Interoceptive Accuracy Enhances Deception Detection with Greater Age

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Abstract:
Difficulties with deception detection may leave older adults especially vulnerable to fraud. Interoception, i.e., the awareness of one's bodily signals, has been shown to influence deception detection, but this relationship has not been examined in aging. The present study investigated effects of interoceptive accuracy (IAcc) on deception detection in 76 young (18-34 years) and 74 older (53-82 years) adults. Deception detection was assessed across two distinct and ecologically valid tasks: *i*) a lie detection task in which they made veracity judgments of genuine and deceptive individuals, and *ii*) a phishing email detection task to capture accuracy in online deception detection. Greater IAcc was associated with greater lie detection accuracy. Furthermore, with greater chronological age among older adults, greater IAcc was associated with better accuracy in both detecting deceptive people and phishing emails. These findings support IAcc as a relevant factor for interventions aimed at enhancing deception detection abilities in aging.

Deception targeted towards older adults is a growing problem, as millions of older adults are scammed annually[1]. Older adults are notably vulnerable to financial exploitation, which is estimated to cost seniors about $36.5 billion each year and affect about 40% of seniors in any five-year period[2]. Financial exploitation can be devastating for older adults who may lose a lifetime of accumulated assets with limited opportunities to recover[3,4]. Factors contributing to older adults' susceptibility to fraud include demographics, such as income and literacy[4], as well as psychological factors such as depression[5], age-related changes in the brain resulting in declining executive functioning and decision-making capacity[6–9], and increased levels of trust[10–13]. In fact, compared to young adults, older adults are typically less accurate at detecting deception[14,15] and exhibit a greater truth bias, which is the tendency to believe others are telling the truth rather than lying[16,17]. These findings are in accordance with evidence that interpersonal trust increases across the adult lifespan[18,19].

A growing body of research suggests that people may have unique physiological reactions (i.e., changes in skin temperature and heart rate) to liars and truth-tellers[20,21]. However, this differential physiological reactivity to lies versus truths is not directly associated with greater performance on lie detection tasks[21,22], suggesting that unique reactions to viewing liars do not directly result in higher accuracy at detecting lies. Rather, a recent study by ten Brinke et al.[21] showed increased deception detection following an interoceptivity intervention in which participants were trained to attend to their physiological signals, suggesting that interoceptive accuracy (IAcc), defined as the ability to detect internal functions such as heartbeats[23], is needed to incorporate physiological reactions into direct lie detection. Research on the relationship between interoception and deception detection is limited, however, and has not yet been extended to older adults. This is surprising as older compared to young adults typically have lower IAcc[24,25]. This age-related reduced IAcc may be associated with decreased deception detection among older adults, rendering them more vulnerable to exploitation[12]. This assumption also aligns with emerging evidence of older adults' reduced sensitivity to negative information such as deceptive cues[10,11,26].

In addition to video-based scenarios involving deception (e.g., deception from crime suspects or individuals pleading for help), in our growingly interconnected, digitalized world, people increasingly encounter deception in the cyber realm. In particular, email phishing is an ever more sophisticated form of online attack largely relying on deception in which seemingly legitimate emails attempt to manipulate the receiver into providing sensitive information or access to a system[27]. Prior research has documented worsening of the ability to discriminate between fraudulent and legitimate emails with greater age[28–30]. A better understanding of factors influencing susceptibility to fraud among older adults is needed as older adults are often targeted by financial scammers online[31].

Building on these considerations, this study investigated the relationship between IAcc and deception detection and determined the extent to which this association was moderated by age. We assessed two forms of deception detection: video-based and email-based deception detection, to cover two real-life contexts of deception. In particular, in the LIE Task, participants viewed highly salient videos of family members pleading for the safe return of their loved one. In half of the videos, the pleader in the video was responsible for the disappearance and was subsequently convicted of kidnapping/murder. Based on evidence that attending to physiological reactions to deceit increases lie detection accuracy, we hypothesized that greater IAcc, assessed via a heartbeat-counting task, would be associated with enhanced lie detection accuracy (*Hypothesis 1*). We furthermore expected this association to be stronger in older adults due to their typically lower deception detection accuracy as well as their lower IAcc compared to young adults (*Hypothesis 2*). Participants also completed the short Phishing Email

Suspicion Test (S-PEST), an ecologically valid lab-based measure of phishing susceptibility[32] (Hakim et al., 2020) in which participants make judgments about their suspiciousness towards both safe and phishing emails. We hypothesized that the predicted associations among IAcc, deception detection, and age would generalize to detection of phishing emails in the context of online deception (*Hypothesis 3*).

