Bachelor-Thesis

"Self-reported stress evaluation and physiological response"

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19.01.2016

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Abstract

We all experience emotions such as anger and stress on a regular basis. The various responses to such emotions are commonly thought to be coherent, meaning that they can be seen as one coordinated response system. However, due to inconsistency in empirical data Evers et al (2014) proposes a dual-process model of emotions. He distinguishes between an automatic and a reflective response system. This research examines the coherence between self-reported and physiological responses as a reaction to a social, environmental and cognitive stressor. Stress results were obtained by inducing social (Sing a Song Stress Test), environmental (Loud Noise) and cognitive (Stroop Task) stress in undergraduate students. Physiological responses were compared to self-reported stress for each task. The environmental stressor and the cognitive stressor failed to induce stress in students. The results for the social stressor indicate no coherence between physiological and self-reported data and therefore support the idea of a dual-process model.

We ervaren regelmatig emoties zoals boosheid en stress. Het wordt gewoonlijk verondersteld dat de verschillende reacties op dergelijke emoties coherent zijn, wat betekent dat ze kunnen worden gezien als een gecoördineerd reactiesysteem. Als gevolg van inconsistentie in empirische gegevens stelt Evers et al (2014) een dual-proces model van emoties voor. Hij onderscheidt automatische en reflectieve reactiesystemen. Dit onderzoek gaat in op de samenhang tussen zelf-gerapporteerde en fysiologische reacties op een sociale, milieu en cognitieve stressor. Stress resultaten werden verkregen door het induceren van sociale (Sing A Song Stress Test), milieu (Loud Noise) en cognitieve (Stroop Taak) stress bij studenten. Fysiologische reacties waren in vergelijking met zelf-gerapporteerde belasting voor elke taak. De milieu-stressor en de cognitieve stressor riepen geen stress op in studenten. De resultaten voor de sociale stressor geven geen samenhang tussen fysiologische en zelf-gerapporteerde data en ondersteunen daardoor het idee van een dual-process model.

Introduction

1.1 The dual-process perspective on emotions

Everyone encounters stressful situations once in a while. This stress response prepares the body for a potentially dangerous situation by putting him into a state of arousal (Fibiger & Singer, 1984). On the other hand humans also have the capability of describing their stress to others. Those two reactions to stress (bodily vs. self-reported) were long thought to be two coordinated responses. However, some inconsistency can be found between self-reported and physiological reactions to stress (McLeod, Hoehn-Saric, & Stefan, 1986). The dual-process perspective proposed by Evers et al. (2014), introduces a possible answer to the inconsistency found in the response to emotional stimuli when comparing different methods of assessment (Evers et al., 2014). Evers makes a distinction between two major processing systems. He proposes that a response to an emotional stimulus can be automatic or reflective. Automatic processing is described as a relatively fast, unconscious and effortless system, whereas the reflective system is a slow and effortful system but therefore relatively conscious and deliberate. An example for an automatic system would be the body's reaction to an emotional stimulus. An example for a reflective system could be the answer on an evaluation questionnaire to an emotional stimulus.

Evers et al 2014 suggests the dual-process model, which finds a lack of coherence across the physiological parameters and the self-reported measures of anger. Can the same lack of coherence be found when examining stress responses instead of responses to anger? This paper aims to explore whether or not the dual-process perspective can be supported by data retrieved from the measurement of stress.

1.2 Stress

In order to do that a clear definition of stress is needed. Research indicates two different ways to categorize stressors. There is a distinction made between physiological stressors and psychological stressors (Dayas, Buller, Crane, Xu, & Day, 2001; Fibiger & Singer, 1984; www.humanstress.ca, 2015). A physiological stressor could be a life threatening situation or a challenging physical activity. A psychological stressor on the other hand can be among others classified in environmental stressors and social stressors (Aneshensel, 1992; Evans, 1982). An environmental stressor can be a loud and noisy sound. A social stressor could be a speech in front of strangers. Research also indicates a second distinction between psychological stressors. They can be categorized as cognitive (workload) and emotional stressors (Lyle E. Bourne, Jr. Yaroush, & Yaroush, 2003; Renaud & Blondin, 1997). An often cited cognitive stressor is the Stroop Task (Lattimore, 2001; Renaud & Blondin, 1997). An emotional stressor could be anger through provocation as implemented by Evers.

1.3 The reaction to stress: Physiology and Self-Report

The reaction to stress can vary per individual. On a physiological level, stress is simply the reaction to a certain demand (www.mtstcil.org, 2015). The body's sympathetic nervous system reacts to such demands by releasing adrenaline (Fibiger & Singer, 1984). At the same time the muscles become tense, pupils enlarge, heart rate goes up, and perspiration occurs (www.health.harvard.edu, 2011). As described above, a distinction is made between physiological and psychological stressors. Both stressors can induce comparable physiological responses, including an increase in *skin conductance* (see: The measurement of stress) (Cohen, Kessler, & Gordon, 1997; www.mtstcil.org, 2015). Due to the fact that a *physiological response* to any kind of stressor is relatively fast and unconscious, this kind of reaction is classified as relatively *automatic*.

Subjective stress evaluation is expected to be an effortful and relatively slow process through introspection, as is the subjective evaluation of anger in the study of Evers. For the purpose of this study it is therefore classified as a *reflective* response to stress.

1.4 The measurement of stress

An EDA-sensor has the potential to lay the link between physical responses and stress. There is no such thing as a device for the measurement of stress. It is possible however to measure any increase or drop in *skin conductance level* with a so called EDA sensor or skin conductance sensor (Affanni & Chiorboli, 2015; Garbarino, Lai, Bender, Picard, & Tognetti, 2015; van Dooren, de Vries, & Janssen, 2012; www.empatica.com, 2015a, 2015b, 2015c). Skin conductance levels are higher, the more a person is sweating. Since the body's reaction to a certain stressor includes an increase in perspiration, the link between stress and skin conductance level can be made.

As to the measurement of self-reported stress; it is possible to use a questionnaire in order to assess the subjective experience of a stressful event (Oldehinkel et al., 2011).

1.5 Research Question & Hypothesis

The study of Evers et al concerned emotional stimuli and emotional self -reports. The present study examines whether the dual process perspective also correctly predicts the lack of coherence between physiological parameters and self-reported measures when the focus is on stress.

> ***H1****: The correlation between self-reported stress and the number of skin conductance responses as a reaction to a social, environmental and cognitive stressor will be small or non-existent.*

Method and Material

2.1 Participants

Twenty-two respondents took part in this study. All of them were bachelor students at the University of Twente. Therefore, a basic knowledge of the measurement devices used can be expected. However, this should not influence the results since the study aims to stimulate the autonomous responses of the body. Ten males and twelve females between the ages of eighteen and thirty participated in the study (age M = 20.5 years, SD = 2.57). Participants with diagnosed heart disease, epilepsies or other medical difficulties involving stress were excluded from the study beforehand to prevent negative effects on their health. Furthermore, five participants needed to be excluded from the analysis due to technical difficulties. Two women needed to be excluded from the analysis because they did not fill in the questionnaire properly. Eight men (age M = 20.13 years, SD = 1.73) and seven women (age M = 21.0 years, SD = 3.52) were included in the final analysis. All participants signed an informed prior to the experiment, which was approved beforehand by the ethical commission of the University of Twente.

2.2 Material

The following tasks and measurement devices were used in the experiment.

2.2.1 Tasks The Sing A Song Stress Test was reconstructed with the PsychoPy2 Builder Version 1.83.01 (Sourcecode: Appendix 2), using the same material used in the study of Lars Nijboer (Nijboer, 2015). All phrases presented on the screen were translated into English (Appendix 1). The fire alarm sounds was implemented into the experiment using the PsychoPy Builder. It can be found at:

https://www.youtube.com/watch?v=myRr2k_ktMU&list=PLVL4S6W_F3vOCKIbOgqf4MgTbC3DwU8ca&index=1. During the fire alarm the participants saw a timer on a black background counting down to zero. The effects of exposure to noise and its implications for stress are shown in various studies (Passchier-Vermeer & Passchier, 2000; Westman & Walters, 1981). The Stroop Task is a color-word interference task in which the participant has to pay attention and react to the color of a word while ignoring the word itself. This task was also constructed using the PsychoPy Builder. The stimuli were the words “green”, “red”, “yellow”, “blue” written in all four different colors. The words were presented randomly for each participant. The participant was then asked to identify the color of the word while ignoring the word itself. All participants used their right hand. They had to press “up” for the color red, “down” for the color yellow, “right” for the color blue and “left” for the color green. They did not receive feedback on whether their answer was correct or not. Various researches support the stress inducing capabilities of the Stroop Task (Lattimore, 2001; Renaud & Blondin, 1997).

2.2.2 Measurement devices For the physiological data, all participants were connected the ‘Infiniti’ measurement device from Thought Technology (left fingers and both wrists) during the whole duration of the experiment. The Infiniti from Thought Technology is a USB interface that can receive up to 8 channels of bio feedback input. It is designed for a laboratory setting and is powered by a battery that lasts for 20+ hours. It is 130x95x37mm in size and weighs approximately 200g (www.thoughttechnology.com, 2015). The skin conductance sensors are Ag/AgCl electrodes and were connected to channel one and two of the receiving device.

