Psychological Reactance in HCI - A Method Towards Improving Acceptance of Devices and Services

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ABSTRACT
Psychological reactance is well known in psychology and marketing, but has not yet been adopted in HCI-research. The authors aim at assessing the benefit of measuring psychological reactance in the context of usability and user experience evaluation in a HCI context. To date, there are no tools that are designed to evaluate psychological reactance in the context of HCI. We used an established questionnaire from personality research for an exploratory factor analysis to test, if the concept can be applied to HCI. A between-subjects study was performed that compared effects of self-adaptive vs. user-adaptable systems on users' psychological reactance while interacting with a spoken dialogue system. Results show that interaction with self-adaptive systems can increase psychological reactance, compared to interaction with user-adaptable systems. It is argued, that the concept of psychological reactance is especially relevant for HCI with regard to smart services and assistants like Apple's Siri.

Author Keywords
Adaptive Systems; Personal Assistant; Spoken Dialogue System; Smart Home; Psychological Reactance; Usability Evaluation

ACM Classification Keywords
H.5.2. User Interfaces: Evaluation/methodology, Theory and methods; H.1.2. User/Machine Systems: Human factors

INTRODUCTION
Increasingly, mobile technology employs adaptation mechanisms based on sensor information, user profiles or log-data. The aim of that approach is to enable a system to initiate actions on its own (proactive behaviour) or to optimize the human-computer interface by tailoring it to a specific situation and user. Adopting such technologies is often intended to increase the ease of use and to reduce the workload of the user. For example, Google's Now service uses user information to provide recommendations to news articles and gives navigational assistance on travels. However, the inherit feature of adaptive devices to be proactive and customized necessarily takes away control over the system and the users' data. Additionally, the perceived freedom of choice might be affected, e.g. when a service already provides articles of interest, thereby filtering out supposedly irrelevant articles. This may be experienced positively as intuitive or intelligent behaviour, but it may also result in a feeling of reduced control by the users. The users' feeling of losing control can become a serious issue because it might trigger psychological reactance (Brehm, 1966; Brehm et al., 1981). Psychological reactance represents a well-established theory in social psychology, with demonstrated empirical impact (Dillard et al., 2005). The concept was first introduced by Brehm, 1966. It describes a psychological mechanism that is triggered when a person experiences a loss of control or freedom of choice (Brehm, 1966). According to Brehm, psychological reactance is a mechanism aimed at restoring the lost freedom of choice or control (Brehm, 1966). That is, if a person is confronted with a freedom threat, reactant behaviour will be triggered and the person will try to restore the freedom by counteracting to the freedom threat. For the HCI context, this means that e.g. an application that triggers psychological reactance faces the risk of being avoided or regarded more negatively. A clear example of this is the bloatware that the company Samsung used to pre-install on its popular Galaxy smartphones. Samsung used to deliver the smartphones with a lot of pre-installed applications of its own services that could not be uninstalled by the users, apparently to increase market share of those services. However, this resulted in psychological reactance, as can be observed by the angry comments and negative ratings of those applications in Samsung's app-store. Instead of

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facilitating those applications, the practice probably even damaged the reputation of the services or Samsung itself. Recently, Samsung refrained from this practice and started to decrease the amount of bloatware that comes pre-installed on its new devices and to enable uninstallation (Sammobile.com, 2015). Psychological reactance has been shown to be influenced by socially relevant stimuli (Roubroeks et al., 2011). As people use their smartphones for ever more tasks and intelligent personal assistants with spoken dialogue capabilities become more popular, psychological reactance is likely to be increasingly relevant in that context in the future. Especially with respect to the personality traits that are added to the respective intelligent personal assistants, like a signature voice (Siri, Cortana) and even humorous behaviour.

A perspective on interaction with intelligent personal assistants is the integration of stationary devices by adding remote control capabilities to mobile and stationary devices. This is very prominent at the moment when viewing newly integrated features for Smart Home environments of Apple's Siri (Apple Inc., 2016) or Google's Now (Nest Labs, 2016). This means, that an intelligent personal assistant that is already aware of a large amount of information about a user is being equipped with the capability of controlling connected, physical devices of that user. A consequence of this would be that such services occupy an ever increasing part of peoples' lives and even their environment. Psychological reactance as a psychological phenomenon is likely to be highly relevant in this context because the intelligent personal assistant is becoming a more capable and human-like interaction partner.