Results

We examined the association between IAcc on deception detection (*Hypothesis 1*), and the effect of age on this relationship (*Hypotheses 2 and 3*), in a sample of 75 young (18-34 years) and 74 older (53-82 years) adults. We ran multilevel logistic regression models to accommodate for the hierarchical structure of the dataset (e.g., task trials nested under participants). Accuracy served as outcome variable for both the LIE Task and S-PEST in the respective models. Models included age group, chronological age, and their interactions as predictors to examine age-group differences and variations by chronological age on LIE task and S-PEST accuracy, respectively. See Table 1 for descriptive data for central variables.

To address *Hypothesis 1*, we examined the association between IAcc and LIE Task accuracy on true videos (pleader veracity is genuine) and lie videos (pleader veracity is deceptive). The interaction between IAcc and pleader veracity on LIE Task accuracy was significant ($\chi^2 = 17.64$, $p < 0.001$). Separate follow-up analyses on lie and truth videos showed that greater IAcc was associated with greater accuracy in lie detection ($\chi^2 = 5.28$, $p = 0.022$), supporting *Hypothesis 1*. Greater IAcc was also associated with lower accuracy in truth detection ($\chi^2 = 4.80$, $p = 0.029$).

To address *Hypothesis 2*, we examined the interaction between IAcc and age on LIE Task accuracy. The interaction between IAcc, pleader veracity, age group, and chronological age on LIE Task accuracy was significant ($\chi^2 = 13.52$, $p = 0.0002$). Follow-up analyses within each age group separately showed a significant interaction between IAcc, pleader veracity, and chronologfical age in older ($\chi^2(1) = 11.71$, $p = 0.0006$) but not young ($\chi^2 = 2.57$, $p = 0.11$) participants (see Fig. 1). In particular, greater age in older adults with greater IAcc was associated with better lie detection accuracy ($\chi^2 = 4.92$, $p = 0.03$), supporting *Hypothesis 2* (see Figure 1). Greater IAcc was also associated with lower truth detection among older adults ($\chi^2 = 4.40$, $p = 0.04$).

