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Examining changes in HRV and emotion following art-making with three different art materials

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TITLE:

Examining Changes in HRV and Emotion Following Artmaking with Three Different Art Materials

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KEYWORDS:

Heart rate variability, Respiratory Sinus Arrhythmia, art making, emotional response, psychophysiology, Self-assessment manikin (SAM)

SUMMARY:

The goal of the protocol is to guide researchers in conducting experiments that are intended to measure changes in emotional response and heart rate variability following art making with different materials. The protocol can easily be adapted for use in a variety of behavioral conditions and activities.

ABSTRACT:

This protocol enables the examination of psychological and physiological responses to different types of behavioral engagements. Specifically, in this study, the emotional response and changes in heart rate variability are examined in response to artmaking with three different art materials that vary in their levels of fluidity. This protocol can be adapted to examine other types of behavior or engagement in artmaking with other materials. There are several benefits to using this protocol. Firstly, the order randomization of the materials improves the probability that the response measured is associated with its qualities and not the order of presentation. Secondly, the continuous measuring of electrocardiogram enables the examination of changes in heart rate variability after engagement with each art material and changes that might occur during the artmaking itself. The advantages of this protocol should be considered with their limitations. The music listening is before each art making session; thus, the return to baseline can only be measured in the first two conditions. The return to baseline provides information on how fast individuals recover after response to working with each of the materials. Furthermore, a more liquid material instead of gouache paint with a brush, such as finger paints, provides more difference between materials. Finally, this protocol can be adapted to specific research needs.

INTRODUCTION:

The purpose of this protocol is to examine the physiological and emotional response to artmaking in different conditions. In this case, the difference in response to art making with three different art materials varying in levels of fluidity is examined. The rationale behind the development of this experiment is to provide support for theories of art therapy claiming that artmaking with more fluid art materials is related to enhancing emotional expression[1]. Heart rate variability (HRV) in general, and respiratory sinus arrythmia (RSA) specifically, is indicative of emotional engagement and regulation[2,3]. In this study, the order of the art materials used are randomized to control for an order effect. There are no other studies with this study design found.

The advantage of this method is that the ongoing measurement of heart rate variability (HRV) enables the examination of the physiological response to artmaking during the art making itself and it is noninvasive. This is in opposition to measuring bio-markers in blood or saliva following art making, which is important and relevant, but can be challenging to time accurately and requires uncomfortable (drooling in to a tube) or invasive (providing a blood sample) collection methods[4].

This protocol can be adapted to measure response to a variety of behavioral activities, and art making with different materials. To do so, replace the artmaking with three materials with the desired behaviors to be examined. It is important to make sure that most elements of the behaviors being examined are similar other than the quality of the behavior being examined (i.e., the liquidity of the art material). **Figure 1** is a flow chart of the experiment.

PROTOCOL:

This study was conducted with the approval of the Faculty of Social Welfare & Health Sciences at the University of Haifa, ethics committee. Informed consent was obtained, and research was performed in compliance with Helsinki guidelines for human welfare.

NOTE: The research is conducted at a table, using art materials and a portable, wireless and non-invasive electrocardiogram (ECG) recording device.

1. Participant selection

1.1. Recruit healthy participants between the ages of 18 and 40. For a wider range of ages, a division to sub-groups is recommended due to age related changes in heart rate variability.

1.2. Exclude participants with current or a history of heart disease as heart disease can affect heart rate variability, thus limiting the ability to examine whether change is due to the behavioral activity.

1.3. Invite all subjects to the laboratory between 08:00-15:00, to ensure similar conditions. Set any time frame as long as the experiment can be conducted within it.

1.4. Greet the participant and confirm that in the 2 hours before the experiment the participant did not drink coffee, eat, smoke or vigorously exercise.

1.5. Obtain written informed consent to ensure that participants know they are free to leave the experiment at any point in time without consequence and are aware of any risks and benefits to participation.

2. Experimental protocol

2.1. Adhere the biopatch two fingers below the sternum with 2 Ag-AgCl disposable electrodes. The ECG is sampled (1000 Hz, 16 bit) and recorded with the biopatch.

2.2. Examine that the values of the data collected (i.e., heart rate, HRV) appear on the graphic interface ensuring that data is being collected. The software will also transmit an audio alarm when the biopatch goes offline.

