IT IS NOT ONLY ABOUT THE USER: THE ROLE AND PERSPECTIVE OF PRESENT OTHERS IN PUBLIC TECHNOLOGY INTERACTIONS

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Abstract

Mobile technologies such as smartphones, tablets, laptops, and fitness trackers are constant companions in everyday life. Our environment has also undergone a "technologization" in recent decades. Technology now shapes the image of public space, be it in restaurants, supermarkets, or on train station concourses. Interactive technologies are omnipresent and closely intertwined with our everyday activities. Publicness implies the presence of others who can influence the user's behavior and experience when interacting with technology. Conversely, the technology interactions of users also affect the attendants, i.e., people not using the technology themselves but co-experiencing the interaction of the user. So, how can we ensure that public technology (interaction) enriches our everyday lives or at least does not make them worse – regardless of which role we currently take, that of the user or attendant?

In times such as these, when technology is less and less limited by stationary devices and usage within one's own four walls, it is no longer enough to consider the needs and requirements of users. The focus of investigation needs to be extended to the stakeholder group of attendants to meet the demands of different or changing social contexts. A better understanding of (positive) technology-mediated experiences is required, from the user and attendant perspective.

This thesis focuses on public technology interactions and explores four subordinate research questions: How do positive experiences with technology emerge in public settings, and what role do attendants play (research question 1)? How can the attendant perspective in public technology interactions be specified and analyzed (research question 2)? How do attendants (co-)experience public technology interactions (research question 3)? Which action and design strategies can improve the attendant experience of public technology interactions (research question 4)? These research questions are addressed in six empirical studies.

Study 1 examined users' technology experiences in public vs. private contexts and uncovered differences in their emergence. For example, the needs for relatedness and popularity are more relevant for usage situations in which other people are present. In addition, context changes can worsen the user experience, i.e., technology interactions that are considered positive experiences in a private context are not automatically (equally) positive in public contexts. The study thus underlines the importance of an interaction-context fit in public technology use.

Similar findings have been reported in study 2 on the ideal interaction with a service robot. If the need for relatedness and popularity was pronounced, people favored expressive interaction, i.e., they preferred that others can co-experience their interaction with technology. The relationship with the attendant (unknown vs. close) also matters; relatedness seems more relevant for usage situations in which we know the attendant, and popularity is more important when they are strangers to us. Moreover, the need for relatedness mediated the preference for expressivity with emotionally close attendants, and additional factors, namely attribution and success expectation, influenced the association between popularity and expressivity.

In study 3, we interviewed individuals about positive and negative observation situations that were particularly memorable to them to gain initial insights into the attendant experience. The collected experience reports were also used for an initial test of our "role model", distinguishing four types based on two characteristics. In doing so, we not only gained a more accurate picture of various everyday attendant situations but also showed our typology to be suitable for capturing the role of the attendant in public technology interactions. Our typology covered all experience reports, and each type could be assigned to both positive and negative experiences.

The qualitative results of study 3 were supplemented by an experimental investigation, study 4. By comparing the experience of the four types in a concrete use case, we aimed to test the typology (this time based on mainly quantitative analyses) and gain further insights into the perception and evaluation of attendants of public technology interactions. The study results underline the relevance and usefulness of a more distinct differentiation of the social context into several types. However, type-specific differences were found not only in the attendant experience but also with regard to recommended action and design strategies.

In study 5, experts were asked to adopt the perspective of a specific type to uncover further characteristics of ideal attendant experiences and supporting design and (re-)action possibilities. The expert survey confirmed the findings of previous studies that a variety of positive technology-mediated experiences are also possible from the attendant perspective. Type-specific solutions (in terms of attendant behavior and technological functions) and more general strategies, i.e., those that address the needs and requirements of multiple types, can be helpful.

In addition, we conducted a workshop with students (study 6) to gather further explorative findings on the attendant experience under practical conditions, i.e., in personal contact with participants without any particular specialized or previous knowledge. The workshop involved individual work and subsequent group discussions about the outcomes. The comparison of the perspectives of different types of attendants revealed that the relevance of psychological needs and the evaluation of social interaction with the user can vary, but there are also some similarities.

