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A cognitive stressor for event-related potential studies: the Portland arithmetic stress task

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Abstract

In this experiment, we developed and evaluated the Portland Arithmetic Stress Task (PAST) as a cognitive stressor to evaluate acute and sustained stress reactivity for event-related potential (ERP) studies. The PAST is a titrated arithmetic task adapted from the Montreal Imaging Stress Task (MIST), with added experimental control over presentation parameters, improved and synchronized acoustic feedback and generation of timing markers needed for physiological analyzes of real-time brain activity. Thirty-one older adults ($M = 60$ years) completed the PAST. EEG was recorded to assess feedback-related negativity (FRN) and the magnitude of the stress response through autonomic nervous system activity and salivary cortisol. Physiological measures other than EEG included heart rate, respiration rate, heart rate variability, blood pressure and salivary cortisol. These measures were collected at several time points throughout the task. Feedback-related negativity evoked-potential responses were elicited and they significantly differed depending on whether positive or negative feedback was received. The PAST also increased systolic blood pressure, heart rate variability and respiration rates compared to a control condition attentional task. These preliminary results suggest that the PAST is an effective cognitive stressor. Successful measurement of the feedback-related negativity suggests that the PAST is conducive to EEG and time-sensitive ERP experiments. Moreover, the physiological findings support the PAST as a potent method for inducing stress in older adult participants. Further research is needed to confirm these results, but the PAST shows promise as a tool for cognitive stress induction for time-locked event-related potential experiments.

Keywords

Stress reactivity; feedback-related negativity; cognitive stressor; event-related potential

Introduction

Background

There is a need for experimental stressors in event-related potential (ERP) research. Time-locked brain activity can be used to better define stress resilience, either as the amplitude or

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as a duration of stress-related changes. The goal of this experiment was to develop and test the validity of a cognitive stressor that can be readily adapted for ERP studies. We named this task the Portland Arithmetic Stress Task (PAST).

The PAST is modeled on the Montreal Imaging Stress Task (MIST), which uses mental arithmetic to induce stress (Dedovic et al., 2005). The MIST has been shown to produce consistent stress-related physiological changes, such as heart rate, galvanic skin response, salivary cortisol and deactivation of brain regions, associated with the HPA axis (Dedovic et al., 2005; Nagano-Saito et al., 2013; Pruessner et al., 2008). Previous experiments have also demonstrated stress-related physiological changes resulting from the MIST in older adults (Chamine & Oken, 2015).

While reactivity to sustained or prolonged stress can be quantified using a difficult cognitive task like the MIST, the MIST itself was originally developed for blocked design functional imaging research; it did not facilitate event-related analyses, the acute response to a stressful event. ERP studies and other designs reliant on real-time electrophysiological activity would benefit from time-locked stimuli in a similar task. The PAST was developed to measure sustained stress response in a manner similar to the MIST, but with identifiable event markers for use in event-related studies of acute stress response.

Event-related potentials and stress assessment

The goal of this experiment was to evaluate changes in autonomic stress reactivity elicited by the PAST while incorporating stress-induced ERP measures. The experiment was designed to assess changes in brain activity following transient stressful events, which we measured using feedback-related negativity (FRN) in the context of correct versus incorrect performance feedback. Previous studies have utilized ERP measures to quantify stress response (Qi, Gao, Guan, Liu, & Yang, 2016; Yang, Qi, Guan, Hou, & Yang, 2012), but that research has focused on examining electrophysiological differences between sustained stressful and nonstressful states, rather than reactivity to single stressful events (e.g. negatively administered error feedback). Although related, it is important to note that responses that can be measured to sustained and transient stressors are different because of the varied time courses of the physiological effector pathways (Oken, Chamine, & Wakeland, 2014).

Since reactivity is central to this investigation, it is helpful to explain the known behaviors of these endogenous components. Feedback-related negativity is closely related to error-related negativity (ERN), error monitoring and dopamine systems generated in the anterior cingulate and its prefrontal cortex connections (Gehring, Liu, Orr, & Carp, 2012; Holroyd & Coles, 2002; Gehring & Knight, 2000; Mathewson, Dywan, & Segalowitz, 2005; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Expectancy plays a large role in differentiating the ERN and FRN. Specifically, the ERN is observed when the respondent is aware of an error as it is made, while the FRN is seen when an outcome may be unknown to the respondent, hence the term “feedback”. The ERN can be self-generated without any feedback. Of note, the ERN is increased in one clinical disorder of excessive worrying: obsessive-compulsive disorder (Gehring, Himle, & Nisenson, 2000; Endrass, Klawohn, Schuster, & Kathmann, 2008; Johannes et al., 2001). Moreover, FRN is modulated via