2.3. After the participant adapts to the environment and wears the biopatch, measure 5 min of resting heart rate in a sitting position to establish baseline HRV. Instruct the participant to sit still, and avoid chewing or talking, which affects the HRV.

2.4. Following the 5 min rest to establish baseline HRV, instruct participants to fill out pencil and paper questionnaires with demographic data, a question about art making habits and the self-assessment manikin (SAM)[5]. Instruct participants to mark the drawing that is closest to how they feel at the current moment (See **Figure 2**).

2.5. To establish a comparable emotional state, have participants listen to 5 min of relaxing music of their choice (nature sounds, new age or classical music) before each artmaking session. The relaxing music is purposely chosen by the participant to ensure that it is relaxing for them[6].

2.6. Provide participants with a (50 cm x 35 cm) sheet of paper and instruct them to engage in a 10 min artmaking session (pencil, oil pastels or gouache paint). To reduce an order affect, randomize the order of the art materials.

NOTE: Here, after drawing with pencil, the participants used oil pastels and then gouache paint.

2.6.1. Encourage participants to engage in an exploration of the materials in any way they feel fit and use the entire 10 min for artmaking. Provide encouragement by reminding participants that the art product and its aesthetics are not important and that they can draw anything at all.

2.6.2. Present the pencil with a pencil sharpener and an eraser.

2.6.3. Instruct participants to report their emotional state using the SAM.

2.7. Turn on music and instruct participants to listen to 5 min of relaxing music of their choice (nature sounds, new age or classical music).

2.8. Place an open box of 12 colors of oil pastels on the table and instruct participants to use them in any way they choose including peeling the wrapper and breaking the pastel if needed.

2.8.1. Replace the box of pastels for the next subject if their general appearance is significantly affected by use.

2.8.2. Instruct participants to report their emotional state using the SAM.

2.9. Turn on music and instruct participants to listen to 5 min of relaxing music of their choice (nature sounds, new age or classical music).

2.10. Present gouache paint in primary colors (yellow, red and blue), black and white in a plastic palette, divided into 6 bowls and 4 mixing surfaces, to control the quantities of paint. In addition, provide a jar of water, a soft, flat-headed brush (size 6) and a cloth.

2.10.1. Tell the subjects that they can request additional paint if needed.

2.10.2. Provide a short explanation of mixing colors and cleaning the brushes.

2.10.3. Instruct participants to report their emotional state using the SAM.

2.11. Remove the biopatch from the participant at the end of the session. Download the data recorded with the biopatch to the computer using the biopatch download log.

3. Data analysis

3.1. Convert the data to a text file that is appropriate for import to the visual analysis software (e.g., QRSTool)[7], saving only the time stamp and voltage vectors, using a MATLAB script. The MATLAB script* is helpful in saving the timestamp and voltage vectors, while erasing the rest. This can be done manually but is very time consuming. The resulting text file example is presented in **Figure 3**.

3.2. Import the text file created by the MATLAB script to the QRSTool using the visual interface: **File | Import | (Choose File)**. Make sure that the sample rate 1000 Hz button is pressed. The file with then be graphically displayed in the window of QRSTool.

3.3. Visually inspect the ECG series for artifacts. Identify the R component of the ECG using the QRS-tool software (See **Figure 4**). The software automatically detects the R spikes, by flagging all points with a red triangle, above a threshold marked manually.

NOTE: For more information contact the third author at: jallen@email.arizona.edu

3.3.1. Visually inspect each ECG series alongside the identified heartbeats, time points and artifacts (missed or wrongfully identified heartbeats), which may have an additional triangle in the QRST wave, or a missing triangle. Correct this manually by clicking to remove the extra triangle or adding one where missing.

3.3.2. In areas of data with noise, not showing an identifiable QRS wave, divide the data into several chunks, of 30 seconds at least.

NOTE: Remember, tails of cropped data cannot be added together. Analyze these separately and create a mean of all chunks.

3.3.3. Mark or divide the data according to various phases of the experiment. To do so, use the visual interface to cut off and save only the data for each event and export them separately to CMetX (described below). Divide the data based on the experiment stages described above (baseline, music listening and art making with the various materials).

3.4. When all data is clean, export to CMETX by using the visual interface **File | Export | OK**. This will open the CMetX viewer window with an added line with the indices of HRV.

