Understanding the Social Acceptability of Mobile Devices using the Stereotype Content Model

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ABSTRACT

Understanding social perception is important for designing mobile devices that are socially acceptable. Previous work not only investigated the social acceptability of mobile devices and interaction techniques but also provided tools to measure social acceptance. However, we lack a robust model that explains the underlying factors that make devices socially acceptable. In this paper, we consider mobile devices as social objects and investigate if the stereotype content model (SCM) can be applied to those devices. Through a study that assesses combinations of mobile devices and group stereotypes, we show that mobile devices have a systematic effect on the stereotypes' warmth and competence. Supported by a second study, which combined mobile devices without a specific stereotypical user, our result suggests that mobile devices are perceived stereotypically by themselves. Our combined results highlight mobile devices as social objects and the importance of considering stereotypes when assessing social acceptance of mobile devices.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**; *Ubiquitous and mobile devices*; *Social engineering (social sciences)*;

KEYWORDS

Stereotype content model; mobile devices; stereotypes; social acceptance; social objects.

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1 INTRODUCTION

Mobile devices are often used in social settings while surrounded by other persons. The potential judgments of our surrounding influence if and how we use these devices. Social perception is, therefore, not only an important factor for developing successful devices but also to understand the adoption and rejection of existing ones. Particularly the social acceptance of devices and interaction techniques in public spaces has been the subject of extensive discussions. Certain interaction techniques, such as expressive head gestures, are, for example, not socially acceptable [34]. Consequently, social acceptance is an important factor when designing mobile devices and interaction techniques.

Previous work focused on investigating the social acceptance of specific devices and interaction techniques. Developing methods and tools to assess devices' social acceptance has also been subject to related research. One example is the work by Kelly and Gilbert who developed the WEAR scale, a questionnaire to measure the social acceptance of wearable devices [17]. Further, Profita et al. assessed the perceived social acceptability of specific devices and found that it is not independent of the user if a device is socially accepted [29, 30]. Smart glasses, for example, seem to become socially more accepted when it is indicated that such devices are used by persons with disabilities [29]. Thus, we know that social acceptability of a device depends on the assumed abilities of the user's social group. When bystanders determine the user's social group they are influenced by their *stereotypical* perception.

Stereotyping is a cognitive process and deeply rooted in human nature [1, 7, 10]. Through stereotyping of other individuals, humans can quickly assess if a person is a threat and if there is a need to defend the own resources [7]. By perceiving similar or dissimilar features, humans infer that a person is a member of a social group, which is used for making quick decisions and prediction future behavior. Thus, stereotyping is beneficial from an evolutionary perspective as it simplifies the social worldview by reducing the mental effort to handle new individuals. Even though over-generalization of individuals and social groups does not necessarily reflect reality and misleads people into making early prejudices, social categorization is omnipresent in everyday life. While methods and tools exist to assess the social acceptance of specific stereotypes, we lack an understanding of the basic social and stereotypical mechanisms underlying the perception of users with mobile devices. Without such an understanding, it is necessary to study each combination of device type and user stereotype individually, which limits the insights we can gain to a few specific devices and few user types.

Assessing common stereotypes and the underlying cognitive mechanisms has been subject to extensive research in social psychology [1, 15, 28]. Fiske et al. developed the stereotype content model (SCM) [10], which postulates that interpersonal impressions and groups stereotypes form along the conceptually orthogonal dimensions *competence* and *warmth*. The model hypothesizes that the stereotypical status of a group is predicted by the four competence-warmth combinations: paternalistic (high warmth, low competence), admirable (high warmth, high competence), contemptuous (low warmth, low competence), or envious (low warmth, high competence). Stereotypical individuals that do not compete for the same pool of resources are considered as warm and individuals that are able to carry out their intentions are considered competent.

Social psychology and related disciplines showed that the SCM is a robust model that can be applied across cultures [7]. Further, previous work showed that the SCM enables predictions not only about stereotypical groups, but also about how brands [18] and even products [39] are perceived by consumers. As these examples show, also more abstract objects can be transformed by interpersonal and cognitive processes into *social objects* [32] reflecting stereotypical views.

To gain a deeper understanding of the influence of stereotypical perception on users with mobile devices we use the SCM and investigate if the model can be applied to group stereotypes using such devices. Specifically, we study if mobile devices themselves are perceived stereotypically. This paper is motivated by the assumption that the stereotypical perception of mobile device users is a combination of the perception of a user's stereotypical group and the perception of a stereotypical mobile device. We further assume that effects are systematic to a level that allows predictions about the perception of stereotypical users of stereotypical devices. This enables us to assess stereotypical groups and stereotypical devices individually and to predict the perception of combinations thereof. After discussing previous work on the acceptance of mobile devices and the SCM, we present two studies that apply the SCM to users of mobile devices. Through the first study with 71 participants, we show that using a mobile device systematically affects the stereotypical groups' warmth and competence. In a second study with 77 participants, we show that assessing devices and stereotypical groups individually enables to reliably predict the perception of their combinations. We discuss how the SCM and our results can be utilized to assess social acceptance of mobile devices.

2 RELATED WORK

Related work in human-computer interaction (HCI) investigates the perception of wearable and mobile devices and focus on quantifying their social acceptance. In social sciences, social acceptability has been often linked to stereotypes. Thus, we shed light on the Stereotype Content Model as a foundation to understand social groups and objects.

