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Effects of meta-stereotype threat on working memory: the mechanisms of emotion and core self-evaluations

Tiantian Dong[1] · Wei Tong[1] · Wen He[1]

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Abstract
Scholarly evidence on how meta-stereotype threat affects working memory is still lacking. Therefore, this study conducted two experiments to investigate whether negative meta-stereotypes decreased working memory, focusing on the mediating role of emotion and the moderating role of core self-evaluations. Experiment 1 showed that activated negative meta-stereotypes could lead to lower positive emotions, higher negative emotions, and poorer working memory performance. In this context, negative meta-stereotypes affected working memory through reduced positive emotions. Experiment 2 confirmed the results of Experiment 1, showing that the adverse effects of meta-stereotype threat had more substantial effects on working memory in participants with high core self-evaluations. In contrast, such effects were weak in participants with low core self-evaluations. These findings expand on existing literature concerning how meta-stereotype threat affects working memory, mainly by providing new insights into the processes and conditions of the meta-stereotypes threat effect.

Keywords Meta-stereotypes threat · Positive emotion · Negative emotion · Core self-evaluations · Working memory

Introduction

Meta-stereotypes refer to individual beliefs about stereotypes that outgroup members hold toward ingroup members (Vorauer et al., 1998). In general, meta-stereotypes have a negative valence (Vorauer et al., 1998). When a negative meta-stereotype is activated, the adverse effects are referred to as the "meta-stereotype threat effect" (Sun et al., 2015). Many studies have demonstrated the effect. For example, activated negative meta-stereotypes can worsen intergroup attitudes and emotions while diminishing expectations for intergroup interactions and cooperative behaviors (Owuamalam & Zagefka, 2014). Recent research has examined negative meta-stereotypes' cognitive effects. One study found that negative meta-stereotype activation can adversely affect working memory (Sun et al., 2015). However, knowledge on its underlying mechanisms is still lacking. Therefore, this study comprises two experiments to examine the roles of emotion and core self-evaluations in the relationship between negative meta-stereotype activation and working memory. This area is important to investigate, given the dearth of research on cognitive effects. Such research would also promote the development of comprehensive theories that simultaneously consider social and cognitive factors related to both intergroup interaction and individual performance.

The impact of meta-stereotype threat on working memory

Threat-related thoughts springing from negative meta-stereotype activation produce extremely poor intergroup perceptions among members. At the same time, they induce fear and catalyze stress experiences (Lammers et al., 2008; Owuamalam et al., 2013; Sun et al., 2015). The stress reaction consumes valuable cognitive resources (Beilock & DeCaro, 2007). For example, researchers have found that negative meta-stereotype activation uses up working memory capacity, impairing working memory task performance (Sun et al., 2015). A recent study of older adults found that this activation leads to increased cognitive load during working memory tasks. This impairment specifically manifests in decreased accuracy and increased response time (Li et al., 2021). Therefore, working memory performance tends to decline under meta-stereotype threat.

✉ Wen He
hewen@shnu.edu.cn

[1] Department of Psychology, Shanghai Normal University, Guilin Road 100, Shanghai 200234, China

Emotions as mediators

Negative meta-stereotype activation creates extra situational burdens that interfere with working memory performance (Li et al., 2021; Sun et al., 2015). However, evidence concerning the mechanisms that promote the occurrence of this is lacking. Emotional mechanisms may be involved as meta-stereotype threat causes stress and worry (Finchilescu, 2010; Finkelstein et al., 2015). A large body of evidence supports associations between negative meta-stereotypes and emotions in this process (Finchilescu, 2010; Finkelstein et al., 2015; Gordijn, 2010; Owuamalam & Zagefka, 2013; Voyles et al., 2014). For example, when outgroup members negatively evaluate a group, its members experience emotional reactions such as anxiety, fear, and worry (Finkelstein et al., 2015; Stephan & Stephan, 1985). However, researchers explore the role of positive affect less frequently. Recently, Fowler and Gasiorek (2019) have found that negative meta-stereotype activation reduces positive emotions and increases negative emotions. Thus, emotional deterioration manifests as diminishing positive emotions and increasing negative emotions. This pattern suggests emotions play mediating roles between negative meta-stereotype activation and working memory.

Moreover, Processing Efficiency Theory (Eysenck & Calvo, 1992) posits that negative emotions can adversely influence intrinsic thoughts. This influence demands resources from the central executive and phonological loop, with detrimental effects on the cognitive tasks managed by these systems. Research has also shown that individuals experiencing negative emotions may use more cognitive resources to ensure ongoing task completion while preventing damage caused by emotional deterioration (Yüvrük et al., 2020). Thus, increases in negative emotions and decreases in positive emotions may similarly result in a form of cognitive consumption that leads to the depletion of cognitive resources. For example, Beckwé and Deroost (2016) found that participants with negative emotions performed worse than their neutral counterparts during working memory tasks.

The aforementioned literature demonstrates the close relationship between negative meta-stereotypes, emotions, and working memory. Specifically, negative meta-stereotype activation may lead to more unpleasant emotional experiences, including a decrease in positive emotions and an increase in negative emotions, and reduced working memory. In turn, worse emotional experiences can influence working memory performance. Therefore, activated negative meta-stereotypes may adversely affect working memory performance through the influence of emotions.

Core self-evaluations as a moderator

It is also important to note that specific factors may moderate the effect of negative meta-stereotype threat. In this regard, Finkelstein et al. (2015) suggested that core self-evaluation may work as a moderating variable. Individuals with high core self-evaluations may be more resistant to meta-stereotype threat (Finkelstein et al., 2015, 2020). More specifically, core self-evaluations is a higher-order trait that simultaneously consists of generalized self-efficacy, self-esteem, internal locus of control, and emotional stability (Judge & Bono, 2001; Judge et al., 1998). It is a fundamental evaluation of an individual's ability and value. In addition, it is a central self-concept trait variable that affects essential psychological behavioral reactions (Li & Nie, 2010).