3.5. Export to a CSV file for data analysis

3.5.1. Use two indices of HRV: the estimated respiratory sinus arrythmia (RSA) as a vagal or parasympathetic index and the cardiac sympathetic index (CSI) – based on a Lorenz plot that estimates sympathetic influence. **Figure 4** is an example of the output provided by the CMetX software.

NOTE: Choosing the appropriate HRV index to represent vagal or sympathetic cardiac regulation can be tricky and requires some methodologically and theoretically based decisions that are beyond the scope of this presentation. For further information we recommend reading: Allen, J. J., Chambers, A. S., & Towers, D. N. (2007). The many metrics of cardiac chronotropy: A pragmatic primer and a brief comparison of metrics[8].

3.6. Estimate HRV reactivity by subtracting the mean HRV index during music listening from the mean HRV index during the following artmaking session (i.e., positive values represent higher HRV during artmaking compared to the proceeding relaxation).

REPRESENTATIVE RESULTS:

As mentioned above, the CMetX software provides several matrices of HRV. Here, the RSA measure, was calculated for each participant per each experimental condition. **Figure 5** depicts mean RSA values (±SE) for the three artmaking tasks and their preceding resting periods. A within subjects ANOVA revealed a statistically significant main effect for artmaking ($F^{(1,49)}$ = 26.155, $p < .001$), with a large effect size ($\eta_p^2 = .348$), which can be intuitively interpreted as

thirty five percent of the variability of RSA explained by artmaking (compared to resting). A statistically significant interaction ($F^{(2,98)} = 5.965$, $p = .004$, $\eta_p^2 = .109$) indicated that the change in mean RSA levels was dependent on the art material. Pairwise comparisons (with a Sidak adjustment for multiple comparisons) demonstrated a significant change in mean RSA during artmaking with oil pastels ($t_{(49)} = 5.51$, $p < .0005$, *Cohen's D* =0.475) or gouache ($t_{(49)} = 3.63$, $p = .001$, *Cohen's D* = 0.195) but not during drawing with pencil ($t_{(49)} = 1.40$, $p = .168$, *Cohen's D* = 0.105).

[Insert Figure 5 here]

In addition to heart rate variability, the three self-reported emotional response measures of the SAM[5] visual analogue scale were used to estimate whether there were differences in the emotional responses to the various art materials. Mean (±SD) values of the valence, arousal and dominance self-report measures following each artmaking task, as well as following a baseline resting period, on a centered scale ranging from -4 to 4 are detailed in **Table 1**. A repeated within subjects ANOVA demonstrated a statistically significant effect for art material on valence but not on arousal or dominance (**Table 1**). Post hoc pairwise comparisons revealed that, on average, emotional valence was more positive following painting with gouache in comparison to emotional valence following drawing with a pencil ($p = 0.038$), but not in comparison to baseline valence ($p = 0.744$).

[Insert Table 1 here]

For detailed results, please see: Emotional response and changes in heart rate variability following artmaking with three different art materials[7].

This protocol could be easily used to examine differences in emotional response after and changes in HRV during and after a variety of activities, and do not have to be limited to artmaking. Furthermore, this protocol can be modified to examine differences in emotional and physiological response to artmaking with a wider variety of art materials as well.

FIGURE AND TABLE LEGENDS:

Figure 1: A flow chart of the experiment, originally published in a previous publication and is printed here with permission[7].

Figure 2: An example of the SAM measure[5].

Figure 3: An example of what a text file prepared to be imported to QRSTool looks like.

Figure 4: An example of the data exported by CMetX.

Figure 5: RSA at rest and during artmaking.

Table 1: Valence, arousal, and dominance measures of emotional response during rest and art-making.

DISCUSSION:

This protocol is designed to measure differences in RSA during artmaking with art materials varying in their levels of fluidity[7]. The biopatch[9,10] is a small round physiological monitoring telemetry device that attaches to a holster that connects to two Ag-AgCl disposable electrodes and enables the collection of physiological data, including basic ECG. The device stores and transmits vital sign data including ECG, heart rate, respiration rate, body orientation and activity. There are several critical steps in the protocol. It is very important to conduct some sort of returning to baseline activity. We chose listening to relaxing music, and let participants choose one of three types of music to ensure that indeed this music is relaxing for them. We also had the participants listen to the same music before engaging in art making with the goal of "neutralizing" any stimulation that participants may have entered the laboratory with that day. There are some disadvantages to allowing participants to choose the type of music they listen to as it could impact variability between how participants respond. However, the purpose of the music is to provide an opportunity to return to baseline and we believe that having participants choose how to return to baseline is preferred over the potential that the music would be annoying and thus missing its purpose of return to baseline.