The self-reported data was retrieved through a questionnaire of four questions per task (also see: 2.3 Design and Procedure, Appendix 3). With a mouse klick, participants had to give answers on a Likert-Scale from 1 to 7 for each question; 1 indicating the lowest and 7 indicating the highest stress level.

2.3 Design and Procedure

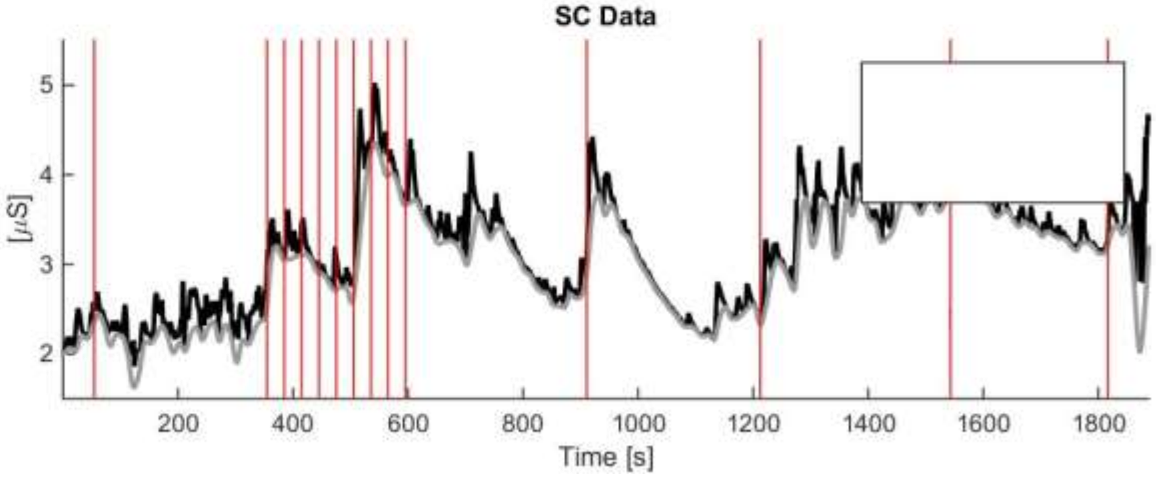
The design of the experiment was the same for every participant. Only the stimuli within the Stroop Task were randomly assigned. The experiment was designed to include these three different kinds of psychological stressors (social, environmental and cognitive).

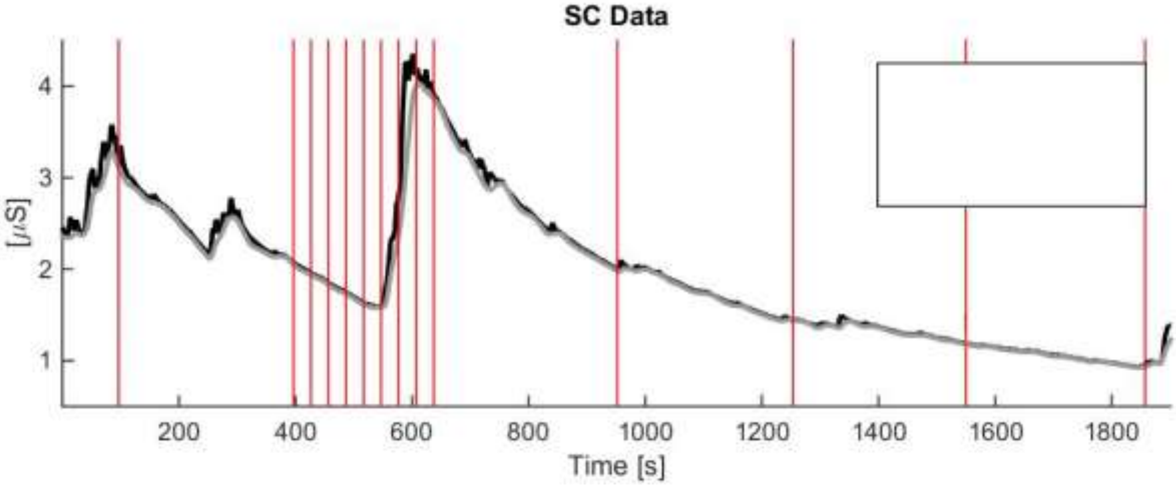
All stressors included in the design are stressors that are, in one form or the other, common stressors of everyday life, which are chosen to create more generalizable results.

The experiment took place in one of the lab rooms of the University of Twente. The participants were welcomed by the male researcher and brought into the research room. All participants sat down in a chair in front of a computer and were asked to read and sign the informed consent (Appendix 4). Physical activity is known to have a significant effect on the EDA results. Therefore, participants were asked to sit still while solving all the tasks. They were informed beforehand about the measurement devices and the likelihood of feelings of stress during the experiment. Furthermore, all participants were informed that they could stop the experiment at any time. After signing the informed consent, all participants had time to ask questions. Then they were connected to the Infinity measurement device. The recording of data was started by the researcher. Participants were told that they could start the experiment whenever they were ready. The participants pressed a button on the keyboard which started the experiment. First of all, participants had to sit still for 5 minutes before starting the first task. In this period it happened often that participants asked more questions about the experiment or moved their hands, probably due to the expectation of a stressful task. Then, the Sing A Song Stress Test (social stressor) started. After finishing this test the researcher left the room. Secondly, they had to listen to the sound of a fire alarm for 5 minutes (environmental stressor). Finally, they had to solve the Stroop Task for 5 minutes (cognitive stressor). All participants had a break of 5 Minutes between every task in which they filled in a short questionnaire of four questions each (Appendix 3). Those four questions asked about (1) the stress level before, (2) during, (3) directly after the task and (4) the current stress level. Only question two and four are taken into the final analysis. Question two for the self-reported data of the task and question four for the self-reported data of the breaks. In total the experiment lasted for around 45 minutes. A logbook was made by the researcher during the first experiment in which he captured information about special circumstances of a session as well as information about whether or not the participant sang a song in the first task (Appendix 5). After 45 minutes the researcher entered the room again, saved all data, disconnected the participant from the measurement device and said thank you and goodbye to the participant.

2.4 Data analysis

The data from the Infinity was recorded by the Bioinfinity saved as .XLSX and .TEXT files for both heart rate and skin conductance. Furthermore, there were (1) scores from the questionnaire, (2) UNIX Time stamp for every routine and (3) correct and wrong responses to the Stroop Task saved in .XLSX and .LOG files. All data was saved in one folder on the researcher's laptop (provided on demand). The questionnaire for the subjective evaluation delivered ordinal scores from 1-7. 1 equals the lowest and 7 the highest stress level. The data from the Infinity were continuous. Three examples of the results retrieved from the Infinity are shown in Figure 1.





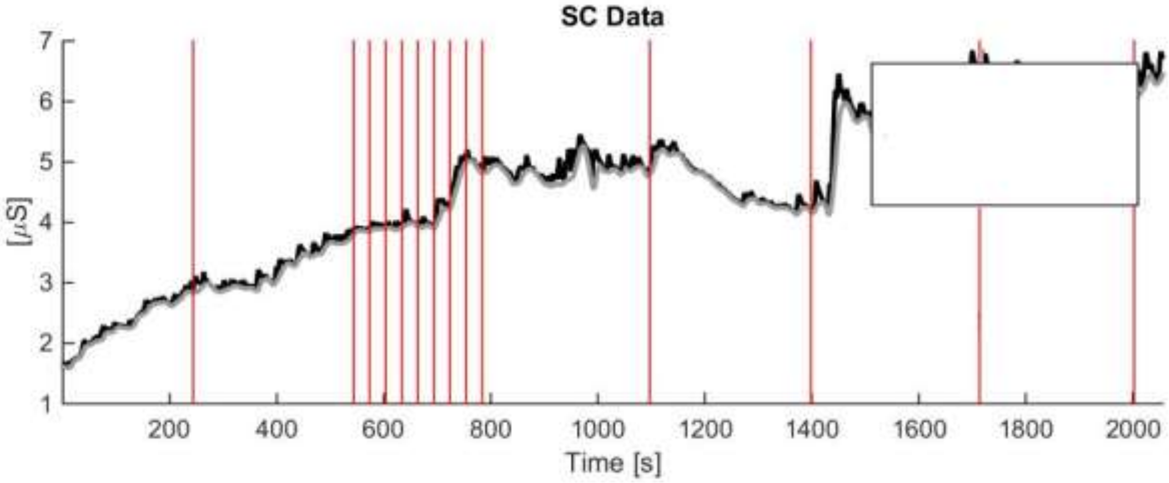


Figure 1. 3 examples of the raw data sets retrieved from the EDA-sensor are shown. Each graph shows the skin conductance level of one person over the whole period of time. The red lines indicate the start of a new task or break. The first line is the start of the first break. The second line indicates the start of the SSST and the eight lines that follow were printed every 30 seconds, because a new sentence was presented to the participants every 30 seconds. The last line of this series indicates the start of the second break, Then the start of the audio task, the start of the third break and the start of the Stroop Task. The black line indicates the amplitude of the continuous data. This figure was created for each participant. For the analysis, the peaks within each 30 seconds of the experiment were summarized into one score.

This research focuses on the amount of peaks per time interval to make a comparison with the self-reported data possible. Ledalab was used to convert the raw data as shown in Figure 1, into peaks per time period. It was chosen for an interval of 30 seconds in all tasks as well as the breaks because 30 seconds is the smallest period any question on the self-report focused on. This gave a total of 10 scores per task and break. The tasks were further divided to meet the focus of each question (Appendix 6). After that, subjective and objective data was listed per person individually to make a comparison in SPSS possible.

