Implicit activation of the aging stereotype influences effort-related cardiovascular response: The role of incentive

ZAFEIRIOU, Athina, GENDOLLA, Guido H.E.

Abstract

Based on previous research on implicit effects on effort-related cardiovascular response and evidence that aging is associated with cognitive difficulties, we tested whether the mere activation of the aging stereotype can systematically influence young individuals’ effort-mobilization during cognitive performance. Young participants performed an objectively difficult short-term memory task during which they processed elderly vs. youth primes and expected low vs. high incentive for success. When participants processed elderly primes during the task, we expected cardiovascular response to be weak in the low-incentive condition and strong in the high-incentive condition. Unaffected by incentive, effort in the youth-prime condition should fall in between the two elderly-prime cells. Effects on cardiac pre-ejection period (PEP) and heart rate (HR) largely supported these predictions. The present findings show for the first time that the mere activation of the aging stereotype can systematically influence effort mobilization during cognitive performance—even in young adults.

Reference


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Implicit activation of the aging stereotype influences effort-related cardiovascular response: The role of incentive☆

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A B S T R A C T

Based on previous research on implicit effects on effort-related cardiovascular response and evidence that aging is associated with cognitive difficulties, we tested whether the mere activation of the aging stereotype can systematically influence young individuals’ effort-mobilization during cognitive performance. Young participants performed an objectively difficult short-term memory task during which they processed elderly vs. youth primes and expected low vs. high incentive for success. When participants processed elderly primes during the task, we expected cardiovascular response to be weak in the low-incentive condition and strong in the high-incentive condition. Unaffected by incentive, effort in the youth-prime condition should fall in between the two elderly-prime cells. Effects on cardiac pre-ejection period (PEP) and heart rate (HR) largely supported these predictions. The present findings show for the first time that the mere activation of the aging stereotype can systematically influence effort mobilization during cognitive performance—even in young adults.

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1. Introduction

We are living in a complex social environment in which people must adapt by finding cognitive tools helping them to simplify their perception, judgments, and actions. Social stereotypes are such a cognitive tool—they are mental representations of groups of people that reflect beliefs about group members’ characteristics (see McGarty et al., 2002). Most likely, stereotypes’ function is to preserve resources and organize our perception of the complex social reality (Macrae et al., 1994).

A typical and strong stereotype in the Western culture is the negative aging-stereotype—the idea that aging is associated with a decline in cognitive efficiency (Harada et al., 2013). Most Western people associate aging with cognitive difficulties (Cuddy et al., 2005; Cuddy and Fiske, 2002; Kite and Wagner, 2002; Kite et al., 2005). Moreover, aging research has shown that older people indeed mobilize more effort in cognitive tasks, mirrored by stronger cardiovascular reactivity, than younger people to attain the same level of cognitive performance (Smith and Hess, 2015). Correspondingly, older people experience higher subjective task demand and show stronger effort-related cardiovascular response than younger individuals if they are facing cognitive challenges of the same objective task difficulty level (Hess et al., 2015). Aging effects on subjective task demand are even stronger among elderly suffering from mild cognitive impairment, leading already to disengagement due to excessive subjective demand in objectively easy cognitive tasks (Stewart et al., 2016).

Based on the evidence that aging is associated with cognitive difficulties and that most people in the Western culture believe that this is a general effect, the basic idea of the present research was that the implicit activation of the aging stereotype can systematically influence effort-related cardiovascular response when people are confronted with a cognitive challenge. Extending previous research, we posit that not only biological aging is associated with cognitive difficulties and resulting effects on effort (Smith and Hess, 2015; Hess et al., 2016), but that the mere activation of the aging stereotype should have a similar effect—even in young people. The reason for our hypothesis is that cognitive difficulties are a central feature of the aging stereotype and that the implicit activation of this stereotype should render the performance difficulty concept accessible. This should in turn augment experienced task demand and affect effort during cognitive performance.

Our hypothesis is grounded in a recent research program on the impact of the implicit activation of emotion stereotypes on cognitive effort that was guided by the Implicit-Affect-Primes-Effect (IAPE) model (Gendolla, 2012, 2015). Accordingly, people acquire knowledge about emotions that is stored in long-term memory—they develop emotion concepts (Niedenthal, 2008). People learn that the experience of performance ease or difficulty is typical for different affective states. For example, people learn that coping with a challenge is easier in a happy mood than in sad mood (see Gendolla and Brinkmann, 2005). Likewise, people learn that performance is relatively easy when one is angry, but relatively difficult when one is fearful. The reason is that anger is associated
with the experience of high coping potential (i.e., subjective ability), while fear is associated with low coping potential (Lerner and Keltner, 2001). That way, ease and difficulty become features of the mental representations of different emotions, which can become accessible by affect primes—implicitly processed affective stimuli. Effort can then be influenced, because effort mobilization is grounded in a resource conservation principle: People mobilize effort proportionally to subjective demand—but only as long as success is possible and the necessary effort is justified (Brehm and Self, 1989).

