DOCUMENTATION

of

PSYCHOPHYSIOLOGY METHODS

in

MIDUS Refresher 1 Neuroscience Project (P5)

University of Wisconsin ♦ Institute on Aging
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INTRODUCTION

This document provides an overview of the MIDUS Refresher 1 Neuroscience Project's psychophysiology methods. Various psychophysiology data were collected during the Psychophysiology Emotional Response Task and during the Functional MRI Emotional Response Task and Resting State Scans. Variable names have been provided where appropriate. For more detailed information on the Psychophysiology Emotional Response Task paradigm, variable names and data collection procedures, please see:
MR1_P5_DOCUMENTATION_OF_BEHAVIORAL_COGNITIVE_20260206
MR1_P5_VARIABLE_NAMES_20260206
MR1_P5_DOCUMENTATION_OF_PROCEDURES_20260206

During the Psychophysiology Emotional Response Task we collected facial electromyography, electrodermal activity, respiration, and electrocardiography data. During the fMRI Emotional Response Task we collected electrodermal activity, respiration, and pulse oximetry. For more information about raw psychophysiology data see *MR1_P5_RESTRICTED_ACCESS_20260106.*

Differences Between MIDUS Waves

MIDUS 2 vs MIDUS Refresher 1

MIDUS Refresher 1 was the first instance of a hearing test as well as collecting electrocardiography and electromyography of the zygomaticus major. Therefore, measures from the hearing test, zygomaticus EMG and heart rate variability are only available in MIDUS Refresher 1 and MIDUS 3.

MIDUS 3 vs MIDUS Refresher 1

Part way through MIDUS 3, two additional frequencies (2000 and 4000Hz) that were not collected during MIDUS Refresher 1 were added to the hearing test.

For the MIDUS Refresher 1 sample, there was a variable timing delay (mean ~62 ms) between when the startle probe was intended to be presented and when it was actually presented due to computer software/hardware changes. Data processing procedures were adapted to account for this timing delay when processing EBR data from the MIDUS Refresher 1 sample. No such delay existed for data collected in the MIDUS 2 sample nor the MIDUS 3 sample.

Additionally, the summary measures of heart rate variability were calculated using different processing methods for MIDUS Refresher 1 and MIDUS 3. Please see below for more information on heart rate variability processing for MIDUS Refresher 1.

HEARING TEST

Hearing Test **[RA5O]**: Tones of various frequencies (250, 500, 1000 Hz) were played for participants in one ear at a time. Participants indicated when they were able to hear a tone. Data represents the lowest decibel level at which participants were able to hear a tone at a particular frequency in each ear.

FACIAL ELECTROMYOGRAPHY (EMG)

An experimenter placed electrodes on the seated participant's face. Electrodes were placed on either the left or right side of the face for each EMG measure (eyeblink startle reflex, corrugator supercilii, and zygomaticus major) following a predetermined counterbalance system, and then the participant was escorted into an electrically shielded booth to complete the computerized Psychophysiology Emotional Response Task (for description of task please see *MR1_P5_DOCUMENTATION_OF_BEHAVIORAL_COGNITIVE_20260206*). Participants were instructed to remain seated and face forward with both feet flat on the floor while avoiding large body

and head movements. All EMG related variables were calculated from physiological recordings during the Psychophysiology Emotional Response Task.

A computer located outside the booth recorded psychophysiological data. This portion of data collection took place in the Waisman Brain Imaging Core, located in the Waisman Center on the UW-Madison campus.

BIOPAC recording:

Raw EMG signals were amplified 5,000 times prior to digitization at 1000 Hz with 16-bit precision using Biopac AcqKnowledge software. The BIOPAC MP150 hardware system (ERS100C amplifiers) was used (BIOPAC systems, Inc., Goleta, CA).