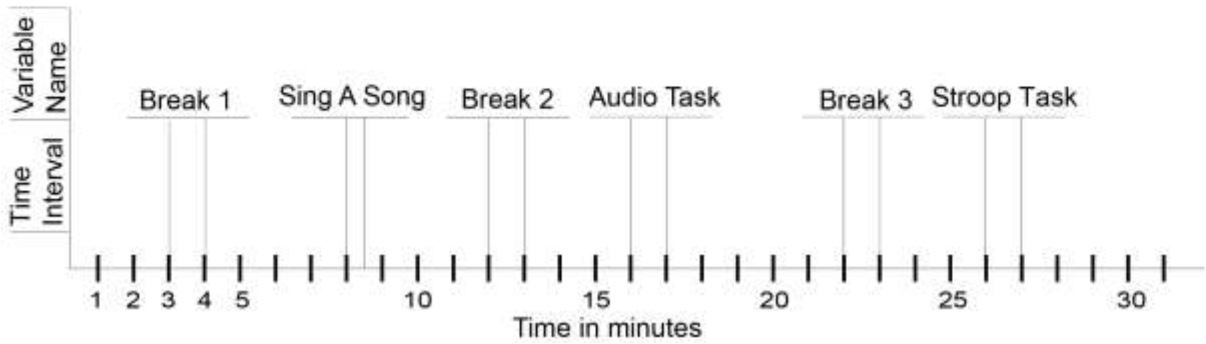


Figure 2. Summary of raw physiological data into variables

For the analysis it was chosen to summarize the variables Baseline, Break 2-3 and Task 1-3 as shown in figure 2. All physiological variables are summarized in intervals of 30 seconds. V1 hereby stands for the first 30 seconds of the experiment. V2 for the 30 seconds after this. To bring together the self-reported stress data with the physiological data, two intervals of 30 seconds of the physiological data were brought together and divided by 2. For example question 3 was specifically asking about the 30 seconds in which the participant had to sing: "How did you feel DURING singing?" It was therefore chosen to define the Sing A Song Stress Task as equal to V17 because V17 were the 30 seconds in the experiment in which all participants had to sing out loud. The baseline was defined as V7 plus V8 divided by 2, based on the SSST research of Lars Nijboer (Nijboer, 2015). This research shows that the physiological data is high in the first two minutes of the experiment. It is likely that people that come in face a new situation and are stressed because of that. After approximately 3 minutes the data indicates the lowest stress level. One minute before the experiment starts, stress levels go up again; possibly due to the expectation of the task. Therefore, it was chosen in this paper to concentrate on the third time period. Break 2 and 3 were calculated accordingly. Task 2 and Task 3 are continuous tasks over a time period of 5 minutes. The questions for those tasks asked about the entire 5 minutes. To keep the analysis consistent it was chosen to use 1 minute instead of the mean of the whole time interval of the task. The main reason for this choice was that almost all other questions were asking about a very specific time interval of 30 seconds. For the same reason as the definition of the baseline it was chosen for a point in time that was not the beginning and not the end of the task. Furthermore, the Baseline also features a time period of one minute somewhere in the middle of the whole interval. Therefore it keeps a certain consistency and makes the data more comparable.

Most importantly the analysis needed to compare the physiological data with the data from the self-report. For this comparison, a Pearson correlation was performed and summarized in a list. This list was then transferred into a boxplot to explore the distribution of each score. Error bars for both data sets were created to examine the differences between physiological and self-reported scores visually. A scatterplot was made to explore a possible correlation between both data sets for each participant individually.

Results

3.1 Core findings

A Pearson correlation per person was constructed to explore the correlation between physiological and self-reported data (Table 1). A weak or no correlation between physiological and self-reported data was expected. A positive correlation would mean that the higher the score of the self-reported data, the higher the score of the physiological data. A negative correlation would indicate a negative linear relationship between the two scales. The hypothesis expects a weak or no linear correlation.

Participant	*Pearson correlation*
6	-.387
7	-.174
8	.800
9	.968
12	-.511
14	.068
15	.575
16	.628
17	.690
18	.785
19	-.499
20	.250
21	-.059
22	.592

Table 1. Pearson correlation between baseline and mean of task1-3 per participant.

As shown in Table 1, the Pearson correlations take strong positive as well as negative scores. Participant nine showed a significant correlation between the self-reported and the physiological data $r(4) = .97$, $p < .05$. All other scores showed no significant correlation.

To examine whether or not these scores sum up to a positive or negative value, a boxplot is made.

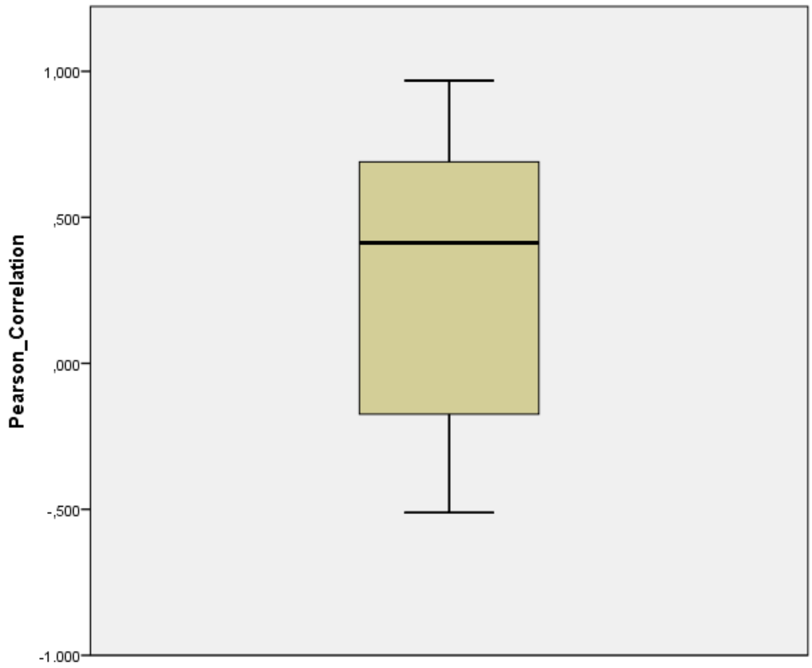


Figure 3. Boxplot for all scores correlations between self-reported and physiological data for all participant.

All scores sum up to a median of .413, (M=0.27, SD=0.52). According to Dancey and Reidy (2007), an r value greater than .20 and smaller .50 are considered a moderate correlation (Dancey & Reidy, 2007).

Variable	*Pearson Correlation*	*Sig.*
Baseline	-.300	.30
Sing A Song Stress Test	.006	.99
Audio Task	.316	.27
Stroop Task	.587*	.03

Table 2. Pearson Correlation between self-reported and physiological data for the baseline as for each task separately.

3.2 Error Bars

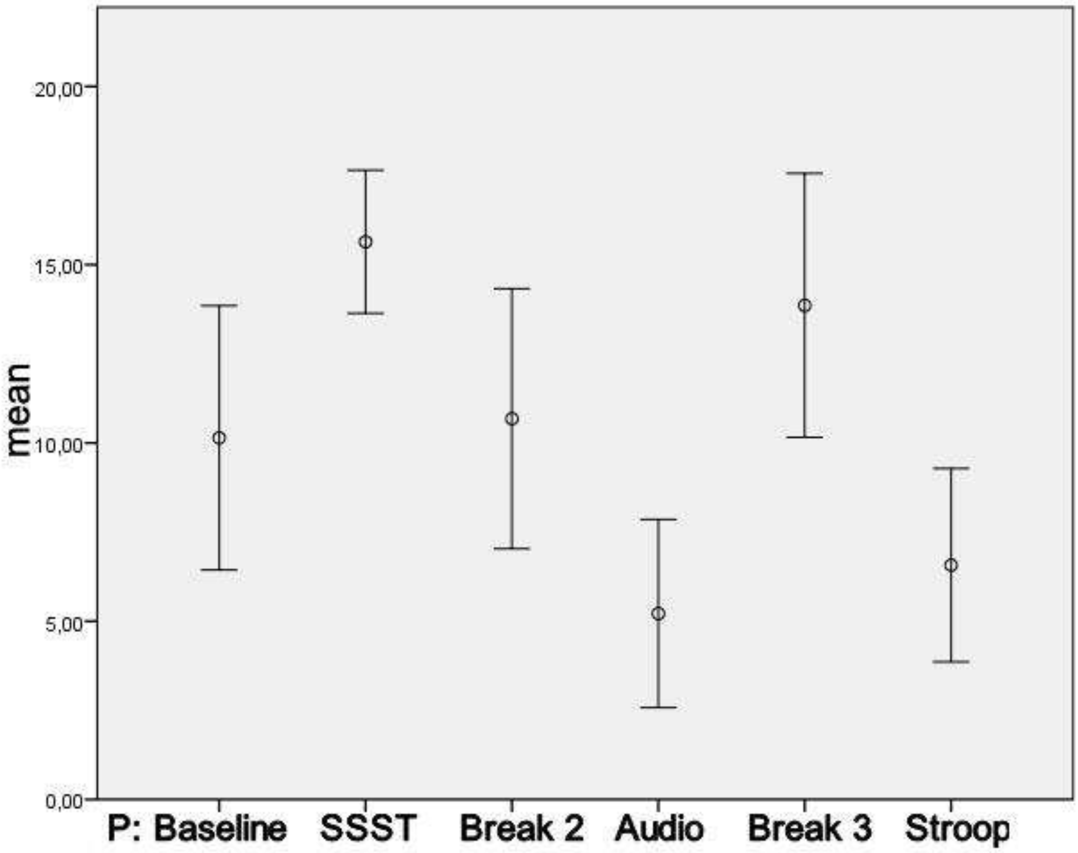


Figure 1. The physiological data for all participants is displayed in error bars for every task and break.