Taking time to ensure that the time one activity ended and the next one began is marked accurately is important. The absolute time provided by the biopatch and internet time can be synchronized manually to ensure that the ECG recordings are divided according to the different activities.

The SAM is a 9-point visual analogue scale measuring the valence, arousal, and dominance of emotional response administered on paper and pencil with 3 rows of 5 drawings of human figures, and a scale of 1-9 below each row (see **Figure 2**). The valence scale ranges from unhappy or sad to happy or joyful. The arousal scale ranges from calm or bored to stimulated or excited. The dominance scale ranges from submissive or "sense of being without control" to dominant or "in control". The first row is a valence scale, which has drawings that have a range of facial expressions starting with a smile and slowly transitioning to a frown. The smile indicates a very happy mood, while a frown indicates a very sad mood. There are 3 drawings in the middle, with a small smile, a neutral expression and a slight frown. The second-row measures arousal, and the human figure drawn has a large explosion like drawing in the middle of the human figure, which transitions to become smaller and smaller until the figure on the far right only has a dot in the mid-section, indicating a low level of arousal. The dominance scale at the bottom has a small figure in the center of the square that progressively gets larger, until the far-right figure emerges from the bounds of the square.

Since ECG artifacts, which may be caused by participant movements, or temporary disconnection of the biopatch system, might be like those of R waves, it may result in R-R (i.e., Inter-Beat-Intervals - IBI) miscalculations. In areas of data with noise (not showing an identifiable QRS wave), use QRSTool to divide the data into several long enough chunks, of 30

seconds at least. The visual interface of QRSTool enables the user to mark a certain section of data, if suspected to be noise and then crop it out, so that it is not included in the outputted data. Another advantage of dividing the data into the 30 second segments is that the metric of HRV will not be influenced by length of usable data, as longer recordings can produce higher HRV estimates.

CMetX software is a command-line based utility that calculates various metrics of HRV given a simple IBI series as an input. The following values are calculated: mean interbeat interval, mean heart rate, the average of the rate-transformed IBIs, standard deviation of IBIs, root mean square of differences between IBIs, mean of absolute value of consecutive IBI difference, proportion of consecutive IBI differences greater than 50 ms, Toichi Cardiac Vagal Index, Toichi cardiac sympathetic index, natural log of variance of IBI series, natural log of variance of filtered (.12-.40 Hz) IBI series, number of IBIs on which the metrics are based, which allows for loss for implementing the filter to band-limit RSA. All values are calculated for the IBIs that are retained after the filter is applied to band-limit the signal to calculate RSA. The filter results in a loss of 12 seconds of data at the beginning and 12 seconds at the end of the file. Further documentation and training videos on scoring ECG can be found on: https://jallen.faculty.arizona.edu/content/resources-and-downloads.

As mentioned earlier, the protocol can be modified to examine differences in emotional response and physiology to different types of behaviors. In addition, the protocol can be modified to use additional self-report measures as well. Parts of the ECG recordings from the beginning and end of sections may need to be removed if time synchronization is not optimal. The protocol is also not limited to 3 different types of activities or materials and can be expanded or restricted. Having said that, the protocol is limited to behaviors and activities that can take place in one room in a similar setting for all participants and all activities for each activity. This is because the environment may affect HRV and to ensure the differences observed are due to the activity or behavior and not the environment.

The level of experience in art making, individuals' level of anxiety from art making, along with any other stressful experiences that may occur before the experiment, may have an effect on individual's response. In this study, we asked participants regarding their experience in artmaking, however we did not find any difference based on artmaking experience (novice, hobby or professional). Further studies may want to take the other considerations mentioned in to account. Another suggestion would be to have open ended questions to probe individuals about the reasoning behind their emotional state.

In the future, this protocol can be used to compare response to drawing with regular art materials or digital media. Given the finding regarding oil pastels, we suggest conducting a further study to test the variability between a waterier type of paint and comparing finger painting with different types of paint brushes. The results of studies employing this protocol can be used to expand the body of knowledge regarding the effect of the use of different materials which in turn may be used to tailor art-based interventions to the specific needs of art therapy clients.

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DISCLOSURES: The authors have nothing to disclose.