Social Perception of Technological Devices in HCI

HCI research on social perception of devices is particularly interested in reasoning about the acceptance (or rejection) of mobile and wearable devices when interacting with them in different settings. Such interactions require the utilization of different modalities to control them. Hence, we use speech, gestures, and body expressions [33, 34, 40]. Montero et al. distinguish between user's and spectator's social acceptance [25]. In their work, they focus on how culture, time, and interaction type influence social acceptance of gestures. They found that the spectators' perception of others depends on the ability to interpret the device manipulation. Rico and Brewster investigated which gestures for mobile interfaces are socially acceptable [34]. The authors used a continuum of familiarity (partner, family, friends, colleagues, strangers) to determine if the kind of audience influences the willingness to perform gestures. They found that social acceptability increases with the familiarity of the audience.

As factors affecting social acceptability of wearable devices are "not well understood", Kelly and Gilbert developed the Wearable Acceptability Range (WEAR) scale that aims to predict and quantify the acceptance of wearable devices [17]. Their work is based on the the assumption that two factors contribute to social acceptance: *the fulfillment of aspirational desires* and *the absence of social fears*. The authors propose that as any clothing, accessory, or body modification, wearable devices align with aspirations and fears and must be consistent with the own self-image "to receive a positive reaction from one's 'tribe' " [17].

Particularly, the social acceptance of devices with head-mounted displays came to the fore in previous HCI research [24, 26, 27, 35, 42]. For example, Schwind et al. found that the acceptance of emerging and affordable VR glasses depends on the situation and the number of people in the context of the user [36]. Furthermore, devices with built-in cameras, such as smart glasses or life-logging cameras, can reduce social acceptance when bystanders have privacy concerns, which has been shown in studies by Koelle et al. and Wolf et al. [20, 41]. This has counter effects on the user itself, when surrounded by strangers; the willingness to interact with a device is reduced and the user can feel embarrassed and uncomfortable [12, 13, 22].

Thus, previous work in HCI investigates the social acceptance of devices and interaction techniques. While researchers showed that social acceptance increases if it supports a person with physical disabilities [29], the more general question is, how the perceived user stereotype change social perception of devices. A CHI workshop in 2018 highlighted that social acceptability of emerging technologies is still challenging and showed that reliable models are required to understand which factors affect social perception [19].

Stereotype Content Model

The stereotype content model (SCM) is an established theory from social psychology explaining social perception and group stereotypes. Fiske et al. developed the SCM to examine stereotypes and explain the discrimination of social groups [10]. The SCM hypothesizes that group stereotypes and interpersonal impressions form along the two dimensions competence and warmth (see Table 1) [6, 10]. Stereotypical individuals that do not compete for the same pool of resources are considered as warm. Groups considered warm are associated with characteristics such as friendly, well-intentioned, and trustworthy. Stereotypical individuals that are able to carry out their intentions are considered competent and are stereotypically individuals with high social status. While different groups form individual stereotypes, Cuddy et al. showed that stereotyping follows universal principles across cultures [7]. The SCM has been applied to a large number of domains and can help to understand diverse phenomena, including racism [21], sexism [9], and ageism [5].

The SCM has also been used to understand how non-human entities or social objects respectively such as brand and products are perceived. Work by Kervyn et al. suggests that consumers perceive brands in a similar way they perceive people [14, 18]. Consumers perceive, feel, and behave towards brands in ways that mirror their attitude towards other people and social groups. The authors conclude that a brand's perceived relational intentions are strong predictors of purchase intent and brand loyalty [18]. Accordingly,

Table 1: The stereotype content model (SCM). Table adapted from Fiske et al. [10]. The stereotypes and affective emotions result from the combinations of perceived warmth and competence.

		Competence: Low	Competence: High
Warmth	High	**Paternalistic prejudice** low status, not competetive pity, sympathy (e.g., elderly people, disabled people, housewives)	**Admiration** high status, not competetive pride, admiration (e.g., in-group, close allies)
	Low	**Contemptous prejudice** low status, competitive contempt, disgust, anger, resentment (e.g., welfare recipients, poor people)	**Envious prejudice** high status, competetive envy, jealousy (e.g., Asians, Jews, rich people, feminists)

Ivens et al. add that brand managers should develop brand positioning and communication strategies that deliberately take into account brand stereotypes to stimulate favorable response toward brands [14].

The desire to present a positive self-image to others is an important factor for the adoption of products [39]. Investigating the adoption of responsible brands, Antonetti and Maklan suggest that the warmth and competence of the stereotypical users of a brand have an effect on a person's desire to buy and own the brand [3]. Results by Chattalas indicate that consumer expectations and purchase likelihood are even affected by national stereotypes about a product's country of origin [4].

Personas and Stereotypes

Personas are user models based on fictitious characters developed to determine target groups and their characteristics in a user-centered design process. Previous work in HCI and in software engineering research extensively discussed the use of stereotypes when designing personas. Some researchers advocate to decrease the risk of stereotyping when developing or designing personas [23, 38] as stereotypes can lead to systematic errors when predicting the behavior of users [31]. Others explicitly suggests using stereotypes to inform design [2]. Researchers who suggests using stereotype argue that they can be useful tools to develop personas as they can generate social intuitions that the designer cannot ignore [11]. We conclude that work that consciously employs stereotypes could utilize the SCM to support the design process.