The SSSST (M=15.64, SD=3.48) was found to show more peaks than the Baseline (M=10.14 SD=6.42). The Audio Task (M=5.21, SD=4.57) and Stroop Task (M=6.57, SD=4.70) were found to give lower values than the baseline measurement. On the physiological scale Break 3 (M=13.86, SD=6.41) stands out by taking s score close to the first task, the SSST.

The mean scores for the self-reported data are summarized in figure 5.

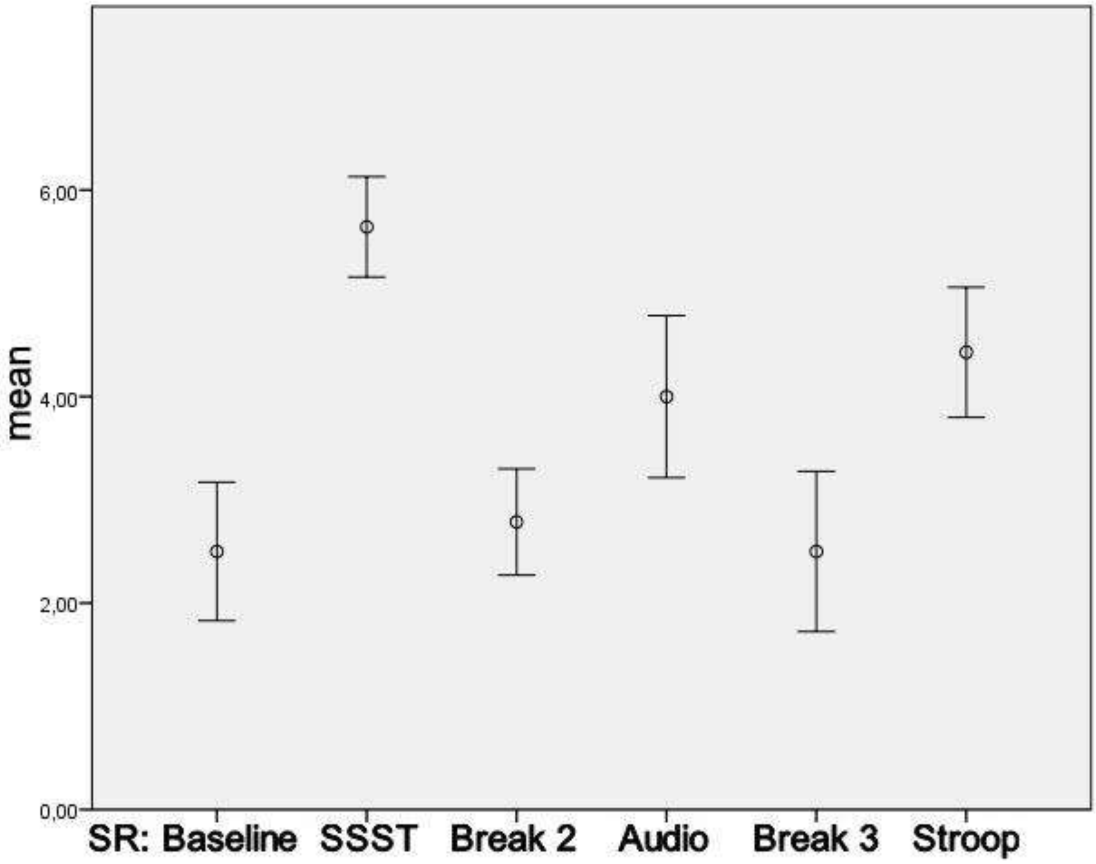


Figure 2. The self-reported data for all participants is displayed in error bars for every task and break.

In the self-reported data, all tasks were evaluated as more stressful than the baseline measurement (M=2.50, SD=1.16). The SSST (M=5.64, SD=0.84) was found to show most peaks per time interval. The Audio Task (M=4.00, SD=1.36) and Stroop Task (M=4.43, SD=1.09) were found to give values that are lower than the SSST and higher than the baseline. In the self-report, the baseline and the two breaks provide similar means and standard deviations.

It could be shown that the physiological and the self-reported data peak on the SSST. The physiological data for the baseline is found to give relatively high scores in comparison to the Audio Task und Stroop Task. The data for the self-report on the other hand was found to give the lowest scores for the baseline in comparison to all tasks. A Pearson correlation reveals an overall positive linear relation between self-reported and physiological stress. A relatively strong correlation between self-reported and physiological data can be found in the data of the Stroop Task when analyzing all tasks separately.

Discussion

In order to address the research question properly, the discussion is divided into four sections. First of all, the general topic of the research is shortly summarized. Second of all, the research question is answered on the background of all analyses. Thirdly, the limitations of this research are discussed. In the last section, the conclusions are summarized and implications for future research are given.

4.1 Research topic

The aim of this study was to test whether the dual process perspective on autonomic and reflective measures, as proposed by Ever et al. (2014) for the lack of coherence between reactions to emotional stimuli, also correctly predicts the lack of coherence between autonomic and reflective measures to stressful stimuli. We found that there was no sufficient evidence for a clear coherence between skin conductance responses and self-reported stress levels as reaction to three different types of stressors. However, some coherence is found between the self-reported and physiological data for the cognitive task. These findings will be discussed below in the light of theories on stress. The hypothesis was:

> H1: *The correlation between self-reported stress and the number of skin conductance responses as a reaction to a social, environmental and cognitive stressor will be small or non-existent.*

4.2 Answer to the research question

The results show that there is a moderate positive correlation between the overall self-reported and physiological data (Dancey & Reidy, 2007). This would mean that the dual-process model cannot be supported. However, when analyzing all three tasks separately, no correlation was found for the Sing A Song Stress Task, a weak correlation was found for the Audio Task and a strong correlation was found for the Stroop Task. The results therefore suggest that there is some coherence in the two different forms of measurements when assessing environmental and cognitive stress. The SSST is found to be the only task supporting a dual-processed model.

Task	*Pearson Correlation*	*Pearson* r2	*Error Bars (physiological)*	*Error Bars (self-reported)*
SSST	0.01	.99	Stress High	Stress High
Audio	0.32	.27	No Stress	Moderate Stress
Stroop	0.59*	.03	No Stress	Moderate Stress

Table 3. Table 3 summarizes all results per task.

When examining the error bars, a different conclusion needs to be considered. On a physiological level the SSST seems to be the only task that actually induced stress in the participants. The possibility must be considered that the Audio Task and the Stroop Task failed to induce stress. (Possible explanations for this are discussed in the following paragraph) If the SSST was indeed the only task inducing stress, then the correlation between physiological data and self-reported data for this task is the only one with value for this paper.

4.3 Limitations & Implications for future research

First of all, the results could give a wrong impression due to the variance of physiological results per individual. As shown in Figure 1 the raw data varies greatly from one participant to the other. Some participant’s skin-conductance level got higher over the whole amount of the experiment. Some participant’s skin-conductance level got lower and some stayed relatively constant. Those differences in physiological data might contribute to the ambiguity of the results and the moderate positive correlation of physiological and self-reported data. At the same time these differences do not contradict the idea of a dual-process model. If anything, these differences could be part of the reason why physiological data can be seen as a completely different construct as self-reported data and therefore support a dual-process perspective. Furthermore, the examples of raw data from the Infinity measurement device illustrate that there are differences in the amount of peaks and the amplitude. For this experiment the researchers focused on the amount of peaks per 30 seconds instead of the amplitude in order to make a comparison with the self-reported data statistically possible.

The choice of a specific time interval as well as the choice to analyze the peaks instead of amplitude might have altered the outcome.

Second of all, there is a possible limitation due to the physiological scores retrieved. And that is, that the Audio Task and the Stroop Task likely failed to induce stress. On a physiological level the scores for both tasks were below the baseline measurement. For the Stroop Task, a possible explanation could be that this experiment only examined psychology students. It can be assumed that they (1) all knew about the Stroop Task and (2) likely had to solve the Stroop Task before. Therefore, the stress inducing capabilities of the task might have been weakened. For the audio task this could be explained by the design of the task. The research this task was based on implemented the audio task with a white noise stimulus. This stimulus was repeatedly presented for a very short period of time, whereas this experiment was constructed with different fire alarm sounds, continuously presented over the whole 5 minutes. Support for the idea that the audio task failed to induce stress is found in literature. Gardner (1978) showed that negative effects of noise are prevented if the experiment makes use of an informed consent that contains the information about the stressor (Gardner, 1978). Gardner argues that the perception of control plays an important role in coping with an environmental stressor. The informed consent might have affected the participants stress level and possibly altered the self-evaluation.