Nevertheless, whether core self-evaluations can buffer negative meta-stereotype threat remains unclear. Indeed, higher core self-evaluations is not always better (Judge, 2009). Resource conservation theory (Alarcon et al., 2011) states that core self-evaluations is a positive psychological quality that may buffer the effects of negative meta-stereotype threat effects (Finkelstein et al., 2020). Specifically, individuals with strong core self-evaluations tend to be better at responding to threats. In these cases, negative meta-stereotype activation may not substantially affect working memory. By contrast, individuals with low core self-evaluations are more likely to feel threatened, meaning that negative meta-stereotype activation would have more substantially impaired working memory. Alternatively, the stress-vulnerability hypothesis (Li et al., 2012; Wang et al., 2010) posits that individuals with positive qualities perform well in low-stress situations but deteriorate rapidly in high-stress situations. Therefore, individuals with high core self-evaluations are more likely to be affected by negative meta-stereotype activation, while individuals with low core self-evaluations are less likely to be threatened. Thus, investigating the moderating role of self-evaluations has essential implications for understanding meta-stereotype activation effects on cognitive processing.

The current study

To clarify the mechanism behind the meta-stereotype threat effect, this study investigated how negative meta-stereotypes affected working memory, with a particular focus on the mediating role of emotion and moderating role of core self-evaluations. Two experiments were performed; a negative meta-stereotype manipulation task and the Positive and Negative Affect Schedule (PANAS) with an N-back paradigm (Experiment 1 and Experiment 2) and

Core self-evaluations scale (Experiment 2). Of note, there is evidence that negative meta-stereotypes are more easily activated in disadvantaged groups. At the same time, research has demonstrated that rural college students tend to hold many negative meta-stereotypes (e.g., indecisive, untidy) (Meng, 2013). Therefore, these experiments were conducted with a sample of rural college students. According to the arguments outlined above, the following hypotheses were proposed:

- H1: Negative meta-stereotype activation decreases working memory.
- H2: Emotion mediates the relationship between negative meta-stereotypes and working memory.
- H3: Core self-evaluations moderates the relationship between negative meta-stereotypes and working memory.

Methods

Experiment 1

Experiment 1 examined how negative meta-stereotypes affect working memory, focusing on emotion as an underlying mechanism. Participants completed a measure of working memory and emotion scale test under different conditions (with/without mate-stereotype threat).

Participants

A statistically significant medium effect (2 × 3 design) with an f of 0.25 and an α of 0.05 requires approximately 86 participants to attain 80% power. Ninety college students (Ten males and 80 females; $M_{age} = 19.89 \pm 1.28$) were recruited via recruitment advertisements. After excluding four participants with invalid data (e.g., incomplete questionnaires, accuracy, and reaction time beyond three standard deviations), the final sample consisted of 46 participants in each condition. All participants were right-handed and had normal or corrected-to-normal vision. Each individual provided written consent prior to participation and received approximately 3 USD as compensation.

Design

A 2 (Activation Type: negative/control) × 3 (Task Level: low/medium/high) mixed design was adopted. The Activation Type was the between-subject variable, and the Task Level was the within-subject variable. The dependent variables included PANAS scores and N-back performance.

Measures and stimuli

Meta-stereotype activation manipulation

We manipulated meta-stereotype activation similarly to Owuamalam and Zagefka (2011). The negative meta-stereotype activation group was asked to list four negative impressions that they thought the urban college students held about rural college students. The control group members were asked to list four opinions on current developments in science and technology.

Meta-stereotype manipulation examination

We checked the effectiveness of the valence manipulation immediately after the meta-stereotype activation task by asking participants to what degree they thought that the beliefs on rural college students held of urban college students were negative/positive. Answers were provided on a 7-point scale (1 = negative, 7 = positive) (Matera et al., 2015).

Positive and negative emotions

Participants responded to items from Qiu et al. (2008). First, they completed the Positive and Negative Affect Schedule (PANAS) to indicate their emotions (1 = *very slightly/not at all*, 5 = *very much*). In this step, positive and negative emotions associated with the meta-stereotype (Fowler & Gasiorek, 2019) were selected. Positive emotional items included *enthusiastic*, *happy*, and *energetic*. Negative emotional items included *upset*, *nervous*, and *scared*. The scale received a Cronbach's α of 0.90 in this study.

Working memory task

The N-back task was used to measure working memory performance. Three solid black geometric shapes (triangle, circle, and square) were selected for this task. The stimulus size measured 6.5 cm × 6.5 cm at 187 × 308 pixels.

Procedures

They were randomly assigned to a negative or a control condition. After finishing the meta-stereotype activation, they immediately completed the meta-stereotype manipulation examination. They then completed the PANAS questionnaire, followed by the N-back task. All four phases took approximately 15 min to complete.

Eprime 2.0 was used to compile the N-back program. The task contained three blocks: 0-back, 1-back, and 2-back, representing low, medium, and high difficulty, respectively. Each block has three shapes: triangle, circle, and square. In the 0-back task, participants were required

to press "L" immediately upon seeing a triangle but pressed "A" for any other shapes (circles and squares). In the 1-back task, they were asked to compare a new shape with one previously presented, thus judging their consistency. In the 2-back task, participants were instructed to press A if the current shape matched the shape presented two positions previously and to press L if not. Instructions were presented on a computer screen during the task. A practice experiment was first conducted, with the formal experiment conducted when participants fully understood the requirements in each block. In the practice experiment, feedback was given for each response. The practice experiment shapes were identical to those in the formal experiment. A fixation point was presented for 500 ms in each trial, followed by the stimulus, also presented for 500 ms. The time allotted for participant judgment was 2,000 ms.

Results and discussion

All statistical analyses were carried out using IBM SPSS Statistics Version 23.0 software.

Manipulation examination

Participants' responses to the manipulation examination question were analyzed using an Independent Samples *t*-test to examine the effectiveness of meta-stereotype activation. The results were significantly different across the Activation Type, $t_{(84)} = 6.60$, $p < 0.001$, $d = 1.44$. The item score in the negative activation condition ($M = 3.40$, $SE = 0.13$) was lower than that in the control condition ($M = 4.77$, $SE = 0.16$). This indicated that the experimental manipulation was effective.

Emotion

Next, positive and negative emotion scores were analyzed using an Independent Samples *t*-Test. The analysis revealed a main effect of Activation Type for the positive [$t_{(84)} = 2.11$, $p = 0.038$, $d = 0.46$] and negative emotions [$t_{(84)} = 2.16$, $p = 0.034$, $d = 0.47$]. More positive emotion was detected in the control condition ($M = 3.02$, $SE = 0.13$, 95% CI = 0.03–0.84) than that in the negative activation condition ($M = 2.58$, $SE = 0.16$) and more negative emotion in the negative activation condition ($M = 1.72$, $SE = 0.09$) than that in the control condition ($M = 1.45$, $SE = 0.09$, 95% CI = 0.02–0.52).