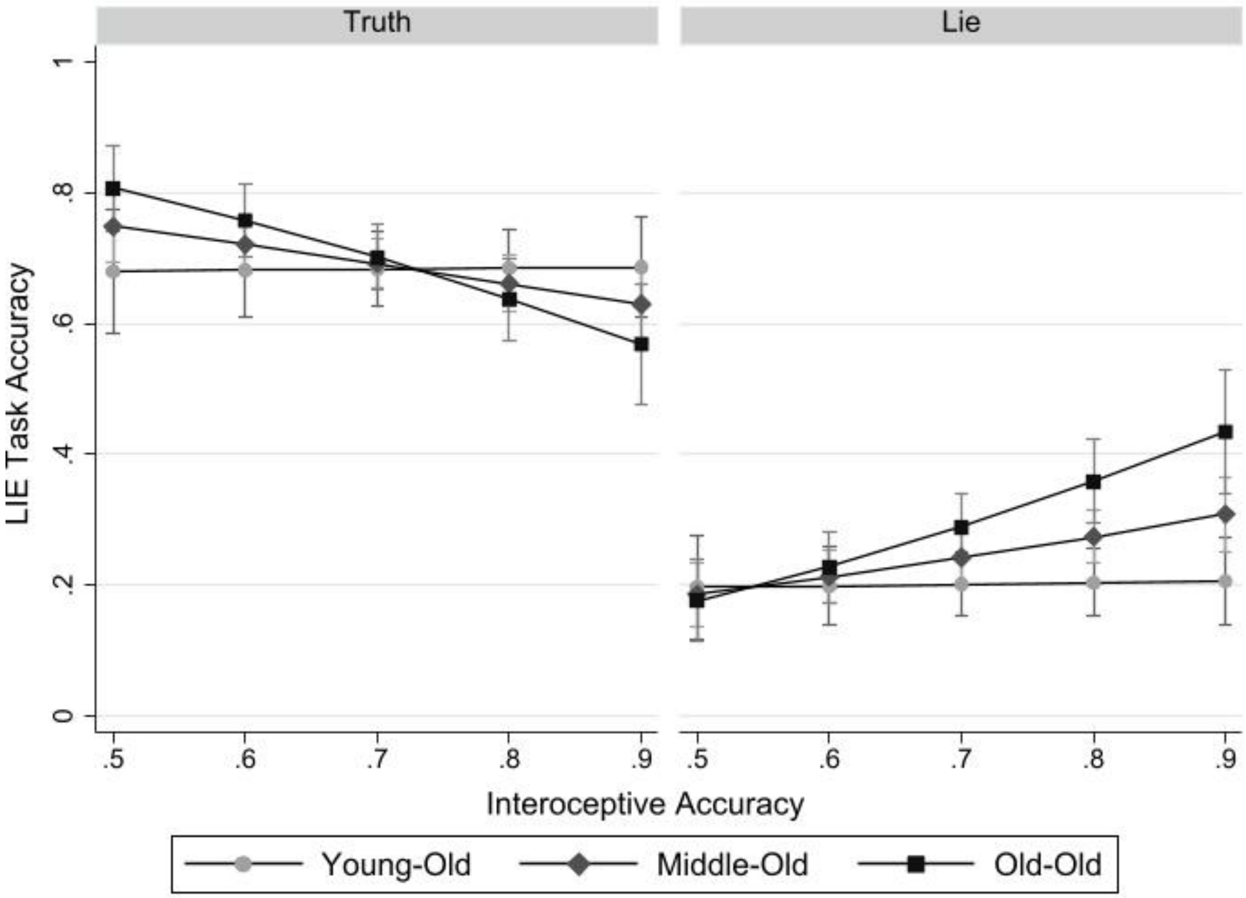

Figure 1. LIE Task accuracy (predicted value from the model) varied as functions of pleader veracity, interoceptive accuracy, and chronological age among older adults. For graphical depiction of the results, age (young-old, middle-old, old-old, depicted as categories here but based on continuous assessment) within the older adult participant group was defined by the mean of the standardized z-score of chronological age. The middle-old age line (diamond line) represented older adult participants with the mean age; the young-old (circle line) and the old-old (square line) age lines represented older adult participants one standard deviation below and one standard deviation above the mean age, respectively. Error bars indicate the 95% confidence intervals.

Finally, we examined age effects on the association between IAcc and our second measure of deception detection, S-PEST. We observed a significant interaction between IAcc, age group, and chronological age on S-PEST accuracy (χ^2 = 6.38, p = 0.012). Follow-up analyses within each age group separately showed a significant interaction between IAcc and chronological age in older (χ^2 = 4.68, p = 0.031) but not young (χ^2 =2.07, p = 0.150) participants. Consistent with LIE Task accuracy, greater age in older adults with greater IAcc was associated with better email phishing detection accuracy, supporting *Hypothesis 3*.

