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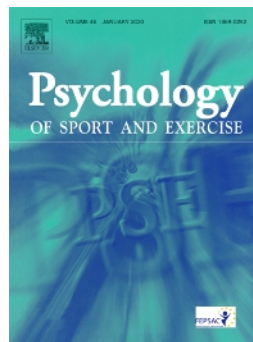
“The threat is in the head, not in the legs”:
Activating negative age stereotypes generates extra cognitive load during walking

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Highlights

- Activating negative age stereotypes impaired Stroop performance during walking
- Activating negative age stereotypes did not impair walking performance
- Results suggest stereotype threat occurs even if motor performance is unaffected
- Data were analyzed using linear mixed models to reduce risk of Type I error

Abstract

Objective. Activating negative age stereotypes has been consistently shown to impair cognitive performance in older adults, but not motor performance, especially on mobility tasks. We tested the hypothesis that older adults may still *experience* stereotype threat, even if mobility performance is not affected. To do so, we examined whether inducing negative stereotypes may increase cognitive load during a walking task.

Method. This question was investigated in a dual-task paradigm: older adults performed simultaneously a walking task and a Stroop task, in stereotype and control conditions.

Results. Results showed that the stereotype induction did not affect walking parameters but decreased performance on the Stroop task, indicating that this induction increased cognitive load during walking.

Discussion. These results suggest that negative age stereotypes may be damaging even if walking parameters are not affected, by altering older adults' attention to their walking environment. We conclude by highlighting theoretical and practical implications.

Keywords: stereotype threat; older adults; mobility; cognitive load.

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1. Introduction

Age stereotypes are prevalent in western societies, with aging being associated with physical decline, frailty, weakness, sickness, helplessness, and dependency (e.g., Hummert, 1990). Importantly, these negative stereotypes have been shown to impact older adults' motor performance. For example, telling older participants that they would be compared to younger people impaired their performance on a handgrip test by up to 50% as compared to control participants (Swift, Lamont, & Abrams, 2012). This performance reduction may result from the concern of being judged negatively based on age stereotypes, a phenomenon called stereotype threat (e.g., Hess, Auman, Colcombe, & Rahhal, 2003): people may fear being judged in terms of their age, and these negative thoughts and feelings may disrupt their performance, resulting in the confirmation of the stereotype.

However, although stereotype threat effects have been consistently observed on older adults' cognitive performance (for a meta-analysis see Lamont, Swift, & Abrams, 2015), results on motor performance are mixed: whereas a few studies have reported this phenomenon (Barber, Hamel, Ketcham, Lui, & Taylor-Ketcham, 2020; Chiviacowsky, Cardozo, & Chalabaev, 2018; Swift et al., 2012), most research showed no significant stereotype threat effect (Lamont et al., 2015), and more especially on tasks assessing stability during gait (Hausdorff, Levy, & Wei, 1999; Horton, Baker, Pearce, & Deakin, 2010; Marquet et al., 2018; Moriello, Cotter, Shook, Dodd-McCue, & Welleford, 2013). This absence of effect may be due to the task usually used to assess mobility: preferred walking speed, also called comfortable gait speed, which is considered a valid index of general physical health and is associated with independent living in older adults

(Alexander, 1996). This parameter is evaluated by asking individuals to walk at the speed they consider normal, which makes the task non-difficult. One may contend that stereotype threat is not relevant in such situations, because performing an easy task is unlikely to be interfered with by the pressure generated by stereotypes (e.g., Spencer, Steele, & Quinn, 1999). A recent study confirmed this assertion, by showing stereotype threat effects on a difficult gait task (i.e., walking within a 15 cm narrow base of support) but not on preferred walking speed in older adults (Barber et al., 2020).

