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Acknowledgement

We are Siege Geerinck and Celine Spronck, both rehabilitation sciences and physiotherapy students in our second and last master year at the university of Hasselt. This observational case study is the second part of our master thesis.

At the beginning of the first master year, a topic for the master thesis is given to everyone according to their preference.
Our topic is: emotion measurement in people with a severe physical and/or cognitive disability. We chose this topic because we are both interested in the way emotions control our reactions and how different people express them.

In the first master year a literature search about this topic is required. In the second year, a study with the correct population is required, in our case we focus on people with a severe physical and/or cognitive disability.

Sint Oda in Pelt, a care home for people with a moderate or severe physical and/or cognitive disability, reached out to our university and asked if someone could research this topic for them. This meant that we would be working with them and their residents for two years to explore the possibility if emotions can be measured in people with a severe physical and/or cognitive disability.

We decided that we could make the best end product when both of us had input in every part of our thesis project. Because of this, there was no strict division of tasks. We worked on every part (literature search, observation in Sint Oda, writing) together, we discussed it and then chose what worked best in both of our opinions. Every written part is completed and proofread by both of us. We also wrote the protocol and the other documents necessary for the ethical committee (Appendix 3) of UHasselt together with the approval of our promotor Prof. dr. Raf Meesen and copromotor dr. Ben Schouten.

We would like to thank our promoter Prof. dr. Raf Meesen for his guidance during this two-year process to make this a good and interesting master thesis.

Secondly we would like to thank our copromotor dr. Ben Schouten, coordinator scientific research for VZW Stijn, Kim Scheepers, project manager of innovation and quality, and all

the helpful staff members at service center Sint Oda for supporting us and letting us use their facilities so we could observe two of their residents.

Thirdly we send lots of love to our family for grammar and spell-checking, listening, support and their endless advice.

Lastly, we would like to thank each other for the support and inspiration that was given, especially during the Covid-19 crisis, which made it possible to end this master thesis successfully.

Research Context

The research domain of this observational case study is neurological rehabilitation and mental health care.

There are people with a severe physical and/or cognitive disability who cannot express their emotions. They cannot tell their caregivers or health care practitioners how they feel and their communication through facial expressions is not always accurate because of their physical and/or cognitive disability. This can lead to unexpected outbursts and situations that are difficult for caregivers to deal with. To give the best care, it is useful to know if the client is feeling happy, angry, stressful... during a treatment or activity. Knowing if the treatment is or is not stressful could make the client's life more comfortable and the caregivers' task easier to execute. That is why it would be interesting to measure the emotions of the client with a device that immediately tells the caregiver if the treatment or activity is provoking stress and therefore should be changed.

This master thesis part 2 is guided by our copromotor dr. Ben Schouten, coordinator scientific research for VZW Stijn. VZW Stijn offers accompaniment and support for people with a disability. They stand up for people with the biggest need for care and with complex problems (https://www.stijn.be). We worked together with Sint Oda in Pelt, a care home for people with a moderate or severe physical and/or cognitive disability.

This case study was conducted independently and did not fit into an ongoing investigation.

Given the circumstances of the research (participants react differently when someone new enters their surroundings) an observational study design was chosen by us, the student-researchers in consultation with the promoter and copromotor. The method was elaborated by the student-researchers and then reviewed and approved by the promoter.

Recruiting happened at Sint Oda by the head physician based on the requirements that were drafted by the student-researchers. Data acquisition happened with the Empatica E4 wristband and cameras. It was performed by the supervisors of the community where the recruited participants live in and the project manager innovation and quality of Sint Oda. The supervisors of the community put on the Empatica E4 wristband and the project manager

innovation and quality of Sint Oda took the data of the watch and the camera footage and put them on a USB stick.

Data processing happened by the student-researchers after receiving the data and the camera footage. After the observations, the student-researchers started to write down their findings.

The introduction and the documents needed for the Ethical Committee were written by the student-researchers with the support of Prof. dr. Raf Meesen, the other parts of this paper were completely written by the student-researchers. The student-researchers also participated in the meeting of the CME UHasselt for the approval of this observational study.

This is an observational case study written by two authors: Siege Geerinck and Celine Spronck, under the supervision and guidance of Prof. dr. Raf Meesen and dr. Ben Schouten.

Title

Observation of people with a severe physical and/or cognitive disability with the Empatica E4: an observational case study.

Abstract

Background: There are people with a severe physical and/or cognitive disability who cannot express their emotions. To give the best care, it is useful to know if the client is feeling happy, angry, stressful... during a treatment or activity. Knowing if the treatment is or is not stressful could make the client's life more comfortable and the caregivers' task easier to execute.

Objectives: The aim of this investigation is to link certain outcome parameters from an emotion meter with a certain behavior in people with a severe physical and/or cognitive disability. Is there a link between a certain outcome parameter and a certain behavior and can an emotional outburst be prevented?

Participants: Two residents of Sint Oda with a severe cognitive disability, behavioral problems and autism. They have deficiencies in non-verbal communication.

Observation: The residents are under 24/7 camera surveillance. Both residents wore the Empatica E4 for several days. After every day, the data of the Empatica E4 was uploaded to Empatica online platform 'E4 connect'. The student-researchers watched the camera footage of those days and compared it with the data of the Empatica E4.

Results: To analyze the observation, actions that occurred multiple times were selected and the trend in electrodermal activity (EDA) changes was noted. Some situations recurred multiple times or seemed to provoke a specific reaction. EDA signals of recurring events were inspected to see if similarities in the reactions could be found.

Conclusion: Changes in the EDA are observed without a clear visible reaction of the participants in the camera footage. This makes that the Empatica E4 can be used to help interpret the emotions of people who have difficulties expressing their emotions.

Introduction

"Emotion plays an important role in human-human interaction"(Das Chakladar & Chakraborty, 2018). Emotions are processes directed towards a specific event or object, which result in physiological changes in both behavior and bodily state during communication (Jang, Park, Park, Kim, & Sohn, 2015).

For some people with a severe mental disability or a psychiatric disability, showing emotions does not come naturally. Either they show their emotions differently from healthy people or they do not show it at all. They cannot express their emotion because they did not learn to understand their own emotions and emotional experiences. So, they are not capable of mentally representing their emotions by relating them to the repertoire of emotional experiences they should have acquired when they were children (Pereira & de Matos Faria, 2015).

This causes them to build up inner emotions until they burst out. Those outbursts of emotions can be aggressive of nature. They often lead to injuring themselves or the staff members of their community. Aggressive behavior directed toward staff members and fellow clients in psychiatric treatment settings is a worldwide problem, as it threatens the safety and well-being of those involved (Hensel, Lunsky, & Dewa, 2014). For that reason, it is of utmost importance to recognize changes in emotions in an early stage.

Two years ago, Sint Oda contacted the university of Hasselt to explore the possibilities to detect changes in emotions in mentally disabled persons. In this perspective last year, we conducted a literature study about the use of emotions meters on healthy subjects. We wanted to know which emotion meters existed and which one of them would be fit to use with mentally disabled persons.

The conclusion of this literature study was that, of all the devices that were used in the articles on measuring emotions, the Empatica E4 wristband was referred to the most and chosen as the preferred candidate for our tests to measure emotion. It is available and easy to use and it has the most outcome parameters (3-axis accelerometry, skin temperature, blood volume pressure, heart rate (HR), heartbeat inter-beat interval and electrodermal activity (EDA)).

Electrodermal Activity (EDA) refers to electrical changes, measured at the surface of the skin, that arise when the skin receives innervating signals from the brain. The human brain sends signals to the skin to increase the level of sweating when they experience emotional activation, increased cognitive workload or physical exertion,. You may not feel any sweat on the surface of the skin, but the electrical conductance increases in a measurably significant way as the pores begin to fill below the surface (Empatica Inc, 2019).

It is expected that the EDA will substantially rise preceding an aggressive incident, such as has been reported in a case study by (Nijman, 2014). In another pilot study, the EDA level of a patient rose significantly in the period preceding aggressive behavior on the ward, well before the staff members noted the aggressive behavior (de Looff et al., 2019). The study of de Looff et al. (2019) on 100 subjects with a mild cognitive impairment indicated that heart rate, skin conductance level, and the number of nonspecific skin conductance responses per minute rose significantly in the 20 min preceding aggressive incidents.

These current findings may provide opportunities for the development of individual prediction models to aid acute risk assessment and to predict aggressive incidents in an earlier stage. The results on the physiological indicators of aggression are promising for reducing aggression and improving both staff as well as patient safety in psychiatric mental health institutions (de Looff et al., 2019).

The aim of the present investigation is to link the outcome parameters from an emotion meter with a certain behavior in people with a severe physical and/or cognitive disability. If there is a link between a certain outcome parameter and a certain behavior, can an emotional outburst be prevented?