Eyeblink Startle Reflex (EBR)

A pair of Ag-AgCl 4mm Touchproof shielded electrodes were placed below one eye on the inferior orbicularis oculi muscle to measure blink magnitude in response to acoustic startle probes (50ms duration at 105 dB) presented at one of three possible timings: 2.9 seconds after picture onset, 0.4 s after picture offset or 1.9 s after picture offset (pictures are presented for 4 seconds). For an introduction to EBR methods please see Blumenthal and colleagues (2005) guidelines paper and/or "The Skeletomotor System: Surface Electromyography" chapter in the *Handbook of Psychophysiology* (Tassinary & Cacioppo, 2000; Tassinary et al., 2007). For research on emotion and attentional modulation of EBR see Bradley et al. (2006).

Startle processing/scoring:

Processing with Matlab included 30 Hz highpass filtering, rectification and integration with a time constant of 20 ms. Eyeblink reflex magnitudes (in microvolts) were calculated by subtracting the amount of integrated EMG at reflex onset from that at peak amplitude (maximum amount of integrated EMG between 20 and 120 ms following probe onset). Trials with no perceptible eyeblink reflex were assigned a magnitude of zero and included in analysis. Trials scored as “bad” (a blink happening earlier than 20ms or later than 120 ms, or deemed as just noise) are not included in analysis. Eyeblink reflex magnitudes were log-transformed to normalize the data, then z-scored to range-correct the data separately for each participant. Eyeblink reflex amplitudes were calculated similarly, except trials with no perceptible eyeblink reflex were excluded from the analysis. Summary variables are separated by trial type (valence type and startle probe time). Trial-by-trial data of all startle responses is available via restricted access (see *MR1_P5_RESTRICTED_ACCESS_20260106*).

Data quality filter variable:

A filter variable is provided indicating the quality of the EBR measures **[RA5BF].** Poor-quality data may have included issues during acquisition, so it is recommended to exclude the poor-quality data if at all possible given the sample. Another variable is provided including the number of valid eyeblink responses across the entire session **[RA5B]**. There were a total possible of 81 eyeblinks across the session (9 trials did not include a probe, or, 3 trials per valence). Therefore, it is recommended that those participants who did not provide at least 10 or more valid eyeblinks across the session be dropped from analyses.

Probe timing:

For the MIDUS Refresher 1 sample, there was a variable timing delay (mean ~62 ms) between when the startle probe was intended to be presented and when it was actually presented due to computer software/hardware changes. Data processing procedures were adapted to account for this timing delay when processing EBR data from the MIDUS Refresher 1 sample.

Corrugator supercilii (CORR)

A pair of Ag-AgCl 4mm Touchproof shielded electrodes were placed above one brow line on the corrugator supercilii muscle to measure “furrowing of the brow” responses to positive, neutral, and negative pictures. For an introduction to emotion-modulation of CORR and CORR methods, please see Cacioppo et al. (1986), Larsen et al. (2003), and/or "The Skeletomotor System: Surface Electromyography" chapter in the *Handbook of Psychophysiology* (Tassinary & Cacioppo, 2000; Tassinary et al., 2007).

CORR processing:

After 60 Hz notch filtering, the data were visually inspected, and artifacts were removed from the corrugator data. A Fast Fourier Transform (FFT) was performed on all artifact-free 1s chunks of data (extracted through Hanning windows with 50% overlap) to derive estimates of spectral power density (μV^2/Hz) in the 30 – 200 Hz frequency band. These values were log-transformed to normalize the data. Corrugator activity was computed for 13 distinct epochs for each of the image valences (positive, neutral, negative). The first epoch covers a 1s pre-picture epoch that served as a baseline recording and was subtracted from corrugator activity in the subsequent 12 epochs. The baseline-corrected epoch data were then Z-scored within subject and averaged across 4-seconds creating 3 distinct blocks, in order to create a summary score of corrugator activity during the picture presentation (1-4 seconds~EARLY corrugator activity), immediately following picture offset (5-8 seconds~MIDDLE corrugator activity), and later after offset (9-12 seconds~LATE corrugator activity). Summary variables are separated by trial type (valence) and epoch timing (early, middle, late). Trial-by-trial data of all 1-second epochs per picture are available via restricted access. Some processing steps vary between summary and trial-by-trial data. The 4-second aggregates are highly correlated but may differ (see *MR1_P5_RESTRICTED_ACCESS_20260106*).

