Examination of Interpersonal Attachment with the Help of a Digital Tablet Application: A Proof of Concept Study

Sebastian Unger[1,3], Cony Theis[2] and Thomas Ostermann[3]
[1]*Didactics and Educational Research in Health Science, Faculty of Health, Witten/Herdecke University, Germany*
[2]*Fine Arts, University of Applied Sciences and Arts Ottersberg, Germany*
[3]*Department of Psychology and Psychotherapy, Faculty of Health, Witten/Herdecke University, Germany*

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Abstract: At present, interpersonal attachment has a subordinate role in the field of healthcare, but recent research results assume this as an important parameter, especially in prevention and mental health. Our aim was to develop a digital application that extends the previous approaches with a measurement over a specific time interval. Designed specifically for Windows-based tablets, this application performs a drawing test while capturing the transitions of two mental states, transmitted by the users. The results were collected over a period of three minutes, allowing the application itself, along with the SiZer analysis, to determine how closely the participants were mentally connected. The tablet application has shown its first usefulness to enhance the healthcare, but further investigations are strongly recommended. In addition, its ease to use allows an uncomplicated integration into similar areas.

1 INTRODUCTION

Attachment describes the tendency of humans to seek contact among themselves as a specific part of interpersonal relationships (Fearon et al., 2017). It addresses a bundle of topics from developmental aspects (i.e. the relationship of children to their parents) to adult relationships or group coherence (Ein-Dor and Hirschberger, 2016). Recent studies suggest that attachment on a higher level can also contribute to understand socio cultural phenomena, which may affect actual problems such as migration or the feeling of social inequality (Sroufe, 2016).

In the field of healthcare, interpersonal attachment has been ignored for a long time as a specific parameter to enhance therapeutic outcome, i.e. in group settings or in the field of individual care, giving in nursing (Blanco et al, 2016). Recent research suggests that such interpersonal relationships play an important role for prevention and healthcare especially in the field of mental health (Degnan et al., 2016, Diener et al., 2011).

However, when it comes to measure attachment dynamics, most of the approaches use questionnaire assessments for single time points, i.e. using questionnaires like the Interpersonal Relationship Anxiety Questionnaire (Naz and Kauser, 2015) or maternal and paternal antenatal attachment scales (Göbel et al, 2019). Sándor et al. (2015) who used a pictorial assessment for the description of interpersonal relationship in children presented an unconventional idea beyond questionnaires. Taking into account recent research on the dynamics in the tree drawing process in patients with Alzheimer's disease (Robens et al., 2019) and based on communications with art therapists, we developed a prototype of a digital app to measure interpersonal attachment over the course of time called IU, which due to its easy to use design has a low threshold and thus can be used in various contexts.

2 MATERIAL AND METHODS

2.1 Overall Description

As a new approach to determine interpersonal attachment between two people, the digital tablet application IU was created. The name IU has emerged from the main function of the application, the measurement of two mental states of a person (see also Figure 3). The first state is to be with oneself and the second is to be with the other. The letters "I" and "U" stand for the English personal pronouns "I" and

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"You", representing these two states. In addition, the IU is the first application that supports that kind of data in a digital from used in a further step of determining interpersonal attachment: the evaluation of measurement results.

2.2 Setting

No ethical permission was required for this proof of concept study in healthy subjects. However, each participant had to sign a consent form. After agreeing to participate, they were asked to sit opposite each other in pairs, holding eye contact during the whole drawing process. A tablet with an installed version of the IU-App was in front of both. The starting point of the digital pen was a centerline, which divides the screen into two sections. The one closest to the subject is defined as the "I"-state, while the area near the counterpart is defined as the "U"-state. When participants feel attached to the other, they are advised to move their pen beyond the centerline towards the "U"-state until they feel unconnected or more connected to themselves. In that case, the pen is moved to the "I"-state and probably crosses the centerline. This process continues for three minutes (min). Within this period, both participants have created a line drawing. One example is presented in Figure 1. Although the final drawings might look similar, the attachment of participants might either be "in touch", meaning that both participants mainly were interconnected with both pens, located in the "U"-state, or they were not attached to each other, resulting in different locations of the pen ("I" versus "U").