Besides an overview of the empirical work, including summaries of the studies (results) and their contribution to the HCI (Human-Computer Interaction) field, a theoretical contribution, in the form of a book chapter, is also addressed. This discusses the challenges posed by the increasingly technological nature of the public space, the so-called technified public sphere. Furthermore, starting points are presented for overcoming the status quo, i.e., technical progress at the expense of harmonious social co-existence. By embedding the topic of visibility or publicness in technology use in a broader societal context, the theoretical contribution also underlines the relevance of the empirical part of this work, i.e., the systematic research.

Following a comprehensive discussion of the findings from the empirical studies to answer the research questions, general theoretical and practical implications of the present work are drawn. This thesis contributes to the body of research that takes a positive, need-based and possibility-driven instead of a problem-oriented approach. It should be viewed as a criticism of the prevailing user-centricity in HCI, and emphasizes the relevance of the social context or a better understanding and more detailed assessment of the attendant perspective in public technology interactions. As a possible resource for positive technology experiences, the attendant (experience) must be taken into account appropriately, making a theoretical grounding of the construct in HCI essential. Implications for practice relate to a (more) reflective procedure and critical questioning of one's own actions. Study results may serve as inspiration and orientation in product development as well as for everyday interaction. Designers and developers are encouraged to implement adjustable and context-sensitive technological features instead of offering one-size-fits-all solutions. However, consumers are also responsible for positive technical experiences, as users and attendants have various (re-)action options. Finally, general cross-study limitations are discussed, and potential starting points for future studies in the sense of a more holistic research and design approach are outlined.

Zusammenfassung

Mobile Technologien wie z.B. Smartphones, Tablets, Laptops und Fitnesstracker sind heutzutage ständige Begleiter im Alltag. Unsere Umgebung hat in den letzten Jahrzehnten ebenfalls eine „Technisierung“ erfahren. Technik prägt inzwischen das Bild des öffentlichen Raums, sei es des Restaurants, des Supermarktes oder der Bahnhofshalle. Interaktive Technologien sind omnipräsent und eng verwoben mit unseren alltäglichen Aktivitäten. Öffentlichkeit impliziert die Anwesenheit anderer, die das Verhalten und Erleben von Nutzern bei der Interaktion mit Technik beeinflussen können. Aber auch umgekehrt haben die Technikinteraktionen der Nutzer einen Einfluss auf Beobachter, d.h. Menschen, die eine Technik nicht selbst nutzen, sondern die Interaktion des Nutzers miterleben. Doch wie kann sichergestellt werden, dass öffentliche Technik(-interaktion) unseren Alltag bereichert oder zumindest nicht schlechter macht – unabhängig davon welche Rolle wir gerade innehaben, die des Nutzers oder Beobachters?

In Zeiten in der Technik immer weniger durch stationäre Geräte und die Nutzung innerhalb der eigenen vier Wände begrenzt ist, reicht es also nicht mehr nur aus, die Bedürfnisse und Anforderungen der Nutzer zu berücksichtigen. Der Untersuchungsfokus muss auf die Stakeholdergruppe der Beobachter erweitert werden, um verschiedenen oder wechselnden sozialen Kontexten gerecht zu werden. Es braucht ein besseres Verständnis von (positiven) Technikerlebnissen, sowohl aus Nutzer- als auch Beobachterperspektive.

Diese Dissertation widmet sich öffentlichen Technikinteraktionen und geht vier untergeordneten Forschungsfragen nach: Wie entstehen positive Erlebnisse mit Technologie in der Öffentlichkeit, und welche Rolle spielen die Beobachter dabei (Forschungsfrage 1)? Wie lässt sich die Beobachterperspektive bei öffentlichen Technikinteraktionen spezifizieren und analysieren (Forschungsfrage 2)? Wie erleben Beobachter öffentliche Technikinteraktionen (Forschungsfrage 3)? Welche Handlungs- und Designstrategien können das Beobachtererleben bei öffentlichen Technikinteraktionen verbessern (Forschungsfrage 4)? Diese Forschungsfragen werden in sechs empirischen Studien beantwortet.