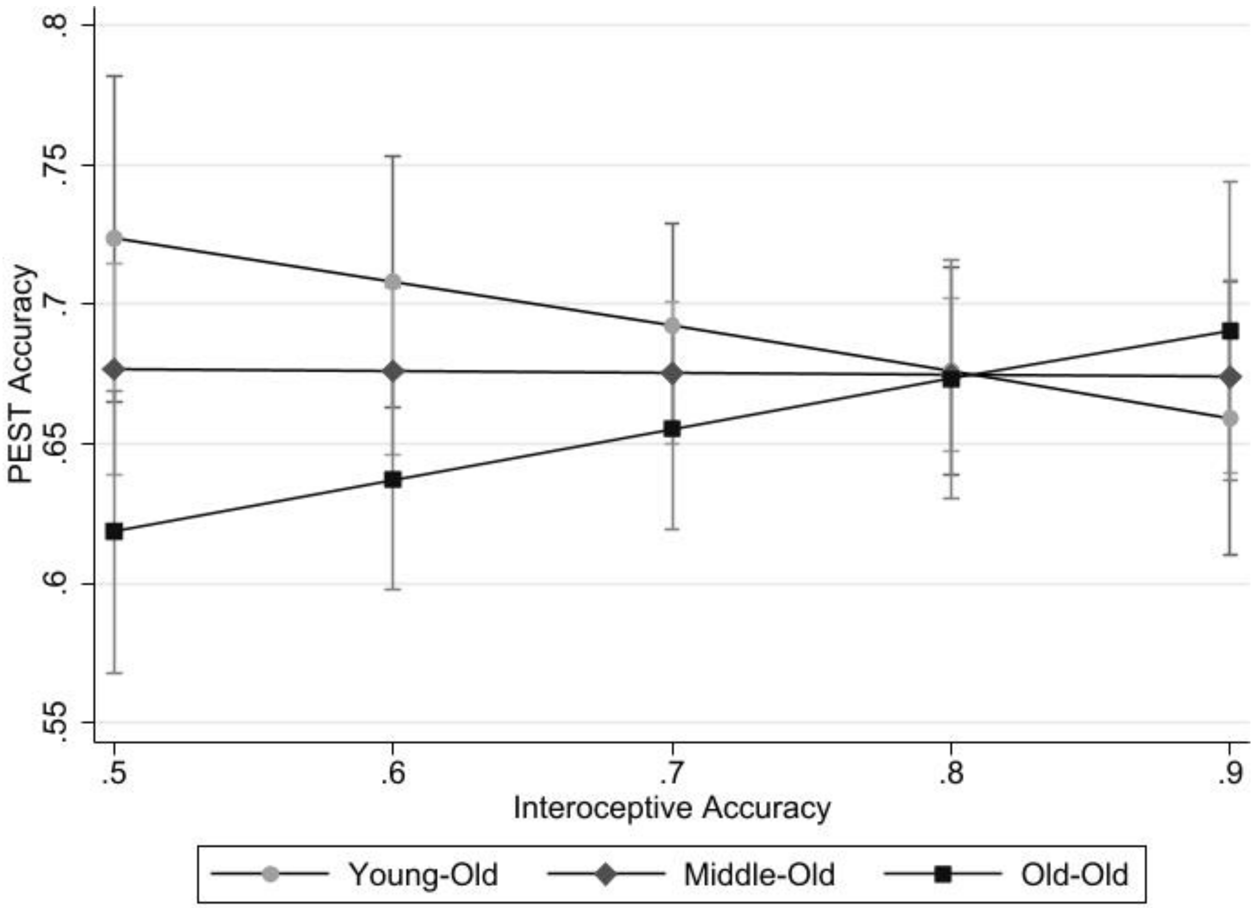

Figure 2. Among older adults, phishing email detection accuracy in PEST varied as function of interoceptive accuracy and chronological age. For graphical depiction of the results, age (young-old, middle-old, old-old, depicted as categories here but based on continuous assessment) within the older adult participant group was defined by the mean of the standardized z-score of chronological age. The middle-old age line (blue line) represented older adult participants with the mean age; the young-old (light blue line) and the old-old (dark blue line) age lines represented older adult participants one standard deviation below and one standard deviation above the mean age, respectively. Error bars indicate the 95% confidence intervals.

Discussion

This study investigated the impact of IAcc on deception detection among young and older adults. There were three central findings: (i) greater IAcc was associated with better lie detection; (ii) this effect strengthened with greater age among older adults; and (iii) greater IAcc was associated with better phishing email detection with increasing age in our older adult cohort. Integrating parallel lines of research on age and deception detection[14,15] and IAcc[24,25], we provide evidence that greater IAcc enhances deception detection across the continuum of older adulthood, observed on two independent, naturalistic deception tasks (video-based lie telling and email-based phishing).

Greater IAcc was associated with greater lie detection accuracy, with this effect strengthened with greater age among older adults, as our age-moderation analysis showed. This finding identifies IAcc as a determinant of deception detection in older (but not younger) adulthood. This suggests that older adults rely on different perceptual processes (e.g. intrinsic versus extrinsic) when making deception judgements. Consistent with this idea, older adults perform more poorly on emotion recognition tasks[33], potentially heightening the influence of intrinsic signals and IAcc in facilitating deception detection as older adults move through later life.

Greater IAcc was also associated with lower truth detection accuracy. While this outcome was not predicted, performance on lie detection tasks often reveals a truth bias, leading to higher accuracy in detecting truths than lies[34]. In fact, individual differences in truth biases, rather than lie detection, accounts for most of the variation in overall deception detection[35]. As a result, reducing such truth biases is an important component of lie detection. This may be especially important for older adults, as they typically exhibit a greater truth bias and lower lie detection accuracy than young adults[16,17], increasing exploitation risk.

While this study does not address the neural mechanisms underlying these observed associations between IAcc and deception detection in older adulthood, we note that the anterior insula cortex has been associated with trust perception/evaluation[10] and IAcc[36,37] as well as with cognitive control[38] and financial risk-taking[39]. Thus, reduced insula volume with age[40,41] may be a neural marker of lower deception detection related to reduced IAcc in later life. Although speculative, this hypothesis is consistent with a report showing reduced insula volumes for older adults who had fallen victim to financial exploitation compared to those who had avoided fraud attempts[42]. Specifying neural markers and mechanisms associated with deception risk is an important direction for future research[9].