outcome likelihood, which ties in with the error rate titration of the PAST task with the goal of controlling for this issue. ERN generally occurs when an error is made, whereas FRN occurs shortly after (250–300 ms) negative feedback is received (Gehring et al., 2012). We are interested in how the negative feedback during the PAST affects brain activity, and thus, we anticipate a sustained negative polarity increase for incorrect responses versus correct responses in FRN.

Methods

Participant characteristics

Thirty-one older adults aged (range: 51–76 years, $M = 60$) years were recruited as part of a randomized clinical trial of mindfulness meditation (Table 1). This was a convenience sample for assessing the efficacy of the PAST as a cognitive stressor. Only data from the prerandomization first visit are included in these analyses. Eligible participants had to be between 50 and 80 years old, cognitively intact as determined by a Telephone Interview for Cognitive Status (TICS) score ≥ 31 and Neurobehavioral Cognitive Status Exam (NCSE) judgment score ≥ 3 . Good general past and present medical health and access to a computer with the Internet for materials and questionnaires were required. All participants were required to be experiencing stress, with scores ≥ 9 on a 10-item modified version of the Perceived Stress Scale (PSS). The sample was 81% female and 81% white. Most participants in this study had completed a college education (M years of education = 16). Exclusion criteria included significant medical or neurological disease, untreated depression and/or post-traumatic stress disorder, significant visual or hearing impairment, and usage of medications that might interfere with outcome measures, such as benzodiazepines or neuroleptics. Stable doses of antidepressants were acceptable. Participants were also required for the mindfulness meditation randomized trial to not have taken meditation or mind-body classes within the last 2 years and not have engaged in regular meditation practice over the 30 days leading up to the start of the study.

Study design

The PAST was administered during an in-laboratory baseline assessment visit that was performed in the morning because of logistical constraints of the intervention study. EEG was recorded during the PAST, and several supplemental physiological assessments of stress were evaluated: blood pressure, heart rate, heart rate variability, respiration rate and salivary cortisol. Blood pressure, discrete heart rate and salivary cortisol were measured at time points before, halfway through and after administration of the PAST. Electrocardiogram (ECG) and respiration were measured continuously throughout the task in order to assess HRV and breathing rate. These physiological responses have a longer time course than ERP responses to negative feedback. Thus, the control condition could not be within the PAST containing intermingled positive and negative feedback events and the control for these measures was the tones task. Two subjective measures, a brief Likert-scale stress assessment questionnaire and a state version of the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988), were also administered before and after the PAST.

PAST task description

As a cognitive experimental stressor, the PAST is composed of computerized mental arithmetic problems with an adaptive failure algorithm. It attempts to maintain an error rate of approximately 40% for the duration of the test and adds a social-evaluative threat component as well as visual and auditory feedback components. The PAST was created for use with Eprime 2.0.10.353. Please contact the primary author for access to the executable run file.

The layout of a single trial of the PAST is illustrated in Figure 1. Each trial began with the presentation of an arithmetic problem and immediate onset of a distracting auditory stimulus. Participants were instructed to solve the presented arithmetic problem in their head as quickly and as accurately as possible before using a stimulus-response box to select the correct answer from a number wheel at the bottom-right of the screen. As participants attempted to solve equations presented at each trial, a green “elapsed time” bar below the equation filled from left to right with red. Trials ended when either a response was provided or when the “elapsed time” bar was completely filled. Performance feedback was presented to the left of the answer wheel instantaneously either upon submission of an answer or after filling of the “elapsed time” bar. Feedback remained on-screen for 2 sec before an inter-trial-interval (ITI) of approximately 1.5 sec was then presented to clear the old equation and reset the “elapsed time” bar before the start of the next trial.

Titration of task difficulty was achieved using five levels of adjustment based on problem complexity and allotted stimulus–response time (i.e. the speed of the “elapsed time” bar). Complexity was based on number of operands (2–4), number of digits in the operands (1 or 2), types and combinations of operators (+, −, × and /) and the presence or absence of fractions. Participant’s accuracy was calculated after each group of five trials (Figure 2). If more than three of five trial responses were correct, difficulty was increased and the period of time allowed for a response was reduced. If fewer than three of five trials were correct, difficulty decreased and the response time window period was increased. No change to difficulty was made when three out of five problems are answered correctly, ensuring that error rates trended toward 40%.