2.3 Hard- and Software

In order to ensure the user a realistic and best possible drawing experience, the application was developed especially for tablet computers with touch function, using a digital pen or a finger as interaction medium. The wide range of user acceptance of Windows operating systems and the support of a stylus with pressure sensitivity of 1024 for future purposes led to use an ASUS Transformer Mini T102HA (see Figure 1) for these needs.

It is also equipped with a high definition (HD) display, having a resolution of 1280 x 800 pixels, and 4 gigabytes (GB) of random-access memory (RAM), resulting in adequate image quality and system performance.

As programming language for the back-end of the application, C# was chosen. This dynamic language is used by a growing community of developers and convinces by its simple object model, small libraries resulting in efficient syntax and coding which finally enables more agile development (Thomas, 2008).

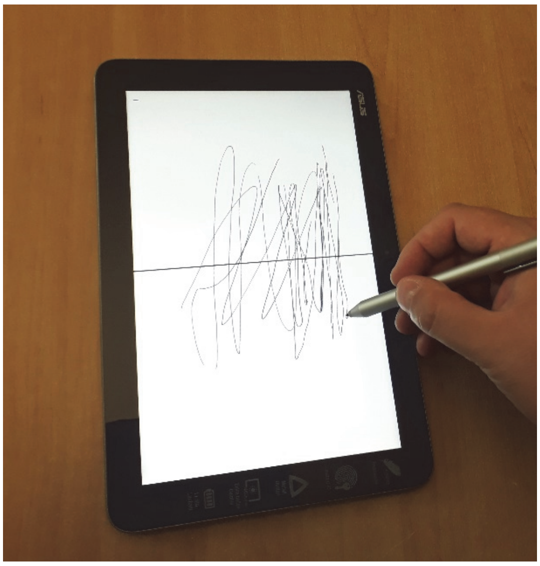

Figure 1: Data acquisition via ASUS Tablet.

The used development environment was Microsoft Visual Studios along with the .NET framework 4.5.2. The framework is compatible to the Microsoft Expression Encoder 4 application, recording the tablet's screen during the drawing, and includes Windows Presentation Foundation (WPF), an approach to a Graphical User Interface (GUI) framework. The Extensible Markup Language (XML)-based WPF was applied for designing the front-end.

2.4 Functionality

The GUI of the application can be divided into three main parts: First, the start page, second, the drawing page and, third, the review page. All pages are designed in order to be user-friendly according to the same principle. They have a bar for selecting the general functions on the top and interaction options designed to be touchable

The start page is the center of the IU. It shows up after launching the application and is the same page to close it again. Furthermore, users can switch to the other two pages from this hub.

The data acquisition is accomplished in the drawing page. The figure above shows the process up to saving the result. At the beginning, users have to provide some personal data. In addition to age, gender, profession and user (identifier) ID a questionnaire on social orientation was implemented. The questionnaire consists of ten items with four

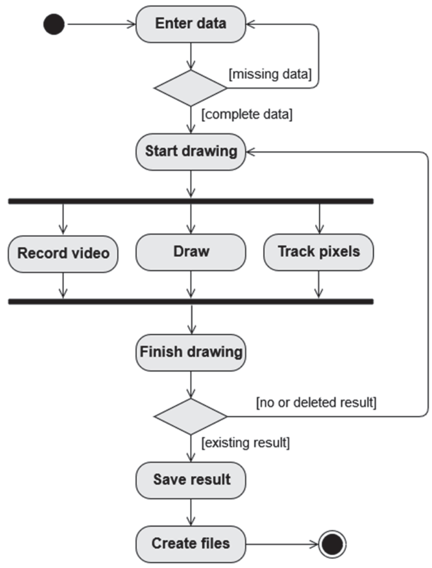

Figure 2: Activity diagram of the drawing page.