Does this suggest that older adults are immune to aging stereotypes when they walk at their own pace? We do not believe so, and propose that even if preferred walking speed is not affected by negative stereotypes, older adults may still *experience* stereotype threat in this situation. Indeed, activating negative stereotypes has been shown to affect task performance, but also to induce negative thoughts as well as monitoring of the self and one's own behavior (Schmader, Johns, & Forbes, 2008). These psychological consequences could be present when assessing mobility. We propose to capture them by measuring cognitive load during walking: if an extra cognitive load is observed when walking under stereotype threat, this would suggest that older adults experience stereotype threat (Schmader et al., 2008). We investigated this hypothesis based on a dual-task paradigm, in which participants simultaneously performed a walking task and a Stroop task (Boisgontier, Beets, Duysens, Nieuwboer, Krampe, & Swinnen, 2013; Palluel, Nougier, & Olivier, 2010). If inducing stereotypes generates additional cognitive load, this should impair performance on the Stroop task (Boisgontier, Olivier, Chenu, & Nougier, 2011). We examined whether this effect may be generalized across different Stroop task difficulties. Finally, in line with past research (Barber et al., 2020; Hausdorff et al., 1999; Horton et al., 2010;

Marquet et al., 2018; Moriello et al., 2013), we did not expect walking parameters to be affected by the stereotype activation.

This question has important practical implications as preferred walking speed is the most typical type of mobility observed in everyday life. If older adults' attention to the walking environment is altered by the presence of negative stereotypes, this could result in increased fall risk (Muir, Gopaul, & Montero Odasso, 2012), even if walking speed is not affected.

2. Methods

2.1. Participants

Based on the meta-analysis of Lamont et al. (2015), we expected an effect size of $d=.57$, given that stereotypes effects were hypothesized on cognitive performance (not walking). The a priori power analysis indicated that a total sample size of 24 (80% power) to 36 participants (95% power) was necessary for a within-subject design. The study sample included 27 retired older adults (20 women, $M_{age}=81.93$, $SD=7.76$) recruited in retirement homes or fall prevention classes. All participants were physically and cognitively well (as attested by a medical certificate), lived independently at home or in assisted living facilities. Inclusion criteria were the ability to read the Stroop words projected on the screen, the ability to walk without assistance, and no history of significant trauma, illness, or mood disturbance.

2.2. Procedure and measures

This research was approved by the Institutional Review Board at Univ. Grenoble Alpes. Older adults took part in all conditions of a 2 (negative stereotype / control) \times 3 (Stroop-congruent / Stroop-incongruent / no Stroop) within-subject design. Individual sessions took place in quiet places either at the retirement home or at the gymnasium where fall prevention lessons were provided. After having signed the consent form, participants completed questions relating

to their *sex*, *chronological age*, *subjective age*, (“how old do you feel most of the time?”, response from 0 to 120 years; Stephan, Chalabaev, Kotter-Grühn, & Jaconelli, 2013), *self-rated health* (“In general, how would you rate your current health status?”, response from (1) very bad to (6) very good; Benyamini, Leventhal, & Leventhal, 2003), *balance confidence* (“To what extent are you confident in your balance?”, response from (1) not at all confident to (4) very confident; Hadjistavropoulos et al., 2012), and *fear of falling* (“In general, do you fear falling?”, response from (1) not at all to (7) very much; Hadjistavropoulos et al., 2012).

Participants then performed the dual-task protocol, in stereotype and control conditions (order was counterbalanced across participants). The within-subject manipulation of stereotype threat was based on past research (Deshayes, Clément-Guillotin, & Zory, 2019; Deshayes, Zory, Seitchik, Chalabaev, & Clément-Guillotin, 2019; Deshayes, Zory, Seitchik, Chalabaev, & Clément-Guillotin, in press). More particularly, given the within-subject nature of the design, we did not activate stereotypes by manipulating task diagnosticity, as is classically done in stereotype threat research. Indeed, we reasoned that it was not credible to present to the same participants the task as diagnostic of motor ability in one condition, and as non-diagnostic of the same ability in another condition. Instead, stereotypes were activated by telling participants that their walking performance would be compared to younger adults (stereotype condition) or to adults of the same age (control condition) (Swift et al., 2012). More particularly, negative age stereotypes were activated by informing participants that the goal of the study was to examine differences in walking parameters between older adults and younger adults. They were further informed that older adults referred to people aged 65 years and over, and that younger adults referred to people aged 30 years and less. In the control condition, participants were told that the goal of the study was to examine differences in walking parameters among older adults aged 65

years and over. While participants may perceive aging as a potential explanation of age differences in performance in the former group, this is less likely to be the case in the latter group, which emphasized individual differences in mobility.