N-back performance

N-back test results were examined using a repeated-measures ANOVA. The accuracy analysis revealed a main effect of Activation Type [$F_{(1, 84)} = 5.97$, $p = 0.017$, $\eta_p^2 = 0.07$], with higher accuracy in the control condition ($M = 0.86$, $SE = 0.01$, 95% CI = 0.01–0.06) than that in the negative activation condition ($M = 0.83$, $SE = 0.01$). The main effect of Task Level was also significant [$F_{(2, 168)} = 198.70$, $p < 0.001$, $\eta_p^2 = 0.70$], accuracy in the low difficulty condition ($M = 0.96$, $SE = 0.01$) was higher than that in the medium difficulty condition ($M = 0.89$, $SE = 0.01$), (95% CI = 0.06–0.09) and high difficulty conditions ($M = 0.68$, $SE = 0.02$), (95% CI = 0.24–0.31); accuracy in the medium difficulty condition was higher than in high difficulty condition (95% CI = 0.17–0.24). The interaction between Activation Type and Task Level was significant, $F_{(2, 168)} = 10.98$, $p < 0.001$, $\eta_p^2 = 0.12$, (see Fig. 1). Simple effect analysis showed that accuracy in the high difficulty and control conditions ($M = 0.74$, $SE = 0.02$), was higher than that in the

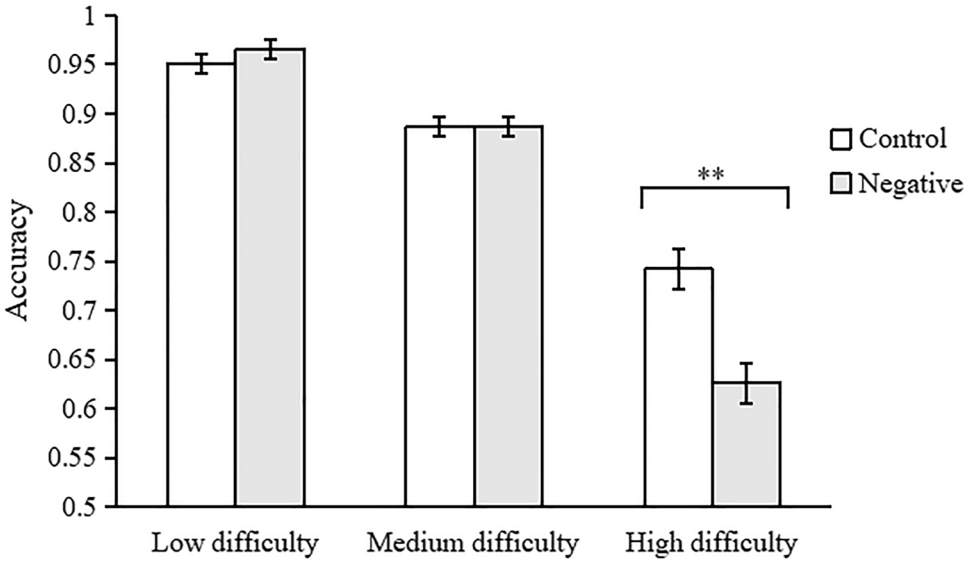

Fig. 1 Average accuracy under the different conditions. Notes: $^{**}p < 0.01$

negative activation condition ($M = 0.63$, $SE = 0.02$), (95% CI = 0.05–0.18). There was no significant difference in other conditions.

The reaction time (RT) analysis revealed a main effect of Activation Type [$F_{(1, 84)} = 4.42$, $p = 0.038$, $\eta_p^2 = 0.05$]. Shorter RT was found in the control condition ($M = 649.59$, $SE = 18.28$), than in the negative activation condition ($M = 703.95$, $SE = 18.28$), (95% CI = 2.95–105.76). The main effect of Task Level was also significant [$F_{(2, 168)} = 184.41$, $p < 0.001$, $\eta_p^2 = 0.69$]. RT in the low difficulty condition ($M = 468.00$, $SE = 8.11$) was shorter than that of the medium difficulty ($M = 729.06$, $SE = 16.57$), (95% CI = 232.82–289.32) and high difficulty conditions ($M = 833.25$, $SE = 23.34$), (95% CI = 322.73–407.78). RT in the medium difficulty condition was shorter than that of high difficulty condition (95% CI = 60.05–148.33). The interaction between Activation Type and Task Level was not significant, $F_{(2, 168)} = 0.88$, $p = 0.415$, $\eta_p^2 = 0.01$.

Mediating effect of emotion

The correlation between the variables examined was shown in Table 1, which showed that meta-stereotype manipulation was significantly correlated with the performance of positive and negative emotions and the accuracy in the high difficulty condition.

To investigate the role of emotion in meta-stereotype threat and working memory performance, The Bootstrap method of the PROCESS in SPSS was used to evaluate the mediation (indirect) effect (Hayes, 2013). The repeated samples were set to 5000 times, and the 95% CI was calculated to run the mediation effect.

The results showed that the meta-stereotype threat negatively predicts positive emotions ($\beta = -0.45$, $p = 0.038$, 95%CI = [-0.87, -0.03]). In addition, meta-stereotype threat positively predicts negative emotions ($\beta = 0.46$, $p = 0.034$, 95%CI = [0.04, 0.88]). Moreover, positive emotions positively predict working memory performance ($\beta = 0.24$, $p = 0.024$, 95%CI = [0.03, 0.45]); negative emotions negatively predict working memory ($\beta = -0.22$, $p = 0.037$, 95%CI = [-0.43, -0.01]). Furthermore, the direct effect of meta-stereotype threat on working memory performance was also significant ($\beta = -0.47$, $p = 0.030$, 95%CI = [-0.89, -0.05]). In the total model, the 95%CI of the indirect effect of negative emotions contains zero. Thus, the results indicated that the effect of meta-stereotype threat on working memory was partly mediated by positive emotions (See Table 2).