Several studies have supported this systematic impact of implicitly processed affect primes on effort-related cardiovascular response in cognitive tasks (e.g., Chatelain and Gendolla, 2015; Freydefont and Gendolla, 2012; Gendolla and Silvestrini, 2011; Lasauskaite et al., 2013). The present research applied a similar logic to explain how the aging stereotype can influence effort mobilization. Accordingly, cognitive performance difficulty should be a central feature of Western individuals’ mental representation of the elderly—the aging stereotype. Activating the aging stereotype by implicitly processed aging primes during cognitive performance should render the performance difficulty concept accessible and thus increase experienced task demand and effort—but only as long as success is possible and justified.

1.1. Effort-related cardiovascular response

Integrating the predictions of motivational intensity theory (Brehm and Self, 1989) with the active coping approach (Obrist, 1981), Wright (1996) posited that β-adrenergic sympathetic impact on the heart responds proportionally to the level of experienced task demand as long as success is possible and justified. The purest non-invasive measure of β-adrenergic impact is cardiac pre-ejection period (PEP)—the time interval between the beginning of left ventricular excitation and the opening of the left ventricular cardiac valve in a cardiac cycle (Berntson et al., 2004). PEP reflects the force of myocardial contractility—it becomes shorter with stronger contractility of the heart’s left ventricle. Supporting Wright’s integrative hypothesis, studies have shown that PEP sensitively responds to variations in experienced task demand (e.g., Richter et al., 2008), incentive value (e.g., Richter and Gendolla, 2009), and combinations of both (e.g., Silvestrini and Gendolla, 2011a).

Several studies have also operationalized effort as response of systolic blood pressure (SBP)—the maximal pressure in the vascular system between two heart beats—which is systematically influenced by cardiac contractility through its impact on cardiac output (see Gendolla and Richter, 2010; Wright and Gendolla, 2012; Wright and Kirby, 2001). However, SBP is also influenced by peripheral vascular resistance, which is not systematically influenced by β-adrenergic impact (Levick, 2003). That is, SBP can mirror effort, but PEP is the more sensitive measure. The same applies to an even stronger degree to diastolic blood pressure (DBP)—the minimal arterial pressure between heart beats. Still other studies have used heart rate (HR) to assess effort (e.g., Brinkmann and Gendolla, 2007; Eubanks et al., 2002; Gendolla, 1998). But given that HR is determined by both sympathetic and parasympathetic nervous system activity, it should reflect effort mobilization only when the sympathetic impact is stronger—which is not always the case (Bernston et al., 1993). Consequently, PEP is the most reliable and valid indicator of effort mobilization among these parameters (Kelsey, 2012).

1.2. Incentive as moderator of age prime effects on effort

Motivational intensity theory states that effort is mobilized proportionally to subjective demand—but only as long as success is possible and justified (Brehm and Self, 1989). Consequently, high incentive is needed to justify the high effort that appears to be necessary for a subjectively highly difficult task. Without high incentive, high demand should lead to effort withdrawal due to disengagement. Importantly, previous research has shown that the implicit activation of the difficulty concept by sadness or fear primes during an objectively difficult cognitive task in fact leads to effort withdrawal when no high success incentive is provided (Blanchfield et al., 2014; Chatelain et al., 2016; Freydefont et al., 2012; Lasauskaite Schüpbach et al., 2014; Silvestrini and Gendolla, 2011b). However, high success incentive could eliminate this effort mobilization deficit and boosted effort-related cardiovascular response (Chatelain and Gendolla, 2016; Freydefont and Gendolla, 2012). Extending this effect, Silvestrini (2015) found that high incentive also increased effort-related cardiovascular responses of participants who implicitly processed pain-primes during a difficult cognitive task. The present experiment tested if the same would apply to the effect of elderly primes.

1.3. The present experiment

Extending the IAPC model logic (Gendolla, 2012, 2015) to the effect of age primes on effort mobilization, we tested whether high monetary incentive could eliminate the expected effort—mobilization deficit of young individuals who process elderly-primes during an objectively difficult cognitive task—similarly as it was previously found for implicitly processed sadness-primes (Freydefont and Gendolla, 2012), fear-primes (Chatelain and Gendolla, 2016), or pain-primes (Silvestrini, 2015). As outlined above, effort was operationalized as performance-related cardiovascular response, especially cardiac PEP.

Participants worked on an objectively difficult version of a short-term memory task (Sternberg, 1966) during which they processed very briefly presented pictures of faces of elderly vs. young individuals. To manipulate success incentive, participants expected a low vs. high monetary reward for success. With the prime manipulation, we expected to activate participants’ related cognitive representations—the stereotype related to elderly people (aging stereotype) and that related to young people (youth stereotype). Evidence from the literature discussed above on the aging stereotype allows us to posit a link between the elderly primes and accessibility of the concept of difficulty. For the youth primes this is less clear. We think that cognitive performance ease should be a feature of the youth stereotype, but in contrast to the elderly-difficulty link, we are not aware of any reported evidence that youth is clearly associated with performance ease. Our predictions are depicted in Fig. 1.