Participants had to walk at a self-paced speed over a 5.20 m long Gaitrite® electronic walkway. Participants started and finished walking 2.50 m before and after the walkway. Three parameters were analyzed with the Gaitrite software: two temporal parameters – velocity (i.e., preferred walking speed) and cadence – and one spatial parameter – step length. Velocity and step length were normalized for each participant with respect to their limb length. These parameters were chosen because they are classically used in clinical settings to distinguish between fallers and non-fallers (Hamacher, Singh, Van Dieen, Heller, & Taylor, 2011).

In both stereotype and control conditions, participants performed the walking task under three modalities: in one condition, participants fixated a cross located at the centre of a screen (200 cm × 150 cm) that was placed 3 m after the walkway. In the second and third conditions, they performed a verbal Stroop task: they were instructed to name as quickly and as accurately as possible the color of words that appeared on the screen, while walking on the walkway. Presentation of Stroop words started simultaneously with the walking task on the “go” signal. Words were presented one by one on the screen and the following word was immediately presented once participants had named the color of the displayed word. In the Stroop congruent (easy) condition, the word’s color matched with its semantic meaning (e.g., *grey* in grey ink). In the Stroop incongruent (difficult) condition, the word’s color did not match with its semantic meaning. Because the incongruent task requires maintaining the goal of naming each word’s color while inhibiting the automatic tendency to read it, it is thought to require more attentional resources than the congruent task (Engle, 2002). Order of Stroop task difficulty was

counterbalanced across participants. Participants provided their responses out loud and the experimenter reported them on a computer. Responses were also recorded with a tie-clip microphone, enabling us to measure the time in milliseconds taken by participants to provide each response. No performance feedback was provided. Performance was assessed by the number of correct responses, the number of errors, and response time (Palluel et al., 2010).

Before each Stroop condition, participants performed three familiarization trials. Three trials were then performed in each condition (18 trials in total: 3 trials x 3 cognitive load conditions x 2 stereotype conditions). In order to prevent dissipation of stereotypes effects over time (Lamont et al., 2015), the stereotype-related instructions were repeated every three trials. Finally, participants were fully debriefed and thanked. No one was suspicious about the true goal of the study.

2.3. Analytical strategy

Data were analyzed using linear mixed models. Unlike traditional analyses of variance, linear mixed models consider the sampling variability of both participants and experimental conditions, reducing therefore the risk of Type 1 error (Boisgontier & Cheval, 2016). Moreover, these models allow generalizing the results not only to the population of participants, but to the population of conditions as well. Finally, linear mixed models prevent information loss due to averaging of observations, as the model accounts for all single trials (e.g., Boisgontier et al., 2017).

Specifically, performance on the cognitive and motor task were analyzed using linear mixed models, with participants and cognitive task difficulty as random factors. The stereotype condition was coded as follows: 0=stereotype condition and 1=control condition. The continuous covariates were centered on zero. The stereotype condition (negative stereotype vs. control) was

included as a predictor, as well as the covariates (sex, chronological age, subjective age, self-rated health, balance confidence, and fear of falling). In addition, order of trials was included in the model to control for potential fatigue and/or learning effects (e.g., Lemay, Bédard, Rouleau, & Tremblay, 2010). Order of the stereotype condition was also included in order to control for potential spillover effects. Indeed, activating negative stereotypes first may have altered subsequent performance in the control condition.