Experiment 2

Experiment 1 was an important step for understanding how the meta-stereotype threat undermined performance during working memory tasks. Under the threat condition, working memory performance was found to decline, thus supporting H1; that is, negative meta-stereotypes created additional cognitive burdens that interfered with complex cognitive tasks. Meanwhile, this process entailed emotional deterioration. We also questioned whether the same effects were produced in all situations. As such, Experiment 2 explored the role of core self-evaluations (an important individual difference variable) in the meta-stereotype threat effect, with the goal of producing evidence on how and when the meta-stereotype threat affects working memory while also providing a theoretical basis for relevant interventions.

Table 2 The mediating effect of emotion

Path	Effect size	Relative effect size	95%CI
Meta-stereotype threat → Positive emotion → Accuracy of high difficulty	-.11	16.18%	[-.28, -.002]
Meta-stereotype threat → Negative emotion → Accuracy of high difficulty	-.10	14.71%	[-.33, .01]
Total mediating effect	-.21	30.88%	[-.49, -.04]
Total direct effect	-.47	69.12%	[-.89, -.05]

Table 1 Correlation coefficient between the various measured variables

Variable	1	2	3	4	5	6	7	8	9
1 Activation Type	1								
2 Positive emotion	-.23*	1							
3 Negative emotion	.23*	.19	1						
4 Accuracy in the low difficulty	.14	.001	.11	1					
5 Accuracy in the medium difficulty	-.02	-.08	-.02	.11	1				
6 Accuracy in the high difficulty	-.34**	.25*	-.23*	.09	.26*	1			
7 RT in the low difficulty	.25*	-.09	-.04	.19	-.01	-.01	1		
8 RT in the medium difficulty	.13	-.11	-.001	.11	-.08	-.16	.53**	1	
9 RT in the high difficulty	.19	.10	-.10	.11	.01	.26*	.43**	.44**	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Similarly hereinafter

Participants

A statistically significant medium effect (2 × 3 design) with an f of 0.25 and an α of 0.05 requires approximately 86 participants to attain 80% power. Ninety-two college students (22 males and 70 females; $M_{age} = 21.20 \pm 2.58$) were recruited via recruitment ads. After excluding six participants with invalid data (e.g., incomplete questionnaires, accuracy beyond three standard deviations), the sample consisted of 43 participants in each condition. All participants were right-handed and had normal or corrected-to-normal vision. All participants provided written consent prior to participation and received approximately 3 USD as a reward.

Design

Experiment 2 implemented a 2 (Activation Type: negative/control) × 3 (Task Level: low/medium/high) mixed design. The Activation Type was the between-subject variable, and the Task Level was the within-subject variable. The dependent variables were PANAS scores and N-back performance.

Measures and stimuli

Core self-evaluations scale

This study used the core self-evaluations scale developed by Judge et al. (2003), which contains 12 items across one dimension. All items were answered on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Higher scores indicated higher core self-evaluations. The scale received a Cronbach's α of 0.87 in this study. In addition to this, we conducted meta-stereotype activation manipulation, as done in Experiment 1.

Procedures

Participants were randomly assigned to one of two conditions (negative or control). They first completed the self-evaluation scale, then finished the meta-stereotype activation component, and immediately completed the meta-stereotype manipulation examination. Finally, they completed the positive and negative emotion scores, followed by the same N-back task used in Experiment 1. All five phases took approximately 15 min to complete.

Results and discussion

Manipulation examination

To examine the effectiveness of meta-stereotype activation, participants' response on the manipulation examination question were entered into the Independent Samples t-Test. The results of the were significant different across the Activation Type, $t_{(84)} = 5.19$, $p < 0.001$, $d = 1.13$. The item score in the negative activation condition ($M = 3.58$, $SE = 0.15$) was lower than that in the control condition ($M = 4.70$, $SE = 0.16$). This suggested that the experimental manipulation was effective.

Emotion

Then, positive and negative emotion scores was submitted to the Independent Samples t-Test. The analysis revealed a main effect of Activation Type both of the positive [$t_{(84)} = 2.13$, $p = 0.036$, $d = 0.46$] and negative emotion [$t_{(84)} = 2.06$, $p = 0.043$, $d = 0.45$], with more positive emotion in the the control condition ($M = 3.05$, $SE = 0.12$, 95% CI = 0.03–0.73) than that in the negative activation condition ($M = 2.67$, $SE = 0.13$) and more negative emotion in the negative activation condition ($M = 1.98$, $SE = 0.13$) than that in the control condition ($M = 1.63$, $SE = 0.11$, 95% CI = 0.01–0.70).

N-back performance

Then, the performance in the N-back test was submitted to a repeated measures ANOVA. For the accuracy, the analysis revealed a main effect of Activation Type [$F_{(1, 84)} = 6.32$, $p = 0.014$, $\eta_p^2 = 0.07$], with higher accuracy in the control condition ($M = 0.88$, $SE = 0.01$, 95% CI = 0.01–0.07) than that in the negative activation condition ($M = 0.84$, $SE = 0.01$). The main effect of Task Level was also significant [$F_{(2, 168)} = 135.44$, $p < 0.001$, $\eta_p^2 = 0.62$], accuracy in the low difficulty condition ($M = 0.96$, $SE = 0.01$) was higher than that both of medium difficulty condition ($M = 0.89$, $SE = 0.01$), (95% CI = 0.05–0.09) and the high difficulty condition ($M = 0.72$, $SE = 0.02$), (95% CI = 0.20–0.27); accuracy in the medium difficulty condition was higher than that of high difficulty condition (95% CI = 0.13–0.20). The interaction between Activation Type and Task Level was significant, $F_{(2, 168)} = 11.53$, $p < 0.001$, $\eta_p^2 = 0.12$, see Fig. 2. The simple effect analysis showed that the accuracy in the high difficulty condition, the control condition ($M = 0.78$, $SE = 0.03$) was higher than that in the negative activation condition ($M = 0.66$, $SE = 0.03$), (95% CI = 0.05–0.19). There was no significant difference in other conditions.