In the low-incentive condition, depicted in Panel A of Fig. 1, we expected the weakest effort —related cardiovascular response in the elderly-prime condition, because the low incentive did not justify the subjectively high necessary effort, resulting in disengagement. We assumed that effort in the youth—prime condition should be higher, because the task should appear as difficult but still feasible since youth is not associated with cognitive performance difficulties. By contrast, as depicted in Panel B of Fig. 1, high incentive should boost effort—related cardiovascular response in the elderly prime condition by justifying the very high subjectively necessary effort, leading to the strongest effort. In the youth—prime condition, we expected lower effort, because the task should still appear as feasible. Consequently, incentive should have no effect in the youth—prime condition, because here it was not necessary to justify the necessary effort. Taken together, we predicted effort-related cardiovascular response to be the weakest in the elderly—prime/low—incentive condition and the strongest in the elderly—prime/high—incentive condition. Unaffected by incentive, effort in the youth—prime condition should fall in between the two elderly—prime cells.

2. Method

2.1. Participants and design

We aimed at collecting valid data of at least 20 participants per condition (see Simmons et al., 2011). Therefore, 89 university students from different disciplines (51 women, 38 men, mean age 25 years)
were randomly assigned in a 2 (Prime: elderly vs. youth) × 2 (Incentive: low vs. high) between-persons design. Participation was anonymous, voluntary, and remunerated with 10 Swiss Francs (approximately 10 USD). We had to remove 4 participants because they indicated taking medication that could have influenced their cardiovascular functioning, 2 participants because of incomplete cardiovascular data, and 2 other participants because their PEP responses exceeded the grand sample mean by > 2.86 SDs and were thus considered as outliers. This left a final sample of N = 81 participants whose characteristics regarding sex and age were balanced across the conditions: elderly-prime/low-incentive condition (11 women, 10 men, mean age 25 years), youth-prime/low-incentive condition (10 women, 8 men, mean age 25 years), elderly-prime/high-incentive condition (11 women, 9 men, mean age 23 years), and youth-prime/high-incentive condition (13 women, 9 men, mean age 25 years).

2.2. Apparatus and physiological measures

PEP (in milliseconds [ms]) and HR (in beats per minute [bpm]) were continuously and noninvasively assessed with electrocardiogram (ECG) and impedance cardiogram (ICG) signals using a Cardioscreen® 1000 haemodynamic monitoring-system (Medis, Ilmenau, Germany) (for a validation study see Scherhag et al., 2005). Four pairs of disposable electrodes (Medis-ZTEC™) were placed on the right and left side of the base of the participant’s neck and on the right and left mid auxiliary line at the level of the xiphoid. The Cardioscreen® 1000 monitoring-system automatically sampled the ECG and ICG signals with a rate of 1000 Hz. ECG and ICG signals were processed with Bluebox 2 V1.22 software (Richter, 2010) applying a 50 Hz low pass filter. R-peaks in the ECG signal were identified using a threshold peak-detection algorithm and visually confirmed (ectopic beats were deleted). The first derivative of the change in thoracic impedance was calculated and the resulting dZ/dt-signal was ensemble averaged over periods of 1 min using the detected R-peaks (Kelsey and Guethlein, 1990). B-point location was estimated based on the RZ interval of artifact-free cardiac cycles (Lozano et al., 2007), visually inspected, and—if necessary—corrected as recommended (Sherwood et al., 1990). PEP (in ms) was determined as the interval between ECG R-onset and the ICG B-point (Bernston et al., 2004). Shorter PEP indicates a stronger beta adrenergic impact on the heart, and therefore higher effort intensity. HR (in beats per min [bpm]) was determined by means of the same software.

In addition, SBP and DBP (in millimeters of mercury [mm Hg]) were assessed with a Dinamap ProCare monitor (GE Medical Systems, Information Technologies Inc., Milwaukee, WI) that uses oscilometry. The Dinamap’s blood pressure cuff was placed over the brachial artery above the elbow of the participants’ nondominant arm and was automatically inflated in 1-min intervals to assess arterial pressure.

2.3. Age primes

Highly standardized front perspective greyscale pictures of young (age 19 to 25 years) and old (age 71 to 84 years) individuals of the Lifespan-Adult-Faces database (Minear and Park, 2004) were used as primes (picture codes: Wfemale19, Wfemale20, Wfemale22, Wmale20–2, Wmale22–2, Wmale71, Wmale76, Wmale84, Wmale78, Wmale79, Wmale82). Half the pictures showed female faces and half showed male faces.

