *LL* = lower limit; *UL* = upper limit.
BREQ-2 = motivation to exercise. [1] Threat condition = 1, Control condition = 0.
[2]Lift condition = 2, Control condition = 0. The multi-categorical analysis was conducted with the control condition as the reference group. [3] Female = 0, Male = 1.

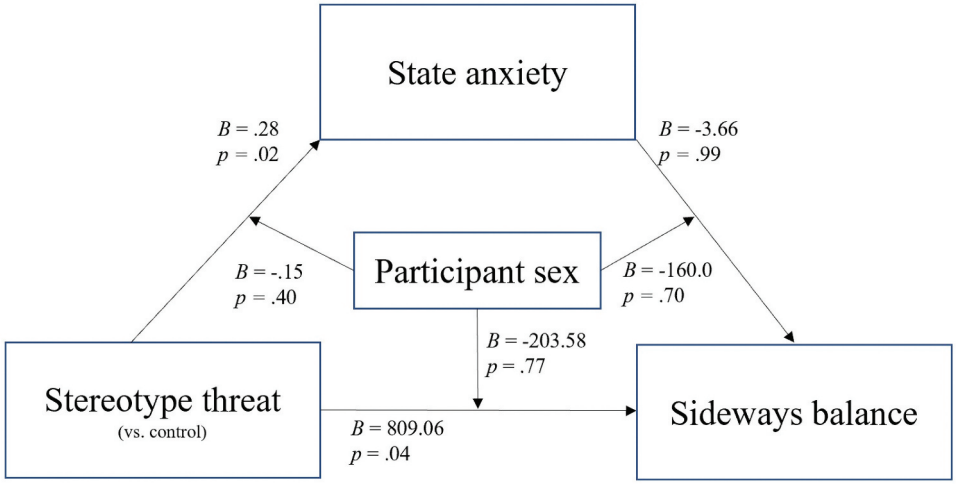

Figure 4. Mediation effects of state anxiety on the association between stereotype threat on sideways activity counts as moderated by participant sex.

anxiety relative to the control condition. However, stereotype lift exposure did not decrease state anxiety relative to the control condition. More specifically, women exposed to stereotype threat who also experienced more state anxiety displayed reduced forward-backward movement in a running task. This finding confirmed the hypothesis that stereotype threat can decrease physical activity and highlighted the importance of state anxiety as a mediator of this effect (Osborne, 2001; Spencer et al., 1999).

This study provided boundary conditions for the effects of state anxiety in the stereotype threat literature. This factor only operated as a reliable mediator on forward-backward movement and did so among women but not men. Future research may attempt to replicate this effect through physiological instead of self-reported indicators of state anxiety and collect state anxiety measures following immediate exposure to stereotype threat or during task performance (Steele et al., 2002). Considering the present mixed support for state anxiety, future studies may tackle other mediators, such as evaluation apprehension and decreased self-efficacy (Spencer et al., 1999), along with increased vigilance and self-regulation (Schmader et al., 2008).

The findings provided initial evidence for how conveying stereotype threat in the format of memes – a mainstream form of online communication that blends images and text – influenced running activity as objectively measured with accelerometers. In doing so, this study extended the ecological validity of stereotype threat and lift effects across new forms of mediated visual communication, such as avatars (Chang et al., 2019; Lee et al., 2014; Li et al., 2014), television ads (Davies et al., 2002), news and entertainment media (Appel & Weber, 2021), and social media posts (Walsh et al., 2022). The results have practical implications as they illustrate how stereotype threat may interfere with women's attempt to physically exercise with more effort. For example, fitspiration memes and social media posts intended to increase physical activity may backfire among women if anxiety is inadvertently increased by threatening ingroup members' physical prowess. However, men did not display stereotype threat effects on forward-backward movement that were mediated by state anxiety. It is possible that this effect was present only among women because their perceptions were more strongly influenced by stereotypical societal beliefs about women's physical capabilities in sports (Hively & El-Alayli, 2014). This is consistent with how sports gender-typing was correlated with decreased participation rates (Plaza et al., 2017) and that women are the main targets of negative stereotypes in sports (Chalabaev et al., 2008; Gentile et al., 2018; Stone & McWhinnie, 2008).

Moreover, men displayed a stereotype lift effect on forward-backward movement relative to the control condition. This was consistent with how men presented with a negative stereotype about women performed comparatively better at physical tasks, such as balancing (Chalabaev et al., 2008), muscular endurance (Deshayes et al., 2020), and strength (Chalabaev et al., 2013). Our findings innovated on previous research by inducing stereotype lift through visual messages and expanded such effect to forward-backward running movement, which is a critical component of running. It is possible that the low task difficulty (O'Brien & Crandall, 2003) and more neutral gender-typing of the present running task (Chalabaev et al., 2008; Gentile et al., 2018) also contributed to men displaying increased forward-backward movement following stereotype lift exposure. Future studies should replicate this effect using physical tasks that require more dexterity and difficulty. This finding has implications regarding how to increase physical activity among men and, at the same time, such lift effect is problematic for practical and social purposes as it relied on stressing stereotypes about the physical inferiority of women. This stereotype lift effect was not observed among women, which implied that stressing stereotypes about the physical inferiority of men did not yield the same outcome on women.