Studie 1 untersuchte Technikerlebnisse von Nutzern in öffentlichen vs. privaten Kontexten und deckte Unterschiede in deren Entstehung auf. So sind die Bedürfnisse Verbundenheit und Popularität relevanter für Nutzungssituationen in denen andere Personen anwesend sind. Außerdem können Kontextänderungen das Nutzererleben verschlechtern, d.h. Technikinteraktionen, die in privatem Kontext ein positives Erlebnis darstellen, sind das nicht automatisch auch in öffentlichen Kontexten. Damit unterstreicht die Studie die Bedeutung einer Passung von Interaktion und Kontext bei öffentlicher Techniknutzung.

Ähnliches zeigte Studie 2 zur idealen Interaktion mit einem Service-Roboter. Wenn das Bedürfnis nach Verbundenheit und Popularität ausgeprägt war, bevorzugten Menschen eine expressive Interaktion, d.h. dass andere ihre Interaktion mit der Technik miterleben können. Auch die Beziehung zum Beobachter (fremd vs. bekannt) spielt hierbei eine Rolle. So erscheint Verbundenheit relevanter für Nutzungssituationen, in denen wir die Beobachter kennen, und Popularität wichtiger, wenn sie uns fremd sind. Darüber hinaus mediierte das Bedürfnis nach Verbundenheit die Präferenz für Expressivität bei bekannten Beobachtern und der Zusammenhang von Popularität und Expressivität wurde von zusätzlichen Faktoren, nämlich Attribution und Erfolgserwartung, beeinflusst.

In Studie 3 interviewten wir Menschen zu positiven und negativen Beobachtungssituationen, die ihnen besonders im Gedächtnis geblieben sind, um erste Einblicke in das Beobachtererleben zu gewinnen. Anhand der gesammelten Erlebnisberichte wurde außerdem unser „Rollenmodell“, das vier Typen

anhand zweier Merkmale unterscheidet, getestet. So konnten wir nicht nur ein genaueres Bild verschiedener alltäglicher Beobachtungssituationen gewinnen, sondern auch zeigen, dass sich unsere Typologie für die Erfassung der Beobachterrolle bei öffentlichen Technikinteraktionen eignet. Die Typologie deckte alle Erlebnisberichte ab und jeder Typ konnte positiven sowie negativen Erlebnissen zugeordnet werden.

Die qualitativen Ergebnisse von Studie 3 wurden durch eine experimentelle Untersuchung, Studie 4, ergänzt. Der Vergleich des Erlebens der vier Typen in einem konkreten Anwendungsfall diente einer erneuten Testung der Typologie (diesmal basierend auf hauptsächlich quantitativen Analysen), sowie der Gewinnung weiterer Einsichten in die Wahrnehmung und Bewertung von Beobachtern öffentlicher Technikinteraktionen. Die Studienergebnisse unterstreichen die Relevanz und Nützlichkeit einer stärkeren Differenzierung des sozialen Kontexts in mehrere Typen. Typspezifische Unterschiede zeigten sich aber nicht nur im Beobachtererleben, sondern auch hinsichtlich empfohlener Handlungs- und Gestaltungsstrategien.

In Studie 5 sollten Experten die Perspektive eines bestimmten Typen einnehmen, um weitere Charakteristika von idealen Beobachtererlebnissen und unterstützender Design- und (Re-) Aktionsmöglichkeiten aufzudecken. Die Experten-Befragung bestätigte die Ergebnisse aus den vorherigen Studien, dass auch aus Beobachterperspektive eine Vielzahl positiver Technologie-mediierter Erlebnisse möglich sind. Typspezifische Lösungen (in Bezug auf Beobachterverhalten und technologische Funktionen), aber auch allgemeinere Strategien, d.h. solche die Bedürfnisse und Anforderungen mehrerer Typen adressieren, können hilfreich sein.