2.4. Aging stereotype questionnaire

We created a questionnaire, composed of 6 items, to assess participants’ explicit aging stereotype. Participants indicated their agreement with each item (e.g., “Older people are slow in processing information”) on 7-point scales (1 = not at all, 7 = very much). Two items were reversed coded (e.g., “Older people have good memory capacities”).

2.5. Procedure and experimental task

The study was conducted in accordance with the ethical guidelines of the University of Geneva and the procedure had been approved by the local ethical committee. The protocol was run in individual sessions, which took 30 min each. After the experimenter had welcomed the participants, they took a seat in a comfortable chair in front of a computer monitor and signed a consent form. Then, the experimenter attached the electrodes for the ECG and ICG measures and the blood pressure cuff. After that, she left the room and monitored the experiment from an outside control room. The procedure was computerized with a script running in E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA), which controlled the presentation of instructions and stimuli and collected participants’ responses. After reading some introductory information, participants rated 2 items related to happiness (happy, joyful) and 2 items related to sadness (sad, downcast) from the UWIST mood checklist (Matthews et al., 1990) on 7-point scales (1 = not at all, 7 = very much) to assess their global affective state before exposure to the age primes in the cognitive task. This was followed by the recording of cardiovascular baseline activity during a habituation period. To do so, cardiovascular measures were taken while participants watched a highly neutral documentary film about Portugal (8 min).

Next, participants received instructions (“Please respond as quickly and accurately as possible”) for an objectively difficult short-term memory task adapted from Sternberg (1966). Task trials started with a
fixation cross (1000 ms), followed by a random dot pattern as forward mask (133 ms) and a picture of an individual of the Lifespan-Adult-Faces database (27 ms; i.e., 2 frames on a 75 Hz monitor). According to the prime condition, a picture of an old human face or of a young human face was presented. Faces were randomized and the same picture did not appear successively. The face pictures were immediately backward masked with a second random dot pattern (133 ms) followed by a second fixation cross (1000 ms) and then by a string of 7 letters, presented for 750 ms. Next, a target letter appeared in the middle of the screen and a row of the letter “X” masked the previously presented letter string. Participants indicated by pressing a “yes” or “no” key on the numerical keyboard with the fingers of their choice of their dominant hand if the target letter was part of the previously presented letter string or not. The target letter remained on the screen until participants gave a response within a maximal response time window of 3 s. After responding, the message “response entered” appeared. If participants did not respond within 3 s, the message “please answer more quickly” was presented for 1 s. To assure that all participants worked for the same time on the main task and were exposed to the same number of face pictures independently of their working speed, the respective message appeared for 4 s minus participants’ reaction time. The inter-trial interval randomly varied between 1.5 and 3 s.

Before the onset of the main task, which consisted of 36 trials, participants worked on 10 practice trials including only neutral dotted silhouettes as primes. During this practice participants received correctness feedback. No correctness feedback was given during the main task to prevent performance-related affective reactions (e.g., Kreibig et al., 2012) that could interfere with the effect of the manipulations.

We aimed at administrating an objectively difficult cognitive task. The task difficulty calibration was based on the assumption that the average capacity of working memory is up to 4–5 items (Cowan, 2000). Thus, displaying series of 7 letters should tax participants’ working memory to a degree that corresponds to an objectively difficult task. This manipulation had also been applied in previous studies with an objectively difficult Sternberg-type task (e.g., Chatelain and Gendolla, 2016; Freydefort and Gendolla, 2012; Freydefort et al., 2012).

The monetary incentive manipulation was made as follows: After the 10 practice trials, participants were informed that they could additionally earn 1 Swiss Franc (i.e., about 1 USD) in the low-incentive condition vs. 15 Swiss Francs (i.e., about 15 USD) in the high-incentive condition if they met the success criterion of at least 90% correct responses in the short-term memory task (“If you succeed in at least 90% of the trials, you will win...”).

After the task, participants rated the level of subjective task difficulty (“Was it difficult for you to succeed on the task?”) and the importance of succeeding on the task (“How important was for you to succeed the task?”) on 7-point scales (1 – very low, 7 – very high) retrospectively. Then, participants evaluated their global affective state again with the same four affect items as at the procedure’s onset to control for possible age prime effects on participants’ feelings. Moreover, participants indicated some personal data (e.g., sex, age) and responded to questions about possible medication and hypertension family history.

Finally, the experimenter interviewed the participants in a standardized funnel debriefing procedure about the study’s purpose and what they had seen during the task. Participants who mentioned “flickers” or “flashes” were asked to describe them to assess to which extent they had been aware of the age primes’ content. At the end of each experimental session, participants were debriefed, thanked for their participation, and received their remuneration.