The task as configured for this study consisted of two runs of 80 trials, with a short pause between runs for physiological measurements such as blood pressure.

Stimuli

During equation presentation, auditory stimuli consisted of an arcade-like sound that started at a low frequency and increased in frequency until the end of the trial. If a trial ended in a timeout or an incorrect response was entered, a sound like a spoon on a metal bowl was played as feedback. If a correct response was entered, a more pleasant bell sound was heard. Auditory and visual components were used for the feedback to maximize the negative impact of the feedback, similar to what was previously used with the MIST. It is important to note that the physical differences in the feedback are unlikely to influence the FRN given it is a long-latency ERP (e.g. Mathias, Gehring, & Palmer, 2017). Similarly, visual feedback was also provided. First, participants were told that their performance on the test would be

compared to a “group average.” A performance bar ranging from “worse” to “better” was displayed throughout the test with indicators for both group accuracy performance and the individual participant’s real-time test accuracy. The indicator for an individual’s test accuracy was updated at each titration and moved towards “worse,” “better,” or left alone in conjunction with adjustments to difficulty. There was also a countdown bar for each trial that starts unfilled and is filled as the trial proceeds. The bar is synchronized with the auditory signal so they both end at the same time. The color shifts from green at the beginning to red as participants near the end of the time limit for the trial (Figure 1).

Since autonomic changes require a significantly longer time to assess than ERPs, the control condition for these autonomic measures could not simply compare incorrect versus correct responses. As a control condition for autonomic arousal during cognitive testing, participants completed an auditory response task prior to the PAST in which they were instructed to press a button to distinguish an infrequent (occurrence: 15%), higher pitched tone (2000 Hz) from frequent (1000 Hz) tones and infrequent, lower pitched tones (500 Hz). Tones were presented at randomized intervals from 1500 to 2500 ms apart with an average of 45 higher-pitched tones within a 15-min testing period. The tones identification task was completed prior to the start of the PAST. It served as our baseline attentional task for examining the effects of sustained stress on the non-EEG physiological measures that have an intrinsically longer time course than the ERPs to the negatively administered incorrect feedback.

Event-related potential recordings

A BioSemi 32-channel, 24-bit resolution, ActiveTwo system was used to record EEG with Ag-AgCl passive-sensor electrodes (BioSemi, Amsterdam, the Netherlands). EEG data were collected at a 1024 Hz sampling rate and electrodes were placed using Modified Combinatorial Nomenclature (MCN) at AF3/4, F7/8, F3/4, FC1/2, FC5/6, T7/8, C3/4, CP1/2, CP5/6, P7/8, P3/4, P03/4, o1/2, Oz, Fz, Cz and Pz. The bandwidth settings were 0.1–70.0 Hz. The common mode sense (CMS) reference and driven right leg (DRL) electrodes were used midway between Cz and C3/4.

FRN was analyzed from the Fz and Cz electrode sites in BrainVision Analyzer (Version 2.1.1.327, Professional Edition). For offline processing, data were re-referenced to linked mastoids and filtered with 70 Hz low-pass, 0.1 Hz high-pass and 60 Hz notch filters. Participants were asked to refrain from clenching and sudden head movements to minimize artifact but given no restrictions regarding eye blinks or fixation. Artifacts were semiautomatically rejected to remove data contaminated by non-neuronal activity, with rejection criteria set at a maximal allowed voltage step of 50 $\mu\text{V}/\text{ms}$, a maximal allowed absolute difference of 125 $\mu\text{V}/\text{ms}$ within an interval length of 50 ms, a maximum EEG amplitude of $\pm 75 \mu\text{V}$ and a minimal amplitude of 0.5 μV within an interval length of 100 ms. Moreover, activity ± 200 ms from an artifact event was removed.

ERPs were time locked to the onset of visual and auditory response feedback, which co-occurred immediately after participants either provided a response or timeout occurred. The 200 ms prior to feedback onset were used for baseline correction, with analyzed epochs extending to 1000 ms postfeed-back onset. N1 was identified using semiautomated peak

detection with criteria set at the most negative peak occurring 100–200 ms postfeedback. Similarly, P2 was labeled as the most positive value between 175 and 300 ms. The FRN peak was semiautomatically identified as the most negative peak occurring within 250–400 ms from the feedback event. Both the P2 and FRN were calculated peak-to-trough from the previous peak. The difference waves were calculated as the most positive peak minus the most negative peak in the specified range.

