Developing Personas based on Physiological Measures

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Abstract: The objective of this paper is to propose a novel approach for the creation of user personas using common patterns in psychophysiological signals. We illustrate the persona creation process through a case example. Using this method, we were able to identify 4 distinct subgroups of varying experience and satisfaction levels. This novel approach illustrates the potential of physiological measures in the identification of various user clusters, based on one or more experiential aspect, as these signals can provide information as to what users are experiencing during the interaction without interference. This should be useful for user experience researchers, practitioners and designers alike to build more accurate user profiles, especially in the context of large scale public installations and immersive experiences.

1 INTRODUCTION

In the context of design and user experience (UX) practice and research, personas represent a group of target users which share common behaviours, goals, wants, needs, and frustrations when using a product (Cooper, 1999).

However, according to McGinn et al., a common issue with the development of personas is that they are often not based directly on user data (McGinn and Kotamraju, 2008). Expanding on this idea, Tu et al. state that self-reported data from surveys, interviews and user observation are not only disconnected from user behaviour, but also weakly reflect users actual use of a product (Tu et al., 2010).

To meet these challenges, researchers have concentrated their efforts on finding new ways to create personas based directly on user data. For example, Zhang et al., have attempted to create personas based on user behavior using clickstreams. Others, like Tu et al. have tried to create data driven personas using a multi-method approach, with both qualitative data (i.e. observation and interview) and quantitative data (i.e. cluster analysis) (Tu et al., 2010). In the context of immersive interaction environment, Loke et al. have proposed movement-oriented personas and scenarios for representing multiple users (Loke et al., 2005).

Adding to this body of work, our research objective is therefore to propose a novel approach for the creation of user personas that focuses on the experiential dimension of human-computer interaction (HCI), as we believe that the addition of physiological measures in persona creation could help improve on some of the well-documented problems with persona use in HCI and UX design practice. This should be particularly useful in the context of interactive and immersive environments, or any other circumstances where it may be difficult to accurately observe and assess user experience.

An experiment was conducted to provide an illustration of the potential of this novel method.

2 METHOD

Creating personas which reflect the unpredictable changes in users can be challenging (Zhang et al., 2016). To do so, we propose a novel approach: using physiological measures in the development of user personas. The proposed approach is based on the analysis of users' physiological signals, recorded during their interaction. Our aim was to answer the following question: is it possible to identify subgroups of individuals with similar psychophysiological states over time? In other words, are we able distinguish groups of individuals with similar emotional responses, experienced during the same period of time, in a given experience?

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Physiological signals, such as electrodermal activity, is indicative of emotional response and was selected to provide valuable insights as to what users are experiencing during the interaction, without interference (Roto et al., 2009). To account for the longitudinal (i.e. temporal) aspect of the experiment, a curve clustering approach (Abraham et al., 2003) was used to establish the existence of several configurations of psychophysiological experiences. Although Cugliari et al. used the technique to identifying super consumers based on electricity consumption, the curve classification approach has never been used to our knowledge in the context of psychophysiological data (Cugliari et al., 2015). An experiment was conducted to provide an illustration of the potential of this novel method.

2.1 Experimental Validation

An in-situ data collection was conducted to identify and develop various user personas based personas common patterns in psychophysiological signals using curve clustering. The goal of the experiment was to gather a large physiological data set representative of different user experiences to assess the accuracy of the proposed method.

2.1.1 Setting

The experience consisted of an interactive multimedia installation in the forest, developed by a company specialized in the creation of large scale interactive experiences.

The location of the data collection was selected among the installations already in operation and open to the public. This gave us the opportunity to work with an interesting physiological dataset without having to build the interactive environment ourselves, and to have access to a large and diverse population.

Figure 1: An image of the illuminated nocturnal trail.

The experience, which consisted of a one hour walk, occurred entirely outdoors, in a forest in North America, on a levelled dirt trail. The trail included hills of moderate slopes. Access to 1.5-km illuminated multisensory nocturnal trail (see figure 1, 2 and 3) was done via a chairlift. The trail weaves its way down the hill through the woods, crosses streams and clearings.

Figure 2: An image of the illuminated nocturnal trail.

Visitors also wore an interactive amulet which changed color as they progressed through the trail.