2.6. Data analysis

We tested our theory-based predictions about effort-related cardiovascular response with contrast analyses—the most powerful and thus most appropriate statistical tool to test complex interactions (Rosenthal and Rosnow, 1985; Wilkinson and The Task Force on Statistical Inference, 1999). As outlined above, we aimed at testing whether high-performance-contingent incentive could compensate the expected effort-mobilization deficit of participants exposed to elderly-primes during an objectively difficult cognitive task. The cardiovascular response pattern should be as follows: Effort should be the lowest in the elderly-prime/low-incentive condition (contrast weight = −2) due to disengagement and the highest in the elderly-prime/high-incentive condition (contrast weight = +4), because the high incentive should justify the subjectively high necessary effort. In both youth-prime conditions effort should be low and fall in between the elderly-prime conditions (contrast weights = −1), because the task was expected to be experienced as still feasible and incentive should thus not influence effort-related cardiac response by justifying high engagement (cf. Chatelain and Gendolla, 2016; Freydefort and Gendolla, 2012; Silvestrini, 2015).

Other measures, for which we had no theory-based a priori predictions, were analyzed with conventional 2 (Prime) × 2 (Incentive) between-persons ANOVAs. The affect ratings were subjected to a 2 (Prime) × 2 (Incentive) × 2 (Time) mixed model ANOVA. The alpha-error level for all tests was 5%. For the cardiovascular measures for which we had directed hypotheses, we applied one-tailed tests for follow-up cell comparisons. For the sake of an easier interpretability, effect sizes for 1 degree of freedom tests were transformed to η².

3. Results

3.1. Cardiovascular baselines

We created baseline scores of PEP, HR, and SBP by averaging the 1-minute scores of the last 5 min of the habituation period. These values were internally highly stable (Chronbach’s α ≥ 0.98) and did not differ significantly according to repeated measures ANOVAs, Fs < 1.87, ps > 0.11. However, the DBP values of the last minute differed significantly from the values assessed in the minutes before (ps < 0.03). Consequently, we retained only the values assessed in the last minute as DBP baselines. Cell means and standard errors of the baseline scores appear in Table 1.

We conducted 2 (Prime) × 2 (Incentive) between-persons ANOVAs to test for a priori differences in baseline scores between the experimental conditions. No significant differences were found for PEP, HR, and DBP (ps > 0.19). However, for SBP, the analysis revealed a Prime × Incentive interaction effect, F(1,77) = 4.33, p = 0.04, η² = 0.05. Below we will deal with this finding with an analysis of covariance (ANCOVA). Moreover, preliminary analyses revealed that SBP baseline values were higher for men (M = 111.49, SE = 1.67) than women (M = 104.57, SE = 1.98), which is a common finding (Wolf et al., 1997). HR baseline values were higher for women (M = 77.74, SE = 2.05) than for men (M = 70.38, SE = 1.88), Fs > 6.71, ps ≤ 0.01, η² > 0.07. No significant sex effects emerged on the PEP and DBP baselines (ps > 0.28).

3.2. Cardiovascular reactivity

We computed task scores for each participant by averaging the five 1-minute scores of PEP, HR, SBP, and DBP assessed during task

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means and standard errors (in parentheses) of the cardiovascular baseline values.</th>
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<tbody>
<tr>
<td></td>
<td>Elderly primes</td>
</tr>
<tr>
<td></td>
<td>Low incentive</td>
</tr>
<tr>
<td>PEP</td>
<td>103.40 (2.52)</td>
</tr>
<tr>
<td>HR</td>
<td>74.77 (3.13)</td>
</tr>
<tr>
<td>SBP</td>
<td>106.79 (2.37)</td>
</tr>
<tr>
<td>DBP</td>
<td>59.67 (1.08)</td>
</tr>
</tbody>
</table>

Note: PEP = pre-ejection period (in ms), HR = heart rate (in beats/min), SBP = systolic blood pressure (in mm Hg), DBP = diastolic blood pressure (in mm Hg), N = 81.
performance (Cronbach’s α ≥ 0.95) and calculated reactivity scores by subtracting the cardiovascular baseline values from these averaged task scores. Preliminary ANCOVAs of the reactivity scores with respective baseline values as covariate did not find any significant associations for any cardiovascular index (ps > 0.28). Therefore, we further analyzed all reactivity scores without baseline-adjustments. Moreover, the below reported effects on cardiovascular reactivity were not moderated by participants’ sex, since no contrast x sex interactions were significant (ps ≥ 0.06). Sex had also no significant main effects on cardiovascular response (ps ≥ 0.06).

3.3. PEP reactivity

Our theory-based a priori contrast for PEP reactivity—our primary measure of effort—was significant, \( F(1,77) = 4.80, p = 0.03, \eta^2 = 0.06 \). Cell means of the PEP responses are depicted in Fig. 2 and largely displayed the anticipated pattern: As expected, the strongest PEP reactivity emerged in the elderly-prime/high-incentive condition.