Physiological stress assessment

Respiration rate was recorded throughout the PAST session using a light elastic piezoelectric belt (Ambu-Sleepmate, MD), which was placed around participants' ribcages close to the diaphragm. As with EEG recordings, respiration rate was assessed in BrainVision Analyzer (Version 2.1.1.327, Professional Edition). Breaths were semiautomatically identified using a voltage trigger to label peaks, meaning that a new breath was labeled whenever the respiratory reading was positive and crossed zero voltage, as previously reported (Atchley et al., 2016). Blood pressure readings were collected using an OMRON manual inflation arm cuff and 7300IT automatic blood pressure monitor unit (OMRON, the Netherlands).

As described by Chamine and Oken (2015), cortisol samples were collected using Sarstedt Salivettes (Sarstedt AG & Co, Numbrecht, Germany). Samples were stored in a refrigerator after collection and centrifuged after study sessions were completed, then stored at –80 F before being processed by the Oregon Clinical Translational Research Institute Core Laboratory. Baseline and poststressor saliva samples were run in the same assay batch. Values for cortisol levels were obtained using a commercially available ELISA kit (Salimetrics, State College, PA) as described by Wahbeh, Goodrich, Goy, and Oken (2016). We obtained ApoE-4 status to further evaluate the effects of stress on cognition in the meditation randomized controlled trial that included the PAST. ApoeE-4 status is an important covariate that may also be related to stress effects (Hu & Lu, 2015). DNA was extracted from salivary samples collected with salivettes using Puregene DNA purification kits as outlined by the manufacturer (Qiagen Inc., Hilden, Germany). Following PCR amplification, ApoE genotyping was performed by direct DNA sequencing using BigDye 3.1 sequencing reagents (Life Technologies, Carlsbad, CA) on a 3130XL Genetic Analyzer (Applied Biosystems Inc., Foster City, CA).

Electrocardiogram (ECG) recordings were taken throughout testing to assess heart rate and heart rate variability (HRV). Electrodes were placed bilaterally, inferior to the clavicles and digitized at 1024 samples per second with BioSemi amplifiers (Active 2, Biosemi, Amsterdam, the Netherlands). ECG waves were automatically detected and inspected for error in BrainVision Analyzer (Version 2.1.1.327, Morrisville, NC). Recordings were segmented into 5-minute block before inter-R wave latencies were exported to Kubios HRV (Version 2.2, Kuopio, Finland) software for further analysis. Low frequency (LF, 0.04–0.15 Hz) to high frequency (HF, 0.15–0.40 Hz) ratios and standard deviation of the RR interval (Mukherjee, Yadav, Yung, Zajdel, & Oken, 2011) were calculated.

Analysis

Respiration was recorded continuously and compared during the PAST and tones discrimination task. Blood pressure and pulse were recorded at baseline, half way through the PAST, immediately after, then out 15 min, 30 min and 45 min. Stress questionnaire, mood questionnaire, cortisol levels and feedback-related negativity readings were assessed pre- and post-PAST. All statistical analyses were performed in SPSS (version 22, IBM, Armonk, NY) using paired-sample *t*-tests. Repeated-measures ANOVAs were used to follow up on significant results.

Results

Feedback-related negativity

Five participants did not have discernable FRN responses or had excessively noisy recordings that were excluded from the analyses. The average artifact rejection rate across all feedback conditions in the PAST was 30.4%. By condition, rejection rates were 27.4% for correct trials and 35.9% for incorrect trials. There was a significant, negative-leaning increase in raw voltage (Fz Corr $M = 4.77 \mu\text{V}$ [SD = 8.39]; Fz Incorr $M = 1.03 \mu\text{V}$ [SD = 7.53]; Cz Corr $M = 4.95 \mu\text{V}$ [SD = 6.55]; Cz Incorr $M = 1.58 \mu\text{V}$ [SD = 5.37]) when comparing correct to incorrect feedback at the Fz electrode site, $t(25) = 2.06$, $p = .050$, as well as the Cz electrode site, $t(25) = 2.17$, $p = .040$ (Figure 3). This effect was also true for the peak-to-trough calculations at the Fz site, $t(25) = 2.17$, $p = .040$ and Cz site, $t(25) = 2.55$, $p = .017$ (Table 2). FRN difference wave topography (incorrect – correct) at 300 ms postfeedback was generated for the Fz electrode site (Figure 4). A possible explanation for the lateralization of the FRN topography is that participants were consistently moving their eyes back and forth from the answer wheel (always to the right) and the equation area (always center).