A failure of the self-report might be due to social desirability (Crowne & Marlowe, 1960). Maybe the participants rated the tasks more stressful than the breaks because the tasks were introduced and meant to induce stress. Participants expected a stressful event and therefore also evaluated the tasks as more stressful than the breaks even though they weren't. In the case of an inaccurate self-report a second implication needs to be considered. If the EDA measurement device correctly identified the participants stress level in all situations, then based on the findings it must be assumed that the breaks in between the tasks were more stressful than the environmental and cognitive stressor. It could be possible that the expectation of a stressful event triggers the body's nervous system and therefore the anticipation of a stressful task leads to stress itself. Literature suggests that thoughts about a stressful event have the potential to end in a peak in the physiological data (May & Johnson, 1973; Nikula, Klinger, & Larson-Gutman, 1993; Wegner, Shortt, Blake, & Page, 1990). It is not unlikely that the participants used the five minutes before the task to mentally "prepare" for the task by picturing it. A second implication that follows out of the ones above is that the differences between self-reported data and physiological data are evident because the environmental and cognitive condition failed to induce stress.

Future research might explore the relationship between physiological and self-reported environmental and cognitive stress to find further support for the dual-process model. It could also focus on the responses to a completely different area of emotions, such as happiness.

4.4 Summary

Only the Sing A Song Stress Task actually seemed to induce stress in the participants. Therefore, only this task can be taken into account when comparing physiological responses with self-reported data. For this task, no coherence between both measurements can be found, wherefore the hypothesis can be confirmed and the idea of a dual-process model can be supported. Even though it is still uncertain if the model holds true for environmental and cognitive stress, the foundation of research towards an understanding of the dual-process model regarding stress is laid.

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Acknowledgements & Appendix

Appendix 1 – Sentences SSST (translated)

1. Sit still, try to relax and concentrate on your breath while the timer is counting down.
2. Think about different animals that start with the letter P.
3. Think about things you can find in a kitchen.
4. Imagine things that are important for organizing a wedding.
5. Imagine as many teamsports as possible which aren't played with a ball.
6. The next task is to sing a song out loud. Think about what song you want to sing in the next 30 seconds.
7. Now sing the song for the next 30 seconds and try to hold your arms still. Keep singing.
8. Sit still, try to relax and concentrate on your breath while the timer is counting down.

Appendix 2 – Source Code

(on demand)

Appendix 3 – Questionnaire (for self-report)

1. How do you feel right NOW?

2. How did you feel 1 minute BEFORE singing?
3. How did you feel DURING singing?
4. How did you feel directly AFTER singing?
5. How do you feel right NOW?

6. How did you feel right BEFORE the noise?
7. How did you feel DURING the noise?
8. How did you feel directly AFTER the noise?
9. How do you feel right NOW?

10. How did you feel right BEFORE the color-word task?
11. How did you feel DURING the color-word task?
12. How did you feel directly AFTER the color-word task?
13. How do you feel right NOW?

Appendix 4 - Informed Consent + Structure Research

Informed Consent

This informed consent form is meant to inform the participants of this study about the experiment. Please read this page carefully. This experiment is constructed by Jan Hemmelmann for the Human Factors and Engineering department of the University of Twente Enschede.

General information

The purpose of this experiment is to compare three different kinds of stressors with each other by measuring electro dermal activity during all tasks.

Procedure

The experiment includes three stressful tasks. In task one you are asked to read phrases from the computer screen and follow the instructions given. Task 2 is an auditory task in which you have to listen to a sound with your eyes open. In task three you have to solve the Stroop Task which is a word-color task. All three tasks will be explained in more detail before they start. Every task will last 5 minutes. In between all tasks you have a break of 5 minutes in which you will be asked to fill in a short questionnaire. The whole experiment will last around 45 minutes. Be aware that both tasks may induce as feeling of discomfort and/or stress. You participate voluntarily which means that you can leave the experiment at any point in time. Before the experiment starts you will be connected to three different kinds of sensors. One on your wrists. The second one on the fingers of your left arm. The third one is a heart rate sensor that you are asked to put around your chest. Data from all three sensors will be recorded throughout the whole experiment. Since physical activity has an immense impact on the data, it is important that you try to sit still during all tasks. All collected data are being saved, processed and published anonymously.

I have read the foregoing information and was informed about the kind of research, the method and the aim of this research, as well as the risks. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I know that my data will be handled confidentially and anonymously. I don't have any medical issues that would indicate a negative influence of stress on my

health. I consent voluntarily to participate as a participant in this research. I understood that I can leave or withdraw from the experiment at any given moment in time.

Print Name of Participant__________________

Signature of Participant ___________________

Date ___________________________

I have given verbal and written information to the participant over the reasearch. I will answer any questions about the research to the best of my knowledge. The participant won't be facing any negative consequences due to an early withdrawal from the experiment.

Print Name of Researcher__________Jan Hemmelmann________________

Signature Researcher____

Date_______________________

Structure Research

Before Experiment:

Respondent comes in.

Researcher: „Thank you for coming. Come with me.“

Researcher and Respondent go to the research room.

Researcher: “Please have a seat.”

Researcher points on chair and sits down in his own chair while respondent sits down.

Researcher: “I’m going to give you some general information about the experiment now. After that you will get the informed consent which I ask you to read carefully before you sign it. Before we start the experiment you will be given the possibility to ask any questions about the experiment.

Basically this experiment is designed to compare two measurement devices in front of you. Both measure skin conductance. So it basically measures how much you sweat on your fingers or wrist. This measurement indirectly provides information about the stress level of a person. Therefore you will be facing 3 different tasks in this experiment. All of them are likely to increase your stress level. I will be with you in this room while you are going through each task. If you don’t feel comfortable you can withdraw from the experiment at any time.

Here is the informed consent. You will find more detailed information about the experiment there.”

Respondent reads and signs the informed consent.

Researcher: “Do you have any questions?”

//Short break. If yes, researcher answers the questions.

Researcher: “I’m going to connect both measurement devices now. One goes on your fingers and one goes on your wrist.”

Researcher attaches both measurement devices on the left arm/fingers.

Researcher: “Are you comfortable?” //short break

Researcher starts the program.

Researcher: “The first experiment is an auditory task. Please take these headphones.”
Researcher hands the headphones to the participant.
Researcher: “The experiment will start when you are ready and pressed any key. After that it will continue until the end of the experiment. More instructions will be given to you during the experiment. They will be displayed on the screen. Please remember to sit still throughout the experiment. Please put on your headphones now. You may start whenever you are ready.”

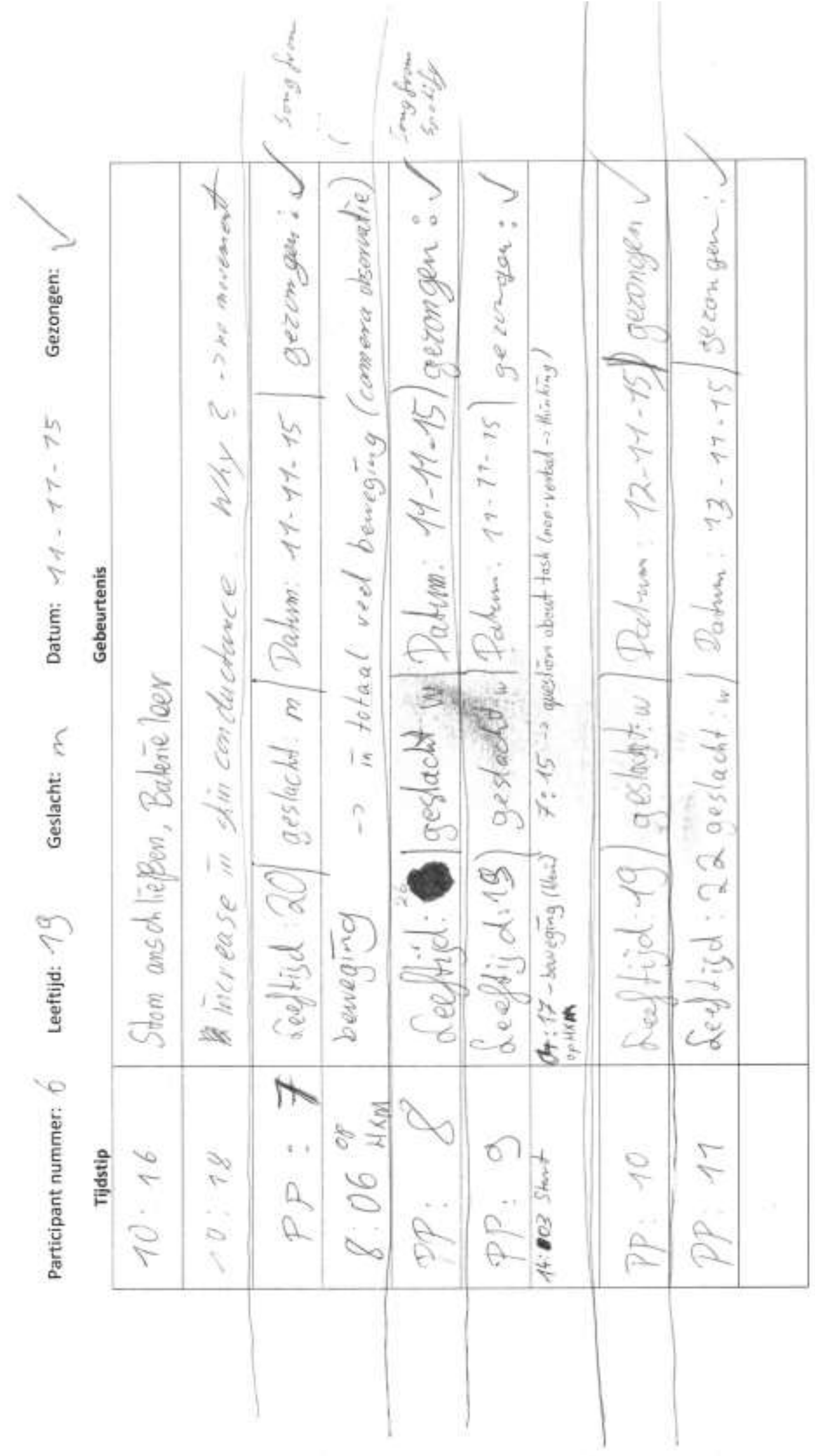
Experiment:

Participant puts on the headphones. Participant reads the information displayed on the screen and presses a key to start. Participant goes through the experiment.