For the reaction time (RT), the analysis revealed a main effect of Activation Type [$F_{(1, 84)} = 4.22$, $p = 0.043$, $\eta_p^2 = 0.05$], with shorter RT in the control condition ($M = 624.97$, $SE = 19.12$), than that in the negative activation condition ($M = 680.52$, $SE = 19.12$), (95% CI = 1.76–109.33). The main effect of Task Level was also significant [$F_{(2, 168)} = 153.13$, $p < 0.001$, $\eta_p^2 = 0.65$], RT in the low difficulty condition ($M = 464.04$, $SE = 10.08$) was shorter than that both of medium difficulty condition

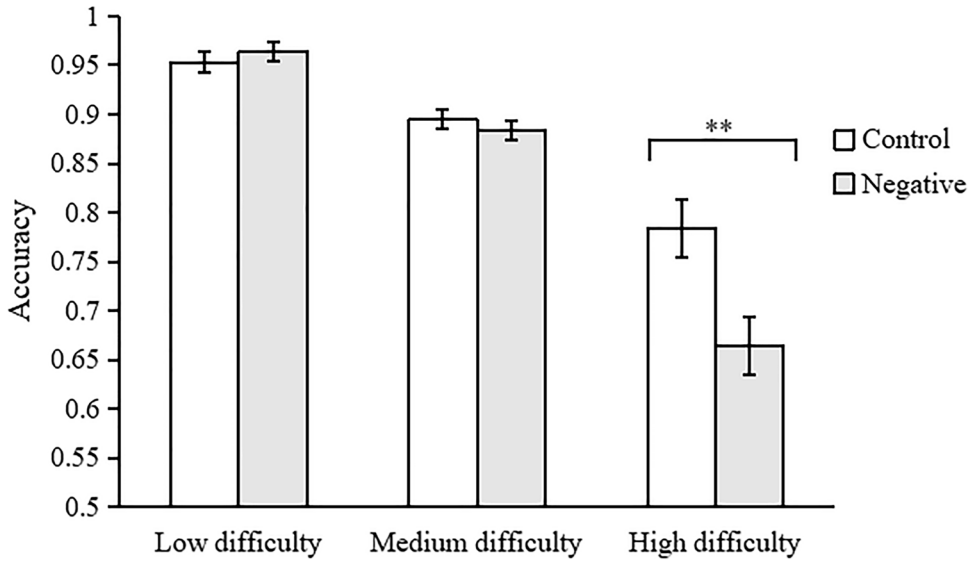

Fig. 2 Average accuracy under the different conditions

($M = 683.72$, $SE = 16.23$), (95% CI = 187.55–251.82) and the high difficulty condition ($M = 810.47$, $SE = 24.18$), (95% CI = 299.15–393.71); RT in the medium difficulty condition was shorter than that of high difficulty condition (95% CI = 88.12–165.38). The interaction between Activation Type and Task Level was not significant, $F_{(2, 168)} = 1.74$, $p = 0.179$, $\eta_p^2 = 0.02$.

Mediating effect of emotion

The correlation between the variables examined was shown in Table 3, which showed that meta-stereotype manipulation was significantly correlated with the performance of positive and negative emotion and the accuracy in the high difficulty condition.

To investigate the role of emotion in meta-stereotype threat and working memory performance, The Bootstrap method of the PROCESS in SPSS was used to evaluate the mediation (indirect) effect (Hayes, 2013). The repeated samples were set to 5000 times, and the 95% CI was calculated to run the mediation effect.

The results showed that the meta-stereotype threat negatively predicts positive emotions($\beta = -0.45$, $p = 0.036$, 95%CI = [-0.87, -0.03]); meta-stereotype threat positively predicts negative emotions ($\beta = 0.44$, $p = 0.043$, 95%CI = [0.01, 0.86]). Moreover, positive emotions positively predict working memory performance ($\beta = 0.34$, $p < 0.001$, 95%CI = [0.15, 0.54]); negative emotions negatively predict working memory ($\beta = -0.22$, $p = 0.026$, 95%CI = [-0.42, -0.03]). And the direct effect of meta-stereotype threat on working memory performance is also significant ($\beta = -0.45$, $p = 0.028$, 95%CI = [-0.84, -0.05]). But in the total model, the 95%CI in the indirect effect of negative emotion is contain 0. The results indicated that the effect of meta-stereotype threat on working memory was partly mediated by positive emotions (See Table 4).

The moderating effect of core self-evaluations

Model 5 of the PROCESS in SPSS was used to analyze the moderating effect. With meta-stereotype threat as the independent variable, positive emotions as the mediating

Table 3 Correlation coefficient between the various measured variables

Variable	1	2	3	4	5	6	7	8	9
1 Activation Type	1								
2 Positive emotion	-.23*	1							
3 Negative emotion	.22*	.07	1						
4 Accuracy in the low difficulty	.10	.01	.03	1					
5 Accuracy in the medium difficulty	-.07	.06	-.21*	.30**	1				
6 Accuracy in the high difficulty	-.35**	.38**	-.25*	.23*	.30**	1			
7 RT in the low difficulty	.11	-.14	-.10	-.13	-.06	-.13	1		
8 RT in the medium difficulty	.17	-.08	.03	.01	-.16	-.22*	.33**	1	
9 RT in the high difficulty	.21	-.15	-.06	.32**	.19	-.07	.27*	.61**	1

Table 4 The mediating effect of emotion

Path	Effect size	Relative effect size	95%CI
Meta-stereotype threat → Positive emotion → Accuracy of high difficulty	-.15	21.43%	[-.35, -.01]
Meta-stereotype threat → Negative emotion → Accuracy of high difficulty	-.10	14.28%	[-.26, .02]
Total mediating effect	-.25	35.71%	[-.47, -.07]
Total direct effect	-.45	64.29%	[-.84, -.05]

variable, and accuracy of high difficulty condition as the dependent variable, the core self-evaluations was added into the model. The results show that (Table 5), meta-stereotype threat can significantly predict positive emotions ($\beta = -0.45$, $p = 0.036$); meta-stereotype threat can also significantly predict accuracy ($\beta = -0.58$, $p = 0.004$). In addition, positive emotions can significantly predict accuracy ($\beta = 0.27$, $p = 0.013$). The product term of meta-stereotype threat and core self-evaluations predicted the accuracy significantly ($\beta = -0.49$, $p = 0.023$). The results showed that core self-evaluations moderated the relationship between meta-stereotype threat and working memory task performance.

