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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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1 “The threat is in the head, not in the legs”:

2 Activating negative age stereotypes generates extra cognitive load during walking

### 3 **1. Introduction**

4 Age stereotypes are prevalent in western societies, with aging being associated with  
5 physical decline, frailty, weakness, sickness, helplessness, and dependency (e.g., Hummert,  
6 1990). Importantly, these negative stereotypes have been shown to impact older adults’ motor  
7 performance. For example, telling older participants that they would be compared to younger  
8 people impaired their performance on a handgrip test by up to 50% as compared to control  
9 participants (Swift, Lamont, & Abrams, 2012). This performance reduction may result from the  
10 concern of being judged negatively based on age stereotypes, a phenomenon called stereotype  
11 threat (e.g., Hess, Auman, Colcombe, & Rahhal, 2003): people may fear being judged in terms of  
12 their age, and these negative thoughts and feelings may disrupt their performance, resulting in  
13 the confirmation of the stereotype.

14 However, although stereotype threat effects have been consistently observed on older  
15 adults’ cognitive performance (for a meta-analysis see Lamont, Swift, & Abrams, 2015), results  
16 on motor performance are mixed: whereas a few studies have reported this phenomenon (Barber,  
17 Hamel, Ketcham, Lui, & Taylor-Ketcham, 2020; Chiviacowsky, Cardozo, & Chalabaev, 2018;  
18 Swift et al., 2012), most research showed no significant stereotype threat effect (Lamont et al.,  
19 2015), and more especially on tasks assessing stability during gait (Hausdorff, Levy, & Wei,  
20 1999; Horton, Baker, Pearce, & Deakin, 2010; Marquet et al., 2018; Moriello, Cotter, Shook,  
21 Dodd-McCue, & Welleford, 2013). This absence of effect may be due to the task usually used to  
22 assess mobility: preferred walking speed, also called comfortable gait speed, which is considered  
23 a valid index of general physical health and is associated with independent living in older adults

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

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

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

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

## 52 **2. Methods**

### 53 **2.1. Participants**

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

### 63 **2.2. Procedure and measures**

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

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

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

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

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

102 In both stereotype and control conditions, participants performed the walking task under  
103 three modalities: in one condition, participants fixated a cross located at the centre of a screen  
104 (200 cm × 150 cm) that was placed 3 m after the walkway. In the second and third conditions,  
105 they performed a verbal Stroop task: they were instructed to name as quickly and as accurately as  
106 possible the color of words that appeared on the screen, while walking on the walkway.  
107 Presentation of Stroop words started simultaneously with the walking task on the “go” signal.  
108 Words were presented one by one on the screen and the following word was immediately  
109 presented once participants had named the color of the displayed word. In the Stroop congruent  
110 (easy) condition, the word’s color matched with its semantic meaning (e.g., *grey* in grey ink). In  
111 the Stroop incongruent (difficult) condition, the word’s color did not match with its semantic  
112 meaning. Because the incongruent task requires maintaining the goal of naming each word’s  
113 color while inhibiting the automatic tendency to read it, it is thought to require more attentional  
114 resources than the congruent task (Engle, 2002). Order of Stroop task difficulty was

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

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

### 126 **2.3. Analytical strategy**

127 Data were analyzed using linear mixed models. Unlike traditional analyses of variance,  
128 linear mixed models consider the sampling variability of both participants and experimental  
129 conditions, reducing therefore the risk of Type 1 error (Boisgontier & Cheval, 2016). Moreover,  
130 these models allow generalizing the results not only to the population of participants, but to the  
131 population of conditions as well. Finally, linear mixed models prevent information loss due to  
132 averaging of observations, as the model accounts for all single trials (e.g., Boisgontier et al.,  
133 2017).

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

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

144 The equation was as follows:

145 
$$Y_{ij} = (\beta_0 + \gamma_{0i} + \theta_{0j}) + \beta_1 \text{Stereotype}_{ij} + \beta_2 \text{Trial}_{ij} + \beta_3 \text{Stereotype order}_j + \beta_4 \text{Sex}_j + \beta_5$$
  
146 
$$\text{Chronological age}_j + \beta_6 \text{Subjective age}_j + \beta_7 \text{Self-rated health}_j + \beta_8 \text{Balance confidence}_j + \beta_9 \text{Fear}$$
  
147 
$$\text{of falling}_j + \varepsilon_{ij}$$
, where  $Y_{ij}$  is the participant  $j$ 's score in the Stroop condition  $i$ ,  $\beta_0$  to  $\beta_9$  are the  
148 fixed effect coefficients,  $\gamma_{0i}$  is the random effect for condition  $i$  [random intercept],  $\theta_{0j}$  is the  
149 random effect for participant  $j$  [random intercept], and  $\varepsilon_{ij}$  is the error term, with Stroop condition  
150  $i$  being nested within participant  $j$ .

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

### 156 **3. Results**

#### 157 **3.1. Cognitive performance**

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

161 effect). In other words, participants provided less correct responses in the stereotype condition  
162 than in the control condition. No other effects reached significance (see Appendix, Table 1).  
163 Concerning the number of errors and response times on the Stroop task, results did not show any  
164 significant effects of the stereotype condition, indicating that activating negative stereotypes did  
165 not affect the number of errors or response times (see Appendix, Tables 2 and 3).

### 166 **3.2. Walking performance**

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

## 171 **4. Discussion**

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

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

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

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

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

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