Ambient sounds and an original soundtrack also served to enhance visitors' experience. Participants

Figure 3: The figure above shows an overview of the experience. Participants were fitted at the base camp located at the base of the chairlift (zone 1). Zones 1, 4, 5, 6, 7, 10 and 11 were contemplative; zones 2, 3 and 9 were immersive; zone 8 was interactive and zone 12 was participative.

were on the pathway an average of one hour, with a maximum of 300 people admitted onto the course every half-hour. Data was collected during the two last weekends of September and the first weekend of October. After completion of the experiment, participants returned to base camp to remove the physiological sensors and complete the post-experiment questionnaire.

Figure 3 shows the configuration of the trail and its various zones, including: three immersive zones, seven contemplative zones, one interactive and one participative zones.

2.1.2 Participants

For this experiment, a total of 36 participants, which included 22 females, between the ages of 14 and 65 were recruited on site. Due to the considerable difficulty of physiological data collection in natural settings, data from 26 participants had to be discarded from the analyses. Most data loss was due to signal artefact and manipulation errors. Physiological data from 10 participants were used from which 7 were female. Participants were pre-screened for neurological and psychiatric diagnoses. Data from all 36 participants were used in the questionnaire analyses and curve clustering; data from 9 participants were rejected due to missing values (see Section 2.2).

The total experiment duration was of one and a half hours, which included the installation and removal of the sensors, and beginning and end questionnaires. A compensation corresponding to the ticket price (i.e. 31.96 CAD) was given to each participant upon completion of the experiment.

2.1.3 Physiological Signals and Equipment

A Bitalino (r)evolution Freestyle Kit BT (Lisbon, Portugal) was used to record participants' electrodermal activity (EDA). EDA was recorded using two electrodes placed on the palm of the non-dominant hand (see figure 4). An accelerometer was also used to record motion.

EDA measures the activity of the eccrine sweat glands and has been shown to be correlated to arousal. It can also be used to measure emotions (Boucsein, 2012) during system interactions (figure 4). Valence is used to contrast states of pleasure (e.g., happy) and displeasure (e.g., angry), and arousal to contrast states of low arousal (e.g., calm) and high arousal (e.g., surprise). The sensor enclosure box was placed on participants' left arm and secured with an exercise band. EDA was recorded with a sampling rate of 100Hz.

Figure 4: The amulets and physiological sensors. EDA was recorded using two electrodes placed on the palm of the non-dominant hand.

2.1.4 Self-reported Data and Questionnaires

In addition to socio-demographic questions, a 9-point SAM scale was used to measure self-reported arousal and valence of participants before and after the experience. Questions on customer expectations and prior immersive experiences were also included in the questionnaire.

Customer satisfaction was assessed in two different ways. Participants were asked to report their own satisfaction regarding their overall experience. A satisfaction score was also calculated using the ACSI score, the American Consumer Satisfaction Index (Fornell et al., 1996).

2.2 Preliminary Findings and Results

Physiological data from 10 participants were used for the curve clustering. Clustering was done using the galvanic skin response (GSR) based on the number of peaks per minute in each station, which better illustrates the psychophysiological and emotional responses (Garrett, 2010) of participants, as opposed to EDA means. Values were standardized at participant level.

Using this method, we were able to distinguish 4 groups of participants who experienced similar levels of arousal during the same station. Figure 5 illustrates variation of the GSR means of the 4 clusters throughout the 12 stations.

In the context of this experiment, Cluster 1 appears to describe people who are engaged at the start of the experience, but whose interest significantly drops off towards the end. On the other hand, cluster 2 seems to feature participants who start and end the experience on high notes, but experience little activation throughout. Cluster 3 seems to experience a more gradual drop in engagement. As for cluster 4 his experience, despite its ups and downs, seems to remain more constant.

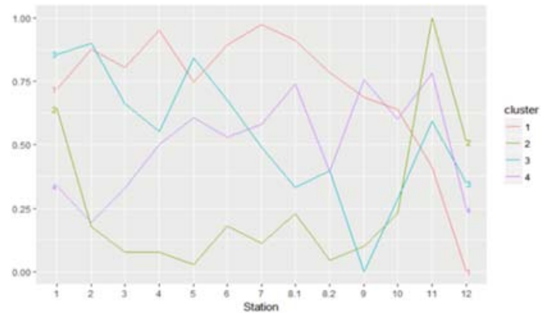

Figure 5: Curves of the 10 participants based on average GSR values per station.

To verify the robustness of our analysis, benchmarking of physiological data to the self-reported questionnaire data was done. In this step of the process, 2 participants were rejected due to missing values in the self-reported questionnaire data. These clusters, identified using EDA, were corroborated by questionnaire data. In other words, had we used the sociodemographic and psychometric variables of the questionnaires to create these clusters, 7 out of 8 participants would still have been assigned to the same subgroup.