Additional focused cell comparisons revealed, however, that the strong reactivity in that condition (\( M = −4.80, SE = 1.23 \)) only tended to be stronger than in the elderly-prime/low-incentive cell (\( M = −3.04, SE = 0.92 \)), since the difference fell short of significance, \( t(77) = 1.35, p = 0.09, \eta^2 = 0.02 \). Moreover, incentive did not lead to a significant difference (\( p = 0.27 \)) between the youth-prime/low-incentive condition (\( M = −1.07, SE = 0.85 \)) and the youth-prime/high-incentive cell (\( M = −2.55, SE = 0.64 \)).

3.4. HR reactivity

As for PEP reactivity, the a priori contrast was significant, \( F(1,77) = 7.02, p = 0.01, \eta^2 = 0.08 \). Also the pattern of HR reactivity largely corresponded to our effort-related predictions, as depicted in Fig. 3. Further fitting with our effort-related predictions, additional cell comparisons revealed that incentive significantly increased HR reactivity in the elderly-prime condition, but not in the youth-prime condition. The difference between the elderly-prime/low-incentive (\( M = 2.74, SE = 0.70 \)) and the elderly-prime/high-incentive (\( M = 5.91, SE = 1.52 \)) cells was significant \( t(77) = 2.18, p = 0.02, \eta^2 = 0.06 \). By contrast, the difference between the youth-prime/low-incentive condition (\( M = 1.88, SE = 0.79 \)) and the youth-prime/high-incentive cell (\( M = 3.42, SE = 0.92 \)) was not significant (\( p = 0.30 \)).

3.5. SBP reactivity

Cell means and standard errors of SBP reactivity appear in Table 2. The a priori contrast was also significant for systolic reactivity, \( F(1,77) = 5.38, p = 0.02, \eta^2 = 0.07 \), and the pattern of cell means largely corresponded to our predictions. Additional cell comparisons found that the difference between the elderly-prime high-incentive condition and the elderly-prime/low-incentive cell was significant, \( t(77) = 1.75, p = 0.04, \eta^2 = 0.04 \). However, incentive had also an effect in the youth-prime condition. Also here, reactivity in the high-incentive condition was significantly stronger than in the low-incentive condition, \( t(77) = 3.05, p = 0.003, \eta^2 = 0.11 \).

3.6. DBP reactivity

Cell means and standard errors of DBP reactivity appear in Table 2. The a priori contrast was far from significance (\( p = 0.58 \)).

3.7. Participants’ age and aging stereotype

An ANOVA of participants’ aging stereotype scores (Cronbach’s α = 0.61) revealed no significant differences between the conditions (\( ps > 0.32 \), average \( M = 22.00, SE = 0.53 \)). Furthermore, ANCOVAs of PEP, SBP, and HR—the cardiovascular measures on which the manipulations had significant effects—revealed no significant associations with participants’ stereotype scores (\( ps > 0.36 \)). The same emerged for participants’ age. An ANOVA revealed neither significant differences between the conditions (\( ps > 0.22 \), average \( M = 24.75, SE = 0.50 \)), nor significant associations between age and cardiovascular reactivity as a covariate (\( ps > 0.19 \)). Thus, the above reported effects are hardly explicable by

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Elderly primes</th>
<th>Youth primes</th>
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<tbody>
<tr>
<td></td>
<td>Low incentive</td>
<td>High incentive</td>
</tr>
<tr>
<td>SBP</td>
<td>3.09 (1.01)</td>
<td>5.97 (1.38)</td>
</tr>
<tr>
<td>DBP</td>
<td>1.92 (0.90)</td>
<td>1.57 (0.77)</td>
</tr>
</tbody>
</table>

Note: SBP = systolic blood pressure (in mm Hg), DBP = diastolic blood pressure (in mm Hg). N = 81.
differences in stereotype strength or participants' age between the conditions.

3.8. Affect ratings

We computed affect scores by averaging the two pre-task and post-task items related to happiness ($r > 0.55$) and those related to sadness ($r > 0.62$). These affect scores were then subjected to $2 \times 2$ ANOVAs. The analysis of the happiness scores did not reveal any significant effects ($p > 0.43$; pre-task $M = 9.49, SE = 0.25$; post-task $M = 9.41, SE = 0.25$). The same was true for the sadness scores ($p > 0.08$; pre-task $M = 3.76, SE = 0.24$; post-task $M = 3.96, SE = 0.25$). Consequently, these data do not provide evidence that the age primes had induced conscious positive or negative affect.

Additionally, we tested with ANCOVAs for possible associations between the post-task affect scores and PEP, HR, and SBP reactivity—the cardiovascular measures on which we had found significant manipulation effects. We did not find any significant associations ($p > 0.29$), meaning that conscious happiness or sadness could hardly explain the significant manipulation effects found on these cardiovascular measures.

3.9. Task performance

A $2 \times 2$ ANCOVA of the percentages of correct responses during the task—with correct responses during the practice trials as covariate to control for individual differences before the manipulations—revealed only a strong covariate effect, $F(1, 76) = 10.19, p = 0.002, \eta^2 = 0.12$. No other effects attained significance ($p > 0.21$; average $M = 87\%$, $SE = 0.01$).