Summary

Previous work in HCI not only investigated the social acceptability of mobile devices and interaction techniques[33, 34, 40] but also provides tools to measure social acceptance [17, 17]. Research also showed that social acceptance not only depends on the device but can also be influenced by its user's physical conditions [29]. As the SCM [6, 10], an established theory of social perception, can be applied to social objects such as brands and products [14, 18], we argue that utilizing a model of stereotypical perception can help to support the design process of devices (*cf. [2, 11]*).

In the following, we refer to the definition of mobile devices by the Oxford dictionary as a "portable computing device"[1] and the definition of social objects by Smith [37] – a mental or physical thing that is "categorically perceived" in a social context. For "social acceptability" of devices, we use our working definition from our previous work that "describes the effect of using the technology on social acceptance and social rejection" [35].

3 STUDY 1: DEVICES AND STEREOTYPES

The SCM is based on the assumption that a cognitive process assesses other peoples' intent (warmth) and the capability to pursue it (competence). The hypothesis of our first study is that the perceived warmth and competence of a member of a known stereotypical group changes when the hypothetical person uses different mobile devices. We used an online survey to investigate different mobile devices and known stereotypes from social sciences.

Study Design

A two-factorial within-subject design was carried out with the independent variables Stereotype and Device. Multiple stereotypes were repeatedly used in studies by previous work. Based on their locations in the SCM, we selected eight stereotypical groups in the four quadrants of the SCM: homeless people and welfare recipients (contemptous), senior citizens (paternalistic), physicians (admiration), career women/men and rich people (envious). Singles and environmentalists were selected due to discussions about their indistinct stereotypes and atypical roles [8, 16].

Stimuli

We used illustrations of externally visible mobile devices. Brief descriptions indicated their functionality as intended by the manufacturer. Through discussions and online research we selected eight commercially available mobile devices from the following categories for hypothesis testing: two medical devices for monitoring physiological data (*blood pressure monitor* and *blood glucose sensor*), two head-worn devices

Figure 1: Illustrations of devices used in Study 1 & 2: (a) Blood pressure monitors, (b) Blood glucose sensors, (c) EEG headsets, (d) VR headsets, (e) Quadcopters, (f) LED glasses, (g) Tablets, and (h) Narrative clips.

(*EEG* and *VR*), two devices used for leisure/fun (*quadcopter* with remote control and *LED glasses*), a commonly known device (*Tablet*) and a camera device for life-logging purposes which could be critically assessed due to privacy concerns (*narrative clips*). Device stimuli are shown in Figure 1. A ninth condition was added to understand how stereotypes were perceived without device. Exemplary photos of male and female persons that are in line with the stereotypes were obtained from shutterstock.com (see Figure 2b-i). They were selected using keyword search and through discussion. The design of the first study included the combination of eight stereotypes and nine stimuli, resulting in a total of 72 conditions.

Participants

We recruited 71 computer science students (15 female, 56 male) as participants for the study. We conducted the study in our institution. Participants were compensated with credit points. Participants' age ranged from 19 to 36 years (M = 23.81, SD = 5.16). Responses and demographic information were collected anonymously.

Survey Procedure

After giving informed consent, participants read the following: *"As viewed by society, how ... are [stereotype] with [device]?"*. Question and stimulus were visible at the same time on each survey page. We used images of the human stereotypes to prevent biases at the expense of the presented device (e.g., that participants oversaw or overread the name of a human stereotype while reading a question). The nine items of the SCM questionnaire by Fiske et al. [10] were presented: *competent*, *tolerant*, *confident*, *warm*, *independent*, *good-natured*, *competetive*, *sincere*, and *intelligent*. The items were presented on a 5-point scale ranging from *not at all* (1) to *extremely* (5). Images of a device and a group stereotype were presented and captioned with a short description (*e.g., Blood pressure monitor: Measures blood pressure at the wrist*, or *welfare recipients: Someone receiving Financial support given to those who are unemployed or otherwise in need*) as shown in Figure 2a. The order of the conditions was randomized for each participant.

[1]https://en.oxforddictionaries.com/definition/mobile_device

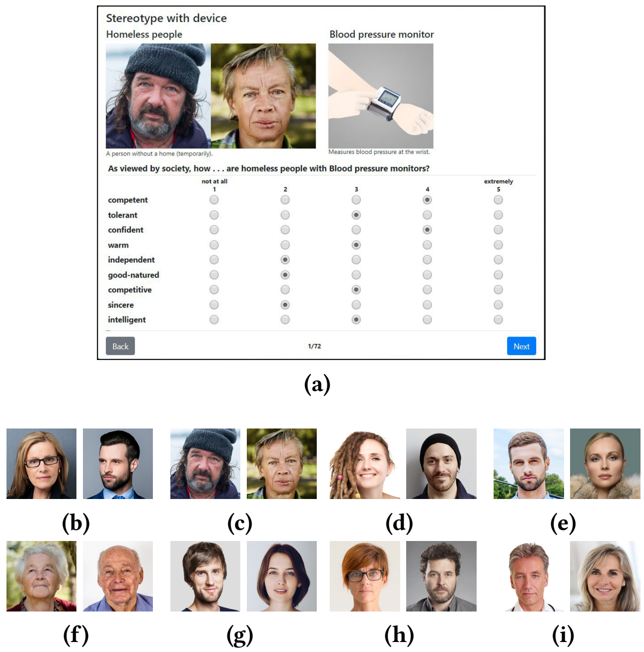

Figure 2: (a) Stimuli presentation stimuli and photos of (b) career women/men, (c) Homeless people, (d) Environmentalists, (e) Rich people, (f) Senior citizens, (g) Singles, (h) Welfare recipients, and (i) Physicians used in Study 1.