The equation was as follows:

$$Y_{ij} = (\beta_0 + \gamma_{0i} + \theta_{0j}) + \beta_1 \text{Stereotype}_{ij} + \beta_2 \text{Trial}_{ij} + \beta_3 \text{Stereotype order}_j + \beta_4 \text{Sex}_j + \beta_5 \text{Chronological age}_j + \beta_6 \text{Subjective age}_j + \beta_7 \text{Self-rated health}_j + \beta_8 \text{Balance confidence}_j + \beta_9 \text{Fear of falling}_j + \varepsilon_{ij}$$

where Y_{ij} is the participant j 's score in the Stroop condition i , β_0 to β_9 are the fixed effect coefficients, γ_{0i} is the random effect for condition i [random intercept], θ_{0j} is the random effect for participant j [random intercept], and ε_{ij} is the error term, with Stroop condition i being nested within participant j .

In order to obtain the more parsimonious models, we compared for each outcome a model that included all potential covariates (Model 1) and a model that included the significant covariates only (Model 1 bis). The fit of the models was compared using the Akaike information criterion (AIC), which enables selecting among models, with lower scores indicating a more accurate fit.

3. Results

3.1. Cognitive performance

Concerning the number of correct responses on the Stroop task, Model 1 bis predicted the data more accurately than Model 1 ($\Delta\text{AIC}=-10.043$). Results showed a significant effect of the stereotype condition, $b=0.303$, $p=.018$, and of trials order, $b=-0.036$, $p=.004$ (indicating a fatigue

effect). In other words, participants provided less correct responses in the stereotype condition than in the control condition. No other effects reached significance (see Appendix, Table 1).

Concerning the number of errors and response times on the Stroop task, results did not show any significant effects of the stereotype condition, indicating that activating negative stereotypes did not affect the number of errors or response times (see Appendix, Tables 2 and 3).

3.2. Walking performance

Results indicated no significant change in cadence, velocity, or step length, following the stereotype activation (see Appendix, Tables 4, 5 and 6), although a marginal effect was observed on velocity ($b=-0.026$, $p=.067$), such that participants tended to walk faster in the stereotype condition than in the control condition.

4. Discussion

This study examined if activating negative age stereotypes generates extra cognitive load during walking. Results were in line with this hypothesis, as indicated by reduced performance (i.e., number of correct responses) on the Stroop task following stereotype activation. This effect was obtained with linear mixed models, which are more stringent than traditional analyses to prevent false positives, and was observed irrespective of Stroop task difficulty. This suggests that the presence of negative age stereotypes increased cognitive load during walking in a significant manner (Boisgontier et al., 2011). Consistent with past research (Barber et al., 2020; Hausdorff et al., 1999; Horton et al., 2010; Marquet et al., 2018; Moriello et al., 2013), walking parameters were not significantly affected by the stereotype manipulation when older adults were asked to walk at their normal speed (although they tended to walk faster in the stereotype condition than in the control condition). A possible explanation is that stereotype threat may not be damaging in this situation, because task demands are not high enough. Therefore, performance is unlikely to

be interfered with by the pressure generated by stereotypes (e.g., Barber et al., 2020; Hess, Emery, & Queen, 2009; Spencer, Steele, & Quinn, 1999).

Interestingly, although the stereotype induction was specific to walking, the performance reduction was not observed on walking, but on the cognitive task, whereas the latter was not relevant to the age stereotype. This result is consistent with the integrated process model of stereotype threat (Schmader et al., 2008), according to which people in a stereotype threat situation are strongly motivated to avoid failure, especially older adults (Popham & Hess, 2015). This motivation may generate distracting thoughts (e.g., worries, evaluation apprehension), which may have prevented older adults from directing their attention to their immediate walking environment (i.e. Stroop task). Consistent with this idea, people tend to prioritize postural control and gait over cognitive activity under threat conditions, and this “posture/gait first principle” has been particularly observed in older adults (Yogev-Seligmann, Hausdorff, & Giladi, 2012). Another potential explanation of these results is related to the stereotype threat spillover hypothesis, according to which coping with the stress of stereotype confirmation leaves people in a depleted volitional state, making them less likely to engage in effortful inhibition of their automatic tendencies (e.g., Inzlicht & Kang, 2010), such as on a Stroop task.