After the experiment:

Researcher: “Thank you again for participating. Do you have any more questions about the experiment?” //break
If participant has questions researcher answers them.
Both leave the research room together and they say goodbye.

Appendix 5 - Logbook scan



Participant nummer: 6 Leeftijd: 19 Geslacht: m Datum: 11-11-15 Gezongen: ✓

Tijdstip	Gebeurtenis
10:16	Stom anschließen, Bakerie leer
10:18	increase in skin conductance Why? -> no movement
PP: 7	Leeftijd 20 | geslacht m | Datum: 11-11-15 | gezongen: ✓
8:06 op HKM	beweging -> in totaal veel beweging (camera observatie)
PP: 8	Leeftijd: [redacted] | geslacht w | Datum: 11-11-15 | gezongen: ✓
PP: 9	Leeftijd: 19 | geslacht w | Datum: 11-11-15 | gezongen: ✓
14:03 Start	4:17 - beweging (Hand) op HKM 7:15 -> question about task (non-verbal -> thinking)
PP: 10	Leeftijd 19 | geslacht: w | Datum: 12-11-15 | gezongen ✓
PP: 11	Leeftijd: 22 geslacht: w | Datum: 13-11-15 | gezongen: ✓

Song from
Song from Spotify

…

Participant nummer: 12 Leeftijd: 21 Geslacht: m Datum: 16-11-15 Gezongen: ✓

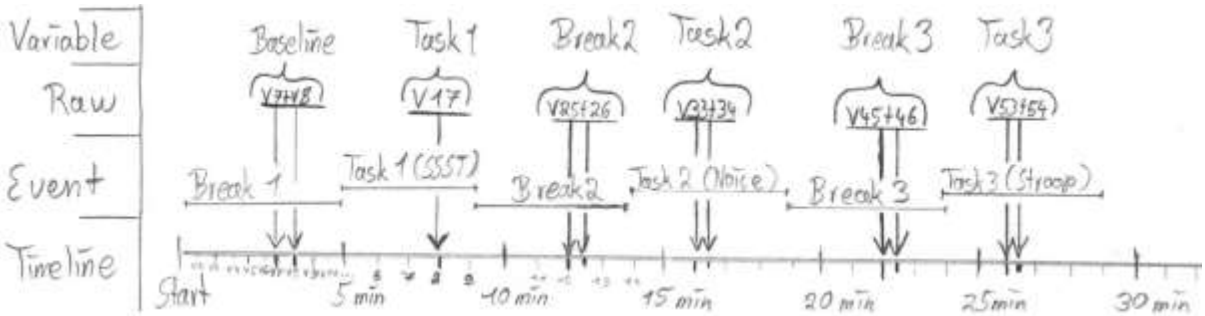
Tijdstip	Gebeurtenis
	veel beweging gedurende de eerste 5 minuten. Stresslevel up and down without further movement.
7:50 op UHR	beweging
PP 13	Leeftijd: 22 geslacht: w Datum: 16-11-15 gezongen:
	begin eerste taak -> vraag naar wat de bedoeling is.
10:37	veel gepmet, gelacht...
PP 14	Leeftijd: 19 geslacht: w Datum: 17-11-15 gezongen: ✓
7:15	iemand kwam kort binnen
PP 15	Leeftijd: 23 geslacht: m Datum: 17-11-15 gezongen: ✓
7:08	Wind -> hard geluid deur
PP 16	Leeftijd: 25 geslacht w Datum: 17-11-15 gezongen: ✓

hard geluid door wind

Participant nummer: 17 Leeftijd: 19 Geslacht: m Datum: 18-11-15 Gezongen: X

Tijdstip	Gebeurtenis
[redacted]	alles goed
PP 18	Leeftijd: 18 geslacht: w Datum: 18-11-15 gezongen: ✓
PP 19	Leeftijd: 22 geslacht: m Datum: 19-11-15 gezongen: ✓
PP 20	Leeftijd: 19 geslacht: m Datum: 19-11-15 gezongen: ✓
PP 21	Leeftijd: 19 geslacht: w Datum: 19-11-15 gezongen: ✓
	Hart Rate looks off sometimes
8:45	vraag gesteld
PP22	Leeftijd: 1[illegible] geslacht: m Datum: 19-11-15 gezongen: ✓

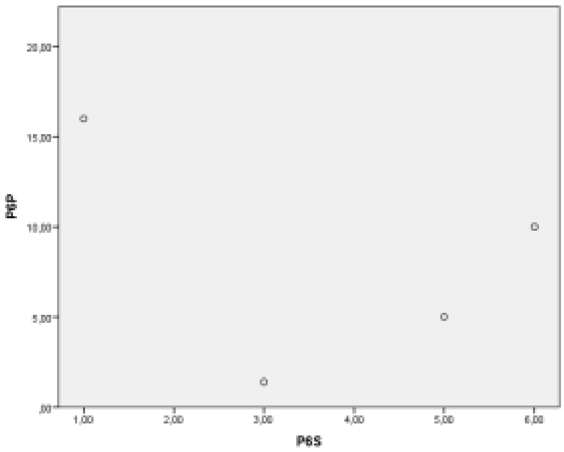
Appendix 6 (Calculation of Variables (+Syntax))

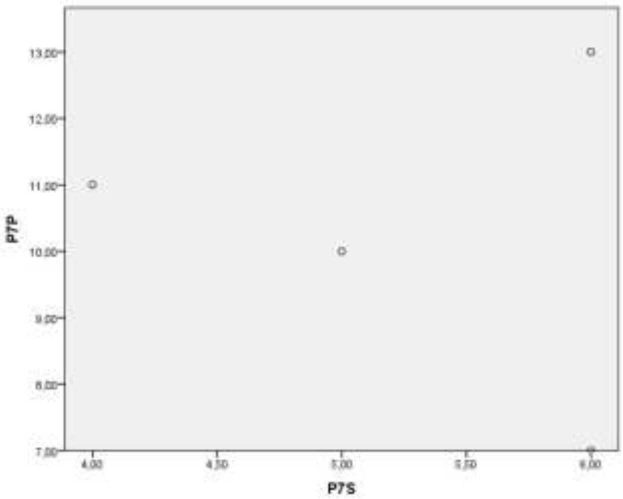


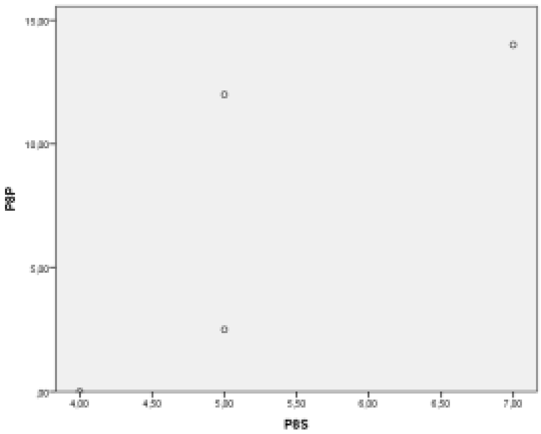
Syntax

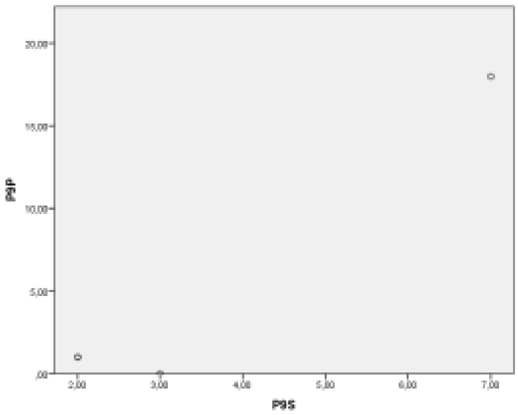
```
DATASET ACTIVATE AlleDatazonder10,11,13.

COMPUTE Baseline=(V7+V8)/2.

EXECUTE.

COMPUTE Task1=V17.

EXECUTE.

COMPUTE Break2=(V25+V26)/2.

EXECUTE.

COMPUTE Task2=(V33+V34)/2.

EXECUTE.

COMPUTE Break3=(V45+V46)/2.

EXECUTE.

COMPUTE Task3=(V53+V54)/2.

EXECUTE.
```