Results

A two-way multivariate repeated measures (RM) analysis of variance (MANOVA) was conducted to determine effects of Stereotype and Device on competence and warmth. Statistically significant effects of Device, $F(16, 55) = 32.99$, $p < .001, Pillai's\,trace = .640, \eta_p^2 = .320$, and Stereotype, $F(14, 57) = 55.017$, $p < .001, Pillai's\,trace = .880, \eta_p^2 = .440$, were obtained. There was also a significant Device × Stereotype interaction effect, $F(112, 7840) = 10.673$, $p < .001, Pillai'strace = .264, \eta_p^2 = .132$.

Univariate RM-ANOVA revealed significant main effects of Device, $F(8, 560) = 33.24$, $p < .001$, and Stereotype, $F(7, 490) = 58.42$, $p < .001$, and a significant interaction effect of Stereotype × Device, $F(56, 3920) = 12.55, p < .001$, on the competence measures. For warmth, there were also significant main effects of Device, $F(8, 560) = 35.38$, $p < .001$, and Stereotype, $F(7, 490) = 45.48$, $p < .001$, and a significant interaction effect of Device × Stereotype, $F(56, 3920) = 5.478$, $p < .001$.

Thus, the results show that warmth and competence are independent measures and that stereotype as well as device could significantly affect competence and warmth. The interaction effect shows that competence as well as warmth depend on both factors. Neither age nor gender of the participants showed any statistically significant effects or interactions with our independent variables (all with $p > .16$).

Table 2: Parameter estimates of competence and warmth from the linear regression determined in our first study.

Device	B warmth	B competence
Intercept (β_0)	3.123^{***}	3.294^{***}
Blood glucose sensors	0.062	-0.144^{**}
Blood pressure monitors	0.071	-0.138^{**}
EEG headsets	-0.121^{**}	-0.078
LED glasses	-0.366^{***}	-0.655^{***}
Narrative clips	-0.523^{***}	-0.339^{***}
Quadcopter	-0.204^{***}	-0.072
Tablets	-0.121^{**}	0.145^{**}
VR headsets	-0.164^{***}	-0.144^{**}

Mapping and Model

Applying the SCM, relations between stereotypes can be determined by their relative locations on a 2D map with the dimensions warmth and competence. The location of each stereotype (without device) and their shift (with device) is shown by the black arrows in Figure 3. Stereotypes without any devices can be found in all quadrants; however, the anticipated usage of a device causes a perceptual shift to different areas on the SCM map. Thus, visual analysis of each plot shows an "attraction" in stereotypical perception of competence and warmth pointing to a *new* location (see Figure 3).

Linear models can be used to predict one or multiple measures by considering individual factors using their parameter estimates. To understand if the shift of the stereotypes is related to the location of the devices, we performed a multiple linear regression analysis by considering only the Device factor. Significant regression equations were found for competence, $F(8, 5103) = 40.97, p < .001$, and and warmth, $F(8, 5103) = 43.37, p < .001$, both with an R^2 and R^2_{Adj} of .16 ($SE = .730$). Scatterplots (not illustrated) of standardized residuals indicated that the data met the assumptions of homogeneity of variance, linearity, and homoscedasticity for both regression analyzes. Parameter estimates are shown in Table 2. Predicted warmth and competence of the eight devices (see Figure 1) determined by the linear regression are shown as blue crosshairs in Figure 3. The model predicts the devices' locations in the SCM without considering specific group stereotypes. Another study is required to confirm the prediction by determining the devices' warmth and competence without group stereotypes.