Technology that accompanies people that much needs to gain high acceptance by its users for the following reasons: First, users have to interact with the system (mobile device and adjacent connected devices) every day and over a long period of time. This makes it very important to avoid usability and user experience problems that might result in frequent hassles. Also, such systems occupy private and sensitive living spaces. At the same time, they usually make use of a variety of sensors that collect personal data. All this influences the acceptance by the user. The authors assume that psychological reactance could be triggered by self-adaptive system behaviour. It would then act as a negative bias that reduces acceptance of a given system. That might be the case even despite positive scores in classical usability metrics. In this work, self-adaptive behaviour does not mean hidden activities such as selecting the best network, but self-adaptive behaviour that the user is aware of. We analyse the factor structure of a questionnaire that measures psychological reactance in order to tailor it to usability evaluation in a HCI context. Furthermore, we test our hypothesis that interaction with a self-adaptive spoken dialogue system (SDS) (system behaviour changes autonomous) triggers higher psychological reactance than interaction with a user-adaptable SDS (system behaviour is configured by the user).

RELATED WORK

Psychological reactance can be measured by a variety of methods, most of them being questionnaires (Hong et al., 1989; Dowd et al., 1991; Gueguen et al., 2010). The most widely used questionnaire for reactance is probably Hong's Psychological Reactance Scale (HPRS) (Hong, 1992). That questionnaire however has a somewhat unclear factor structure. Hong, 1992 argues for a four factor structure, whereas Jonason et al, 2006 argue for it being a unidimensional measure. According to the Intertwined Model, which received much attention in the reactance research community, reactance is likely to consist of anger and negative cognitions, both entangled in a way that the individual effect on reactant behaviour cannot be explained (Dillard et al., 2005).

Psychological Reactance in HCI

To the authors' knowledge, psychological reactance has not been extensively studied in the context of HCI, so far. There have been publications by Roubroeks et al., 2011 who were able to show that psychological reactance can be moderated by the amount of social cues of an embodied virtual agent-based recommender system. Another study that used psychological reactance was done by Kwon et al., 2010, who assessed psychological reactance as a personality trait (with the HPRS, refined version) and not as an affective state, such as the current study. Other studies that are known to the authors have used the concept of psychological reactance in the broader field of HCI but did not try to directly measure psychological reactance (Lee et al., 2009; Murray et al., 2011).

METHODS AND PROCEDURE

There is no conclusive literature available (Jiang et al., 2015) that investigates the way in which users usually use IPAs, or SDSs in Smart Home environments.

Jiang et al., 2015 used an automatic approach that predicted user satisfaction by analysing behavioural patterns of the users while interacting with IPAs. For their approach, they used a set of tasks in a laboratory experiment.

In order to achieve maximum validity, one would prefer a field study to investigate reactance effects in the context of IPAs. As a field study would have required a working system for each user and a way to timely measure reactance, we decided to perform a laboratory experiment reasons of practicability.

Questionnaires

For our experiment, we decided to use the HPRS because it is validated (Hong, 1992) and has been discussed in terms of its psychometric properties in several other works (Brown et al., 2011; Silva, 2006). Due to the unclear factor structure of the questionnaire (Hong, 1992; Jonason et al., 2006), we conducted a factor analysis on the data.

Procedure

The experiment compared two different versions of an interactive system. Both of which were realized in a Wizard of Oz design. A human operator was remotely controlling the devices and triggered the appropriate, pre-

defined system prompts via an interface; without the knowledge of the participants. The Self-Adaptive version acted proactively to match user traits and behaviour during interaction, e.g., it adjusted the voice of the speech output to be of the same gender as the user, or it turned down music when the user spoke. The User-Adaptable system did not act proactively but only when triggered by the user via a voice command. Interaction with both systems included a spoken dialogue part, a music listening task, in which the music adapted (or had to be adapted) to be more quiet when a person would speak, and a reading situation with varying light conditions, in which a reading lamp was turned on automatically or by the user when the ceiling lamp was switched off.