Taken together, these findings identify greater interoceptive accuracy as a protective factor against fraud susceptibility. Critically, we identified this protective effect on two independent, naturalistic deception detection tasks, simulating environmental contexts wherein older adults may be particularly vulnerable (deceptive videos and email phishing). Our findings also highlight IAcc as a crucial intervention target, towards reducing susceptibility to deception and exploitation risk in aging. We maintain that better IAcc reduces the truth bias, particularly among the oldest older adults, thereby enhancing lie detection accuracy in these individuals. Leveraging these data, future interventions may employ strategies such as conscious modulation of interoceptive focus via mindfulness training[43,44] or heartbeat perception training[45]. Older adults may benefit particularly from increased in-the-moment interoceptive awareness when confronted with deceptive cues in real world settings[21]. By informing the design of more targeted training interventions, these results advance the longer-term goal of reducing the burdens of exploitation and deception, which are often more devastating in later life.

Methods

Participants

Seventy-six young (*M* = 21.8 yrs., range = 18-34 yrs., *SD* = 3.6 yrs., 84.2% female) and 74 older (*M* = 68.7 yrs., range = 55-82 yrs., *SD* = 7.3 yrs., 74% female) adults were recruited throughout North Central Florida as part of a larger study investigating susceptibility to exploitation in aging (see Supplementary Table 1 for sample descriptives). Participants were recruited between March 2020 and September 2022 via fliers, advertisements on websites for research studies (e.g., ResearchMatch), mailouts via geolocator address purchases, newspaper and radio advertisements, and word-of-mouth. This research was approved by the university's Institutional Review Board, and all participants provided informed written consent and were reimbursed at study conclusion.

Measures

Heartbeat-Counting Task. Participants completed 7 experimental trials in which they counted their own heartbeats for 9-13 seconds (jittered) and reported their responses via a slider scale (modified after Schandry[23])[*]. Participants were instructed to count their heartbeats by focusing inwards rather than by manually feeling their pulse. During the task, heart rate was recorded with a sampling frequency of 100 Hz using a photoplethysmogram (PPG) lead on the participants ring finger of their non-dominant hand and BIOPAC Acqknowledge acquisition software (Biopac Systems, MP160, CA, USA). Presentation of experimental and control trials was pseudorandomized with no repeated trial types (heartbeat or tone) presented in succession. To counter potential order effects, half of the participants received the reversed trial order. IAcc was calculated as the ratio of perceived to real heartbeats averaged across all trials, according to the following formula:

$$1/7\sum(1-(|\text{recorded heartbeats}-\text{counted heartbeats}|)/\text{recorded heartbeats})$$

IAcc scores could range from 0 to 1, with higher scores indicating better IAcc.

LIE Task. Participants viewed 16 short video clips of individuals (10 male, 6 female) pleading for the safe return of a missing relative (modified after ten Brinke & Porter[46]). The videos were gathered from news agencies in Australia, Canada, the United Kingdom, and the United States. Half of the pleaders were deceptive (5 male, 3 female) and half were genuine pleaders (5 male, 3 female). Each video lasted 20 seconds. Pleaders were classified as either deceptive or genuine based on criminal conviction (i.e., all deceptive pleaders were convicted of participating in the murder of the missing person), supported by overwhelming evidence (e.g., DNA, security camera footage). After each truth/lie video, participants determined pleader veracity (*"Is this person telling the truth or lying?"*)[†]. Video presentation was pseudorandomized with no repeated video types (truth, lie, or control[‡]) presented in succession. To counter potential order effects, half of the participants received the reversed pseudorandomized video presentation order. LIE task accuracy was coded as either correct or incorrect for each trial.

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[*] Participants also completed 7 control trials in which they counted tones played through headphones, using the same slider scale. No interoception was required for the tone counting. The number of tones per trial ranged from 8 to 18, all played at the same pitch and each lasting 200 ms. A control analysis with tone counting accuracy as outcome variable did not reveal the effects observed for heartbeat counting; and a control analysis with tone counting accuracy as covariate did not change the effects reported here.

[†] Participants also provided confidence ratings for their responses, reported how much sympathy they felt for each pleader, and indicated how much hypothetical money they would donate to the pleader's cause. These additional variables were not analyzed here.