Data quality filter variable:

A filter variable is provided indicating the quality of the corrugator measures **[RA5C].** Poor-quality corrugator data may include significant noise and artifact, so it is recommended to exclude the poor-quality data if at all possible given the sample.

Zygomaticus major (ZYGO)

A pair of Ag-AgCl 4mm Touchproof shielded electrodes were placed on one cheek along the zygomaticus major muscle to measure “smiling” responses to positive, neutral, and negative pictures. For an introduction to emotion modulation of ZYGO and ZYGO methods, please see Cacioppo et al. (1986), Larsen et al. (2003), and/or "The Skeletomotor System: Surface Electromyography" chapter in the *Handbook of Psychophysiology* (Tassinary & Cacioppo, 2000; Tassinary et al., 2007).

ZYGO processing:

After 60 Hz notch filtering, the data were visually inspected, and artifacts were removed from the zygomaticus data. A Fast Fourier Transform (FFT) was performed on all artifact-free 1s chunks of data (extracted through Hanning windows with 50% overlap) to derive estimates of spectral power density (μV^2/Hz) in the 30 – 200 Hz frequency band. These values were log-transformed to normalize the data. Zygomaticus activity was computed for 13 distinct epochs for each of the image valences (positive, neutral, negative). The first epoch covers a 1s pre-picture epoch that served as a baseline recording and was subtracted from zygomaticus activity in the subsequent 12 epochs. The baseline-corrected epoch data were then Z-scored within subject and averaged across 4-seconds creating 3 distinct blocks, in order to create a summary score of zygomaticus activity during the picture presentation (1-4 seconds~EARLY zygomaticus activity), immediately following picture offset (5-8 seconds~MIDDLE zygomaticus activity), and later after offset (9-12 seconds~LATE zygomaticus activity). Summary variables are separated by trial type (valence) and epoch timing (early, middle, late). Trial-by-trial data of all 1-second epochs per picture are available via restricted access. Some processing steps vary

between summary and trial-by-trial data. The 4-second aggregates are highly correlated but may differ (see *MR1_P5_RESTRICTED_ACCESS_20260106*).

Data quality filter variable:

A filter variable is provided indicating the quality of the zygomaticus measures **[RA5L]**. Poor-quality zygomaticus data may include significant noise and artifact, so it is recommended to exclude the poor-quality data if at all possible given the sample.

HEART RATE VARIABILITY (HRV)

The MR1 Neuroscience Project HRV analysis outlined below for both ECG and PPG was done using QRSTool and CMetX, which differs from the M3 Neuroscience Project HRV analysis which uses NeuroKit2 (Makowski, 2021; Makowski et al., 2021).

Electrocardiogram (ECG) in psychophysiology session:

An experimenter placed a pair of EL503 electrodes 2 inches below the right collarbone and between the hip and rib cage on the participant's left side. BIOPAC GEL100 was applied to the electrodes used to measure the electrical activity of the participant's heart. The participant was escorted into an electrically shielded booth to complete the computerized Psychophysiology Emotional Response Task. An initial five-minute baseline recording obtained prior to starting the task was used to compute ECG HRV measures. During the entire procedure participants were instructed to remain seated and face forward with both feet flat on the floor while avoiding large body and head movements. A computer located outside the booth recorded data. This portion of the study took place in the Waisman Brain Imaging Core, located in the Waisman Center on the UW-Madison campus.

BIOPAC recording:

Raw ECG signals were amplified 1,000 times using the BIOPAC ECG100C amplifiers set to "normal" mode. The signals were acquired and recorded using Acknowledge software and BIOPAC hardware (BIOPAC systems, Inc., Goleta, CA).