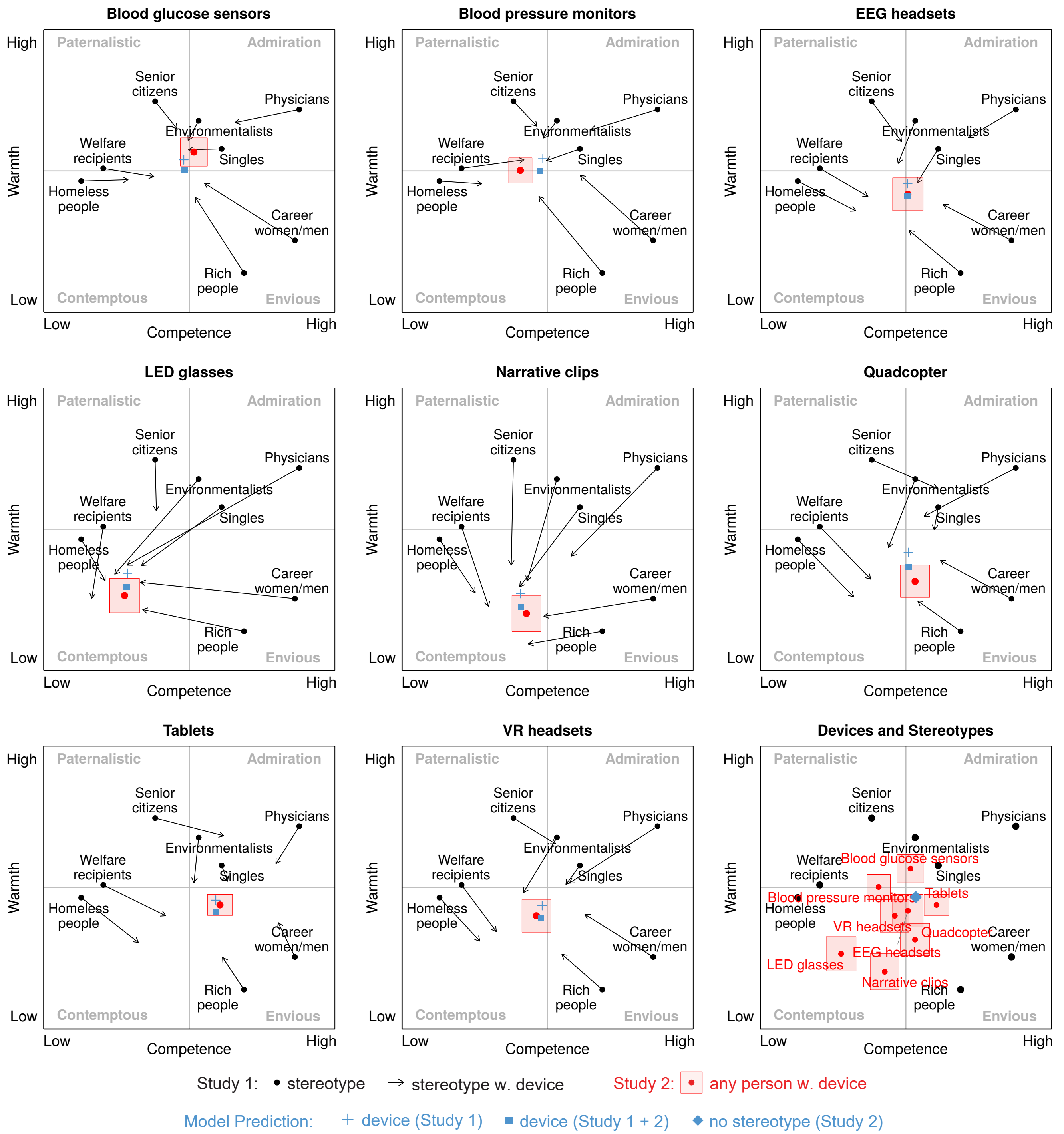

Figure 3: Competence and warmth of the eight devices determined in the first study (black shapes), second study (red shapes), and predicted by the model (blue shapes). The vectors from the first study (black arrows) indicate the systematic attraction of the eight group stereotypes pointing to a new position. We used a linear model to predict the estimated position of the devices (blue cross). To confirm the device locations, we conducted a second study asking participants to rate competence and warmth of *any* person wearing the device (red points, rectangles show CI95). Finally, we used the data from both studies to derive a linear model able to predict the position (blue squared dots). The last plot (br) shows all devices and stereotypes without vectors to compare their original positions. The blue rhombus in the last plot shows the predicted position of people without stereotype ("anyone").

Discussion

In the first study, we found that the warmth and competence of human stereotypes is significantly affected by the anticipated use of mobile devices. Moreover, the plots show a systematic attraction of the warmth and competence vectors which potentially suggests that the presented devices have their own location in the SCM. For example, using narrative clips or LED glasses moves almost all stereotypical groups to the contemptuous quadrant (low-warmth and low-competence). Medical devices (blood pressure monitor, blood glucose sensor) increase perceived warmth. According to the SCM, the emotional effects could be evoked by feelings of pity, but also sympathy as wearing these devices signifies that people compete less for the same pool of resources due to their physical limitations. EEG and VR headsets make people more competitive, however, with medium status and the approach-related affect of contempt. Tablet users are perceived to be more competent and competitive.

A systematic attraction of competence and warmth of people using mobile devices would mean that a mobile device is a social object and perceived stereotypically by itself. Furthermore, such a systematic attraction would move any stereotype into the direction of the presumed center of the pointing vectors. Following the SCM, devices can systematically elicit emotions when people use them. Thus, the SCM can potentially explain previous work's findings that social acceptance of highly competitive devices such as smart glasses depends on the stereotype of the person wearing the device [30].

Not every stereotype moves warmth and competence to the location of a device in the same way. Senior citizens using tablets, VR headsets or quadcopters show a higher influence of the device on competence than on warmth. This is not the case for the other stereotypes, which means that there is potentially an additional factor affecting warmth and competence of some groups and devices. Potential reasons for this deviation are not considered by the SCM and further addressed in our general discussion. Additionally, the effect of the device on warmth and competence of each stereotype differs. Thus, the vectors have different lengths and attraction forces. While LED glasses, narrative clips, blood glucose sensors, and blood pressure monitors strongly attract the stereotypes to their position, VR or EEG headsets, and Tablets have a weaker attraction.