In terms of practical implications, this study suggests that negative age stereotypes may be damaging even if they do not alter walking parameters. Indeed, when people walk, they need to pay attention to potential obstacles and external perturbations. If their attention to the walking environment is altered by the presence of negative stereotypes, this could result in increased fall risk (Muir, Gopaul, & Montero Odasso, 2012). This risk may be non-negligible in daily life, where motor tasks are commonly paired with cognitive tasks (e.g., talking while standing or walking), and this attentional limitation could be particularly problematic given evidence that

older adults need more attentional resources to perform postural tasks than younger ones (Boisgontier et al., 2013).

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Appendix

Table 1.

Linear mixed models predicting the number of correct responses on the Stroop task

Parameters	Model 1			Model 1 bis		
	b	SE	p	b	SE	p
Fixed effects						
Intercept	7.485	3.285	.034	5.270	1.067	.004
Stereotype condition	0.303	0.127	.018	0.303	0.127	.018
Trials order	-0.036	0.013	.004	-0.036	0.013	.004
Stereotype condition order	-0.206	0.474	.669	-0.170	0.401	.675
Sex	0.252	0.549	.459			
Chronological age	-0.004	0.035	.908			
Subjective age	-0.006	0.017	.733			
Self-rated health	0.068	0.448	.880			
Balance confidence	-0.886	0.406	.042	-0.479	0.269	.087
Fear of falling	-0.239	0.187	.218			
Random effects						
	σ^2			σ^2		
Participant intercept	1.022	0.367	.005	0.905	0.293	.002
Stroop condition intercept	0.974	1.389	.483	0.974	1.389	.483
Akaike information criterion	1093.854			1083.811		
Residual	1.307			1.307		

Note. The stereotype condition was coded as follows: 0=stereotype condition and 1=control condition. Sex was coded as follows: 0=women and 1=men. Trials order represented the order in which each trial was performed and ranged from 1 to 18.

Table 2.

Linear mixed models predicting the number of errors on the Stroop task.

Parameters	Model 1			Model 1 bis		
	b	SE	<i>p</i>	b	SE	<i>p</i>
Fixed effects						
Intercept	-2.730	1.557	.095	0.416	0.377	.406
Stereotype condition	-0.135	0.090	.136	-0.135	0.090	.136
Trials order	0.002	0.009	.846	0.002	0.009	.843
Stereotype condition order	0.279	0.225	.229	0.248	0.213	.255
Sex	0.214	0.260	.421			
Chronological age	0.035	0.017	.052			
Subjective age	0.003	0.008	.720			
Self-rated health	0.060	0.212	.782			
Balance confidence	-0.125	0.192	.524			
Fear of falling	0.058	0.089	.520			
Random effects						
	σ^2			σ^2		
Participant intercept	0.198	0.082	.016	0.250	0.087	.004
Stroop condition intercept	0.218	0.314	.488	0.218	0.314	.488
Akaike information criterion	864.210			852.803		
Residual	0.663			0.663		

Note. The stereotype condition was coded as follows: 0=stereotype condition and 1=control condition. Sex was coded as follows: 0=women and 1=men.

Table 3.

Linear mixed models predicting response times on the Stroop task.

	Model 1			Model 1 bis		
Parameters	b	SE	<i>p</i>	b	SE	<i>p</i>
Fixed effects						
Intercept	-1.452	1.057	.186	-0.840	0.755	.278
Stereotype condition	0.011	0.057	.857	0.013	0.057	.822
Trials order	-0.007	0.006	.185	-0.007	0.006	.176
Stereotype condition order	0.074	0.152	.635	0.102	0.134	.454
Sex	0.143	0.181	.442			
Chronological age	0.034	0.011	.008	0.027	0.009	.005
Subjective age	0.002	0.006	.733			
Self-rated health	-0.230	0.152	.147			
Balance confidence	0.244	0.138	.095			
Fear of falling	0.067	0.618	.289			
Random effects						
	σ^2			σ^2		
Participant intercept	0.093	0.039	.017	0.094	0.035	.008
Stroop condition intercept	0.090	0.130	.487	0.091	0.131	.487
Akaike information criterion	501.249			488.104		
Residual	0.236			0.236		

Table 4.