Correspondingly, also a $2 \times 2$ ANOVA of the reaction times for correct responses in milliseconds revealed a strong association between reaction times during the task and the practice trials, $F(1, 76) = 104.85, p < 0.001, \eta^2 = 0.58$, but no other significant effects ($p > 0.35$; average $M = 1077, SE = 17.25$).

An additional correlation analysis revealed that PEP and reaction times (adjusted for the practice trials reaction times) were positively correlated, $r = 0.30$, $p = 0.007$, meaning that faster reactions in the Sternberg task were related to stronger PEP reactivity. No significant correlations emerged between SBP, DBP, or HR and reaction times ($p > 0.23$).

3.10. Task ratings

A $2 \times 2$ ANOVA of participants' subjective difficulty ratings did not reveal any significant effects ($p > 0.10$; average $M = 5.34, SE = 0.15$). The same ANOVA did also not reveal any significant effects on the success importance ratings ($p \geq 0.08$; average $M = 5.35, SE = 0.12$).

3.11. Funnel debriefing

The funnel debriefing procedure revealed that no participant could properly report the aim of the study. When asked to describe a trial, 97% of the participants mentioned having seen faces during the task. 56% of them reported to have identified men and women, whereas 28% of them indicated to have seen faces of old people. This suggests that about 25% of the total sample were aware of the aging primes' content, but that those participants did not make any link between the content of the primes and the purpose of the study.

4. Discussion

This study was based on the idea that activating the aging stereotype in young adults can systematically influence effort-related cardiovascular response during a cognitive challenge. Specifically, we aimed at testing whether high monetary incentive could moderate the expected effort-mobilization deficit of young individuals who implicitly process elderly-primes during a difficult cognitive task. Demonstrating this effect would support the idea that age primes could influence effort-related cardiovascular response in the same way as affect primes do (see Gendolla, 2012, 2015 for overviews).

As discussed above, in the Western culture the negative aspect of the aging stereotype is very pronounced with older people being stigmatized because of the decrement of their cognitive capacities and the difficulties they encounter. Previous studies have shown that activation of this aging stereotype—even without awareness—leads people to behave in stereotype-consistent ways with effects on behavior, performance, and cardiovascular response (e.g., Bargh et al., 1996; Dijksterhuis et al., 2001; Hausdorff et al., 1999; Levy, 1996; Levy et al., 2000; Hsu et al., 2010). Moreover, there is evidence that physical aging is indeed associated with cognitive performance difficulties and resulting effects of effort-related cardiovascular response (Smith and Hess, 2015; Hess et al., 2016; see also Stewart et al., 2016).

The present study was the first attempt to show that the mere activation of the aging stereotype in young adults affects effort-related cardiovascular response. Extending the IAPE model (Gendolla, 2012), we assumed that cognitive performance difficulty would be a central feature of the aging stereotype that could be made accessible by implicitly processed elderly primes. During an objectively difficult cognitive task this should lead to effort withdrawal due to disengagement as long as the subjectively high necessary effort would not be justified by high success incentive. By contrast, effort should be boosted if high incentive was provided, because this should justify the subjectively high necessary effort in this condition.

The present effects on cardiac PEP response, our primary measure of effort-mobilization (Kelsey, 2012; Wright, 1996), largely supported our effort-related hypotheses. As expected, the significant a priori contrast that was modeled according to our effort-related predictions supported the anticipated pattern of PEP response. The pattern suggests that incentive made the expected difference in the elderly-prime condition but not in the youth-prime condition. However, an additional focused cell comparison did not reveal that this effort-increasing effect of high incentive was significant. Moreover, the PEP responses in the elderly-prime/low-incentive condition were on the same level, but not lower than in the two youth-prime cells. That is, despite the significant a priori contrast and although success incentive led to stronger PEP responses in the elderly-prime condition, the results do not completely fit the predictions. One possible explanation could be that the administered short-term memory task was in fact not difficult enough to assure the intended very high subjective task demand and thus disengagement when incentive was low in the elderly-prime condition—by average participants made >80% correct responses.

The expected effort effects were more pronounced for HR responses. Here, high incentive led to the expected significant boost of effort in the elderly-prime condition, while it did not in the youth-prime condition. However, as for PEP, the HR responses in the elderly-prime/low-incentive cell were not weaker than in the youth-prime conditions. We note that there are also other studies that have found that HR sometimes reflects effort-mobilization (e.g., Brinkmann and Franzen, 2013; Freydefont and Gendolla, 2012; Richter and Gendolla, 2007), sometimes even more sensitively than other cardiovascular measures (e.g., Eubanks et al., 2002; Gendolla, 1998). However, given that HR depends on both sympathetic and parasympathetic nervous system impact, those effects are hard to predict.