Zusätzlich führten wir einen Workshop mit Studierenden (Studie 6) durch, dessen Ziel es war weitere explorative Erkenntnisse über das Beobachtererleben unter praxisnahen Bedingungen, d.h. im persönlichen Kontakt mit Teilnehmenden ohne besondere Fach- oder Vorkenntnisse, zu sammeln. Der Workshop beinhaltete Einzelarbeit und nachfolgende Gruppendiskussionen zu den Ergebnissen. Die Gegenüberstellung der Perspektiven verschiedener Beobachtertypen ergab, dass die Relevanz psychologischer Bedürfnisse und die Bewertung der sozialen Interaktion mit dem Nutzer variieren können, es aber auch einige Gemeinsamkeiten gibt.

Neben einem Überblick über die empirische Arbeit bestehend aus Zusammenfassungen der Studien (-Ergebnisse) und deren Beitrag für den HCI (Human-Computer Interaction) Bereich, wird auch ein theoretischer Beitrag in Form eines Buchkapitels behandelt. Dieser diskutiert welche Herausforderungen die Technisierung des öffentlichen Raums, die sog. technisierte Öffentlichkeit, mit sich bringt. Darüber hinaus werden Ansatzpunkte zur Überwindung des Status Quo, d.h. eines technischen Fortschritts auf Kosten eines guten sozialen Miteinanders, präsentiert. Indem das Thema Sichtbarkeit bzw. Öffentlichkeit bei Technologienutzung in einen größeren gesellschaftlichen Kontext eingebettet wird, unterstreicht der theoretische Beitrag auch die Relevanz des empirischen Teils dieser Arbeit, also einer systematischen Erforschung.

Im Anschluss einer zusammenfassenden Diskussion der Erkenntnisse aus den empirischen Studien zur Beantwortung der Forschungsfragen, werden allgemeine theoretische und praktische Implikationen der Arbeit aufgeführt. Diese Dissertation trägt zu der Forschungsliteratur bei, die einen positiven, bedürfnis- und möglichkeitsgetriebenen Ansatz über einen problemorientierten Ansatz wählt. Sie kann als Kritik an der vorherrschenden Nutzerzentrierung in der HCI verstanden werden und betont die Relevanz des sozialen Kontextes bzw. eines besseren Verständnisses und detaillierteren Erfassung der Beobachterperspektive bei öffentlichen Technikinteraktionen. Als mögliche Ressource von positiven Technikerlebnissen gilt es den Beobachter oder das Beobachtererleben angemessen zu berücksichtigen, eine theoretische Verankerung des Konstrukts ist dabei entscheidend. Implikationen

für die Praxis beziehen sich auf ein reflektiertes Vorgehen und kritisches Hinterfragen des eigenen Handelns. So können die Studienergebnisse nicht nur als Inspiration und Orientierung in der Produktentwicklung, sondern auch für das alltägliche Miteinander dienen. Designer und Entwickler sind angehalten anpassungsfähige und kontextsensitive technologische Features umzusetzen, anstatt Einheitslösungen anzubieten. Doch die Verantwortung für positive Technikerlebnisse liegt auch bei den Konsumenten selbst, denn Nutzer sowie Beobachter haben diverse (Re-)Aktionsmöglichkeiten. Zum Schluss werden allgemeine, studienübergreifende Limitationen erörtert und potenzielle Ansatzpunkte für künftige Studien im Sinne eines ganzheitlicheren Forschungs- und Designansatzes skizziert.

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1. Introduction

Technology has become our constant companion. Nowadays, some people view mobile technologies like smartphones or wearables as extensions of their bodies rather than just objects (Harkin & Kuss, 2021; Nelson et al., 2019). Statements such as "My smartphone is the one thing that I never leave my house without." (Harmon & Mazmanian, 2013) probably resonate with many readers. Technology is also omnipresent in public spaces, replacing, supporting, or enhancing human interaction to make our lives easier or better, and technology is interwoven into many everyday activities. Many will be familiar with the sense of relief at being able to bypass the long supermarket queue to use the self-service checkout, or the convenience of asking Alexa to play your favorite song at a party, or amusement at a fellow passenger openly talking about relationship problems on the phone?