2.3 Cluster Creation

Given this high success rate, our next step was to attempt to classify the remaining participants. In other words, we used the self-reported questionnaire data to infer into which cluster each of the remaining 26 participants would belong to (see table 1). Sociodemographic and psychometric variables were used to reproduce the above clustering results by minimizing the Euclidean distance to the centroids of the above clusters (figure 5).

Table 1: The four clusters by mean of self-reported data.

Cluster	cl1	cl2	cl3	cl4
valence_begin	5	4,14	1,5	3,2
arousal_end	3,75	2,14	5,6	5,2
valence_end	2,5	5,43	2,2	3,93
appre_amulet	7,5	4,07	6,9	6,9
satis_ACSI	67,6	43,39	69,64	69,64
education	3	4	4,8	4,8
arousal_begin	6,25	4,71	5,7	5,7
appre_story	6,5	4,93	6,95	6,95
satis_overall	5,75	4,71	6,45	6,45
N	4	7	10	15

Below, a breakdown of the four subgroups describing clusters by mean of the questionnaire variables.

Cluster 1:
- Highest reported valence at the beginning
- Highest reported arousal at the beginning
- Significant drop in arousal from beginning to end
- Lowest level of education

Cluster 2:
- Lowest reported arousal at the end
- Lowest reported appreciation of the amulet
- Lowest reported appreciation of the narrative
- Highest reported valence at the end
- Lowest calculated ACSI satisfaction score
- Lowest reported satisfaction level overall
- Significant drop in arousal from beginning to end

Cluster 3:
- Lowest reported valence at the beginning
- Highest reported arousal at the end
- Highest reported education level
- Lowest reported valence at the end
- Highest level of education

Cluster 4:
- Highest reported appreciation of the story
- Highest calculated ACSI satisfaction score
- Highest reported appreciation of the amulet
- Lowest reported level of education
- Lowest reported arousal at the beginning
- Highest reported satisfaction overall level
- Highest level of education

As previously mentioned, personas describe groups of target users which share common behaviours, goals, wants, needs, and frustrations when using a product (Cooper, 1999). While these user profiles do not yet represent complete personas, the inclusion of physiological measures in combination with traditional methods (i.e. interviews, questionnaires, etc.), can help UX designers to better understand the needs, behaviour and frustrations of users during interactive experiences.

With the addition of qualitative data, this method should help designers by providing an additional level of detail; taking these above clusters from groups of individuals with similar emotional responses experienced during the same period of time, to user based personas.

2.4 Main Conclusions

Using physiological measures as the statistical starting point, we were able to identify four subgroups using a curve clustering method. Although we chose a difficult data collection setting due to partnership constraints, we were able to identify various personas that can help designers improve this interactive trail.

In the context of this experiment, we can observe a significant drop in self-reported arousal from the beginning to the end of the experience end can also be indicative of a lower overall satisfaction level. Cluster 4 was the only subgroup with a self-reported arousal increase from the beginning to the end of the experience. This subgroup also has the highest self-reported and calculated overall satisfaction. This cannot be said of valence.

One of the main challenge of the data collection was the environment itself. The experience occurred entirely outdoors in a forest, on a leveled but non-asphalted trail. This caused movement artefact. Furthermore, the effects of ambient and skin temperatures fluctuations on EDA have long been proven (Edelberg, 1972). These environmental limitations explain in large part the small number of participants included in the physiological data analysis, as many subjects were rejected due to poor quality signal. However, using both qualitative and quantitative not only added depth to our analysis, but also allowed us to recover important participant data. Therefore, this method should be even more efficient under better conditions.

3 CONCLUSION

This novel approach illustrates the potential of physiological measures in the identification of personas based on one or more experiential aspect. Although neither personas nor physiological measures are new to HCI or UX, the combination of the two could help user profiling by bringing groups of archetypal users to life, in order to support user-centred design practice. This novel approach also responds to a need for more data-driven personas, based directly on user data, as we can see even here the discrepancies between experienced and self-reported arousal. This method should be particularly useful to HCI researchers, practitioners and designers, especially in the context of interactive and immersive environments, or any other circumstances where it may be difficult to accurately observe and assess user experience.

4 FUTURE WORKS

The next step is to further develop this method in a more controlled environment, for example a business conference or concert, which will allow us to collect quality data on a much bigger sample size. This will also enable us to include other physiological signals, such as heart rate and mobile eyetracking.

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