Participants

Overall, 44 participants took part in the Experiment. The data sets of 43 of those were taken into account for the analysis. The dataset of one participant was excluded because the person reported to have had a stroke recently. Most of them were recruited by announcements in streets and supermarkets, as well as in an internet portal and an internal test person database. The participant population was generally representative and did not include an unusually high amount of students. Every participant received €10 as reimbursement for taking part in the experiment. Statistics about the test population can be reviewed in Table 1.

	Female	Male	Total
Count	23	20	43
Min. age	18	21	18
Max. age	65	60	65
Mean age	33,85	34,70	34,24
SD	12,90	10,18	11,54

Table 1. Age distribution all participants. (SD = standard deviation)

RESULTS

Components of Reactance

Each of the 43 participants answered two HPRS questionnaires; one prior to the interaction and one after the interaction with the system. Those 86 data sets were used for an exploratory factor analysis with oblique rotation (Oblimin) and two factors assumed according to a parallel analysis (Matsunaga, 2010). The explained variance is rather small (35%, with 18% for factor 1 and 17% for factor 2). In the next step, following (Ferguson et al., 1993), only items with loadings > 0.4 were retained and all cross-loadings (loading difference smaller than 0.2 between two or more factors) were excluded. An additional factor analysis with the remaining items resulted in 44% explained cumulative variance (21% for factor 1 and 23% for factor 2). Cronbach's alpha is 0.79 (factor 1) and 0.73 (factor 2), respectively. Neither the cumulative variance, nor the Cronbach's alpha values of either factor are particularly good results, though they are acceptable. As the observed factor structure matches the factors of the intertwined model (Dillard et al., 2005), which suggests reasonable validity, they were retained. Since the meaning of the items corresponds to the factors that were proposed in the intertwined model, we name the two factors that we found in the HPRS "Anger" and "Counterarguing".

System Influence on Psychological Reactance

The means of the respective items from the two factors were used for further calculation. As there is variation in the mean values between the groups, even for the baseline condition (see Table 2), not the absolute values, but the difference for baseline minus post interaction were used for testing the hypothesis. Table 2 and Figure 1 show the basic statistics of the computed differences. A subsequent t-test for independent samples (Welch correction) showed that there is a significant difference for Counterarguing between the conditions (self-adaptive and user-adaptable, $t(40.492) = 2.273$; $p = .028$*). No significant difference for Anger was observed.

		Pre		Post		Pre-Post	
		Mean	SD	Mean	SD	Mean	SD
React.	S-A	2.89	.46	2.83	.55	.06	.18
	U-A	3.02	.51	2.91	.56	.11	.23
Count.	S-A	2.36	.68	2.40	.71	-.05*	.34
	U-A	2.45	.79	2.27	.92	.18*	.32
Anger	S-A	3.44	.53	3.25	.68	.19	.31
	U-A	3.69	.63	3.53	.62	.15	.42

Table 2. Mean values and standard deviation (SD) of Reactance, Counterarguing and Anger for both conditions (S-A = self-adaptive, UA = user-adaptable) before and after the interaction. Furthermore, the mean value and standard deviation of the change within-subject. *Counterarguing differs significantly before and after interaction in the U-A condition (a = .05 p = .028), but not in the S-A condition.

DISCUSSION

Measuring Psychological Reactance

We performed a factor analysis on the existing items of HPRS and observed a factor structure that is consistent with the intertwined model (Dillard et al., 2005) but differs from the factor structure that was originally postulated for the HPRS (Hong et al., 1989). Due to the results of the factor analysis we argue that psychological reactance, as measured with "Hong's Therapeutic Reactance Scale", consists of the factors Anger and Counterarguing.

However, the explained cumulative variance is just 44%. This might also be due to the relatively small number of data sets. For a reliable factor analysis, one would usually refrain to a larger number of cases. On the other hand, the factor structure that we were able to measure is consistent with (Dillard et al., 2005) who used not only other items but even other survey methods. This is strong evidence for the validity of the factor structure that we observed. Another hurdle for using the HPRS was that it was not

designed to measure psychological reactance as a time-variant affective state but as a personality trait. Even though psychological reactance is originally regarded as undirected (Brehm, 1966), items that directly address the device, that is under survey, would probably be able to produce more contrasty results. This study was intended as a proof of concept for the use of psychological reactance in this context. Therefore it seemed unfeasible to develop a dedicated questionnaire prior to this experiment.