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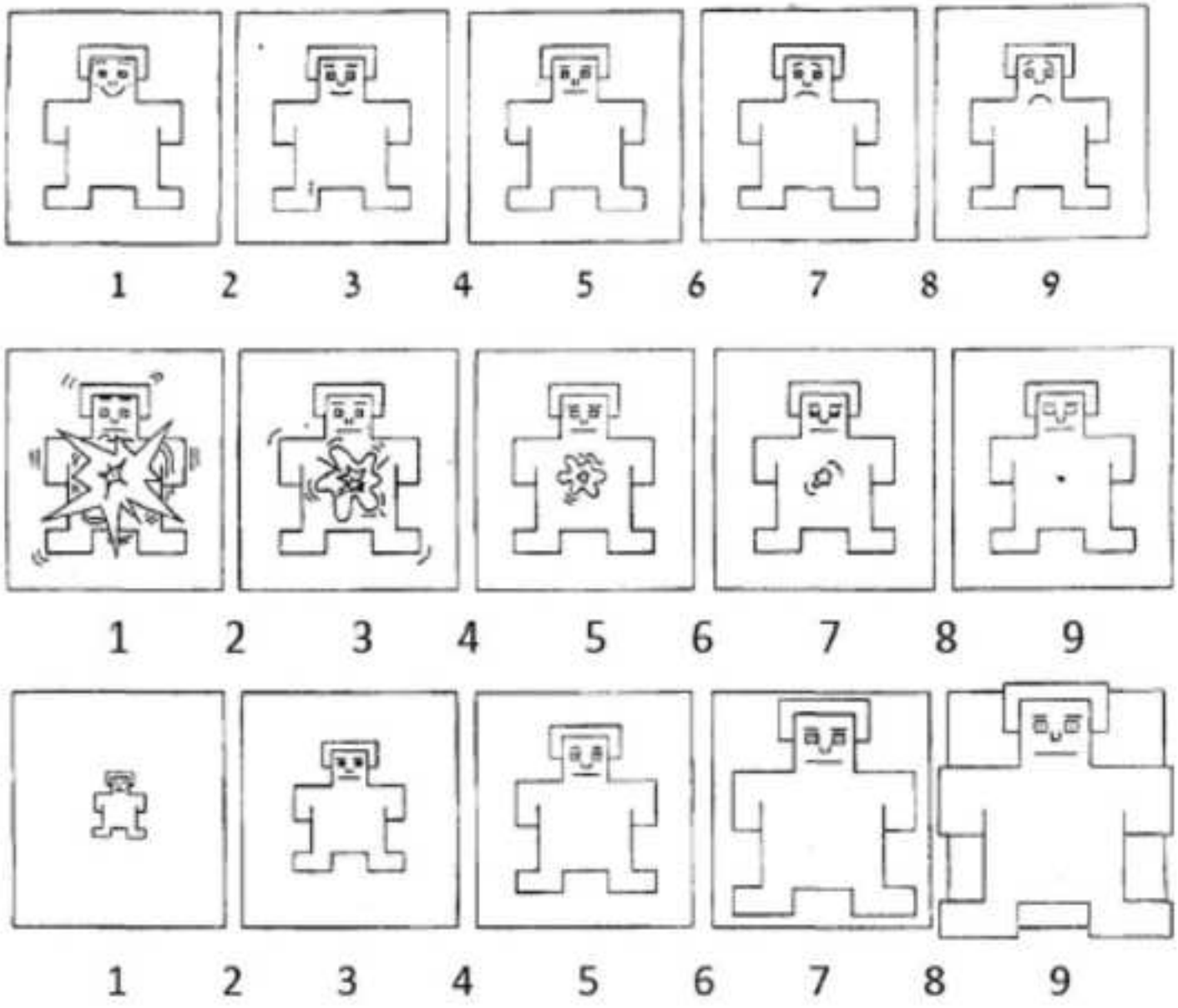

Figure 2: Self-assessment manikin (SAM)