Based on the results of the first study, we hypothesize that mobile devices have their own location in the SCM and, thus, are social objects that are perceived stereotypical. When not used by a specific human stereotype the location of a device in the SCM should be close to the center of the vectors (from stereotype to device). To determine the devices' locations we developed a model that predicts the perception of social objects without a human stereotype.

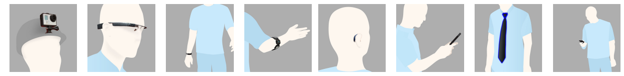

Figure 4: Illustrations of the additional devices used in Study 2: (a) Head-mounted Action Camera, (b) Smart Glasses, (c) Fitness tracker, (d) Gesture tracker, (e) Hearing aid, (f) E-Reader, (g) LED tie, and (h) Smartphone.

4 STUDY 2: STEREOTYPICAL DEVICES

As the SCM can also be applied to objects and abstract constructs, we hypothesized that stereotypes' warmth and competence move from the location of the stereotype in the SCM to the location (or direction) of the device. A potential attraction of stereotypical perception was already determined in the first study. Therefore, in the second study we hypothesize that the perceived warmth and competence of *any person* using a device would be in the center of this attraction. This would confirm the systematic effect predicted based on the first study and help to understand the perception of mobile devices as social objects.

Study Design

A one-factorial within-subject design was used to determine the location of a number of Devices in the SCM. Therefore, we used Device as the only independent variable. We used the eight device groups from the first study to find their locations in the SCM without anticipated stereotype. We used eight additional stimuli (see Figure 4) to investigate where other devices which were not considered in the first study are located in the SCM. Those were not considered in the prediction model and represent an additional and independent contribution of this work. Thus, the second study had 16 conditions, which were randomly ordered for each participant. Competence and warmth were assessed using the same the items and scales as in our first study.

Participants

In our second study, 77 participants (38 female, 39 male) were recruited through mailing lists and social media platforms. Three students already participated in the first study and were not excluded from the analysis. Age of the participants ranged from 19 to 79 years ($M = 25.81, SD = 8.16$). We used the same questionnaires as in the first study and used the device stimuli from the first study (see Figure 1) and the eight new devices (see Figure 4) resulting into 16 conditions for each participant.

Table 3: P-values of Bonferroni-corrected pairwise comparisons of warmth and competence between the 16 devices used in Study 2.

	Action camera	Smart glasses	Blood glucose sensors	Blood pressure monitors	E-Reader	EEG headsets	Fitness tracker	Gesture tracker	Hearing aid	LED glasses	LED tie	Narrative clips	Quadcopter	Smartphone	Tablets	VR headsets
Action camera										<.001**	<.001**					
Smart glasses				<.001**					.01**	<.001**	<.001**	<.001**		<.001**		<.001***
Blood glucose sensors		<.001**								<.001**	<.001**			.039*		
Blood pressure monitors		<.001**			<.001**		<.001**	.008**							<.001**	
E-Reader	<.001**	<.001**							<.001**	<.001**	<.001**	<.001**		<.001**		.002**
EEG headsets					.012*					<.001**	<.001**					
Fitness tracker		.006**			.002**				.003**	<.001**	<.001**	.002**		<.001**		
Gesture tracker		.014*	.023*		<.001**					<.001**	<.001**			.002**		
Hearing aid	<.001**	<.001**	.009**	<.001**		<.001**	<.001**	<.001**							<.001**	
LED glasses			<.001**	<.001**	<.001**				<.001**			.016*	<.001**		<.001**	<.001***
LED tie		.024*							.002**	.015*			<.001**		<.001**	.001**
Narrative clips	.001**		<.001**	<.001**	<.001**	.002**	<.001**	<.001**	<.001**		.005**				<.001**	
Quadcopter			<.001**	.002**	<.001**				<.001**					.027*		
Smartphone			<.001**	.019*	<.001**				<.001**			.015*			<.001**	
Tablets		<.001**			<.001**				<.001**	.003**		<.001**	.032*			.02*
VR headsets		.005**			<.001**				<.001**			<.001**				

warmth competence

Results

The two-way multivariate repeated measures (RM) analysis of variance (MANOVA) revealed a significant effect of Device, $F(30, 47) = 22.41$, $p < .001$, Pillai's trace = .455, $\eta_p^2 = .151$. Two univariate ANOVAs revealed significant main effects of Device on warmth, $F(15, 1140) = 18.34, p < .001$, and competence, $F(15, 1140) = 21.56, p < .001$.

P-values of the Bonferroni-adjusted pairwise comparisons of our post-hoc analysis can be found in Table 3. Mean values and 95% confidence intervals (CI95) of competence and warmth are shown in Figure 5. To understand how the measures are related to the measures of the first study, we inserted the positions and CI95 of the eight devices into Figure 3 (red dots and squares). As the graphs shows, perceived warmth and competence are close to the centers of the stereotype vectors in Study 1 and to the predicted positions of our model.

As in the first study, neither age nor gender of the participants showed any statistically significant effects or interaction with the independent variable (all with $p > .42$).