Autonomic measures

Participants' mean respiration rates increased significantly from 14.36 breaths per minute (SD = 2.94) during the tones baseline task to 15.53 breaths per minute (SD = 3.31) during the PAST, $t(30) = -2.16$, $p = .039$. Likewise, mean systolic blood pressure increased from 138.97 (SD = 18.42) during the recording period at baseline to 143.26 (SD = 19.65) immediately after the PAST, $t(30) = -2.24$, $p = .032$. Mean diastolic blood pressure was not as significantly changed from a baseline of 84.52 (SD = 11.22) to poststress 88.91 (SD = 15.45), with just a trend $t(30) = -1.91$, $p = .066$. Heart rate variability, as measured by STDRR time domain analysis, was lower during the baseline tones task ($M = 34.78$, SD = 15.91) than during the PAST ($M = 39.34$, SD = 17.13), $t(30) = -2.58$, $p = .015$. Average heart rate did not change from the tones baseline ($M = 63.97$, SD = 10.50) in comparison to the PAST ($M = 64.00$, SD = 11.73).

Cortisol analysis did not produce any significant results; however, there was a typical diurnal cortisol profile, meaning cortisol levels universally went down over time, given that testing universally began at approximately 9:00 am. Notably, during the baseline visit, there was a difference in response for participants who carried an apolipoprotein E4 (ApoE-4) allele ($n = 4$). Specifically, E4 carriers had higher cortisol levels than non-E4 carriers overall, with all p

<.007, at baseline before PAST, halfway through, immediately after, 15 min after, 30 min after and 45 min after the PAST.

Questionnaires

Self-reported stress increased from post-tones task baseline to immediately post-PAST, $t(30) = -5.04, p < .001$. Positive and negative PANAS scores did not differ before and after the PAST.

Discussion

To recap, we investigated whether the PAST is an effective tool in eliciting and evaluating psychosocial stress and resilience in time-sensitive ERP experiments. Thirty-one older adults completed the PAST. According to these data, the PAST did successfully produce changes in autonomic nervous system markers that are consistent with stress-induced changes. The autonomic measurement results are also in accordance with participant self-reports of stress. FRN was also apparent during the PAST, which implies that the provided negative feedback was effective in inducing stress. The topographic maps of the FRN's were comparable to what has previously been reported (Menson et al., 2015; Warren & Holroyd, 2012). Overall, these data suggest that participants did perceive the PAST negative feedback as a stressful event and that the goal of assessing physiological stress reactivity using the PAST was successful. Changes in stress reactivity and ERPs over the course of the subsequent clinical intervention trial are outside the scope of this paper, which has focused instead on physiological responses to the PAST. Stress reactivity will be discussed in a future paper once the intervention trial is completed.

There are several novel advantages to the PAST's design that make it useful specifically for event-related potential studies. The PAST was designed to allow exemplary control of stimulus presentations as well as response classifications and an added social-comparison stressor. For studies in which timing is critical, the PAST allows for comprehensive experimental control of presentation and response variables while effectively inducing stress. The sensitive timing of the feedback component also adds extra dimension for analyses beyond that of correct/incorrect responses. The auditory and visual performance feedback successfully elicited FRN and this has potential as a tool in future studies. The PAST's ability to time-lock events makes the task dynamic and will allow for its use in multiple scenarios.

Limitations

Future studies should explore usage of the PAST in the broader population. This study was limited to older adults who were relatively educated and mildly stressed. The sample was also mostly white females. These demographics limit generalizability. There are no major gender differences in ERPs but in general older people have lower amplitude and longer latency ERPs than younger people. Another limitation is that changes in cortisol were confounded by morning recording, which resulted in diurnal declines in cortisol over the testing session that potentially eliminated stress-related increases (Dmitrieva, Almeida, Dmitrieva, Loken, & Pieper, 2013). This problematic aspect of cortisol collection is