By using the Empatica E4 wristband, physiological signals such as the electrodermal activity (EDA) of the participants can be monitored. This will be monitored over a longer time span because most previous studies investigated one-day measurements and we would like to compare recurring events between days. We will keep an eye on artefacts of the EDA when there is a lot of movement. (Chrisinger & King, 2018; Dao, Dang-Nguyen, Kasem, & Hung, 2018; Gouverneur et al., 2017; Hoogerheide, Renkl, Fiorella, Paas, & van Gog, 2019; Ollander, Godin, Campagne, Charbonnier, & Ieee, 2016; Stadler, Jepson, & Wood, 2018; Zhao, Wang, Yu, & Guo, 2018)

Method

The ethical committee of the faculty of medicine and life sciences of the UHasselt approved the protocol for this study on 27/11/2019 with number B9115201942129.

Participants

Three participants are included from their communities according to our in- and exclusion criteria. Inclusion criteria are being residents of Sint Oda Pelt, having a severe physical and/or cognitive disability, unable to express their emotions, having >1 emotional outburst per week and having an age ≥ 18.

The participants are chosen based on an interdisciplinary deliberation between the chief doctor of Sint Oda and the psycho pedagogical department.

Only one community met the criteria. In this community, fake watches were introduced to see which resident would accept to wear a watch. Only the two residents that were fixated, accepted the watch because they were not able to throw them off. The other residents learned very quickly, in circa 20 minutes, how to take off the watch and would throw it away. When the watch was put back on, they would throw it off even faster. Therefore, we decided to do a case study with the two fixated participants whom are also under permanent camera surveillance. The reason that they are fixated is to prevent severe self-mutilation. Because the participants are not able to give consent, their representative (parent or guardian) receives the information about the study and signs the informed written consent.

Procedure

This is an observational case study in collaboration with Sint Oda.

The Empatica E4, which is bought by Sint Oda, is used. It looks like a normal watch and has several different functions. The Empatica E4 has four sensors.

The photoplethysmography (PPG) sensor that measures blood volume pulse (BVP), from which heart rate variability can be derived.
The EDA sensor that measures the changes in the electrical properties of the skin.
The three-axis accelerometer that captures motion-based activity.
And the Infrared Thermopile which reads peripheral skin temperature.

It also has an event mark button that tags events and links them to physiological signals and a real time clock. It can record for up to 60 hours of data (Empatica Inc, 2018).

Two cameras are positioned at opposite sides of a rectangular living room. In each bedroom there is also a camera that gives full view of the resident in his/her bed. Private parts of the residents were covered by the project manager innovation and quality of Sint Oda before we had access to the camera footage. The cameras that are being used are the axis P3224-LV MKII camera. They only record movement and stop recording when there is no movement.

For the layout of this study we searched the database of PubMed. We searched for '(Case report [Title]) AND Guideline [Title]' and a publication date not older than five years. Six articles showed up. Based on title and abstract we excluded 5 articles and included 'Guideline on writing a case report' (Alsaywid & Abdulhaq, 2019). We used this as a base for our study design. We added 'Method' between 'introduction' and 'case presentation'. We shortened 'case presentation' due to privacy reasons. 'Patient's perspective' was an optional section that was left out because the participants cannot speak for themselves. We moved 'consent' to the added title 'appendix'. 'Author contribution' was included in the added title 'Preface'.

Observation

The Empatica E4 is worn every day for two weeks or 10 working days by the participants but due to the schedule of the caregivers, this was not possible. The watch was not put on consistently, because it had to fit in their day planning. The day planning in Sint Oda can change on a daily basis because the caregivers respond to the needs of the clients.

Resident X wore the watch for 7 days, the duration of which can be found in table 1.

Table 1

Day	Measurement time
Day 1	11:38-19:27
Day 2	7:44-7:37 (the next day)
Day 3	10:02-19:09
Day 4	8:16-20:09
Day 5 and day 6	8:11 (sat)-06:57 (mon) total of 46 hours and 45 minutes

Day 7	15:58-19:49

Resident Y wore the watch for 5 days, the duration of which can be found in table 2.

Table 2

Day	Measurement time
Day 1	7:30- 19:05
Day 2	8:56- 1:38 (the next day)
Day 3 and Day 4 and Day 5	7:20- 14:39 and 19:00 (fri) - 10:29 (sun) 39 hours and 26 minutes

Every morning when the participants get dressed, the caregiver puts on the Empatica E4. Sometimes the watch was put on later. When they get ready for bed, the Empatica E4 is taken off by the caregiver to prevent and check for any potential pressure wounds.

After every day or period the participants wear the Empatica E4, the data of the Empatica E4 is uploaded to the Empatica online platform 'E4 connect'. The student-researchers have access to this online platform through a shared password.

Only the camera footage of the participant that is wearing the Empatica E4 watch is copied to a USB drive. For privacy reasons, we could only access the USB with the camera footage from a managed computer connected to the Sint Oda network.

After the collection of the Empatica E4 data and the extraction of the correct camera footage, the student-researchers go to Sint Oda for one week to observe the camera footage and to connect abnormalities in the EDA with it. To make sure the correct correlation can be made, the time of the Empatica E4 and the cameras is synchronised.

All the camera footage is watched by the two student-researchers individually. During the observation, the student-researchers both use a different table to report their findings.

An in-depth observation of the behavior of the residents is made. The date and the time are noted when something is seen on the camera footage or whenever a change in the EDA is detected. For changes in the EDA, the student-researchers focus on increases or decreases in the EDA over time or sudden peaks or drops. An overview of this is shown in the results.

Then, a description is added of the situation in which the resident finds himself. Finally, all the other environmental factors that could potentially have an impact on the residents behavior are also documented. After this, the student-researchers compare their findings and report the results and conclusion together (see table 5 and 6 in appendix 1 and 2).

One month later, the student-researchers will return to Sint Oda for a second week, to repeat the same process. The intention is to execute a test for the intra-rater reliability. Because of the corona crisis, the student-researchers were not allowed to return to Sint Oda for an entire week to do the same observation as the first time. This was to protect the clients and caregivers of Sint Oda from COVID-19. Although Sint Oda did not allow any visitors on their property, they made an exception for us. They were willing to grant access for one day subject to the necessary precautions. In preparation of the one-day observation, the student-researchers compared their first observations and identified missing data or conflicting observations. The missing information and the disagreements were resolved during the one-day return observations.

Client information

Before we dive deeper in the description of the behavior of the observed residents, we will first give an impression of the other members and activities of the community they live in.

In this community, one person is almost always in his/her room next to the living space, looking through the window of the door. Most of the time two supervisors are present in the room, while other supervisors and staff come and go. Four residents spend most of their time in the living room. Two of them can walk around, two of them (our observed residents X and Y) are fixated in their chairs.

Bread is served for breakfast and dinner. For lunch, they eat a cooked meal. Almost every day, most of the residents go for a walk with a supervisor, however this does not include resident Y.

Resident X

The first participant that we observed, resident X, is a male between 18 and 37 years old with a severe mental/cognitive disability and autism. He shows stereotyped repetitive behaviors, automutilation and compulsive behavior. He uses different kinds of medication such as antipsychotics, an antidepressant, medication for cardiovascular disease, a laxative, vitamins and a stomach protector.

When he expresses his emotions, he is crying, shouting, screaming, automutilating and aggressive against his caregivers.

Resident X is washed and dressed around 8:30, he is taken out of bed around 10:30. In the living space, he sits fixated in his chair. Around 16 O'clock he is taken to bed. Sometimes this is later. Generally, he is being fed breakfast and dinner in bed and lunch in his chair.

Resident Y

The second participant, resident Y, is a male between 18 and 37 years old with a severe mental/cognitive disability and autism. He shows compulsive behavior, automutilation and is fixated on the drinks of himself and others. He uses different kinds of medication such as an anti-epileptic, medication for panic disorders, antipsychotics and a stomach protector.

When he expresses emotions, he does this by shouting, screaming and stamping on the ground. In extreme situations, he can get aggressive towards the caregivers.

Resident Y is let out of bed around 7:30. Washing and dressing happens before he is taken to his chair and fixated in his chair. He eats his 3 meals, breakfast, lunch, dinner and sometimes a snack, at the table. He is put to bed around 19:45. In bed he is not fixated but he wears clothes that limit his freedom of movement to prevent automutilation.

Results

To analyze the observation, actions that occurred multiple times were selected, the trend in EDA changes was noted. A possible conclusion for each action was formed which can be found in the discussion below.

Some situations returned multiple times or seemed to provoke a specific reaction, like head banging, so we looked at the EDA signals of those moments to see if we could find similarities in the reactions when the same situation recurred.

Results of resident X

Action: Move from bed to chair was seen 5 times.
No peaks or abnormalities were observed during this action.
We see that EDA gradually increases during the morning and the movement from his bed to his chair has no visible influence on this increase.

Action: Move from chair to bed was seen 6 times
5 times a drop of EDA was observed and 1 time a peak of EDA.

Action: Resident positioned in his chair with the back against the wall of the living room was seen 3 times.
2 times a decrease was observed, 1 time an increase but the increase happens over a long period of time and it does not seem linked to his positioning in the living space.

Action: Resident positioned in his chair facing the kitchen was seen 3 times
2 small increases and 1 decrease of EDA was observed.