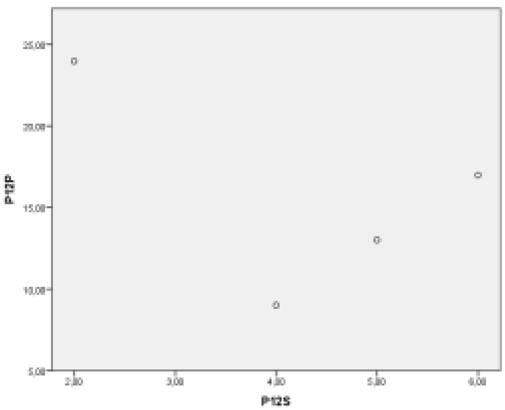
Appendix 7 - Individual scatterplots (self-report (x), physiological (y))

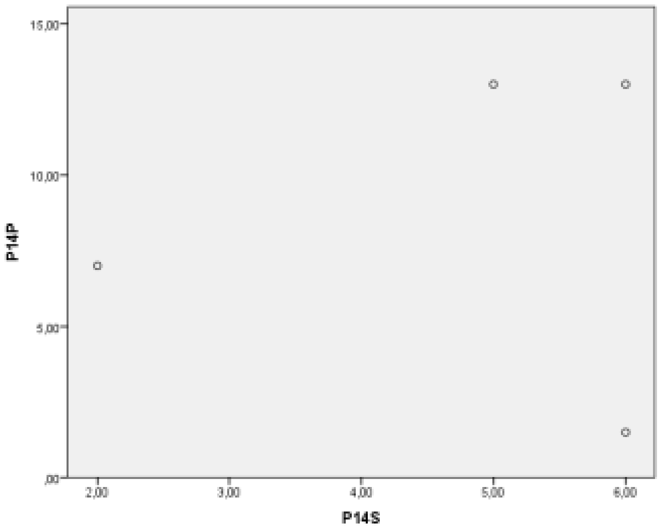


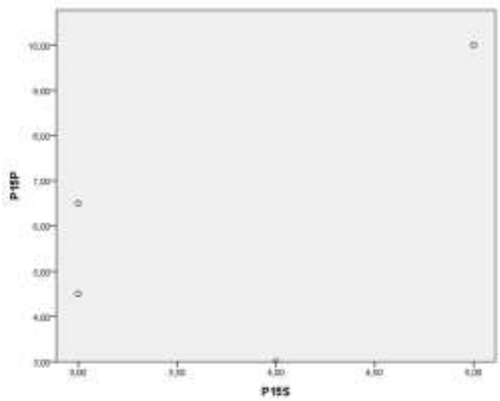


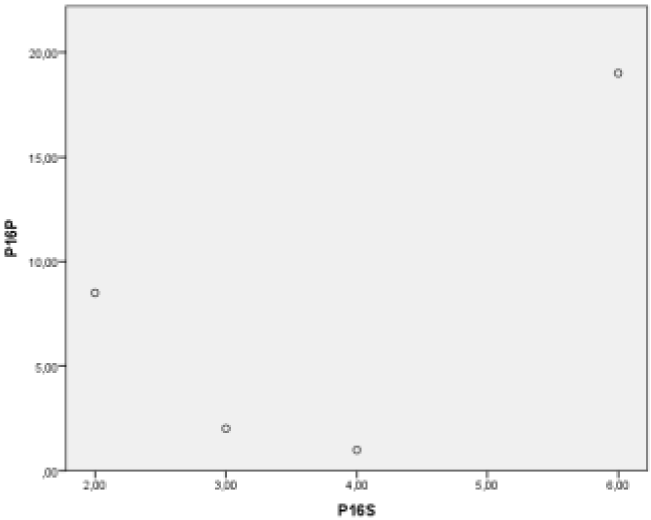


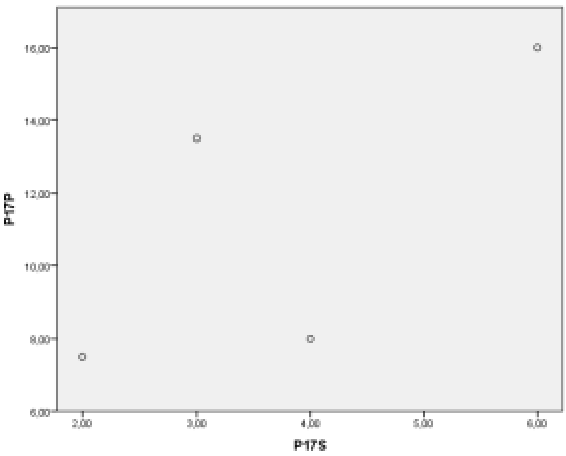


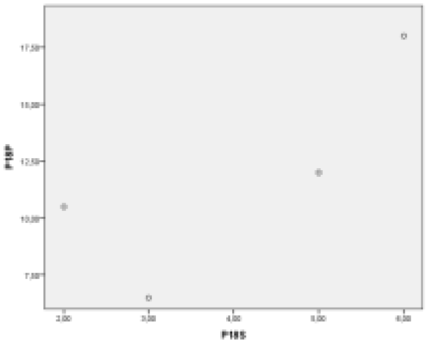


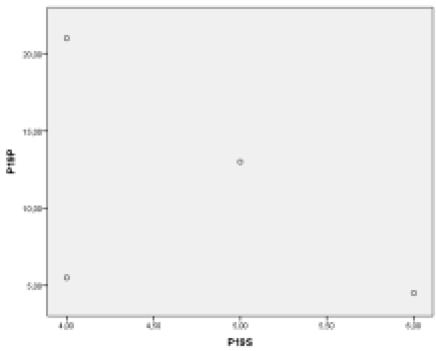


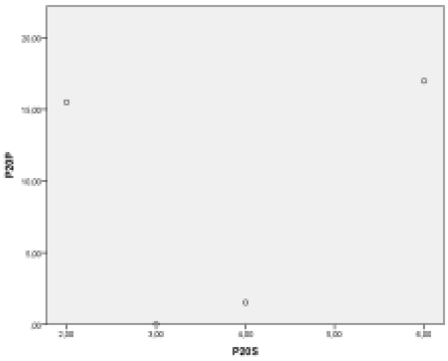

P15P
P15S

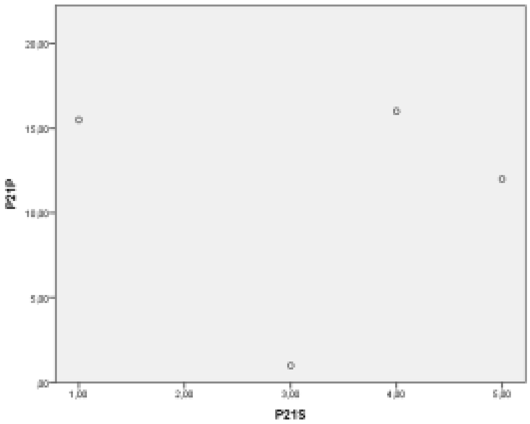

20,00
15,00
10,00
5,00
,00
P16P
2,00
3,00
4,00
5,00
6,00
P16S

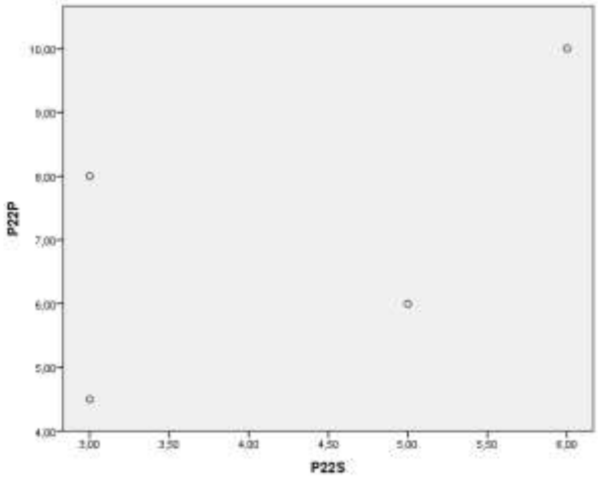

16,00
14,00
12,00
10,00
8,00
6,00
P17P
2,00
3,00
4,00
5,00
6,00
P17S


P18P
P18S


P19P
P19S


P20P
P20S


P21P
P21S
20,00
15,00
10,00
5,00
,00
1,00
2,00
3,00
4,00
5,00


P22P
P22S
10,00
9,00
8,00
7,00
6,00
5,00
4,00
3,00
3,50
4,00
4,50
5,00
5,50
6,00

Appendix 8 – group correlations per group (3rd variable sex and age)