Among women, stereotype threat directly increased sideways movement or sway while running in place. Though at first glance this effect can be interpreted as performance gains due to a reactance effect, previous accelerometry studies link increased sideways movement to wasteful energy expenditure. The increased sway effects caused by stereotype threat exposure might have only been observed among women because of the influence of cultural stereotypes about sports and physical activity as masculine domains (Riemer & Visio, 2003). Considering that women are underrepresented in some sports domains, stereotype threat exposure may affect numerical minority group members differently than numerical majority members because of societal stigmatization made salient by sheer numbers (Cadinu et al., 2003). Future research may attempt to manipulate the number of women and men presented in visual stimuli to test for this hypothesized representation effect. This finding also implied that memes conveying stereotype threat, fitspiration posts, and social media campaigns that raise negative ingroup stereotypes about physical prowess may steer women to increase physical effort at the cost of doing so wastefully or incorrectly. Practitioners thus should refrain from using negative stereotypes about the ingroup to "challenge" women to do better. Future research may investigate how stereotype threat interacts with more feminine or masculine physical activity tasks. For example, competitive contact sports are likely to raise stronger stereotype threat on women as they are perceived as more appropriate for men, whereas dancing and gymnastics may raise an additional threat for men as they code as more feminine sports (Chalabaev et al., 2013). In addition, sex-typed individuals, such as self-identified masculine men and feminine women, may be more likely to apply stereotypes to sports and also be more susceptible to stereotype threat along with their perceived gender appropriateness of a physical task (Chalabaev et al., 2013).

Limitations

Participants in this study had a normal BMI and were young and healthy in general. Future studies should replicate our findings using older and overweight participants, which could conceivably be more at risk of stereotype threat due to prevalent negative stereotypes about age (Lamont et al., 2015) and weight (Seacat & Mickelson, 2009).

Though the intent of this study was to chart the effects of visual messages in the format of memes, a potential limitation was the very nature of this format which

combined images and text to prompt stereotype threat and lift. Future studies may attempt to decouple the effect of text and images along with testing for their combined effects. While the photos used as memes were professionally produced and were very similar, there were small dissimilarities, such as image size, distance of male to female model, arm position of the man, and font size. However, each participant was exposed to a single image and, thus, there was no opportunity for image comparisons. Future research should test for the robustness of one-shot stereotype threat exposure, along with potential repeated exposure effects.

In addition, visual messages conveying stereotype threat and lift were presented to participants on large screens and under forced exposure conditions. Future studies may increase ecological validity by displaying stereotype threat and lift in the format of memes more naturalistically as, for example, having them appear in participants' social media feeds. Future studies may further examine this question by testing for the effect of delivering stereotype threat and lift memes through large or small screens. Consider that participants who watched television content on large instead of small screens experienced more arousal, enjoyment, and excitement (Lombard et al., 2000). In addition, video game players showed increased immersion when playing using large relative to small touch screens (Thompson et al., 2012). However, smaller screen sizes did not impair transportation into audiovisual stories (Appel & Mengelkamp, 2022), thus implying that screen size is not guaranteed to moderate stereotype threat or lift effects.

Additionally, the use of a physical activity task involving running in place may have restricted participants' freedom of movement. For example, there were no differences in step counts among participants, which implies that the manipulations changed the amount of activity involved in taking steps while running in place but not necessarily how much they ran. The manipulations only directly influenced sideways movement and forward-backward movement. However, the remaining hypotheses were not confirmed. Why were stereotype threat and lift effects more pronounced on forward-backward movement relative to the other two physical activity outcomes? One possibility is that the present running task was more aligned in the direction of forward movement (Vathsangam et al., 2011). Thus, it was less likely for upward-downward movement to be applicable because there was no inclination involved in the running task. Future studies may test for stereotype threat and lift effects when people climb stairs or use incline treadmills and stair masters, all which involve more upward-downward movement. In addition, 12.11% of participants failed to correctly identify what image they were exposed to after the running task, which may be linked to fatigue after running or lack of attention to the stimuli. Overall, the findings from this one-shot exposure study were reliable but small in statistical size.

Conclusion

Congruent with the stereotype threat hypothesis, exposure to negative stereotypes in the format of a meme increased state anxiety which in turn decreased forward-backward movement in a running task. This was especially the case among women. Among women, stereotype threat resulted in increased swaying or wasteful sideways movement. However, men exposed to a stereotype lift visual message showed augmented forward-backward movement. This study showed that, under controlled conditions, exposure to visual messages that convey stereotype threat can objectively influence the performance of physical activity.

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