Action: Resident positioned in his chair with the back to the kitchen was seen 6 times.
5 slow increases were observed and 1 time there was a constant high EDA.

Action: 6 times a blanket was put on him (at night or to go for a walk)
Every time this happened, a big drop in EDA was observed.

Action: Eating was seen 16 times (Breakfast: 2X, Lunch: 5X, Dinner 6X, Snack 3X)
During breakfast no changes in EDA were observed. At lunch 3 slight increases, 1 decrease and 1 time no difference was observed. When dinner was served, 3 times a decrease was observed and 3 times there was no change in EDA. When he got a snack 2 times there was a decrease and 1 time there was no reaction.

Action: Direct contact with supervisors was seen 6 times.

2 increases (more than one person), 3 decreases (one or more people) and 1 time EDA stayed constant was observed.

Action: Direct contact with other residents happened 9 times

1 time different peaks in EDA were observed, 3 times a decrease was seen (when rolled around in his chair by resident D, when resident D comes in his field of vision, high five). 1 time EDA stayed constant (decrease when other resident M goes away) and 4 times there was an increase (resident K, all residents are around, resident D).

Action: Head banging was seen 7 times

Increase in EDA when he bangs his head forward, against his mattress or against his chair.

Action: No one was around 4 times.

4 times an increase in EDA was observed.

Results of resident Y

Action: Taken out of his fixation chair was seen 12 times.

10 times we saw a decrease of the EDA, 1 time an increase of the EDA and 1 time also no change of the EDA.

Action: Gets put in his fixation chair was seen 13 times.

We saw 11 times an increase of the EDA and 2 times no change of the EDA.

Action: Other resident is restless when being next to resident Y was seen 8 times. 5 times resident K was clapping in his hands, 2 times resident K was jumping up and down in his chair and 1 time resident X was put in his fixation chair in front of resident Y.

We saw an increase every time.

Action: Resident Y moves his legs restless or bangs his head was seen 6 times.

6 times we saw an increase of the EDA followed by a decrease to the value of the EDA before.

Action: Quiet, no one is around was seen 3 times.

We saw 3 times a decrease of the EDA.

An overview is given of the different observed situations, at the times it occurs and what the EDA reaction was in table 3 and 4.

Table 3

Resident X	
Date/ Time	What? Image/ EDA?
20/01/2020	
11:43	CF: Moves from bed to chair, EDA: 8.07
11:44:15	CF: fixated in chair EDA: 8.91
11:45:30	CF: sits aside with his back against the wall EDA: decreases to 8.02
11:46	CF: resident X can drink
11:47	CF: resident X eats lunch in chair EDA: 9.51
12:14	EDA: 22.67 (3 small peaks)
12:32	CF: Resident X sits with back against the wall, supervisors are standing at the dining table with resident D. Resident X is moving. EDA:22.17
12:35	CF: Resident X moves and looks at table and window EDA: 26.50
12:49:30	CF: Resident X starts banging his head against the chair EDA: sudden increase from 22.73 to 24.27
12:51	CF: supervisors are coming out of the kitchen EDA: drop from 23.44 to 21.14
12:58:18	CF: headbanging of resident X EDA: stays the same until here 21.43
12:59:23	CF: Resident X is being moved away from the living room. EDA: drop from 20.83 to 18.98
12:59:23	Move to bedroom 2
13:00:34	CF: contraction of all his muscles. EDA: peak from 19:02 to 20.62 and back
13:10:30	CF: Resident X starts to get restless EDA: 16.72 and increases from here on.
13:22	CF: banging his head to the front EDA: peak from 18.18 to 19.99
13:34	CF: Resident X is being moved to the living room
13:37:30	CF: Resident X gets rolled around in his wheelchair by resident D. EDA: decreases from 21 to 20.5 and back to 21 when the resident stops
13:38:30-14:10	CF: Resident X sits in the living room alone with his back to the kitchen EDA: slow increasing line from 21.18 to 29.12
14:14	CF: Supervisors are standing next to resident X EDA: stays the same (around 25)
14:30	CF: banging with head EDA: 26.99
14:47	CF: Resident X is giving a high five to resident z. EDA: Decrease to 24
14:48	CF: All moving residents and supervisors are out of sight. EDA: start of increase until 14u52 (EDA = 28)
14:53	CF: Resident z comes into the picture EDA: Constant
14:59	CF: resident z goes away EDA: decreases
14:48-15:32	CF: snack is being made and given to the other residents. EDA: 24.89-28.45-24.74-27-14.51
15:32	CF: someone pushes a cart inside. EDA: 14.51-19.63
15:37	CF: Resident D comes into resident X's field of vision. EDA: decrease to 18.65
15:42-15:55:30	CF: going for a walk in his chair. EDA: decreases 17.76- 9.81
15:55	CF: he sits with his back to the kitchen EDA: Starts to increase
16.09-16:15	CF: someone new enters. EDA: 12.64-28.23
16:31	CF: talking people around him go away EDA: decrease from 27.07 to 24.37

16:37	CF: No one in living room EDA: increase to 29.42 (until 16:50)
16:51	CF: putting on helmet and taking off fixation. Move to bed. EDA: fast decrease 29.11-16.38
16:53	CF: Resident X is fixated on the bed, washed and a new pamper is put on. EDA: remains constant until 18:09
17:27-17:36	eating sandwiches (dinner), no response
18:34	CF: Resident X contracts (makes a weird face) EDA: 17.98
18:39	CF: resident starts to root for a long time, tries to turn around and move his legs. EDA: 19.69
19:06	CF: supervisor enters and pulls down pants to change diaper EDA: 30.11 decreases from now on
19:24	CF: blanket is put on EDA: 18.32 to 0.02 in 1 min

21/01	(All day in bed)
10:32	CF: Resident X is in bed, but is starting to move a little bit more EDA: 11.75
11:40	CF: there is a supervisor present. Lunch in bed. Marker. EDA: 21.7 to 42.92 in 3 min
11:53	CF: lunch is cleared and resident X is put down in his bed again. Supervisor leaves the room. EDA: peak 52.94
11:54-15:58	EDA: decreases gradually
14:23	CF: Supervisor enters the room. EDA: Fast decrease
15:21	CF: someone enters with flan (snack). EDA:13.36
15:59	CF: Resident is awake and moves a lot. EDA: Starts to increase until 16:27 (29.9)
16:56 en 18:06	CF: nothing special happens EDA: 2 huge peaks

17:07	CF: someone enters EDA: drop from 44.28 to 25.76
17:08-17:38	CF: different people enter, his diaper is changed and they put on his pajamas. EDA: 2 large peaks (between 16.54 and 34.51)
17:31	CF: Resident is washed EDA: decrease until 17:42 (12.43)
17:42	CF: Supervisors have left. Resident X is restless in bed EDA: Increases to 65.07 (18:06)
18:33 - 18:37	CF: Resident X eats dinner EDA: starts decreasing from 62.75 with a drop when eating is over at 18:37 to an EDA of 35.20
18:52	CF: head bonking against the mattress. EDA: peak 73.05
19:15	CF: blanket is put on. EDA: Drop from 57.67 to 30.56
22/1	

11:09	CF: move to living room from bed to chair with his back to the kitchen. EDA: 6:20
11:30	CF: resident X is moved so his chair is facing the kitchen. He can eat lunch himself EDA: slow increase (nothing out of the ordinary)
12:50-14:18	CF: Resident X sits in his chair with his back to the kitchen, the supervisors and other walking residents. EDA: plateau period around 30
14:18	CF: blanket/coat is put on EDA: Drop from 34.96 to 20.73
14:32	CF: Blanket/coat is taken away and he is positioned with his back to the kitchen. EDA: Increase to 28.88 (14:40)
14:40	CF: People stand around him EDA: 29.17 (a decrease starts here)
14:50	CF: He gets a snack EDA: 23.22 (decrease ends 3 min after this at 21.97)

15:20-16:40	CF: resident K sits next to resident X EDA: increase to 29
16:45-17:10	CF: Resident X is moved to bedroom, put in bed and washed. EDA: decreases from 29 to 11.36
17:37	CF: Resident can eat dinner himself EDA: decrease from 11 to 6
23/1	
8:30-11:13	CF: breakfast, taking away of blanket, brushing of teeth, dressing. EDA: 0,5-10
11:12	CF: move from bed to chair EDA: small peak from 10.13 to 11.40 and back when he is positioned (with his back to the kitchen)
11:45	CF: lunch is made and brought EDA: decrease from 12.57 to 10.48
12:18 12:20	CF: Resident is fixated again and supervisors start to eat. EDA: 12:37
12:52	CF: start of cleaning EDA: 20

13:43	CF; nothing special EDA: 28.24
15:08	CF: resident X sits with his back against the wall, facing the whole living space. He moves his head. EDA: 29.16 to 24.97
15:59	CF: it suddenly becomes much busier in the living space EDA: From 19.62 to 35.85
16:10	CF: Residents are fixed after the walk, all within sight of resident X. EDA: Decreases to 19.12 (16:35)
16:36-16:46	CF: alternately banging and sitting quietly again EDA increases from 19.42 to 28.69
17:10	CF: he eats dinner EDA: straight line (artifact)
17:31-17:33	CF: he is put in bed, tied, helmet off, night kiss on the forehead and lights out EDA: drop from 29.48 to 15.48
25/1	
10:53	CF: Resident X is moved from his bed to his chair.