possible answers to choose. An ID to specify the measurement itself is automatically generated from the current date and time. Once the data is completed, the drawing can be started. To clarify the beginning and the end of the drawing, they are initiated by a beep sound. The measurement has a fixed time span during which the drawing is being recorded as video and coordinates (x, y) of the touched screen pixels are being tracked with an interval of 100 milliseconds (ms). After finishing the measurement, users can decide to either store or delete the current result including the measured data and the drawn picture. If it gets deleted, the measurement can easily be repeated. By saving the result the IU generates a XML file for the raw data, a Portable Network Graphics (PNG) file for the picture and an Expression Encoder Screen Capture (XESC) file for the video.

The visualization of results takes place on the last of the three pages, the review page. To load a result, a list box displays all available results by their ID from where it can be chosen. The application imports the data of the XML file. In addition to the personal information, the transitions (see Figure 3) between the states are displayed in percent. Each percentage is calculated based on the length of stay in relation to the total time. All information can be faded in and out.

The PNG and XESC file are being linked during the load process. Simultaneously, a time course of the y-coordinates is being created. The IU is designed to show only one of this visual information at a time. Users can decide at which information they want to look at. By selecting the video, they can pause and play it at any time. Moreover, by selecting the time

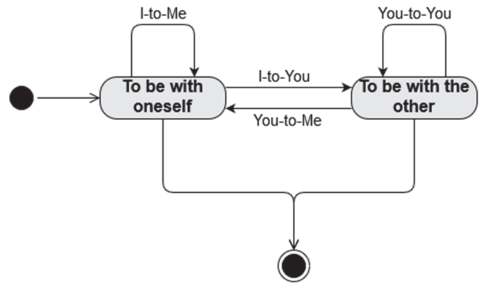

Figure 3: Diagram of mental states.

course, they can add the time course of the partner for comparison purposes as well.

2.5 Sizer Analysis

For statistical evaluation, the data analysis tool SIgnificance of ZERo crossing of the differences (SiZer) was used. It was first introduced with the goal to identify and locate local extrema of a derivative (Chaudhuri and Marron, 1999). Instead of coloring these extrema as significant features, this extended version of SiZer compares two time series based on the difference of two kernel estimates (Park et al., 2009).

The drawing process was analyzed on filtered data from the XML files and displayed as time series t(y, s), using the y-coordinate of the digital pen location as outcome parameter. The SiZer tool uses a local linear smoothing of length 2*h* around a measured value for the time series to be considered. The value *h* is also referred to statistically as bandwidth and is varied for the comparison of the two time series, so that smoothing windows with large and small bandwidths arise. The smoothing is performed by the least squares method, with the weights normally being distributed. For each bandwidth h and each time of the time series t the difference between the two regression lines $f_{1,h}(t)$ and $f_{2,h}(t)$ is tested. Therefore, the null hypothesis can be formulated as:

$$H_0: f_{1,h}(t) = f_{2,h}(t) \quad (1)$$

while the alternative hypothesis is:

$$H_1: f_{1,h}(t) \neq f_{2,h}(t) \quad (2)$$

The test is carried out by using the properties of the standard normal distribution over the confidence interval (CI) of the difference between the empirically ascertained adjustments:

$$f_{1,h}(t) - f_{2,h}(t) \quad (3)$$

If the CI contains the value zero, then there is no significance. Otherwise, if the zero is not contained, the two adjustments are significantly different.

Hence, the initial name SiZer arises: SIgnificant ZERo crossing of the derivatives. The SiZer analysis plots the result of this test graphically over the time *t* and the bandwidth *h* in the coordinate system (*t, h*). A red

$$f_{1,h}(t) > f_{2,h}(t) \tag{4}$$

or blue point

$$f_{1,h}(t) < f_{2,h}(t) \tag{5}$$

at the position (t, h) indicates a significant difference in time series, while a purple dot does not mark a significant difference. Inadequate data is shown in grey in this illustration.