In order to reveal the essence of the moderating effect more clearly, the core self-evaluations was divided into high and low groups according to one standard deviation of plus or minus, and a simple slope analysis was performed. When the core self-evaluations was low (M -1SD), with the increase of meta-stereotype threat score, the decreasing trend of accuracy of high task difficulty was not significant ($\beta_{simple} = -0.09$, $t = -0.34$, $p = 0.736$). When the core self-evaluations was high ($M + 1SD$), with the increase of the meta-stereotype threat score, the accuracy decreased significantly ($\beta_{simple} = -1.07$, $t = -3.67$, $p < 0.001$). This suggested that the effect of meta-stereotype threat on accuracy was greater when the core self-evaluations score was higher (Fig. 3).

Discussion

This study conducted two experiments to investigate the underlying mechanisms by which negative meta-stereotype threat affects working memory. Experiment 1 showed that negative meta-stereotypes had adverse effects on working memory and emotion. Specifically, participants under the threat condition had significantly more negative emotions and fewer positive emotions and poorer working memory. In this arrangement, negative meta-stereotypes affected working memory by reducing positive emotions. Experiment 2 further showed that negative meta-stereotypes produced greater threat effects in participants with high core self-evaluations.

Meta-stereotype threat reduce working memory performance

Most relevant studies have examined the adverse effects of negative meta-stereotypes on intergroup interactions (Méndez et al., 2007; Owuamalam et al., 2013; Van Leeuwen et al., 2014). Consistent with previous research, which revealed a decline in working memory performance on subjection to meta-stereotype threat (Li et al., 2021; Sun et al., 2015), this study found that meta-stereotype threat impaired cognitive resources associated with working memory. This effect may occur as individuals automatically increase their monitoring of threatening cues when negative meta-stereotypes are activated. In turn, occupied cognitive resources directly lead to diminished working memory performance (Beilock & DeCaro, 2007; Ståhl et al., 2012). Therefore, individuals incur additional cognitive burdens under meta-stereotype threat, thus increasing their response times during

Table 5 Bootstrap analysis for significance test of mediating effect

Regression equation		Fitting index			Regression coefficient	
Effect variable	Predictor variable	R	R^2	F	β	t
Positive emotion		.23	.05	4.55*		
	Meta-stereotype threat				-.45	-2.13*
Accuracy in high difficulty		.52	.27	7.42***		
	Positive emotion				.27	2.54*
	Meta-stereotype threat				-.58	-2.98**
	Core self-evaluations				.39	2.15*
	Meta-stereotype threat × Core self-evaluations				-.49	-2.33*

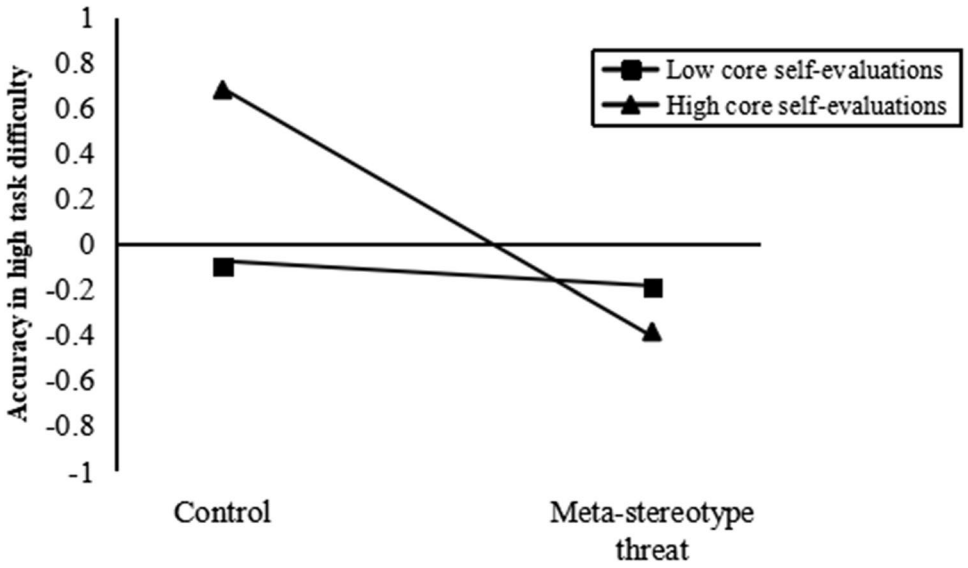

Fig. 3 The moderating effect of core self-evaluations on the relationship between mate-stereotype threat and the accuracy in high task difficulty

the completion of working memory tasks. This is even more problematic during more difficult tasks that require additional cognitive resources, wherein meta-stereotype threat causes greater interference and further reduce accuracy.

The mediating role of emotion

As previous studies have found the role of positive emotions between meta-stereotype and interpersonal communication that the negative meta-stereotype activation reduced interpersonal communication intention and is associated with lower positive emotions(Fowler & Gasiorek, 2018). We also found that meta-stereotype threat affects working memory through reduced positive emotions. Our results support emotion's role as an influential mechanism behind meta-stereotype threat. For example, it plays a vital role in intergroup relations fields (Fowler & Gasiorek, 2018; Owuamalam et al., 2013). Furthermore, our study is one of the first to delineate the mediating role of positive emotions in negative meta-stereotypes' effects on working memory. Therefore, these findings have expanded our understanding of the emotional mechanisms underlying these cognitive effects. The reason why positive emotions are the mechanism by which meta-stereotype threat affects working memory may be related to the fact that negative meta-stereotype causes the decline in positive emotions to occupy cognitive resources. When positive emotions decline, individuals may use more resources to compensate for the deterioration of emotions, which leads to the consumption of cognitive resources(Yüvrük et al., 2020) and then working memory performance impairment. Our findings are inconsistent with previous studies, which found the that negative emotions play a mediating role in meta-stereotype effects (Owuamalam & Zagefka, 2014; Owuamalam et al., 2013). The current study did not confirm this mediating effect. This may be because this study modeled positive and negative emotions simultaneously. Indeed, positive emotions had a significant mediating effect in the tolal model. However, negative emotions did not, indicating that positive affective states have a greater impact on the cognitive effects of meta-stereotypes. Thus, when positive emotions were included in the model, the role of negative emotions was diminished.