	EDA: 2.51 from here on an increase starts for the rest of the day with a peak at 13:02
11:48	CF: resident X gets lunch EDA: Keeps increasing slowly, no peaks
12:46	CF: Resident is sitting in the chair with his back against the wall, other resident is walking around, supervisors are in the kitchen EDA: increase until 13:02 to 43.22
12:53	CF: he pulls forward / pushes forward / tries to move forward EDA: peak from 35.62 to 40.98
13:02-13:06	CF: Nothing special EDA: drop from 43.43 to 34.12
13:50	CF: Resident X moves a lot. EDA: 36.65 this is a valley between 2 peaks of 38.19 and 37.53
14:13	CF: Supervisor sits with him and stays around. EDA: 37.44 and decreases to 32.02 over a period of half an hour.

15:14	CF: move to bed and a new diaper is put on. EDA: Drop from 31.42 to 10.95
16:47	CF: starts to move restlessly EDA: from 6.23 to 8.53
17:33	CF: resident eats dinner EDA: no changes visible
17:58	CF: Resident X gets a new diaper EDA: Decreases from 6.7 to 5.4
18:30	CF: strong restless movements in bed EDA: peak from 6.78 to 14.10
18:46	CF: Resident X calms down (asleep) EDA: decreases to 8.9 until 19:23
19:26	CF: Diaper is changed and blanket is put on EDA: Drop from 8.40 to 4.8
19:30	Very restless night with changes in EDA between 11.98 and 4.71

26/1	
8:24	CF: light is turned on, helmet put on, clothes put on EDA: drop from 7.3 to 2.16
8:40	CF: nothing EDA: Peak from 2.93 to 13.28
8:55	CF: breakfast EDA: stable at 8.56
10:50	CF: Move to chair EDA: Increase from 11.82 to 24.92
10:50-14:48	NO CAMERA FOOTAGE
15:02	CF: move back to bed, change diaper. EDA: decrease from 17.26 to 7.78
16:04	CF: someone enters EDA: Turbulence
17:03	CF: dinner is brought to him EDA: 16.68
17:15	CF: resident X freezes and then relaxes again
	EDA: reaches a valley but there is also a lot of movement on the accelerometer
17:35:30	CF: light is turned off. EDA: 15.02 and drops to 9.5 (at 17:37:30)
18:14	Camera footage stops (measurement of the night)
27/1	
16:04	CF: vest is put on EDA: from 4.4 to 5.8
17:08	CF: resident X is turned around; bib is put on and he is allowed to eat dinner himself EDA: decreases from 13.77 to 8:58
17:30	CF: After dinner, he is fixed again. EDA: in a valley of 5.08 and starts to rise again from here. Sharp peak of 6.89 the moment he is reattached.
17:43	CF: he is turned around and positioned with his back to the kitchen EDA: gradually increases from here on.
18:00	CF: Resident K jumps up and down and claps next to him EDA: increases from 13.50 to 16.43
18:56:30	CF: Resident X moves wildly in his chair EDA: increases from 7.19 to 11.14
19:06	CF: vest is taken of, he bumps his head forward EDA: increases to 13.61
19:10	CF: change into pajamas EDA: peaks but also a lot of movement in the accelerometer
19:18:30	CF: blanket is put on EDA: last small peak up and immediately after it decreases very hard. From 8.87 to 5.26

Table 4

Resident Y	
Date/Time	What? Camera footage (CF) / EDA?
29/01/2020	
8:40	CF: Resident Y sits in his chair EDA: Peaks from 1 to 1.08 and drops back to 0.98
8:53 8:54:30 8:55:30 8:57:30	CF: Resident K jumps from his chair multiple times. EDA: 1st peak: 0.98 to 1.24 2nd peak: 0.98 to 1.06 3rd peak: 0.98 to 1 4th peak: 0.98 to 1.18
10:35	CF: Interaction with supervisor EDA: No special changes
10:45	CF: Many movements of the legs EDA: Peak from 0.68 to 0.75 and back to 0.62
11:15	CF: Supervisor rises to put the TV on or off. EDA: Increases from 0.77 to 0.94
12:29	CF: Resident Y gets taken out of his fixation chair and has to sit down at the table for lunch. EDA: Decreases from 1.12 to 1.07 (12u48)
12:48	CF: Resident Y gets taken back to his fixation chair. EDA: Starts increasing from 1.07 to 1.26 (14u30)
14:28	CF: Supervisor talks to resident Y EDA: Decreases from 1.26 to 1.21
14:41	CF: Resident Y looks restless. Other resident moves. EDA: Peaks from 1.21 to 1.26 and back
14:44	CF: Nothing special EDA: Decreases from 1.20 to 1.09 (15:00)
15:27	CF: Resident Y gets taken out of his fixation chair and has to sit down at the table for a snack. EDA: Peak from 1.1 to 1.14, then a decrease from 1.14 to 0.9
15:37	CF: Resident Y gets taken away and gets fixated back in his fixation chair at 15:38 EDA: Starts decreasing till 15:52
15:56	CF: Laundry enters the room and gets folded by the supervisors EDA: Starts increasing from 0.9 to 1.02 (16:52)
16:54	CF: Resident gets taken from his fixation chair to another room and back 3 minutes later EDA: stays around 1.01
17:51	CF: Resident Y gets taken to the table for dinner EDA: Peak: 1.05
17:55	CF: Resident Y gets fixated in his fixation chair EDA: Same
30/01/2020	
8:58	CF: Resident Y gets fixated in his chair and is restless. EDA: Increases from 0.3 to 0.54 (9:18)
9:24	CF: Other resident has finished his breakfast. EDA: Decreases from 0.5 to 0.37
9:30	CF: Supervisors are sitting at the table eating, other residents are restless EDA: Starts increasing
9:57	CF: Supervisors are done eating and one of them is dancing in sight of resident Y EDA: Peak from 0.44 to 0.51
10:50	CF: 2 supervisors and 2 other persons are standing around resident Y EDA: Increase from 0.49 to 0.61
11:01- 11:06	CF: Resident Y gets taken out of the living room for 5 minutes. EDA: Decreases from 0.57 to 0.53 and increases by return to 0.67
11:31- 11:40	CF: A lot of turbulence EDA: Increase from 0.73 to 0.85

11:53-12:01	CF: Resident Y gets taken out of the fixation chair and gets placed at the table for lunch and gets fixated in his fixation chair at 11u58 EDA: Decrease from 0.95 to 0.85 and afterwards increases to 0.92
12:39	CF: Resident Y abruptly awakes in his fixation chair. EDA: Increase from 1.07 to 1.25
13:39	CF: Resident Y lays slumped in his fixation chair and suddenly awakes. EDA: Peak from 1.11- 1.28
13:59	CF: Another resident across from resident Y is restless EDA: 1.24- 1.30
14:32	CF: Other resident gets taken out of his chair in sight of resident Y EDA: Increases from 1.19 to 1.33 at 14:42
14:49	CF: Restlessness, there are a lot of residents and supervisors in the living room EDA: Peak of 1.31

14:53	CF: Resident Y is alone in the living room EDA: Decrease to 1.20 at 15:04
16:36	CF: Resident Y is alone, sometimes a supervisor walks by EDA: Decrease from 1.13 to 0.96 at 16:52
17:00	CF: End of diner EDA: Increase from 0.97 to 1.05
17:05	CF: Resident K starts clapping his hands on and of EDA: Every time resident K starts clapping, EDA increases with 0.05 and decreases again after a few seconds.
18:41	CF: A man with a guitar walks in EDA: Increases from 0.94 to 0.98 and decreases 30 seconds later again to 0.94
18:46	CF: Resident Y gets taken out of the room and is brought to his bedroom to go to sleep. EDA: Decreases from 0.96 to 0.82

31/01/2020	
7:24	CF: Resident Y sits down in his fixation chair and gets fixated EDA: Peak to 0.42 and decreases afterwards to 0.26 at 7:28
7:46	CF: Resident Y gets taken out of his fixation chair and sits down at the table for breakfast EDA: Decreases from 0.45 to 0.41, Increases at 7u52 when resident Y gets back in his fixation chair.
7:52	CF: Resident Y gets fixated in his fixation chair EDA: Starts increasing
8:56	CF: Another resident gets restless EDA: Peak from 0.7 to 0.8
9:55	CF: Resident Y is banging his head against his hands EDA: Multiples peaks and drops between 0.78 and 0.94
10:42	CF: Resident Y is shaking his head excessively EDA: Peaks from 0.82 to 0.88