Figure 3

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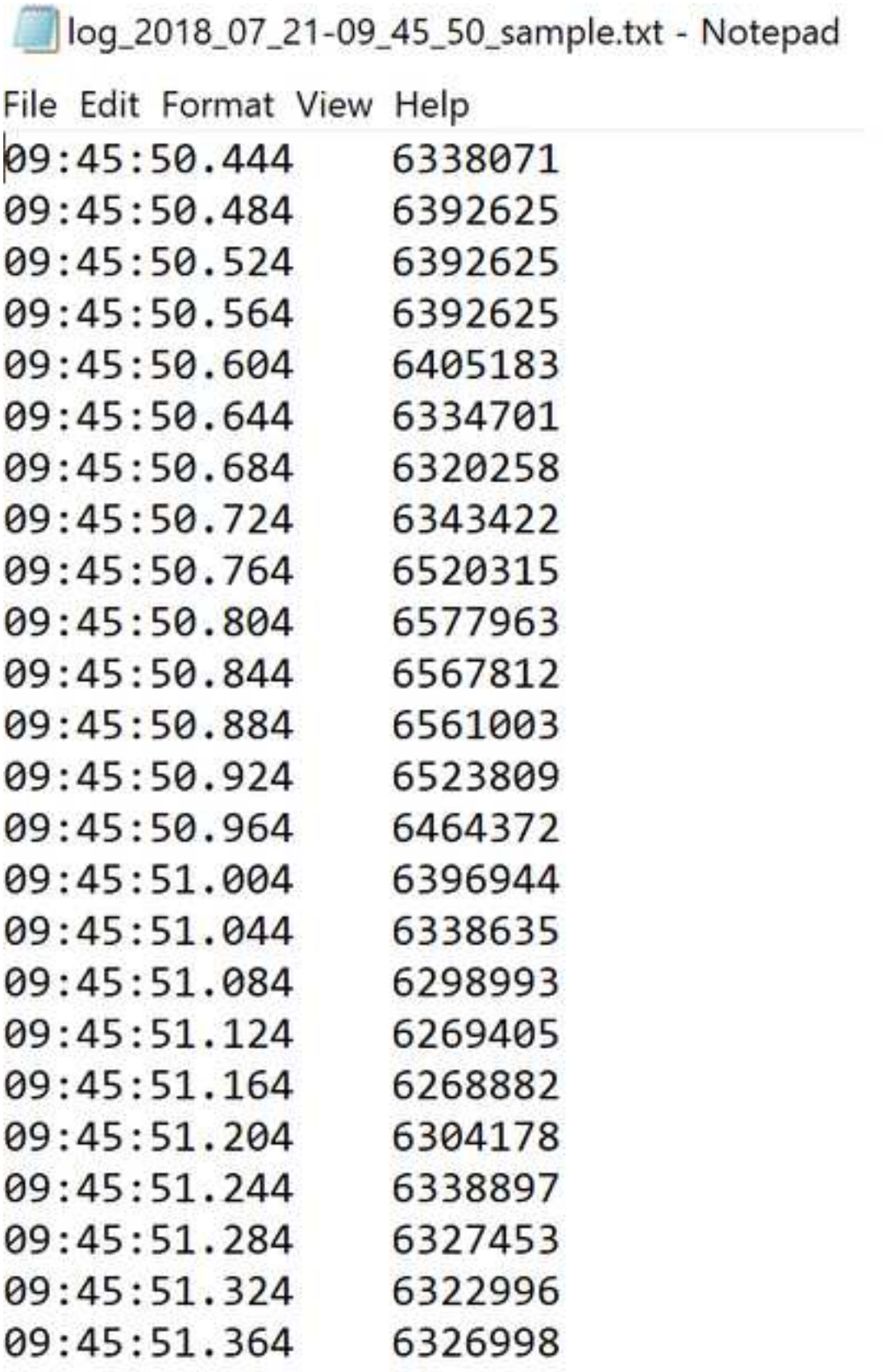