Linear mixed models predicting cadence.

	Model 1			Model 1 bis		
Parameters	b	SE	<i>p</i>	b	SE	<i>p</i>
Fixed effects						
Intercept	141.210	37.710	.001	97.262	5.347	.000
Stereotype condition	-1.650	0.972	.090	-1.658	0.972	.089
Trials order	0.542	0.094	.000	0.542	0.094	.000
Stereotype condition order	-2.554	5.551	.651	-1.429	5.739	.805
Sex	-14.862	6.420	.032	-7.745	6.544	.248
Chronological age	-0.861	0.413	.051			
Subjective age	-0.120	0.203	.561			
Self-rated health	8.365	5.245	.127			
Balance confidence	0.937	4.754	.846			
Fear of falling	-0.292	2.193	.895			
Random effects						
	σ^2			σ^2		
Participant intercept	148.531	50.240	.003	203.758	60.663	.001
Stroop condition intercept	31.035	31.741	.328	31.005	31.712	.328
Akaike information criterion	3654.523			3677.979		
Residual	111.839			111.841		

Note. Trials order represented the order in which each trial was performed and ranged from 1 to 18.

Table 5.

Linear mixed models predicting velocity.

	Model 1			Model 1 bis		
Parameters	b	SE	<i>p</i>	b	SE	<i>p</i>
Fixed effects						
Intercept	1.403	0.830	.107	0.864	0.107	.000
Stereotype condition	-0.026	0.014	.068	-0.026	0.014	.067
Trials order	0.013	0.001	.000	0.013	0.001	.000
Stereotype condition order	-0.135	0.122	.285	-0.058	0.124	.648
Sex	-0.344	0.142	.025	-0.160	0.142	.269
Chronological age	-0.019	0.009	.052			
Subjective age	0.001	0.004	.829			
Self-rated health	0.217	0.116	.077			
Balance confidence	0.049	0.105	.644			
Fear of falling	-0.014	0.048	.777			
Random effects						
	σ^2			σ^2		
Participant intercept	0.074	0.024	.002	0.098	0.029	.001
Stroop condition intercept	0.009	0.010	.325	0.098	0.029	.001
Akaike information criterion		-276.312			-291.811	
Residual	0.023			0.023		

Note. Velocity was normalized for each participant with respect to their limb length.

Trials order represented the order in which each trial was performed and ranged from 1 to 18.

Table 6.

Linear mixed models predicting step length.

Parameters	Model 1			Model 1 bis		
	b	SE	<i>p</i>	b	SE	<i>p</i>
Fixed effects						
Intercept	60.369	29.072	.052	45.405	3.526	.000
Stereotype condition	-0.742	0.530	.162	-0.744	0.530	.161
Trials order	0.408	0.051	.000	0.408	0.051	.000
Stereotype condition order	-3.429	4.288	.434	-0.053	4.113	.990
Sex	-5.564	4.960	.276			
Chronological age	-0.530	0.319	.113			
Subjective age	0.064	0.156	.688			
Self-rated health	3.107	4.051	.453			
Balance confidence	5.419	3.672	.156			
Fear of falling	-0.807	1.694	.639			
Random effects						
	σ^2			σ^2		
Participant intercept	90.530	30.000	.003	112.123	32.263	.001
Stroop condition intercept	10.025	10.235	.327	10.026	10.236	.327
Akaike information criterion	3103.940			3128.514		
Residual	33.255			33.255		

Note. Step length was normalized for each participant with respect to their limb length.

Trials order represented the order in which each trial was performed and ranged from 1 to 18.