11:39	CF: Resident Y gets taken out of his fixation chair to be put at the table for lunch EDA: Decreases from 0.84 to 0.79 at 11u46
11:46	CF: Resident Y gets taken away EDA: Fast peak from 0.8 to 0.84
11:48	CF: Resident Y gets fixated in his fixation chair in the living room. EDA: Peaks to 0.86 from 0.79
12:10	CF: Other resident gets taken out of his bed and put in his fixation chair in front of resident Y EDA: Peak from 0.82 to 0.91
01/02/2020	
5:00	A lot of ups and downs in the EDA
7:45	CF: Resident Y gets fixated in his fixation chair EDA: 1.13 (peak)
11:41	CF: Resident Y gets taken out of his chair and sits at the table for lunch

	EDA: Decreases from 0.94 to 0.88 at 11:49
11:49	CF: Resident Y gets fixated in his fixation chair EDA: Starts increasing to 1
15:02	CF: Resident Y gets taken out of his fixation chair for a snack at the table EDA: Decreases from 0.98 to 0.9. No increase afterwards.
17:05	CF: Resident Y gets taken out of his fixation chair and sits down at the table for dinner EDA: Decreases from 0.9 to 0.83.
17:12	CF: Resident Y gets fixated in his fixation chair EDA: Increases from 0.83 to 0.9.
18:43	CF: Resident Y gets taken out of his fixation chair and is brought to his bedroom EDA: Decrease from 0.92 to 0.73 at 19u04
	Turbulent night with great fluctuations in the EDA. There are also more peaks on the accelerometer. EDA Between 0.68 and 1.16
02/02/2020	
5:50	CF: Resident Y walks around in his bedroom until 7u20 EDA: Stable around 0.95
7:32	CF: Resident Y gets taken to the bathroom EDA: Peak of 1.26
7:35	CF: Resident Y sits at the table for breakfast EDA: Decreases to 1.01 from 1.15
7:42	CF: Resident Y gets fixated in his fixation chair EDA: 2 peaks from 1.17 and 1.13. At 7u46, EDA stabilizes around 1.04
9:25	CF: He is banging with his head EDA: Small peaks of 1.03 and 1.08 and back

Discussion

Interpretation results

During the observations a few actions or situations were seen multiple times. Sometimes with different reactions, sometimes with the same reaction. A couple of presumptions were made and discussed below.

Resident X

Transfer to his chair from his bed does not seem to be a disruptive part in his day. The EDA increase can be explained because it is the start of the day, he is at ease in his bed and his body is adjusting to being awake and having others around him. The caregivers do say that he finds the transfer from his bed to his chair tensive. He can also be unsure when there is a new caregiver. We do not see any peaks during the transfers.

Moving to his bed mostly means that he is also changed into pajamas, that he is washed and that his diaper gets changed. We are not certain that the drop in the EDA can be attributed to the move to his bed or the anticipation of what is coming or the actual ritual of going to bed like washing, changing the diaper and changing clothes.
One time a peak in the EDA is seen, at this moment there is also a lot of movement in the accelerometer. It could be that the measurement is not reliable. He was also wearing another fixation vest of which the supervisors said that he did not like it.

When his chair is positioned against a wall, a decrease in the EDA is seen two times and one time we see an increase. In general, it could be that he is more at ease when he sees the whole living space.

The increase in the EDA when he is facing the dining room could be explained in a few ways. It could be because he sees other people at the table or because he knows food is coming or because he is excited that he can see into the kitchen.

When he is positioned with his back to the kitchen, we see an increase in the EDA every time. We suspect that this means he gets agitated when he cannot see what is happening at the table and around the kitchen.

Covering him with a blanket or a coat seems to give him some kind of rest. Every time he is covered, there is a big drop in the EDA. This happens at night when he goes to sleep and

during the day when he is prepared to go outside. Maybe it is not the blanket but the action afterwards that causes the drop, going to sleep or going outside, but de drop is visible at the exact moment that he gets covered with the blanket. Previous research about the effect of blankets has been done. Weighted blankets may be an appropriate therapeutic tool in reducing anxiety (Eron et al., 2020). Bestbier and Williams (2017) demonstrated that stimulating skin pressure sensory systems seems to benefit most to the population of young people with autism and severe intellectual disability on whom it was trialed.

Contact with the supervisors causes all different reactions. In general, we think that he likes the attention of the supervisors in a peaceful, not to busy environment. But this is no certainty.

When other residents are around and are making noise, like clapping, in his surroundings, an increase in the EDA was observed in most of the occasions. When other residents were around without making too much noise, we saw a decrease in EDA.

The general impression is that the EDA decreases or stays the same when he eats. This can also be explained because he gets one on one attention at these moments.

Headbanging happens after his vest is taken off, after a busy moment in the living space, after restless moments in bed or in his chair and after he looks outside and there is a man visible behind the window. The headbanging could be a way to release tension.

When no one, except for the other fixated resident, is around, he always shows an increase in the EDA. The same happens when it is too crowded and all the residents and supervisors are around. However this situation was only observed 2 times. It could be that he gets stressed when it is too quiet but also when it is too crowded. Or that he calms down when certain caregivers are present.

Resident Y

The EDA of resident Y decreases every time he is taken out of his fixation chair and increases when he is fixated. We suspect that this means that he does not like to be fixated and the increase in EDA indicates stress or agitation. In the study of Róisín Gallinagh (2014) a minority of patients (n=4) had positive feelings about physical restraints as they provided a sense of security to them. The other patients (n=13) had negative comments and their

responses were categorized in terms of institutional control, ritualized care, entrapment and discomfort, and possible alternatives.

When another resident is restless around resident Y, his EDA increases. When he is alone, the EDA decreases. It seems that this indicates that he gets agitated by the movement of others and calms down when he is alone.

It could be that Resident Y expresses his restlessness, increase in EDA, with head banging or leg movements. It could also be that the movements calm him down because the EDA decreases again after a few seconds. Or it could be that it is an artefact of the Empatica E4 due to movement.

Reflection on findings

A previous review found that valence related changes in the physiology of humans are too subtle, this makes it difficult to detect (Schmidt, Reiss, Dürichen, & Laerhoven, 2019).
In the current study, it was the intention to find out what caused an outburst in the participants but it was found hard to distinguish which specific emotion caused the arousal. Therefore, no real comparison could be made between an increase in the EDA because of anger, a negative emotion, or because of joy, a positive emotion.

Other studies have used the Empatica E4 for a short period of time to find certain emotions in that small time frame (Chrisinger & King, 2018; Hoogerheide et al., 2019). In our study there were measurements over multiple days which means that the days can be compared with each other.

It was found that there are significant increases in the parameters of the Empatica E4 prior to an emotion outburst (de Looff et al., 2019). We did not see any emotional outburst in our study. We did see an increase in the EDA in situations that seemed stressful to the residents but only at the moment itself and not prior to it.

During the observation, we looked at all the parameters of the Empathica E4. Because there seemed to be no relevant changes in BVP, HR and temperature, we did not mention them in the results and focused more on EDA and the signals from the accelerometer.

Our study has its limitations.
We noticed that the Empatica E4 sometimes shows a flat line in the EDA for a few seconds or sometimes for a few minutes. This indicates an artefact or a bad connection with the skin. When there is a flat line, the data could possibly be unreliable.

Not all peaks in the EDA are useful. Sometimes when the participants move too much, there can be an artefact in the data. It is important to keep an eye on the accelerometer when there is a peak in the EDA. If there is too much movement, it could be that the peak is not reliable.

The results are specific for each participant and because there are only two participants, they cannot be generalized.

A couple of questions remain.
Resident X has an average EDA around 40. His EDA is at his lowest with 7 and highest with 67. Participants in other studies have an average EDA of 1 with peaks of maximum 3. (Chrisinger & King, 2018; Dao et al., 2018; Gouverneur et al., 2017; Hoogerheide et al., 2019; Stadler et al., 2018; Zhao et al., 2018). Resident Y has an average EDA of 1. It could be interesting to investigate why the EDA of resident X is this high.

Hot, Naveteur, Leconte, and Sequeira (1999) found that the tonic EDA increases linearly throughout the day. In both participants, we see that the EDA rises gradually when they wake up till late in the afternoon. Further research is necessary to determine what causes this increase.

Suggestions for further research

Due to the use of camera footage as an observation method, there were no contributing factors that interfered with the client's routine. The use of cameras or a similar form of observation can be recommended.

The Empatica E4 was easy to use. The caregivers found it easy to put the watch on and off and none of the participants had a rash after wearing the watch for multiple hours. The online platform allowed us to analyze the data anywhere at any time. Overall, the Empatica E4 is very user friendly.

The camera footage used in the present study did not include sound. Sometimes the EDA rises without anything changing in the camera footage. It could be possible that there is a noise in the background that startles the participants. Noise that contains high levels of low-frequency noise is perceived as more annoying than higher frequency noise. It can cause vibrations in objects, walls and human bodies. Noise can also act as a non-specific biologic stressor that is able to provoke reactions that make the body ready for a fight or flight response (Reybrouck, Podlipniak, & Welch, 2019). Therefore, it could be important to have camera footage in combination with sound recording.