Model Validation

To find support for our hypothesis that the devices used by *any person* are close to the device locations predicted in the first study, we compared these locations with the results of the second study. The eight additional devices were not considered for the validation. Spearman's correlation analysis revealed strong and significant positive correlations of warmth, $r_s = .99$, $p < .001$, and competence, $r_s = .90$, $p < .001$, between the predicted and the measured locations of the devices in the SCM. Welch's approximation test of equivalence (TOST) for warmth (df = 59764, $\delta = -.034$) and competence (df = 56675, $\delta = -0.011$) were significant (both with $\epsilon = 1$, $p < .001$). Based on the results of the first and second study we calculated a final model, which can be utilized to determine the locations of all stereotypes, devices, and user-device combinations. We used this model to predict the position of the *anyone* stereotype and to determine the locations of the eight new devices. Position of anyone is indicated by the blue rhombus in the last graph of Figure 3. Locations of all devices can be found in Figure 5. Parameter estimates of the final model are shown in Table 4.

Table 4: Parameter estimates of the final model using combined data of the first and second study.

Device	β warmth	β competence
Intercept (β_0)	2.947***	3.660***
Blood glucose sensors	0.082*	−0.133**
Blood pressure monitors	0.072	−0.162***
EEG headsets	−0.119**	−0.078
LED glasses	−0.375***	−0.658***
Narrative clips	−0.531***	−0.332***
Quadcopter	−0.219***	−0.064
Tablets	−0.115**	0.150***
VR headsets	−0.162***	−0.150***
Action camera	−0.152	−0.087
AR glasses	−0.438***	0.209*
E-Reader	0.319***	0.255**
Fitness tracker	−0.058	0.164
Gesture tracker	−0.146	0.058
Hearing aid	0.448***	−0.282**
LED tie	−0.078	−0.649***
Smartphone	−0.240**	−0.371***
Stereotype		
Environmentalists	0.310***	-0.438***
Homeless people	-0.008	-0.918***
Physicians	0.446***	0.051
Rich people	-0.228***	-0.252***
Senior citizens	0.568***	-0.358***
Singles	0.267***	-0.250***
Welfare recipients	0.058	-0.754***
Anyone	0.079*	-0.370***

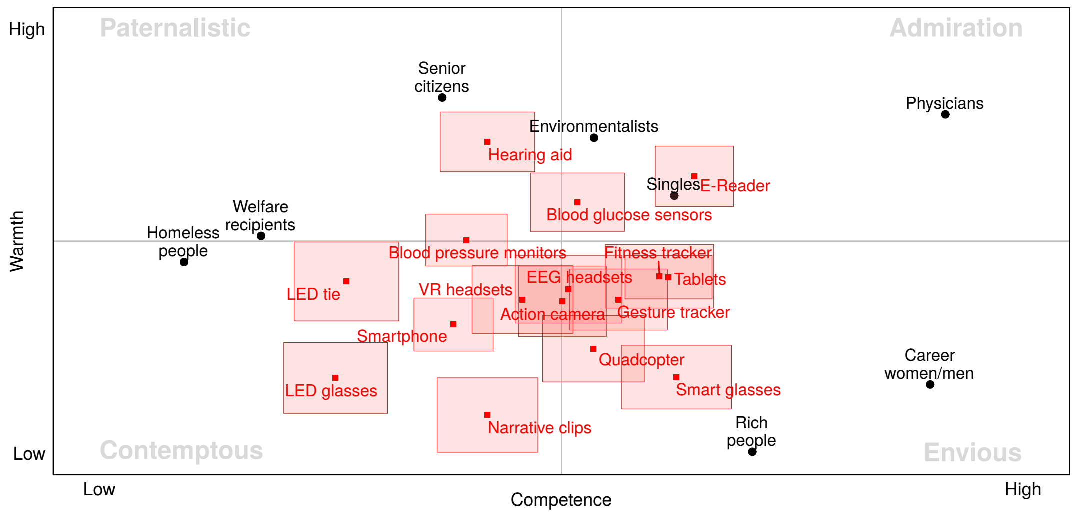

Figure 5: Locations of all devices and stereotypes determined in the first and second study. Rectangles show CI95.

Discussion

The results of the second study show that mobile devices even without a specific stereotype using the device have individual locations in the SCM. More importantly, the findings support our hypothesis that a systematic shift in perception of warmth and competence occurs when people use mobile devices. To determine and to confirm the device locations we asked participants to asses how society views *any person* using the device. Their locations in the SCM are close to the center of the vectors determined in the first study and also close to the location predicted by a linear model. Combined results support the hypothesis that devices are social objects and perceived stereotypical by attracting stereotypical users to the devices' location. As the second study was conducted without images of the human stereotypes and showed no significant difference to the stereotype-device combinations of our first study, we assume that a potential effect of the human stereotype images is negligible.

The second study confirmed the locations of the initial eight devices. Medical devices (blood glucose sensor and blood pressure monitor) gained the highest warmth ratings of these eight devices, quadcopter, EEG and VR headsets are perceived more competitive with medium status. Lowest warmth ratings and the most competitive devices are Narrative clips. LED glasses have lowest and tablets the highest status, while warmth ratings for tablets were significantly higher than for LED glasses.