Figure 3- Notepad example

Figure 4

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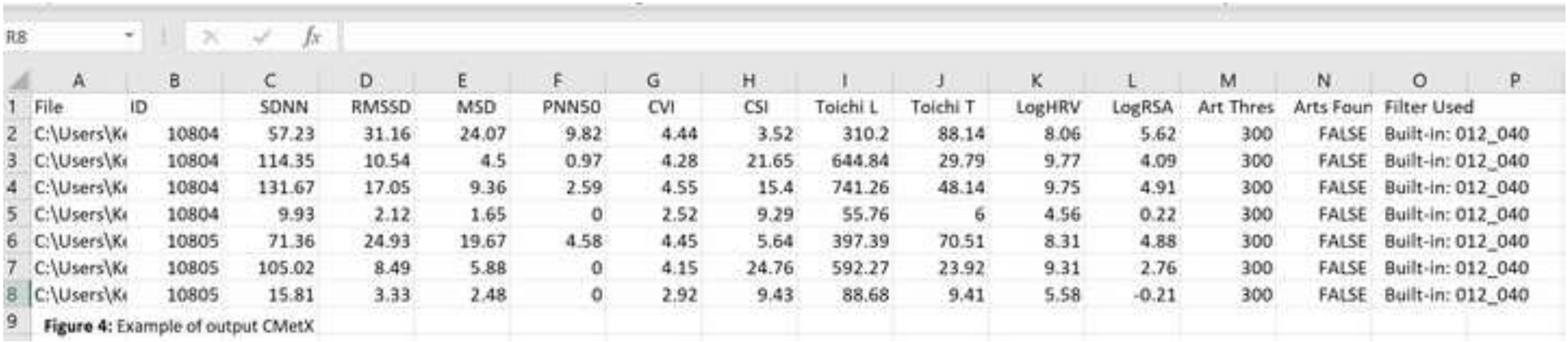

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2	C:\Users\K	10804	57.23	31.16	24.07	9.82	4.44	3.52	310.2	88.14	8.06	5.62	300	FALSE	Built-in: 012_040	
3	C:\Users\K	10804	114.35	10.54	4.5	0.97	4.28	21.65	644.84	29.79	9.77	4.09	300	FALSE	Built-in: 012_040	
4	C:\Users\K	10804	131.67	17.05	9.36	2.59	4.55	15.4	741.26	48.14	9.75	4.91	300	FALSE	Built-in: 012_040	
5	C:\Users\K	10804	9.93	2.12	1.65	0	2.52	9.29	55.76	6	4.56	0.22	300	FALSE	Built-in: 012_040	
6	C:\Users\K	10805	71.36	24.93	19.67	4.58	4.45	5.64	397.39	70.51	8.31	4.88	300	FALSE	Built-in: 012_040	
7	C:\Users\K	10805	105.02	8.49	5.88	0	4.15	24.76	592.27	23.92	9.31	2.76	300	FALSE	Built-in: 012_040	
8	C:\Users\K	10805	15.81	3.33	2.48	0	2.92	9.43	88.68	9.41	5.58	-0.21	300	FALSE	Built-in: 012_040	
9	**Figure 4:** Example of output CMetX															

Figure 1

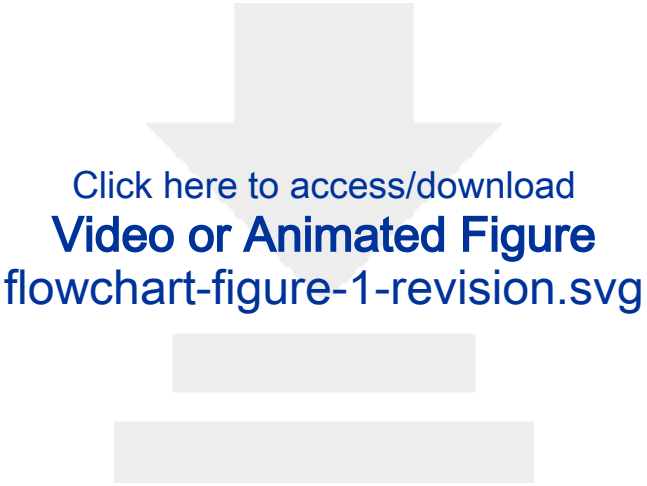

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Figure 5

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Table 1. *Valence, arousal, and dominance measures of emotional response during rest an*

	Baseline	**Pencil**	**Oil Pastel**
	M (SD)	M (SD)	M (SD)
Valence	2.14 (±1.07)	1.96 (±1.65)	2.30 (±1.54)
Arousal	-1.72 (±1.84)	-1.86 (±2.13)	-1.90 (±1.88)
Dominance	-0.02 (±1.41)	0.16 (±1.54)	0.14 (±1.77)

*$p < 0.05$

d art-making

Gouache M (SD)	$F^{(3,147)}$	η_p^2
2.60 (±1.55)	2.93*	0.056
-1.66 (±2.11)	0.47	0.009
0.16 (±1.82)	0.28	0.006