Only the camera footage of the places where the participants were visible, were available. A lot of times we did not see what was going on in another part of the room. In further research, it would be recommended to make sure that the whole room with participants is being surveilled. The reason therefore is to not overlook details or other important aspects that could influence behavior.

The caregivers have put the watch on and off. Because of their routine, it was not possible to put it on at a fixed time or to put it off at a fixed time. This caused the data to vary in time and to vary between the participants. In further research we recommend using the same timeframe every day for every participant for a better comparison between the days and possibly the participants.

In our study, there was a specific focus on the participants and what happened with their internal responses when they ate, slept, went or looked somewhere. In their day to day life, a lot of caregivers are involved to help them with all of those things. However, in the observation, no attention went to which caregiver helped with what. It is found that people with similar personality patterns are more likely to like each other because their personality is more familiar. It is easier to perceive and interpret these familiar stimuli than new information because the familiar stimuli have already been processed before. People tend to like familiar stimuli more than novel stimuli (Tenney, Turkheimer, & Oltmanns, 2009). The caregivers present at a specific moment could therefore have an influence on the mood of the residents at that moment.

Conclusion

The Empatica E4 can be used to measure the EDA of people with a severe physical and/or cognitive disability who are fixated. For those who are not fixated, you need to make sure that they get used to the watch and do not take it off or damage it.

Changes in the EDA are observed without a clear visible reaction of the participants in the camera footage. This makes that the Empatica E4 can be used to help with trying to interpret the emotions of people who have difficulties expressing their emotions.

It is not possible from this research to conclude which specific emotion can be linked with an increase or decrease in the EDA. Rising in the EDA could either mean positive emotions like happiness or negative emotions like anger and stress.

We have a few specific suggestions for the caregivers that we think would have the most calming effects. For resident X we recommend positioning him in a way that he can see the dining table, with his back against the wall or with his face to the kitchen. We also recommend more activities where a blanket is put on him. To conclude, we suspect that he likes people around him that talk but that do not make too much noise. For resident Y we recommend releasing him from his fixation as many times as possible although this is not something that can be realized overnight.

Further research is necessary. With the suggestions indicated in the discussion we think that it is possible to find more relevant information about this subject.

Competing of interest

The authors declare that they have no competing of interests.

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Appendix

Appendix 1

Table 5

Resident X			
Date/ Time	What? Image/ EDA?	Situation (what do we see/suspect/…)	Extra information
20/01/2020			
11:43	CF: Moves from bed to chair, EDA: 8.07		
11:44:15	CF: fixated in chair EDA: 8.91		
11:45:30	CF: sits aside with his back against the wall EDA: decreases to 8.02	Small decrease in EDA between the fixation in the chair and the positioning of the chair aside.	
11:46	CF: resident X may drink	Resident X sits in chair in the living room with back against the wall	11u48: End of drinking
11:47	CF: resident X eats lunch in chair EDA: 9.51	From this moment there is an increase in EDA until 12:35 with a peak EDA of 26.50.	Lunch from 11:47 until 11:51:30
12:14	EDA: 22.67 (3 small peaks)	Other resident is moving in front of him.	
12:32	CF: Resident X sits with back against the wall, supervisors are standing at the dining table with resident D. Resident X is moving. EDA:22.17	Supervisors are talking with resident X. Increase of EDA starts here	
12:35	CF: Resident X moves and looks at table and window EDA: 26.50	Supervisors are talking with each other at the dining table. Through the window a man is visible who is standing at the fence. EDA peak is reached	From this moment, EDA starts decreasing again.
12:49:30	CF: Resident X starts banging his head against the chair EDA: sudden increase from 22.73 to 24.27	Man outside is still visible	
12:51	CF: supervisors are coming out of the kitchen EDA: drop from 23.44 to 21.14	Resident X is still sitting with his back to the wall. All the supervisors were in the kitchen (not visible), when they come out, there is a sudden drop.	
12:58:18	CF: headbanging of resident X EDA: stays the same until here 21.43		
12:59:23	CF: Resident X is being moved away from the living room. EDA: drop from 20.83 to 18.98		
12:59:23	Move to bedroom 2		Temperature drop of 1°, restores gradually.
13:00:34	CF: contraction of all his muscles. EDA: peak from 19:02 to 20.62 and back		
13:10:30	CF: Resident X starts to get restless EDA: 16.72 and increases from here on.	Resident X is sitting with supervisor in bedroom. Supervisor is watching a movie on the computer? Is resident X watching to?	
13:22	CF: banging his head to the front		

	EDA: peak from 18.18 to 19.99		
13:34	CF: Resident X is being moved to the living room		
13:37:30	CF: Resident X gets rolled around in his wheelchair by resident D. EDA: decreases from 21 to 20.5 and back to 21 when the resident stops		
13:38:30 - 14:10	CF: Resident X sits in the living room alone with his back to the kitchen EDA: slow increasing line from 21.18 to 29.12	It seems like no one is around him, resident D is walking behind him but he cannot see that. A few people are walking past his side, chance of shifts?	EDA stabilizes when there are more people around him.
14:14	CF: Supervisors are standing next to resident X EDA: stays the same (around 25)		
14:30	CF: banging with head EDA: 26.99	wild movements with head results in 2 EDA peaks right after each other	
14:47	CF: Resident X is giving an high five to resident M. EDA: Decrease to 24		
14:48	CF: All moving residents and supervisors are out of sight. EDA: start of increase until 14u52 (EDA = 28)		
14:53	CF: Resident M comes into the picture EDA: Constant		
14:59	CF: resident M goes away EDA: decreases		
14:48-15:32	CF: snack is being made and given to the other residents. EDA: 24.89-28.45-24.74-27-14.51	From the moment we see that a snack is being made, EDA starts to increase (can he hear that it is being made in the kitchen?) Then we see a decrease (because someone comes and sits with him?). When the snack is given to the other residents we see another increase with a strong decrease when he eats himself.	
15:32	CF: someone pushes a cart inside. EDA: 14.51-19.63	A cart is being pushed inside. Supervisors are folding clothes and are talking to each other, all this happens behind resident X.	
15:37	CF: Resident D comes into resident X's field of vision. EDA: decrease to 18.65		
15:42-15:55:30	CF: going for a walk in his chair. EDA: decreases 17.76- 9.81	A blanket is put on him, they go outside and come back 13 min later. The blanket is taken away. He sits with his back to the kitchen.	Temperature decreases 2 degrees during this period.
15:55	CF: he sits with his back to the kitchen EDA: Starts to increase		
16.09-16:15	CF: someone new enters. EDA: 12.64-28.23	New people come inside (new shift?), they go and sit with resident X to talk to him. Increase of EDA.	
16:31	CF: talking people around him go away EDA: decrease from 27.07 to 24.37		
16:37	CF: No one in living room EDA: increase to 29.42 (until 16:50)		

16:51	CF: putting on helmet and taking off fixation. Move to bed. EDA: fast decrease 29.11-16.38	Resident X is put to bed.	EDA constant until 18:09
16:53	CF: Resident X is fixated on the bed, washed and a new pamper is put on. EDA: remains constant until 18:09	Bedroom 1	
17:27-17:36	eating sandwiches (dinner), no response		
18:34	CF: Resident X contracts (makes a weird face) EDA: 17.98	Is resident using his diaper?	Increase of EDA starts now.
18:39	CF: resident starts to root for a long time, tries to turn around and move his legs. EDA: 19.69	Resident is fixated for a long time in bed.	fast, clear increase of EDA
19:06	CF: supervisor enters and pulls down pants to change diaper EDA: 30.11 decreases from now on	Resident has a dirty diaper. Could this cause an increase in EDA?	
19:24	CF: blanket is put on EDA: 18.32 to 0.02 in 1 min	Do they take the E4 off of him at this moment? Artefact?	
21/01	(All day in bed)		
10:32	CF: Resident X is in bed, but is starting to move a little bit more EDA: 11.75	build-up of EDA because he still lies in bed? Increase until 21.7 in the next hour.	
11:40	CF: there is a supervisor present. Lunch in bed. Marker. EDA: 21.7 to 42.92 in 3 min	Lunch is served in bed. Marker because he asked to be put in his chair and the answer was no.	
11:53	CF: lunch is cleared and resident X is put down in his bed again. Supervisor leaves the room. EDA: peak 52.94	Affected that he cannot move to his chair after lunch?	
11:54-15:58	EDA: decreases gradually	Some peaks are visible. He lies in bed, nothing special happens.	
14:23	CF: Supervisor enters the room. EDA: Fast decrease		
15:21	CF: someone enters with flan (snack). EDA:13.36	There is no more reaction here than during the rest of the day.	
15:59	CF: Resident is awake and moves a lot. EDA: Starts to increase until 16:27 (29.9)		
16:56 en 18:06	CF: nothing special happens EDA: 2 huge peaks	There is nothing special to explain the peaks. He is in bed but no one comes by and he does not move very much either.	
17:07	CF: someone enters EDA: drop from 44.28 to 25.76		
17:08-17:38	CF: different people enter, his diaper is changed and they put on his pyjamas. EDA: 2 large peaks (between 16.54 and 34.51)		
17:31	CF: Resident is washed EDA: decrease until 17:42 (12.43)		