Eight additional devices were tested to contribute additional samples for future work. Hearing aids showed the highest warmth ratings and, thus, are the least competitive devices we tested. Smart glasses are less warm but more competent. E-Reader are perceived to be as competent and less competitive, which make them admirable. Fitness tracker showed similar ratings as tablets and are perceived to be competent, however, with medium status. Ratings of action cameras are similar to VR and EEG headsets. The additional devices were used to further extend the model and providing further insights about the stereotypical perception of mobile devices.

Smartphones, e-reader, and tablets are similarly used and were similarly illustrated in the studies, however, using smartphones is rated rather contemptuous, whereas using e-readers and tablets is perceived as less competitive with high status. We assume that social perception is crucial here: While tablets and e-readers usually draw attention on neutral (or immersive) content displayed on the device, people using smartphones communicate with a partner who is unknown in the physical context surrounding the device. This potentially induces the social impression that users of such a device are perceived to be a member of an out-group and not an in-group or closed ally. Moreover, repeated discussions about "smombies" – people who pay too much attention to the device – potentially contribute to the low ratings of competence and warmth using smartphones in social settings.

5 GENERAL DISCUSSION

In this paper, we use the SCM to understand the role of mobile devices as social objects and their interdependence with bystanders' stereotypical perceptions. In two studies, we investigated if mobile devices significantly change the social perception of stereotypes and if devices are perceived stereotypical by themselves. Known human stereotypes were used to determine how perceived competence and warmth are affected when individuals of these groups use different mobile devices. We not only found that using these devices significantly change social perception but also that mobile device are social objects and perceived stereotypically. We derived and validated a linear model allowing to predict the social perception of human stereotypes when individuals of such groups interact with mobile devices. We conclude that the SCM is a plausible and reliable framework to explain social perception of mobile devices.

With respect to the questions how the SCM is related to social acceptance of mobile devices, our results show, that the intention and the ability to pursue a goal depends on the combination of user and device. User-device combinations indicating low status and competing for the same resources are perceived to be contemptuous and, thus, socially less accepted. Conversely, user-device combinations indicating high status and less competition are admirable and accordingly socially accepted. Considering the SCM map, social acceptance of a technical device would, therefore, be a diagonal line from contempt to admiration (see Figure 6).

Using the SCM we are able not only to assess social acceptance but also the dependency of device usage. User-device combinations with low status indicating that the user highly relies on the device results in paternalistic stereotypes eliciting emotions of pity and sympathy. Hearing aids, for example, indicate that a user is constrained and requires technical support in daily life. More independence while using a device indicate control and freedom to pursue a certain goal. However, this increases the probability that a user-device combination is becoming too autonomous, which increases the probability that a user will use the device to compete for resources. This would explain why mobile devices used by enthusiasts (*cf.* quadcopter and smart glasses) are highly competitive and indicate high status, however, cause emotions of envy and jealousy. Considering the SCM, device dependency is orthogonally related to social acceptance and reaching from autonomous to constrained.

The relationship between humans and devices is potentially bidirectional. Devices transfer their stereotype to humans, while the position for the stereotypical device may also have been characterized by the frequent use by a specific stereotypes. Devices that are used by a certain group, transfer the respective emotions to the device. This would explain why devices and their stereotypical perceptions are weaker and less distinct than the perceived warmth and competence of human stereotypes (see Figure 5).

The SCM does not explain all results. As noted in the discussion of the first study, tablets, VR headsets or quadcopters have a higher influence on the competence of senior citizens than on their warmth, which was not the case for other groups. Seniors may be considered separately because of assumed physical limitations. The physical disadvantage, which is compensated through a technical device, increases

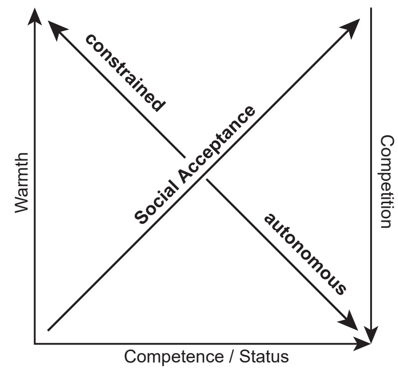

Figure 6: Relations of social acceptance and device dependency in the SCM. Social acceptance increases with competence and warmth while device dependency reaching from autonomous to contrained is a negative function of status and competition.

only the status but not competition if physical possibilities and mental intentions are considered independently. However, the SCM only provides the foundation but not a framework for explaining this phenomenon.

6 LIMITATIONS & FUTURE WORK

In our work, we examined a set of stereotypes and mobile devices, but did not explore any design-specific questions or novel prototypes. Especially the relation and effects between design and functionality of technical devices in social context was not considered. The position of novel devices may be influenced by the perception of known stereotypes, but appearance often do not match with functionality. The relationship and effects of functionality and design in the SCM could be further examined in future work.

In the herein presented study, we draw our sample from technically affine participants to ensure that they have a consistent understanding of the presented devices. This potentially provides insight into a specific population and potentially reflects a certain in-group perspective. However, differences between in- and out-group users were not investigated in the studies. It is conceivable that in-group perception (frequent users of a certain device) differs from out-group perception (people without the device). We found that devices do not move all stereotypes in the same way and more research is needed to understand further factors which influence social perception and acceptance.

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