attributable to design carry-over in the larger intervention study, in which testing was consistently held in the morning in order to facilitate fasting blood draws. The tones control task was consistently given prior to the PAST, in part to avoid carryover effects from the stressful PAST to the control condition. The consistent order does allow the possibility of order effects. However, in general, the longer a participant sits in a laboratory with EEG electrodes attached the more relaxed they become and lower blood pressure and slower heart rates are common as well as drowsiness. Thus, the autonomic arousing effects of the PAST are unlikely to be due to order effects. The differing physical properties of the positive and negative feedback may have also contributed to the observed differences. However, long latency ERPs, such as feedback-related potentials, are not drastically affected by physical properties of stimuli (e.g., Mathias et al., 2017), and negative feedback needs aversive qualities to maximize the FRN. The other fact suggesting physical properties of the feedback did not contribute to the FRN is that even the N1 response, that is more sensitive to physical properties of the stimulus than longer latency ERPs, was not different in the two feedback conditions. As might have been expected, the artifact rejection rates were slightly higher in the epochs following an incorrect response compared to a correct response. There were well-defined artifact rejection criteria, the latency of the FRN is relatively short compared to most movement responses, and the topographic maps are more central than the usual temporal or frontal artifact. These observations all suggest that the feedback potentials are not simply movement or electromyographic responses. Five participants did not demonstrate a clear FRN response. While older adults have lower amplitude and more poorly defined ERPs than younger adults, the FRN absence in a significant minority may limit use in wider samples unless ways are found to increase its amplitude or reliability. Since the FRN modulates with expectancy, there may also be a tie-in with personality traits and performance related to feedback.

Conclusions

Although further research is needed to bolster the cognitive, electrophysiological and autonomic changes observed as a result of this stress task, the initial results are promising. We put forward the PAST as a cognitive stressor specifically built for ERP experiments that evaluate levels of stress and resilience.

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Figure 1. Portland arithmetic stress task trial example. Participants used a three-button response box, where the button on the left moves the green choice cursor counterclockwise and the button on the right moves the cursor clockwise. The center button recorded participants' responses.

Figure 2.

Timeline depiction of a sequence of stimulus–response events and an adaptive titration of difficulty in the PAST. The example shows the final two trials in a 5-trial sequence prior to difficulty titration and the start of a new 5-trial sequence. Participants submitted correct (“C”) or incorrect (“I”) answers before timeout for each presented equation. Equations and performance feedback remained onscreen for 2 s after each answer before the onset of a 1.5-s inter-trial interval that removed the old equation and associated feedback. The figure illustrates poor performance followed by lowered difficulty and also demonstrates the relatively long, allowed stimulus–response intervals that were typically necessary for an older adult population.

Figure 3. Feedback-related negativity at Fz and Cz electrode sites. Group averaged responses to feedback that was presented at time point zero. N1 responses to correct and incorrect feedback are the same, but the difference between the positive and negative feedback, the FRN, can be seen at approximately 300 ms.

Figure 4. Topographical heat maps of difference wave amplitude. Difference wave amplitude (incorrect–correct) was maximal at 300 ms postfeedback for Fz. Topographical heat maps illustrate activity at this time point and averaged over a window of ± 10 ms.

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Table 1

Participant demographics.

<i>n</i>	Age	Female	Male	White	Black	Asian	Hispanic	Multiracial
31	51–76 (<i>M</i> = 60)	25	6	25	1	1	2	2

Table 2

Summary of results.

<i>M</i>	Tones task baseline (SD)	Immediate Post-PAST (SD)
A.		
PANAS positive	31 (± 8)	30 (± 9)
PANA negative	14 (± 6)	16 (± 6)
Stress questionnaire *	2 (± 2)	4 (± 2)
Breaths per minute *	14 (± 3)	16 (± 3)
Systolic blood pressure *	139 (± 18)	143 (± 19)
Diastolic blood pressure	85 (± 11)	89 (± 15)
Heart rate	64 (± 11)	64 (± 12)
Heart rate variability *	35 (± 16)	39 (± 17)
Non-ApoE cortisol	0.17 ($\pm .06$)	0.13 ($\pm .05$)
ApoE-4 cortisol *	0.34 ($\pm .28$)	0.2 ($\pm .03$)
B.		
<i>PAST ERPs</i>	Correct	Incorrect
Fz FRN *	4.78 (± 8)	1.29 (± 8)
Cz FRN *	4.95 (± 7)	1.58 (± 5)
Fz FRN peak/trough difference *	-10.51 (± 6)	-13.95 (± 8)
Cz FRN peak/trough difference *	-10.69 (± 5)	-14.14 (± 7)

* $p < .05$.