The a priori contrast was also significant for SBP—a finding that has numerous precursors and is relatively robust because of cardiac contractility's systematic impact on SBP via its effect on cardiac output (see Gendolla et al., 2012; Richter et al., 2016 for reviews). However, cell comparisons unexpectedly revealed significant incentive effects in both the aging and the youth-prime conditions. We attribute this to a
relatively high measurement error for SBP, which depends besides cardiac contractility on peripheral vascular resistance. Moreover, the PEP and HR reactivity scores were averages of about 370 cardiac cycles, while the blood pressure scores were constituted of only 5 measures, suggesting lower reliability. Effects on DBP were not significant, which is not surprising because this parameter is only weakly influenced by beta-adrenergic impact on the heart.

Summing up, the significant a priori contrast effects support the idea that high incentive increases responses of PEP, HR, and also SBP when young individuals process elderly-primes during an objectively difficult cognitive task. This supports our central hypothesis that high incentive can compensate the effort mobilization deficit of individuals who process elderly-primes without high incentive. But we did not find evidence that this latter condition led to lower effort than processing youth-primes. This result is, however, not too surprising if one considers that there is no clear evidence that performance ease is a clear and central feature of the youth stereotype. Regarding the cardiovascular effects together, it is of note that the PEP responses were not accompanied by significant decreases in HR or blood pressure—in fact we observed the opposite. This is important because it makes it implausible to interpret the PEP effects as being caused by cardiac preload (i.e., left ventricular filling) or afterload (i.e., aortic diastolic pressure) (Obrist et al., 1987; Sherwood et al., 1990) rather than beta-adrenergic impact on the heart.

The age-prime and incentive manipulations had no significant effects on performance outcomes in terms of reaction times or response accuracy in the short-term memory task. This is not surprising because effort and performance are not conceptually identical and their relationship is complex. Effort refers to the mobilization of resources to carry out instrumental behavior, whereas performance describes the outcome of the instrumental behavior (see Gendolla and Richter, 2010). Beside effort, performance depends also (or even more) on task-related ability and chosen strategies (Locke and Latham, 1990), which makes predictions about a direct link between effort and performance difficult. Consequently, one cannot expect that variations in effort automatically result in variations in performance. However, despite the lack of manipulation effects on performance, we have found a significant correlation between PEP reactivity and participants’ reaction times for correct responses. This can be interpreted as indicating a link between effort and performance in the present study.

We have not found manipulation effects on participants’ ratings of subjective demand and success importance that were assessed after the task. Also in our previous studies on affect priming, we have only sometimes found prime effects on subjective demand ratings (e.g., Gendolla and Silvestrini, 2011; Lasauskaite et al. 2013, Lasauskaite Schüpbach et al., 2014; Silvestrini and Gendolla, 2011b), or subjective effort (e.g., Chatelain and Gendolla, 2015). Other studies revealed the expected effort effects without significant effects on these self-report measures (e.g., Freyndefont and Gendolla, 2012; Freyndefont et al., 2012). However, the fact these ratings were assessed retrospectively makes them vulnerable to several biases (Robinson and Clore, 2002). Moreover, there is again a reliability issue: The PEP and HR scores were based on about 370 cardiac cycles, while the task ratings consisted of only single items. This bears reliability problems for the self-report measures with the consequence that effects on these variables must be strong to be detected. Instead, other measures of the implicit association between elderly primes and task demand would be more appropriate. Referring to our previous research on the effect of affect primes on effort mobilization, recent studies by Lasauskaite et al. (2017) found evidence that implicit happiness and sadness are associated with performance ease and difficulty in a sequential priming paradigm. We must leave it to future research to test if such implicit associations also exist for elderly and youth primes. Moreover, it is also open for future research to use words instead of images as primes to create a neutral prime condition to which the age primes could be compared. With face pictures as primes, it is not clear which age a neutral prime condition should show.

Finally, the results of the funnel debriefing procedure suggest that about a quarter of the participants was aware of the age primes’ content. Nevertheless, they did not make a link between the primes and the goal of the present study, supporting the idea that also for these participants the effect of the age-primes on effort-related cardiovascular response was implicit. This may be additionally supported by the fact that participants’ explicit aging stereotype was not significantly related to their effort-related cardiovascular responses.

To summarize, we cautiously interpret the present findings as the first demonstration that implicit activation of the aging stereotype in young individuals influences their effort mobilization during a cognitive task. In a broader perspective, this contributes on the one hand to the evidence for the systematic effects of implicitly processed affective stimuli we have studied before (see Gendolla, 2012, 2015 for reviews). On the other hand, the present findings also extend research that has demonstrated the effects of physical aging on experienced task demand and effort mobilization (Smith and Hess, 2015; Hess et al., 2016). The present study provides the first evidence that similar and corresponding effects can occur by the mere activation of the aging stereotype—also in biologically young adults.

References