Technology interactions taking place in public imply a social context, i.e., other people are present. These people can shape the technology experience[1]. Previous research has shown that the experience of interactions in private, i.e., when using technology while alone, differs from public contexts, i.e., when other people are around. For example, the presence of others can influence how willing or comfortable users feel to use a product or perform an interaction (e.g., Candello et al., 2019; Efthymiou & Halvey, 2016; Lopatovska & Oropeza, 2018). Even an imagined audience can affect the user behavior or experience (Chen et al., 2014; Dalsgaard & Hansen, 2008). In most studies, a public as opposed to a private context is seen as an adverse condition or challenge. However, it is also possible to have a positive user experience in these situations, or to gain for there to be specific qualities that can only be achieved through the public component, we just need to (better) understand how.

While we are surrounded by technology in our everyday lives, we are often not using technology ourselves, but (un-)intentionally co-experiencing another person's interaction, i.e., watching or listening. Thus, despite considering ourselves active technology users, we constantly observe and feel the impact of other people's technology use on our lives (Cumiskey, 2005; Wagenknecht, 2018). The perception and experience of (actively) using technology or (passively) attending the interaction with technology can differ. Let's take one of the everyday examples mentioned above. Imagine interacting with Alexa yourself; having an audience might feel uncomfortable, and if the interaction doesn't work as planned the discomfort might even grow. In contrast, observing someone else's struggle with Alexa is probably less stressful – or even entertaining?

Since most technology interactions nowadays are not limited to our own four walls but can take place in public spaces or social contexts, we need to consider (at least) two stakeholders when designing or evaluating technological products: the users, i.e., people using a technology, and the attendants, i.e., "present others" co-experiencing the interaction. One of the most famous examples of forgetting or neglecting the present others when designing interactive products and its consequences is the first-generation Google Glass launched in 2013. It never got beyond the status of a controversial pilot project, and finally, the technology was taken off the market in 2015 after users reported various negative reactions, even attacks, from the social environment (Gross, 2014; Ladhani, 2014).

It is crucial to understand how the enhanced interaction options in technology-rich environments impact people (Stephanidis et al., 2019), whether they are actively using the technology themselves or

[1] In this thesis, experience is used as a general term for people's perception and reaction when using or attending technology (interactions).

passively co-experiencing the technology interaction. Therefore, this thesis aims to explore technology-mediated experiences in public – from a user and attendant perspective. Hereby, the attendants are not only considered an influencing factor but also an important research object in its own right. The role of need fulfillment and (different) attendants in positive user experiences are highlighted. Furthermore, the so-called attendant typology, aiming to improve the understanding of the attendant perspective in public technology interactions, is introduced. The different types offer insights into (the variance in) the attendant experience. Presented recommendations for actions and design can serve as inspiration and orientation for public technology (usage).

2. Research Rational and Research Questions

"[Bystanders'] presence should be considered the rule, not the exception."
– Goffman (1979, p.8)

This thesis deals with positive technology experiences in public spaces or contexts and explores four subordinate research questions. This section describes how the research questions are derived from identified research gaps, and outlines prior relevant theoretical and empirical work. Further information regarding the relevant constructs and related previous work can be found in the theoretical background section (see section 3.2.).

When it comes to investigating public technology interactions, an important limitation of previous HCI research is the fact that the majority of the studies have a narrow focus of investigation. On the one hand, they often investigate the experience regarding a specific form of interaction with a specific product and exclusively from the user perspective (Dalsgaard & Hansen, 2008; Flammer, 2016). This doesn't mean that there aren't any studies considering the attendant perspective. For example, studies explore the attendant reaction to the public use of wearable devices, emphasizing the necessity for further research and the value of understanding their point of view (e.g., Denning et al., 2014; Profita et al., 2013; Puikkonen et al., 2011). However, there's a prevailing trend to design without sufficient consideration of social aspects or to "design despite the social" (Uhde et al., 2022, p. 89).