Name of Material/Equipment	Company	Catalog Number	Comments/Description
Disposable Ag/AgCl electrodes	Biopac	EL501	
Drawing paper	Stenoplast		
Echo gateway	Medtronic	9600.0303	
Eraser	Factis		
Gouache paint	Giotto		
HB pencil	Milan		
Omnisense 3.9.7	Medtronic	9700.0269	Computer software
Oil pastels 12 colors	Talens		
Zephyr biopatch	Medtronic	9600.041	

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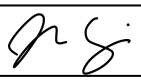
Signature:	
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To: Nam Nguyen, Ph.D.
Manager of Review
JoVE

From: Johanna Czamanski, PhD ATR LPC (AZ)
Faculty of Social Welfare and Health Sciences
University of Haifa

Oct. 3rd, 2019

Dear Dr, Nguyen,

Below please find our response to the editorial and reviewer comments.
We thank the reviewers for the opportunity to better our manuscript and video. Please find our response in italics.

Editorial and production comments:

Changes to be made by the Author(s) regarding the written manuscript:

1. Line 164- A request for the Matlab script to be provided. *We have added a footnote with the email of the third author who can provide the Matlab script upon request.*
2. Line 212- The results need a little more explanation so the protocol and data analysis can be connected more coherently with the representative results. *We have added several sentences that provide an explanation of the representative results and connect them to the protocol.*
3. Lines 237-241. How were these terms calculated? CSI is not mentioned in the manuscript prior. Please define these terms. How were these terms calculated in the protocol? *Indeed, the shorthand version of these terms was not previously mentioned, and this has been corrected, added on line 199. We have also removed the data on CSI as it does not contribute to the representative results. In lieu of this we added more details and clarifications in the representative results.*
4. Please submit these tables as xls/xlsx files instead of doc files. *We have converted Table 1 in to a figure for clarity and have converted table 2 in to a xlsx file, now called Table 1.*

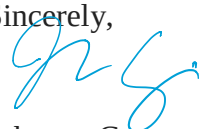
Changes to be made by the Author(s) regarding the video:

1. Please repeat the title card at the end of the video as well. *Corrected*
2. There are frequent harsh edits in the audio of this video. We have noted the ones that should absolutely be corrected, but would encourage the authors to take another pass at the audio editing. There are frequent edits in the middle of breaths as well as other audio edits that are noticeable and jarring. *We have made another attempt at editing the audio removing audible breaths.*

3. 0:00-0:04 - There is a thin black border on the left side of the frame. The white background should be extended to eliminate it. *This has been extended.*
4. 0:16 - The shot shown briefly here is a bit disorienting. It could be removed, and the video could just cut from Dr. Czamanski-Cohen speaking to the image of the art materials on the table. *This edit has been done.*
5. 0:33-0:36 - This clip appears to drift downwards, creating an increasing black border on the top of the frame. This should be corrected. *This has been corrected.*
6. 0:36, 5:38 - Jump cuts, like the one here, where the angle is not changed between shots, should be avoided. Jump cuts tend to have a jarring effect on the audience. Please use cross dissolves (aka fades) or use other video or images (aka B roll) to cover those edits as is done elsewhere in the video. *These have been re-edited to fades.*
7. 0:59 - There is an audible breath here that does not pay off with words. It should be removed. *This has been removed.*
8. 2:37, 2:47, 3:09, 5:52 - There is a fragment of a word or noise in the narration here that should be removed. *These have been removed.*
9. 3:34 - There is some very audible background noise here (something plastic being dropped, perhaps). If this can't be removed, this sentence should be rerecorded. *This has been corrected, the word with the background noise has been removed.*
10. 4:59 - Some noise comes in here that distorts one of the words to the point where the word is unrecognizable. This should be corrected, or this sentence should be rerecorded. *This has been corrected.*
11. 6:14 - There is a blank frame in the middle of this edit. This should be corrected. *Corrected.*
12. 6:27-7:10 - The end of the video here is just blank silence. Future submissions should end on or just after the final title card. *This has been corrected.*
13. Standalone chapter title cards should be inserted in the video, including ones for the representative results and the conclusion. This will allow us to mark navigable chapters for the website's chapter list, displayed to the right of the video. *These have been added.*

Again, we would like to take this opportunity to thank the reviewers and editors for their comments and the opportunity to improve our manuscript.

Sincerely,



Johanna Czamanski-Cohen PhD ATR LPC (AZ)

University of Haifa