17:42	CF: Supervisors have left. Resident X is restless in bed EDA: Increases to 65.07 (18:06)		
18:33 - 18:37	CF:Resident X eats dinner EDA: starts decreasing from 62.75 with a drop when eating is over at 18:37 to an EDA of 35.20		
18:52	CF: head bonking against the mattress. EDA: peak 73.05		
19:15	CF: blanket is put on. EDA: Drop from 57.67 to 30.56		
22/1			
11:09	CF: move to living room from bed to chair with his back to the kitchen. EDA: 6:20		Slow increase of EDA from 10 am until 12:45 (EDA at 12:45 = 31.57)
11:30	CF: resident X is moved so his chair is facing the kitchen. He can eat lunch himself EDA: slow increase (nothing out of the ordinary)		Slow increase remains
12:50-14:18	CF: Resident X sits in his chair with his back to the kitchen, the supervisors and other walking residents. EDA: plateau period around 30		
14:18	CF: blanket/coat is put on EDA: Drop from 34.96 to 20.73	The supervisors make him ready to go for a walk.	
14:32	CF: Blanket/coat is taken away and he is positioned with his back to the kitchen. EDA: Increase to 28.88 (14:40)		
14:40	CF: People stand around him EDA: 29.17 (a decrease starts here)		
14:50	CF: He gets a snack EDA: 23.22 (decrease ends 3 min after this at 21.97)	He calms down with people and food?	
15:20-16:40	CF: resident K sits next to resident X EDA: increase to 29	Is resident K the cause of the higher EDA?	EDA 29 stays constant for a long time.
16:45-17:10	CF: Resident X is moved to bedroom, put in bed and washed. EDA: decreases from 29 to 11.36	During the washing and putting to bed ritual resident X is very calm.	
17:37	CF: Resident can eat dinner himself EDA: decrease from 11 to 6	small peaks when he sees the food and a decrease when he can eat himself.	
23/1			
8:30-11:13	CF: breakfast, taking away of blanket, brushing of teeth, dressing. EDA: 0,5-10	Gradual increase in EDA over a long period. Activities such as washing, changing diapers, dressing, brushing teeth and eating are not disturbing for him ?!	
11:12	CF: move from bed to chair EDA: small peak from 10.13 to 11.40 and back when he is positioned (with his back to the kitchen)		

11:45	CF: lunch is made and brought EDA: decrease from 12.57 to 10.48	Resident sits facing the kitchen and dining table. He can eat himself.	
12:18 12:20	CF: Resident is fixated again and supervisors start to eat. EDA: 12:37	An increase in EDA starts here and lasts until 13:43	
12:52	CF: start of cleaning EDA: 20	Increase becomes sharper. Cleaning is done in the living space.	
13:43	CF; nothing special EDA: 28.24	End of the increase in EDA, nothing really special to see. From here, EDA remains fairly consistently high.	
15:08	CF: resident X sits with his back against the wall, facing the whole living space. He moves his head. EDA: 29.16 to 24.97	Drop seems weird. Before it was very busy at the dining table and the entrance. Is this a way to get rid of tension?	
15:59	CF: it suddenly becomes much busier in the living space EDA: From 19.62 to 35.85	Too many people walking around him cause a big increase in EDA? Peak is reached at 16:04	
16:10	CF: Residents are fixed after the walk, all within sight of resident X. EDA: Decreases to 19.12 (16:35)	Resident X sits in the living room with his back against the wall (he can see the whole living space)	
16:36- 16:46	CF: alternately banging and sitting quietly again EDA increases from 19.42 to 28.69	residents sit in a circle, resident K is moving back and forth, resident D is sitting next to resident X. The other 2 fixed residents are also moving and making noise. The EDA rises sharply when resident X moves restlessly with his body. Is this a response to the movement of the other residents?	
17:10	CF: he eats dinner EDA: straight line (artifact)		Because of the plateaus, there is a change it is an artifact.
17:31- 17:33	CF: he is put in bed, tied, helmet off, night kiss on the forehead and lights out EDA: drop from 29.48 to 15.48		Before and after this measurement we already see several plateaus / artifacts. Is this still a reliable measurement?
25/1			
10:53	CF: Resident X is moved from his bed to his chair. EDA: 2.51 from here on an increase starts for the rest of the day with a peak at 13:02		
11:48	CF: resident X gets lunch EDA: Keeps increasing slowly, no peaks		
12:46	CF: Resident is sitting in the chair with his back against the wall, other resident is walking around, supervisors are in the kitchen EDA: increase until 13:02 to 43.22		
12:53	CF: he pulls forward / pushes forward / tries to move forward EDA: peak from 35.62 to 40.98	Supervisors are all in the kitchen. Resident D is wandering in his field of vision again.	
13:02-	CF: Nothing special	I cannot see anything that would explain	

13:06	EDA: drop from 43.43 to 34.12	this decrease. Maybe the 2 people who are also fixed outside the picture have calmed down or are they behaving differently?	
13:50	CF: Resident X moves a lot. EDA: 36.65 this is a valley between 2 peaks of 38.19 and 37.53	There is nothing to see that would make this period special.	During the period from 13:07 and 14h we see a lot of peaks and valleys. All this between EDA 33.04 and 39.23. We also see with the accelerometer that there is more movement.
14:13	CF: Supervisor sits with him and stays around. EDA: 37.44 and decreases to 32.02 over a period of half an hour.	Supervisor stays close so that he can see her.	
15:14	CF: move to bed and a new diaper is put on. EDA: Drop from 31.42 to 10.95	Blanket is not put on him. Then what explains the sharp decrease? Was he troubled by a dirty diaper or was it too busy in the living room?	
16:47	CF: starts to move restlessly EDA: from 6.23 to 8.53	He has just entered a quiet period after being put in bed. And then suddenly becomes very restless.	
17:33	CF: resident eats dinner EDA: no changes visible		
17:58	CF: Resident X gets a new diaper EDA: Decreases from 6.7 to 5.4		
18:30	CF: strong restless movements in bed EDA: peak from 6.78 to 14.10	It looks like he's sleeping. Is he troubled by a bad dream?	
18:46	CF: Resident X calms down (asleep) EDA: decreases to 8.9 until 19:23		
19:26	CF: Diaper is changed and blanket is put on EDA: Drop from 8.40 to 4.8		
From 19:30	Very restless night with changes in EDA between 11.98 and 4.71	We cannot see what causes this. Bad dreams or too much background noise?	
26/1			
8:24	CF: light is turned on, helmet put on, clothes put on EDA: drop from 7.3 to 2.16		We see a lot of movement when getting dressed. Is this a reliable measurement?
8:40	CF: nothing EDA: Peak from 2.93 to 13.28		
8:55	CF: breakfast EDA: stable at 8.56		
10:50	CF: Move to chair EDA: Increase from 11.82 to 24.92		
10:50-14:48	NO CAMERA FOOTAGE	His mother comes to visit him. Eda: Decreases from 28.2 to 15.83	
15:02	CF: move back to bed, change diaper.		

	EDA: decrease from 17.26 to 7.78		
16:04	CF: someone enters EDA: Turbulence	Someone comes in and wakes him up. The EDA is disrupted. Is this because he wakes up and then has to relax again? Because after this it is the same for a long time	
17:03	CF: dinner is brought to him EDA: 16.68	When the person enters with food, the EDA remains the same and high. When the eating is done, the EDA drops significantly to 9.04	
17:15	CF: resident X freezes and then relaxes again EDA: reaches a valley but there is also a lot of movement on the accelerometer		Reliable measurement? There is a lot of movement on the accelerometer.
17:35:30	CF: light is turned off. EDA: 15.02 and drops to 9.5 (at 17:37:30)	Decline => quiet because light off? Or because someone has just been in the room?	
18:14	Camera footage stops (measurement of the night)		
27/1			
16:04	CF: vest is put on EDA: from 4.4 to 5.8		
17:08	Beeld: resident X is turned around, bib is put on and he is allowed to eat dinner himself EDA: decreases from 13.77 to 8:58	He is turned from the living room to the dining room so he can see the others at the table.	
17:30	CF: After dinner, he is fixed again. EDA: in a valley of 5.08 and starts to rise again from here. Sharp peak of 6.89 the moment he is reattached.		
17:43	CF: he is turned around and positioned with his back to the kitchen EDA: gradually increases from here on.		
18:00	CF: Resident K jumps up and down and claps next to him EDA: increases from 13.50 to 16.43	When he is out of the picture, the EDA gradually decreases again.	
18:56:30	CF: Resident X moves wildly in his chair EDA: increases from 7.19 to 11.14	Other residents and supervisors are currently moving around him to put everyone in bed.	
19:06	CF: vest is taken of, he bumps his head forward EDA: increases to 13.61	Move from chair to bed	
19:10	CF: change into pyjamas EDA: peaks but also a lot of movement in the accelerometer		Are these measurements reliable? Because a lot of movement.
19:18:30	CF: blanket is put on EDA: last small peak up and immediately after it decreases very hard. From 8.87 to 5.26		