Processing:

After passing the data through a low-pass 35 Hz filter and a high-pass 0.05 Hz filter, the data was visually inspected with in-house graphical user interface written for use with Matlab (The Mathworks, 2018). Heart rate variability was extracted in the high frequency band (0.14-0.5) according to guidelines for adult participants from the Task Force of the European Society of Cardiology and North American Society of Pacing and Electophysiology (1996) (as cited in Allen, Chambers, and Towers, 2011). Artifacts were identified and corrected when possible with interpolation. Ectopic beats were identified and corrected using guidelines outlined by Allen, Chambers, and Towers (2011). Data files that contained other non-correctable beats or artifacts could not have high frequency, low frequency, high/low frequency ratio, or heart rate calculated from QRSTool **[RA5K1AT]** and were either excluded, or only the data before or after the ectopic beat or artifact was used in CMetx analysis.

Data quality:

Poor quality heart rate data included significant clipping and/or noise throughout the entire recording. This should be excluded from analysis if possible. Data that required a significant amount of editing, especially throughout the entire recording, was also excluded in accordance with recommendations from Malik and Camm (1995) (as cited in Peltola, 2012). A filter variable is provided indicating the HRV data quality **[RA5K1FV]**.

Analysis:

Interbeat interval text files were generated by Matlab (The Mathworks, 2018) after cleaning the data.

These files were stripped of their time stamps then processed with CMetX (Allen, Chambers, & Towers, 2007) as a batch. All files were sampled at a rate of 10 Hz with the artifact threshold set at the default of 300ms between beats (Allen, Chambers, & Towers, 2007). CMetX took the interbeat interval text files and output comma-separated values files with various HRV metrics for the data collected during the baseline recording (see Allen, Chambers, & Towers, 2007 for more details on CMetX and its output metrics).

Photoplethysmogram (PPG) during fMRI scan session:

A BIOPAC TSD123A pulse oximeter transducer was placed on the participant's left index fingertip. This transducer connected to the BIOPAC OXY100C pulse oximeter module utilizing red and infrared light to measure the participant's pulse and blood oxygenation during the 8-minute resting state fMRI scan. Participants were instructed to remain still and relaxed while looking at a fixation cross. A computer located in a booth outside the scanner room recorded data. This portion of the study took place in the Waisman Brain Imaging Core, located in the Waisman Center on the UW-Madison campus.

BIOPAC recording:

The PPG light signals were transmitted and filtered through the OXY100C module set to "normal", The signals were then recorded using AcqKnowledge software and BIOPAC hardware MP150 system (BIOPAC Systems, Inc., Goleta, CA).

Processing:

The data was visually inspected with in-house graphical user interface written for use with Matlab (The Mathworks, 2018). Heart rate variability was extracted in the high frequency band (0.14-0.5) according to guidelines for adult participants from the Task Force of the ESC and NASPE (1996) (as cited in Allen, Chambers, and Towers, 2011). Artifacts were identified and corrected when possible with interpolation. Ectopic beats were identified and corrected using guidelines outlined by Allen, Chambers, and Towers (2011). Data files that contained other non-correctable beats or artifacts could not have high frequency, low frequency, high/low frequency ratio, or heart rate calculated from QRSTool **[RA5K2AT]** and were either excluded, or only the data before or after the ectopic beat or artifact was used in analysis.

Data quality:

Poor quality heart rate data included significant clipping and/or noise throughout the entire recording. This should be excluded from analysis if possible. Data that required a significant amount of editing, especially throughout the entire recording, was also excluded in accordance with recommendations from Malik and Camm (1995) (as cited in Peltola, 2012). A filter variable is provided indicating the HRV data quality **[RA5K2FV]**.

Analysis:

Interbeat interval text files were generated by Matlab (The Mathworks, 2018) after cleaning the data. These files were stripped of their time stamps then processed with CMetX (Allen, Chambers, & Towers, 2007) as a batch. All files were sampled at a rate of 10 Hz with the artifact threshold set at the default of 300ms between beats (Allen, Chambers, & Towers, 2007). CMetX took the interbeat interval text files and output comma-separated values files with various HRV metrics for the resting state recording (see Allen, Chambers, & Towers, 2007 for more details on CMetX and its output metrics).

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