The moderating role of core self-evaluations

We also found that core self-evaluations moderated the relationship between meta-stereotype threat and working memory performance. Surprisingly, these findings seem counterintuitive in that the dominant effect of core self-evaluations disappears when individuals are under a meta-stereotype threat. At the same time, cognitive resources related to working memory are further consumed. This finding did not support conservation theory but did support the stress-vulnerability hypothesis (Wang et al., 2010). This may be because high core self-evaluations is more likely to conflict with self-perception when facing negative evaluations from outgroups (Finkelstein et al., 2020; Judge, 2009). Thus, individuals with high core self-evaluations perceive more serious threats. As for meta-stereotype threat (high-risk factors), high core self-evaluations did not play a role in resource conservation, but did influence stress vulnerability (Liu & Li, 2017). By contrast, individuals with low core self-evaluations have low evaluations of themselves, which reduces their vulnerability to threats. Thus, meta-stereotype threat intensify under higher core self-evaluation.

This study has theoretical and practical implications. As for the theoretical, we not only investigated the cognitive effects of meta-stereotype threat, but also more clearly

elaborated the paths and conditions of its influences. Specifically, emotion is an important pathway through which meta-stereotype threat affects cognition. When meta-stereotype threat occur, core self-evaluations is a pressure-vulnerable factor; that is, meta-stereotype threat has a greater impact on those with more core self-evaluation. As for the practical implications, our findings should be valuable in designing interventions to mitigate the adverse effects of meta-stereotype threat, specifically by working to enhance positive emotions. At the same time, the level of core self-evaluations should be considered, especially for individuals who think highly of themselves. Although most previous studies have reported that favorable core self-evaluations has positive effects, it also likely works as stress vulnerability factor, thus producing serious negative effects under high-risk conditions.

Limitations and future directions

Although this study provides interesting findings about the relationships between negative meta-stereotypes, emotion, and working memory, it also has some limitations. First, all participants were rural college students; although these individuals represent a typical group (Meng, 2013), additional research is needed to determine whether these results apply to other social groups. Second, we have suggested conditions for reducing the effects of meta-stereotype threat but did not actually implement them. This highlights the need for continued research to determine effective methods for reducing the adverse effects of negative meta-stereotypes. Third, individuals' working memory capacity may influence the effects of the negative meta-stereotype on working memory. It would be interesting and useful to investigate this possible effect to compare working memory capacity with the results of working memory tasks further in control and meta-stereotype threat conditions. Also it would be interesting to explore the degree of the threat registration at conscious level. Fourth, the apparent mechanisms of cognitive deficits promoted by meta-stereotypes observed in current study may involve distraction during the task. Whether the mechanisms are central aspects of cognition related to motivation would be a promising question to explore in future research. Moreover, the N-Back is a popular assessment of working memory. However, the N-Back has some limitations in measuring working memory (Kane et al., 2007; Miller et al., 2009). The 0- and 1-back manipulations do not fully engage the core cognitive processes of 2-back. In 0-back, working memory demand is absent. In 1-back, participants monitor for shape repeats only. This activity requires some retention of the previous shape. However, it does not involve constant buffer updating, as is true for 2-back. Thus, in the future, other tasks related to working memory could be used to test the relationship between the effect of meta-stereotype threat and working memory.

Data availability The data described in this article are openly available in the Open Science Framework at https://osf.io/ny3cg/?view_only=5e88d28cd653476b93797fc2885cbf00.

Declarations

Conflict of interest The authors declare that they had no conflict of interest with respect to their authorship or the publication of this article.

References

Alarcon, G. M., Edwards, J. M., & Menke, L. E. (2011). Student burnout and engagement: A test of the conservation of resources theory. *The Journal of Psychology, 145*(3), 211–227. https://doi.org/10.1080/00223980.2011.555432

Beckwé, M., & Deroost, N. (2016). Induced worrying impairs updating efficiency. *Journal of Psychology & Psychotherapy, 6*(266). https://doi.org/10.4172/2161-0487.1000266

Beilock, S. L., & DeCaro, M. S. (2007). From poor performance to success under stress: Working memory, strategy selection, and mathematical problem solving under pressure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(6), 983–998. https://doi.org/10.1037/0278-7393.33.6.983

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion, 6*(6), 409–434. https://doi.org/10.1080/02699939208409696

Finchilescu, G. (2010). Intergroup anxiety in interracial interaction: The role of prejudice and metastereotypes. *Journal of Social Issues, 66*(2), 334–351. https://doi.org/10.1111/j.1540-4560.2010.01648.x

Finkelstein, L. M., King, E. B., & Voyles, E. C. (2015). Age metastereotyping and cross-age workplace interactions: A meta view of age stereotypes at work. *Work Aging and Retirement, 1*(1), 26–40. https://doi.org/10.1093/workar/wau002

Finkelstein, L. M., Voyles, E. C., Thomas, C. L., & Zacher, H. (2020). A daily diary study of responses to age meta-stereotypes. *Work, Aging and Retirement, 6*(1), 28–45. https://doi.org/10.1093/workar/waz005

Fowler, C., & Gasiorek, J. (2018). Implications of metastereotypes for attitudes toward intergenerational contact. *Group Processes and Intergroup Relations, 23*(1), 48–70. https://doi.org/10.1177/1368430217744032

Fowler, C., & Gasiorek, J. (2019). Age metastereotypes and the content of imagined interage conversations. *Communication Research, 48*(2), 1–34. https://doi.org/10.1177/0093650219849351

Gordijn, E. H. (2010). When thinking that you are fat makes you feel worthless: Activation and application of meta–stereotypes when appearance matters. *Social Cognition, 28*(1), 20–39. https://doi.org/10.1521/soco.2010.28.1.20

Hayes, A. (2013). Introduction to mediation, moderation, and conditional process analysis. *Journal of Educational Measurement, 51*(3), 335–337. https://doi.org/10.1111/jedm.12050

Judge, T. A. (2009). Core Self-Evaluations and Work Success. *Current Directions in Psychological Science, 18*(1), 58–62. https://doi.org/10.1111/j.1467-8721.2009.01606.x

Judge, T. A., & Bono, J. E. (2001). Relationship of core self-evaluations traits–self-esteem, generalized self-efficacy, locus of control, and emotional stability–with job satisfaction and job performance:

A meta-analysis. *Journal of Applied Psychology, 86*(1), 80–92. https://doi.org/10.1037/0021-9010.86.1.80

Judge, T. A., Erez, A., Bono, J. E., & Thoresen, C. J. (2003). The core self-evaluations scale: Development of a measure. *Personnel Psychology, 56*(2), 303–331. https://doi.org/10.1111/j.1744-6570.2003.tb00152.x