[‡] In addition to the 16 truth/lie videos, participants watched 8 control videos (also each 20 seconds in length) which depicted scenarios unrelated to deception detection (e.g., a person discussing flooding in their apartment) but were otherwise comparable to the truth/lie videos. For control videos, participants indicated the impact of the narrated scenario (i.e., *Is this a high or low impact situation for this person?).* Responses to control videos were not analyzed here.

Short Phishing Email Suspicion Test (S-PEST). Participants completed the S-PEST (see Hakim et al., 2021 for the long PEST[32]), which presents 40 emails in randomized order from one of four categories (real-phishing, simulated-phishing, real-safe, simulated-safe), with 10 emails per category. To maintain consistency of real-life deception stimuli between S-PEST and the LIE Task, only the 20 real (10 real-safe and 10 real-phishing) email trials were included in the present analysis. Participants were informed that they would see a series of emails, some of which were phishing and some of which were safe messages and were asked to rate each email on a four-point scale from “definitely safe” to “definitely suspicious”. Participants were told to maximize their score by maximizing accuracy. S-PEST accuracy was coded as either correct or incorrect for each trial, regardless of whether the participant selected the ‘definitely’ or the ‘possibly’ response option.

Analysis

We examined age effects on the association between IAcc, measured by the heartbeat counting task, and two measures of deception detection in generally healthy young (18-34 years old) and older (53-82 years old) adults (see Supplementary Table 1). We ran multilevel logistic regression models to accommodate for the hierarchical structure of the dataset (e.g., task trials nested under participants). Accuracy (0 = incorrect, 1 = correct) served as outcome variable for both the LIE Task and S-PEST in the respective models. All models considered the random effect of the intercept, which accounted for inter-individual variability in accuracy across trials. Statistical significance of effects and interactions was determined via the Wald’s test.

To test *Hypothesis 1*, IAcc, pleader veracity (0 = truth, 1 = lie), and their interaction served as predictors on LIE Task accuracy. To test *Hypothesis 2*, we added age as a predictor. In particular, age group (0 = young, 1 = older), chronological age (standardized within each age group), and their interactions were added as moderators, which allowed us to examine both extreme age-group differences and variations by chronological age within each of the two age groups for a more comprehensive capture of age effects on LIE Task accuracy. Finally, to test *Hypothesis 3*, IAcc, email type (0 = safe, 1 = phishing), age group (0 = young, 1 = older), chronological age (standardized within each age group), and their interactions served as predictors on S-PEST accuracy. See the supplementary for parameter estimates of effects in each analytic model (see Supplementary Tables 2, 3, and 4).

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The authors have no conflict of interest to disclose and have complied with APA ethical standards in human subjects research. The dataset and analysis code can be found in the OSF repository (https://osf.io/5726y/?view_only=20c2267f71fa439ebd8456f78336dcff).

Author contributions

N.C.E., D.P., R.C.W., G.T., and R.N.S. designed the study. Z.H., P.V.H., M.D.G., and L.T.B. contributed study measures. A.H. collected the data. T.L. and N.C.E. developed the formal analytical strategy. A.H. processed data. T.L. conducted analyses. A.H. and N.C.E wrote the introduction and discussion. A.H., T.L., and N.C.E wrote the methods and results. All authors contributed to manuscript conceptualization and editing and approved the final manuscript.

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Table 1. Sample Demographics and Descriptive Data for Central Variables (in percentages)

	Young Participants	**Older Participants**	**Age-Group Differences**
	M (SD)	*M (SD)*	*Cohen's d*
Heartbeat-Counting Task			
IAcc	**0.79 (0.15)**	**0.70 (0.20)**	**0.48**
LIE Task Accuracy			
Truth Video	0.63 (0.25)	0.25 (0.24)	-0.29
Lie Video	0.25 (0.20)	0.70 (0.27)	-0.04
S-PEST Accuracy			
Safe Email	0.61 (0.18)	0.56 (0.24)	0.23
Phishing Email	0.75 (0.16)	0.75 (0.19)	0.01

Note. Sample demographics refer to the total sample for the Heartbeat-Counting Task. One young female participant was excluded from the LIE Task sample due to incomplete responses (N = 75 young, 74 older), and 2 young females and 4 older (3 female, 1 male) participants were excluded from the S-PEST sample due to missing responses (N = 74 young, 70 older). Bold print indicates significant effects at $p < 0.05$. IAcc = Interoceptive Accuracy.