3 RESULTS

The first case presents two adults (male 18 and diverse 58) which were familiar with each other as nephew and uncle. After a total time of three min, the examination was completed. Figure 4 displays snapshots, which were taken at intervals of 1 minute from the videos recorded and played with the IU. As can be seen already, there is an observable congruence in the graphics, which may indicate a high amount of interpersonal attachment.

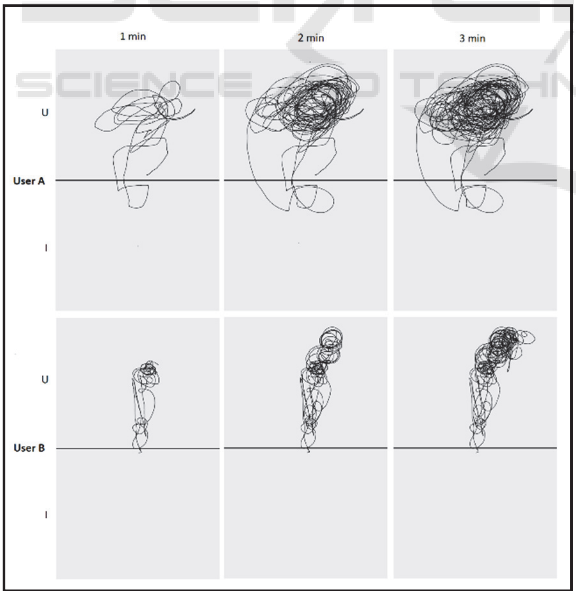

Figure 4: Snapshots of test group A.

Another user pair with unknown relationship (female 21 and male 26) represents the second case. As shown in Figure 5, they have behaved completely different. While user A stayed on the partner's side most of the time (except for one move at a time of two min and 35 seconds (s)), user B tried to attach his counterpart several times. However, the SiZer plot visualized no measurable response.

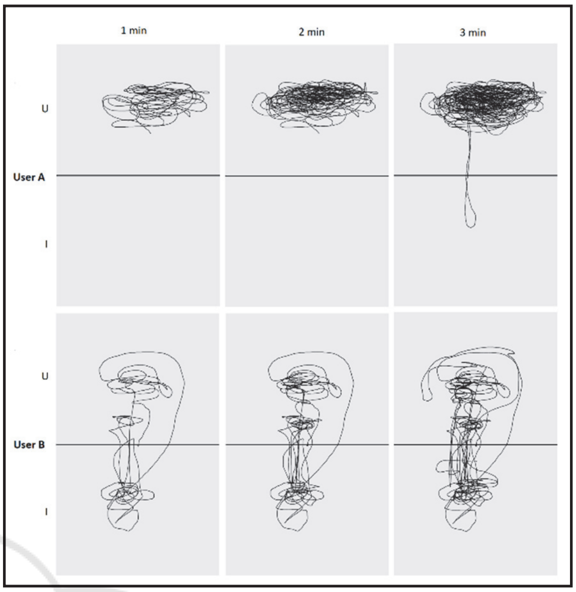

Figure 5: Snapshots of test group B.

The complete drawing process in the course of time together with the results of the SiZer analysis is presented in figure 6.