Judge, T. A., Locke, E. A., Durham, C. C., & Kluger, A. N. (1998). Dispositional effects on job and life satisfaction: The role of core evaluations. *Journal of Applied Psychology, 83*, 17–34. https://doi.org/10.1037/0021-9010.83.1.17

Kane, M. J., Conway, A. R. A., Miura, T. K., & Colflesh, G. J. H. (2007). Working memory, attention control, and the n-back task: A question of construct validity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(3), 615–622. https://doi.org/10.1037/0278-7393.33.3.615

Lammers, J., Gordijn, E. H., & Otten, S. (2008). Looking through the eyes of the powerful. *Journal of Experimental Social Psychology, 44*(5), 1229–1238. https://doi.org/10.1016/j.jesp.2008.03.015

Li, D., Zhang, W., Li, X., Li, N., & Ye, B. (2012). Gratitude and suicidal ideation and suicide attempts among Chinese adolescents: Direct, mediated, and moderated effects. *Journal of Adolescence, 35*(1), 55–66. https://doi.org/10.1016/j.adolescence.2011.06.005

Li, J., & Nie, Y. (2010). Reflection and Prospect on Core Self-Evaluations. *Advances in Psychological Science, 18*(12), 1848–1857. CNKI:SUN:XLXD.0.2010-12-003.

Li, M., Wang, D., & He, W., (2021). A Study on the Cognitive Effects of Negative MetaStereotype Activation Among the Elderly People. *Journal of Psychological Science, 44*(2), 384–390. https://doi.org/10.16719/j.cnki.1671-6981.20210218

Liu, D., & Li, D., (2017). Parenting Styles and Adolescent Internet Addiction: An Examination of the Mediating and Moderating Roles of Ego-Resiliency. *Journal of Psychological Science, 40*(6), 107–113. https://doi.org/10.16719/j.cnki.1671-6981.20170617

Matera, C., Dalla Verde, S., & Meringolo, P. (2015). I like you more if I think you like me: The effect of metastereotypes on attitudes toward people with deafness. *The Journal of Social Psychology, 155*(4), 381–394. https://doi.org/10.1080/00224545.2015.1018857

Méndez, E., Tropp, L. R., & Gómez, Á. (2007). When metaperceptions are affected by intergroup processes. *International Journal of Psychology and Psychological Therapy, 7*(2), 237–250.

Meng, X. (2013). Investigation and Analysis of Stereotype and Metastereotype Characteristics of Urban and Rural College Students. *China Statistics,* (007), 55–57. CNKI:SUN:ZGTJ.0.2013–07–035

Miller, K. M., Price, C. C., Okun, M. S., Montijo, H., & Bowers, D. (2009). Is the n-back task a valid neuropsychological measure for assessing working memory? *Archives of Clinical Neuropsychology, 24*(7), 711–717. https://doi.org/10.1093/arclin/acp063

Owuamalam, C. K., & Zagefka, H. (2011). Downplaying a compromised social image: The effect of meta-stereotype valence on social identification. *European Journal of Social Psychology, 41*(4), 528–537. https://doi.org/10.1002/ejsp.805

Owuamalam, C. K., Issmer, C., Zagefka, H., Klaßen, M., & Wagner, U. (2013). Why Do Members of Disadvantaged Groups Strike Back at Perceived Negativity Towards the Ingroup? *Journal of Community and Applied Social Psychology, 24*(3), 249–264. https://doi.org/10.1002/casp.2165

Owuamalam, C., & Zagefka, H. (2013). We'll never get past the glass ceiling! Meta-stereotyping, world-views and perceived relative group-worth. *British Journal of Psychology, 104*(4), 543–562. https://doi.org/10.1111/bjop.12006

Owuamalam, C., & Zagefka, H. (2014). On the psychological barriers to the workplace: When and why metastereotyping undermines employability beliefs of women and ethnic minorities. *Cultural Diversity and Ethnic Minority Psychology, 20*(4), 521–528. https://doi.org/10.1037/a0037645

Qiu, L., Zheng, X., & Wang, Y. (2008). Revision of the Positive Affect and Negative Affect Scale. *Applied Psychology, 14*(3), 249–254. CNKI:SUN:YXNX.0.2008-03-009.

Ståhl, T., van Laar, C., & Ellemers, N. (2012). The role of prevention focus under stereotype threat: Initial cognitive mobilization is followed by depletion. *Journal of Personality and Social Psychology, 102*(6), 1239–1251. https://doi.org/10.1037/a0027678

Stephan, W., & Stephan, C. (1985). Intergroup anxiety. *Journal of Social Issues, 41*(3), 157–175. https://doi.org/10.1111/j.1540-4560.1985.tb01134.x

Sun, Y., He, W., & Luo, J. (2015). Meta-stereotype threat effects on working memory among migrant children: Mediating effects of intergroup anxiety. *Acta Psychologica Sinica, 47*(11), 1349–1359. https://doi.org/10.3724/SP.J.1041.2015.01349

Van Leeuwen, E., Oostenbrink, J. J., & Twilt, A. (2014). The combined effects of meta-stereotypes and audience on outgroup and ingroup helping. *Group Dynamics Theory Research and Practice, 18*(3), 189–202. https://doi.org/10.1037/gdn0000005

Vorauer, J. D., Main, K. J., & O'Connell, G. B. (1998). How do individuals expect to be viewed by members of lower status groups? Content and implications of meta-stereotypes. *Journal of Personality and Social Psychology, 75*(4), 917–937. https://doi.org/10.1037/0022-3514.75.4.917

Voyles, E., Finkelstein, L., & King, E. (2014). A tale of two theories: Stereotype threat and metastereotypes. *Industrial and Organizational Psychology, 7*(3), 419–422. https://doi.org/10.1111/iops.12171

Wang, J., Li, D., & Zhang, W. (2010). Adolescence's Family Financial Difficulty and Social Adaptation: Coping efficacy of compensatory, mediation, and moderation effects. *Journal of Beijing Normal University (social Science Edition), 4*, 24–34. https://doi.org/10.3969/j.issn.1002-0209.2010.04.002

Yüvrük, E., Kapucu, A., & Amado, S. (2020). The effects of emotion on working memory: Valence versus motivation. *Acta Psychologica, 202*, 102983. https://doi.org/10.1016/j.actpsy.2019.102983