Appendix 2

Table 6

Resident Y			
Date/Time	What? Camera footage (CF) / EDA?	Situation (what do we see / suspect /...)	Extra information
29/01/2020			
8:40	CF: Resident Y sits in his chair EDA: Peaks from 1 to 1.08 and drops back to 0.98	2 other residents get their breakfast served and start eating.	
8:53 8:54:30 8:55:30 8:57:30	CF: Resident K jumps from his chair multiple times. Eda: 1e peak: 0.98 to 1.24 2e peak: 0.98 to 1.06 3e peak: 0.98 to 1 4e peak: 0.98 to 1.18	Every time resident K jumps from his chair, we see a peak of the EDA of +- 0.10	
10:35	CF: Interaction with supervisor Eda: No special changes		Supervisor made a marker for verbal aggression towards him
10:45	CF: Many movements of the legs Eda: Peak from 0.68 to 0.75 and back to 0.62		
11:15	CF: Supervisor rises to put the TV on or off. Eda: Increases from 0.77 to 0.94		
12:29	CF: Resident Y gets taken out of his fixation chair and has to sit down at the table for lunch. Eda: Decreases from 1.12 to 1.07 (12u48)		
12:48	CF: Resident Y gets taken back to his fixation chair. Eda: Starts increasing from 1.07 to 1.26 (14u30)		
14:28	CF: Supervisor talks to resident Y Eda: Decreases from 1.26 to 1.21		
14:41	CF: Resident Y looks restless. Other resident moves. Eda: Peaks from 1.21 to 1.26 and back		
14:44	CF: Nothing special Eda: Decreases from 1.20 to 1.09 (15:00)	There is no other resident or supervisor nearby. He is alone in the room.	
15:27	CF: Resident Y gets taken out of his fixation chair and has to sit down at the table for a snack. Eda: Peak from 1.1 to 1.14, then a decrease from 1.14 to 0.9		Many movements detected. Is this reliable?
15:37	CF: Resident Y gets taken away and gets fixated back in his fixation chair at 15:38	He goes to the bathroom	

	EDA: Starts decreasing till 15:52		
15:56	CF: Laundry enters the room and gets folded by the supervisors EDA: Starts increasing from 0.9 to 1.02 (16:52)		
16:54	CF: Resident gets taken from his fixation chair to another room and back 3 minutes later EDA: stays around 1.01		He gets taken to the bathroom.
17:51	CF: Resident Y gets taken to the table for dinner Eda: Peak: 1.05		17u58
17:55	CF: Resident Y gets fixated in his fixation chair EDA: Same		
30/01/2020			
8:58	CF: Resident Y gets fixated in his chair and is restless. Eda: Increases from 0.3 to 0.54 (9:18)	Resident K is clapping with his hands and jumping up and down.	
9:24	CF: Other resident has finished his breakfast. EDA: Decreases from 0.5 to 0.37		
9:30	CF: Supervisors are sitting at the table eating, other residents are restless EDA: Starts increasing		
9:57	CF: Supervisors are done eating and one of them is dancing in sight of resident Y Eda: Peak from 0.44 to 0.51	The cleaning lady is walking with bedsheets.	
10:50	CF: 2 supervisors and 2 other persons are standing around resident Y Eda: Increase from 0.49 to 0.61		
11:01-11:06	CF: Resident Y gets taken out of the living room for 5 minutes. Eda: Decreases from 0.57 to 0.53 and increases by return to 0.67		He gets taken to the bathroom
11:31-11:40	CF: A lot of turbulence Eda: Increase from 0.73 to 0.85	Folding of the sheets by the supervisors, all the other residents where walking around	
11:53-12:01	CF: Resident Y gets taken out of the fixation chair and gets placed at the table for lunch and gets fixated in his fixation chair at 11u58 Eda: Decrease from 0.95 to 0.85 and afterwards increases to 0.92		
12:39	CF: Resident Y abruptly awakes in his fixation chair. Eda: Increase from 1.07 to 1.25		

13:39	CF: Resident Y lays slumped i his fixation chair and suddenly awakes. EDA: Peak from 1.11- 1.28		
13:59	CF: Another resident across from resident Y is restless EDA: 1.24- 1.30	Does the other resident has something to do with this?.	
14:32	CF: Other resident gets taken out of his chair in sight of resident Y Eda: Increases from 1.19 to 1.33 at 14:42		
14:49	CF: Restlessness, there are a lot of residents and supervisors in the living room Eda: Peak of 1.31	The other residents are getting ready to go outside	
14:53	CF: Resident Y is alone in the living room Eda: Decrease to 1.20 at 15:04		
16:36	CF: Resident Y is alone, sometimes a supervisor walks by Eda: Decrease from 1.13 to 0.96 at 16:52		
17:00	CF: End of diner Eda: Increase from 0.97 to 1.05		
17:05	CF: Resident K starts clapping his hands on and of Eda: Every time resident K starts clapping, EDA increases with 0.05 and decreases again after a few seconds.	It appears that every time resident K claps in his hands or moves, EDA of resident Y rises	ends at 18u43
18:41	CF: A man with a guitar walks in EDA: Increases from 0.94 to 0.98 and decreases 30 seconds later again to 0.94	Is there first an increase because he has to get use to the sound and afterwards an decrease because he is getting used to it? .	
18:46	CF: Resident Y gets taken out of the room and is brought to his bedroom to go to sleep. Eda: Decreases from 0.96 to 0.82		
31/01/2020 (Full night)			
7:24	CF: Resident Y sits down in his fixation chair and gets fixated Eda: Peak to 0.42 and decreases afterwards to 0.26 at 7:28		Gradually increase of the EDA till noon
7:46	CF: Resident Y gets taken out of his fixation chair and sits down at the table for breakfast Eda: Decreases from 0.45 to 0.41, Increases at 7u52 when resident Y gets back in his fixation chair.		Does he like to be not fixated? Or does he like to eat?
7:52	CF: Resident Y gets fixated in his fixation chair EDA: Starts increasing		

8:56	CF: Other resident gets restless Eda: Peak from 0.7 to 0.8	Resident K is banging his back against his chair	
9:55	CF: Resident Y is banging his head against his hands Eda: Multiples peaks and drops between 0.78 and 0.94		Is the banging a reaction to something?
10:42	CF: Resident Y is shaking his head excessively Eda: Peaks from 0.82 to 0.88		
11:39	CF: Resident Y gets taken out of his fixation chair to be put at the table for lunch Eda: Decreases from 0.84 to 0.79 at 11u46		
11:46	CF: Resident Y gets taken away Eda: Fast peak from 0.8 to 0.84		He gets taken to the bathroom?
11:48	CF: Resident Y gets fixated in his fixation chair in the living room. Eda: Peaks to 0.86 from 0.79		
12:10	CF: Other resident gets taken out of his bed and put in his fixation chair in front of resident Y Eda: Peak from 0.82 to 0.91		
01/02/2020			
5:00	A lot of ups and downs in the EDA	Not fixated in bed	
7:45	CF: Resident Y gets fixated in his fixation chair EDA: 1.13 (peak)	He has eaten breakfast before this. When they take him out of bed they first put him at the table.	
11:41	CF: Resident Y gets taken out of his chair and sits at the table for lunch Eda: Decreases from 0.94 to 0.88 at 11:49		
11:49	CF: Resident Y gets fixated in his fixation chair Eda: Starts increasing to 1		
15:02	CF: Resident Y gets taken out of his fixation chair for a snack at the table Eda: Decreases from 0.98 to 0.9. No increase afterwards.	He sees the food on the table and his EDA starts decreasing. The decreasing continues when he gets to eat at the table.	EDA doesn't rise when he gets fixated again.
17:05	CF: Resident Y gets taken out of his fixation chair and sits down at the table for dinner Eda: Decreases from 0.9 to 0.83.		
17:12	CF: Resident Y gets fixated in his fixation chair Eda: Increases from 0.83 to 0.9.		
18:43	CF: Resident Y gets taken out of his fixation chair and is brought to his bedroom Eda: Decrease from 0.92 to 0.73 at 19u04		

	Turbulent night with great fluctuations in the EDA. There are also more peaks on the accelerometer. EDA Between 0.68 and 1.16	
02/02/2020		
5:50	CF: Resident Y walks around in his bedroom until 7u20 Eda: Stable around 0.95	He performs the same ritual over and over again. He walks around, feels at the door knob, throws himself on the bed, walks to the back of his rooms and goes back to the door.
7:32	CF: Resident Y gets taken to the bathroom Eda: Peak of 1.26	
7:35	CF: Resident Y sits at the table for breakfast Eda: Decreases to 1.01 from 1.15	
7:42	CF: Resident Y gets fixated in his fixation chair Eda: 2 peaks from 1.17 and 1.13. At 7u46, Eda stabilizes around 1.04	
9:25	CF: He is banging with his head EDA: Small peaks of 1.03 and 1.08 and back	