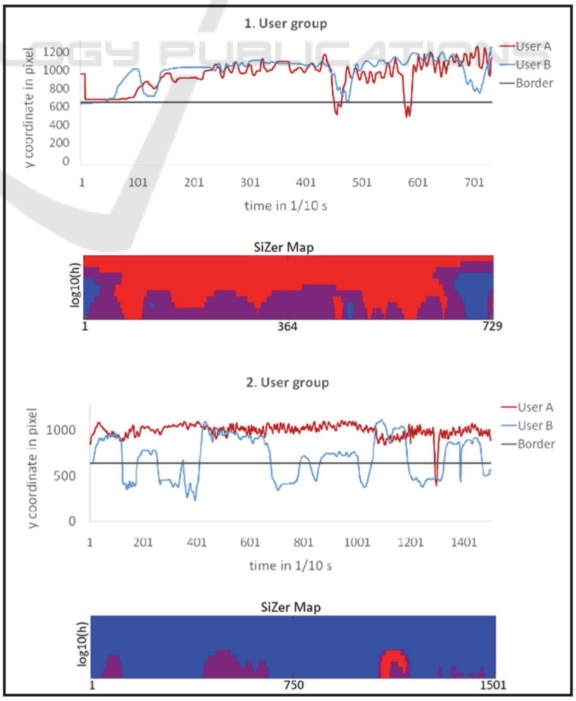

Figure 6: Results of the SiZer analysis tool.

As expected from the snapshots in Figure 4, a high amount of similarity was found in the first two participants. This is one the one hand indicated by similar curves, which in 88 % (user A) and 91.4 % (user B) of the time were above the border, depicted by the black line. In the associated SiZer map (1. User group), the purple pixels are widely distributed in mostly the lower bandwidths, indicating a high amount of correlation. This leads to the assumption that the user pair was most of the time mentally attached to each other. Thus, the null hypothesis in (1) cannot be neglected.

In contrast to this and in accordance with Figure 5, the curves of the second two participants are unequivocally different. User A remained 90.6 % and user B only 54.9 % of the time above the border. There is almost no correlation between these curves, represented by the SiZer map (2. User group) with mostly blue pixels in all bandwidths. Likewise, a reflection of the y-coordinates of one of the users led to a significant dissimilarity, confirming the alternative hypothesis in (2). This suggests the assumption that this user pair had completely different trains of thought.

4 DISCUSSION

In this proof of concept study on the analysis of a digital tablet application for the examination of interpersonal attachment, we were able to measure the attachment of two people by analyzing the drawn lines on a tablet by the IU-App. At least in our two examples, we found a good correspondence between the drawing process in the course of time and the results of the SiZer analysis. Hence, a future study with a higher number of participants should be observed to obtain results that are more meaningful. Moreover, it might be interesting to compare the results with those of electroencephalography (EEG), skin resistance or similar physiological measures.

Although the analysis of digital drawing processes actually has been given a high amount of attention in the field of health informatics, i.e. in the analysis the tree drawing process of patients with mental impairments such as dementia (Robens et al., 2019), the kinematic analysis of the clock drawing test in elderly people with depressive disorders (Heinik et al., 2010) or the neuropsychological testing of perceptual and motor skills in children (Lange-Küttner, 2008), this application, to our knowledge, is the first that uses a tablet application for the analysis of interpersonal attachment.

In line of the suggestions of Zapata et al. (2015), we were able to demonstrate that our app is easy to use and was understood and accepted by the participants. Especially its easiness in use is an important feature of this app, which points to the use in clients with high thresholds for written psychological test instruments, such as young children or participants with language barriers or speech or writing delay (Gómez-Durán et al., 2018). This app thus may contribute to mitigate these barriers.

After having shown its usability, the next step is to evaluate this app by means of its validity and reliability. Therefore, its congruence with relationships scales or social skills inventories (see Jewell et al. (2019) for a review of instruments) will be performed in a next step.

Apart from measuring interpersonal attachment, our app might also be used as a rating instrument for assessing agreement and disagreement or sympathy and antipathy with a given situation in the course of time. Especially in the case of dynamic process of changing, i.e. in the observation of therapeutic processes such as therapists and clients emotional expression (Peluso et al., 2018) or the classification of behaviour into normal or abnormal states (Mabrouk et al., 2018) or movement analysis as narratively described in Chyle et al. (2018), this app might be adapted as a rating instrument for processes within a continuum between two opposite end points.

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