Men

Correlations

		Baseline	BaselinQuestion	Task1	Task1Question	Task2	Task2Question	Task3	Task3Question
Baseline	Pearson Correlation	1	-,310	,614	,213	-,183	,244	,377	,185
	Sig. (2-tailed)		,455	,105	,613	,664	,561	,358	,661
	N	8	8	8	8	8	8	8	8
BaselinQuestion	Pearson Correlation	-,310	1	-,062	-,712*	,092	,485	,010	,517
	Sig. (2-tailed)	,455		,884	,048	,829	,224	,981	,189
	N	8	8	8	8	8	8	8	8
Task1	Pearson Correlation	,614	-,062	1	-,280	-,124	,060	-,022	,275
	Sig. (2-tailed)	,105	,884		,502	,769	,888	,958	,509
	N	8	8	8	8	8	8	8	8
Task1Question	Pearson Correlation	,213	-,712*	-,280	1	,043	,046	,308	-,445
	Sig. (2-tailed)	,613	,048	,502		,920	,913	,458	,269
	N	8	8	8	8	8	8	8	8
Task2	Pearson Correlation	-,183	,092	-,124	,043	1	,009	,624	,035
	Sig. (2-tailed)	,664	,829	,769	,920		,984	,098	,935
	N	8	8	8	8	8	8	8	8
Task2Question	Pearson Correlation	,244	,485	,060	,046	,009	1	,350	,188
	Sig. (2-tailed)	,561	,224	,888	,913	,984		,395	,655
	N	8	8	8	8	8	8	8	8
Task3	Pearson Correlation	,377	,010	-,022	,308	,624	,350	1	,460
	Sig. (2-tailed)	,358	,981	,958	,458	,098	,395		,251
	N	8	8	8	8	8	8	8	8
Task3Question	Pearson Correlation	,185	,517	,275	-,445	,035	,188	,460	1
	Sig. (2-tailed)	,661	,189	,509	,269	,935	,655	,251	
	N	8	8	8	8	8	8	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

Women

Correlations

		Baseline	BaselinQuestion	Task1	Task1Question	Task2	Task2Question	Task3	Task3Question
Baseline	Pearson Correlation	1	-,784	,324	-,523	-,424	-,529	,708	,396
	Sig. (2-tailed)		,065	,531	,287	,402	,280	,115	,437
	N	6	6	6	6	6	6	6	6
BaselinQuestion	Pearson Correlation	-,784	1	-,561	,066	,864*	,774	-,495	,128
	Sig. (2-tailed)	,065		,246	,902	,026	,071	,318	,810
	N	6	6	6	6	6	6	6	6
Task1	Pearson Correlation	,324	-,561	1	,401	-,567	-,867*	-,203	-,623
	Sig. (2-tailed)	,531	,246		,431	,240	,025	,700	,186
	N	6	6	6	6	6	6	6	6
Task1Question	Pearson Correlation	-,523	,066	,401	1	-,286	-,147	-,380	-,680
	Sig. (2-tailed)	,287	,902	,431		,582	,780	,458	,137
	N	6	6	6	6	6	6	6	6
Task2	Pearson Correlation	-,424	,864*	-,567	-,286	1	,622	-,150	,500
	Sig. (2-tailed)	,402	,026	,240	,582		,187	,776	,312
	N	6	6	6	6	6	6	6	6
Task2Question	Pearson Correlation	-,529	,774	-,867*	-,147	,622	1	-,112	,401
	Sig. (2-tailed)	,280	,071	,025	,780	,187		,833	,431
	N	6	6	6	6	6	6	6	6
Task3	Pearson Correlation	,708	-,495	-,203	-,380	-,150	-,112	1	,739
	Sig. (2-tailed)	,115	,318	,700	,458	,776	,833		,093
	N	6	6	6	6	6	6	6	6
Task3Question	Pearson Correlation	,396	,128	-,623	-,680	,500	,401	,739	1
	Sig. (2-tailed)	,437	,810	,186	,137	,312	,431	,093	
	N	6	6	6	6	6	6	6	6

*. Correlation is significant at the 0.05 level (2-tailed).

Age group 18-19

Correlations

		Baseline	BaselinQuestion	Task1	Task1Question	Task2	Task2Question	Task3	Task3Question
Baseline	Pearson Correlation	1	-,562	,248	-,642	-,151	-,101	,080	,445
	Sig. (2-tailed)		,147	,553	,086	,722	,812	,851	,269
	N	8	8	8	8	8	8	8	8
BaselinQuestion	Pearson Correlation	-,562	1	-,679	,501	,287	,104	-,172	-,144
	Sig. (2-tailed)	,147		,064	,206	,491	,806	,684	,735
	N	8	8	8	8	8	8	8	8
Task1	Pearson Correlation	,248	-,679	1	,107	-,093	-,334	-,255	-,358
	Sig. (2-tailed)	,553	,064		,801	,826	,418	,542	,384
	N	8	8	8	8	8	8	8	8
Task1Question	Pearson Correlation	-,642	,501	,107	1	,067	,080	-,541	-,551
	Sig. (2-tailed)	,086	,206	,801		,875	,851	,167	,157
	N	8	8	8	8	8	8	8	8
Task2	Pearson Correlation	-,151	,287	-,093	,067	1	-,269	,243	,165
	Sig. (2-tailed)	,722	,491	,826	,875		,520	,562	,697
	N	8	8	8	8	8	8	8	8
Task2Question	Pearson Correlation	-,101	,104	-,334	,080	-,269	1	,279	,115
	Sig. (2-tailed)	,812	,806	,418	,851	,520		,503	,787
	N	8	8	8	8	8	8	8	8
Task3	Pearson Correlation	,080	-,172	-,255	-,541	,243	,279	1	,775*
	Sig. (2-tailed)	,851	,684	,542	,167	,562	,503		,024
	N	8	8	8	8	8	8	8	8
Task3Question	Pearson Correlation	,445	-,144	-,358	-,551	,165	,115	,775*	1
	Sig. (2-tailed)	,269	,735	,384	,157	,697	,787	,024	
	N	8	8	8	8	8	8	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

Age Groupe 20-22

Correlations

		Baseline	BaselinQuestion	Task1	Task1Question	Task2	Task2Question	Task3	Task3Question
Baseline	Pearson Correlation	1	-,888	,143	,371	,834	-,619	,671	-,371
	Sig. (2-tailed)		,304	,909	,758	,372	,575	,532	,758
	N	3	3	3	3	3	3	3	3
BaselinQuestion	Pearson Correlation	-,888	1	,327	-,756	-,994	,189	-,936	,756
	Sig. (2-tailed)	,304		,788	,454	,069	,879	,228	,454
	N	3	3	3	3	3	3	3	3
Task1	Pearson Correlation	,143	,327	1	-,866	-,427	-,866	-,638	,866
	Sig. (2-tailed)	,909	,788		,333	,719	,333	,560	,333
	N	3	3	3	3	3	3	3	3
Task1Question	Pearson Correlation	,371	-,756	-,866	1	,822	,500	,938	-1,000**
	Sig. (2-tailed)	,758	,454	,333		,386	,667	,226	,000
	N	3	3	3	3	3	3	3	3
Task2	Pearson Correlation	,834	-,994	-,427	,822	1	-,082	,969	-,822
	Sig. (2-tailed)	,372	,069	,719	,386		,948	,159	,386
	N	3	3	3	3	3	3	3	3
Task2Question	Pearson Correlation	-,619	,189	-,866	,500	-,082	1	,167	-,500
	Sig. (2-tailed)	,575	,879	,333	,667	,948		,893	,667
	N	3	3	3	3	3	3	3	3
Task3	Pearson Correlation	,671	-,936	-,638	,938	,969	,167	1	-,938
	Sig. (2-tailed)	,532	,228	,560	,226	,159	,893		,226
	N	3	3	3	3	3	3	3	3
Task3Question	Pearson Correlation	-,371	,756	,866	-1,000**	-,822	-,500	-,938	1
	Sig. (2-tailed)	,758	,454	,333	,000	,386	,667	,226	
	N	3	3	3	3	3	3	3	3

**. Correlation is significant at the 0.01 level (2-tailed).

Age Group 23-26

Correlations

		Baseline	BaselinQuestion	Task1	Task1Question	Task2	Task2Question	Task3	Task3Question
Baseline	Pearson Correlation	1	-,999*	,717	,849	-,999*	-,744	-,470	-,999*
	Sig. (2-tailed)		,022	,491	,355	,035	,466	,688	,022
	N	3	3	3	3	3	3	3	3
BaselinQuestion	Pearson Correlation	-,999*	1	-,741	-,866	,996	,721	,500	1,000**
	Sig. (2-tailed)	,022		,469	,333	,056	,488	,667	,000
	N	3	3	3	3	3	3	3	3
Task1	Pearson Correlation	,717	-,741	1	,977	-,678	-,068	-,952	-,741
	Sig. (2-tailed)	,491	,469		,136	,525	,957	,198	,469
	N	3	3	3	3	3	3	3	3
Task1Question	Pearson Correlation	,849	-,866	,977	1	-,818	-,277	-,866	-,866
	Sig. (2-tailed)	,355	,333	,136		,390	,821	,333	,333
	N	3	3	3	3	3	3	3	3
Task2	Pearson Correlation	-,999*	,996	-,678	-,818	1	,779	,421	,996
	Sig. (2-tailed)	,035	,056	,525	,390		,431	,723	,056
	N	3	3	3	3	3	3	3	3
Task2Question	Pearson Correlation	-,744	,721	-,068	-,277	,779	1	-,240	,721
	Sig. (2-tailed)	,466	,488	,957	,821	,431		,846	,488
	N	3	3	3	3	3	3	3	3
Task3	Pearson Correlation	-,470	,500	-,952	-,866	,421	-,240	1	,500
	Sig. (2-tailed)	,688	,667	,198	,333	,723	,846		,667
	N	3	3	3	3	3	3	3	3
Task3Question	Pearson Correlation	-,999*	1,000**	-,741	-,866	,996	,721	,500	1
	Sig. (2-tailed)	,022	,000	,469	,333	,056	,488	,667	
	N	3	3	3	3	3	3	3	3

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).