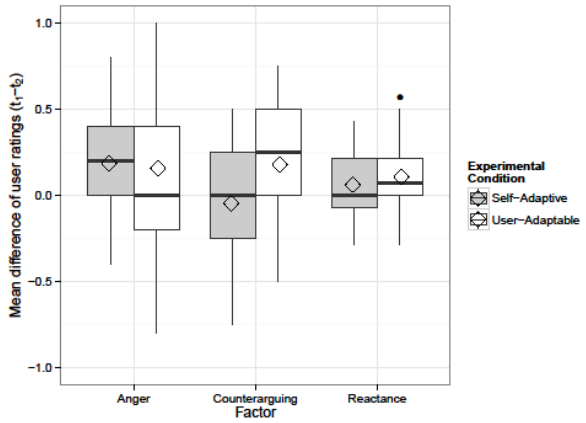

Figure 1. Boxplots of the relative changes of Anger, Counterarguing and Reactance. The diamond marks the mean value.

Paradigm

The Paradigm that we used was not a classical paradigm for psychological reactance research, but for HCI research. In a traditional study about psychological reactance, users' would have been presented with two different stimuli. One of which would have been formulated in a way that it would likely trigger psychological reactance by the use of a commanding tone and a clear freedom threat. The other stimulus text would have avoided such freedom threats and would have had no commanding tone. We used two different adaptation strategies (self-adaptive and user-adaptable), but both were designed in a way that they would try to satisfy the users' needs. We took this decision because we wanted to assess the possibility of using psychological reactance as a metric in HCI research. Therefore a comparison between a "good" system and one that was tuned to induce reactance would have produced less insight in the usefulness of the concept psychological reactance in HCI research. Even though neither of the stimuli was proven to induce psychological reactance prior to the study and were both designed with the intention to satisfy the users' needs, we were still able to observe significant differences between the two conditions, likely because of the different adaptation strategies.

Scientific Results

Our experiment with a between-subject design already shows a difference between the groups in the baseline-measurement. Therefore, we compared the relative change of Anger and Counterarguing between the conditions (within subject). There is no significant difference for the factor Anger. However, there is a significant difference for the factor Counterarguing (a = .05, p = .028). Counterarguing decreased for users of the user-adaptable system, but not for those of the self-adaptive system. We assume that the experimental situation of following the instructions of the examiner might have already resulted in a rather increased psychological reactance from the beginning, whereas the feeling of "doing the contrary" decreased during interacting with the user-adaptable system. This is not the case for the self-adaptive and proactive system. Hence, self-adaptive behaviour of the used system can be regarded as influential on the factor Counterarguing. If this influence can not only keep the loading at the same level, but also increase it, could not be resolved in this study. For the system under observation, an increase in Counterarguing means that the user cognitively rejects the systems' actions. This does not automatically mean that acceptance of the system will decrease, but can potentially lead to such an outcome.

CONCLUSION AND FUTURE WORK

With the described study, we were able to show significant differences in Counterarguing between interaction with a self-adaptive system and a user-adaptable system, despite the shortcomings mentioned above. We therefore regard this work as evidence for the usefulness of psychological reactance as a metric in HCI research and also as evidence that self-adaptive system behaviour can have negative consequences (in the form of psychological reactance) for acceptance by the user (since acceptance is likely to decrease if a system induces anger and negative cognitions in its users).

We are developing a new questionnaire aiming at measuring psychological reactance in a less general manner and which is directed towards assessing psychological reactance as an affective state, instead of a personality trait. To accomplish this, the items should refer to the system directly and include statements about emotional states in the present tense. We propose to investigate if the attitude towards information and communication technology is somehow related to psychological reactance or one of its components in the context of usability evaluation of human-machine interfaces. In the authors' opinion, the rise of personal assistants and personalized services puts HCI research in the need of introducing new research methods to cope with increasing complexity of interaction that also becomes more natural and comparable to human-human interaction. As socially relevant aspects such as personality are introduced to Siri and the likes, new methods that are based on research from social psychology are needed. The concept of psychological reactance is only one element that can lead to a higher acceptance of personalized services.

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