On the other hand, many studies into public technology interactions predominantly focus on eliminating or mitigating negative experiences such as discomfort or disturbance. This is evident, for example, in the research practices around social acceptability, which is "typically defined through negation, or an absence of negative judgment" (Koelle et al., 2020, p. 6). Such a problem-driven approach has, or rather had, a tradition in HCI; in recent years, possibility-driven design approaches have been established as a kind of countermovement (e.g., Desmet & Hassenzahl, 2012; Desmet & Pohlmeyer, 2013; Jiminez et al., 2014). Various studies highlight the added value of this "new" approach of exploring possibilities for positive experience and well-being rather than merely addressing problems (e.g., Frison et al., 2017; Dörrenbächer & Hassenzahl, 2019; Hassenzahl et al., 2013). Against this background, I have shifted or expanded the focus of investigation in my research work to the often-neglected present others co-experiencing technology, i.e., watching or listening, and the positive technology experience in public contexts.

Various studies have shown that the social context shapes our use and experience of technology. In my research, I wanted to go one step further and investigate what exactly it is that creates a positive experience with technology in public settings. A better understanding of the attendant role and perspective, their experience, i.e., how they perceive and react to a public technology interaction, represents an essential research objective. Therefore, I formulated the following research questions:

RQ1. How do positive experiences with technology in public settings emerge, and what role do attendants play?

It is common sense that striving for positive experiences in/through technology design delivers added value (Burmester et al., 2014; Hassenzahl et al., 2013; Hassenzahl et al., 2021). A profound understanding of positive user experience is required to enable positive technology-mediated experiences. Hassenzahl (2014) stated that "emotions and fulfillment of universal psychological needs

[to] have an accentuated role [in this].” (p. 3). Similarly, Partala and Kallinen (2012) emphasized that “understanding needs and emotions also contributes to the general understanding of user experiences beyond traditional measures of usability” (p. 31).

It has been repeatedly explored how technology (experience) can contribute to well-being (Zeiner et al., 2016). Yet, there is a lack of systematic research on the experiential aspects of interactive products, also explicitly considering contextual factors and social dynamics (Lenz et al., 2014; Ross & Wensveen, 2010). Since the social context or the presence of others has a substantial impact on how users engage with technology and their overall technology experience (e.g., Eghbali et al., 2019; Gentile et al., 2017; Vergari et al., 2021) this gap is problematic and needs to be addressed.

However, it’s important to note that present others are not all the same, i.e., they are a heterogeneous stakeholder group. Research shows that it can make a difference for the user who is (possibly) observing them, for example, their relationship with the attendant (e.g., Hsieh et al., 2016; Paay et al., 2017; Rico & Brewster, 2010) or how active the attendant behaves (e.g., Azad et al., 2012; Gentile et al., 2017; Günay et al., 2014).

RQ2. How to specify and analyze the attendant perspective in public technology interactions?

A closer look at the HCI literature on public technology usage reveals that in most cases the main focus is on the human-technology interaction, with context being used as a broad term to encompass “everything else” (Kuutti & Bannon, 2014). Present others as a construct has not yet been universally or clearly defined. Although some studies do specify (different types of) present others, this is very unsystematic – many studies do not differentiate between present others at all or do so imprecisely.

For example, as early as 1963, the sociologist Erving Goffman distinguished between different types of audiences in one of his many books on everyday public interactions. More recent work also emphasizes that the audience or present others cannot or should not be understood as one (e.g., Chen et al., 2014; Wouters et al., 2016; Zenner et al., 2019). They can take on diverse roles depending on their “involvement”, e.g., their interest, understanding, or attention.

For example, Dix and Sas (2010) differentiated, among other factors, between witting and unwitting bystanders, depending on whether they understand that interaction is happening or not. Koelle (2019) described the perspective of bystanders as 2nd person perspective or 3rd person perspective, depending on whether they are interacting or not interacting with the user. Similarly, Gugenheimer et al. (2017) based their differentiation also on whether the other person present interacts with the user, naming them Non-HMD users and observers. Azad et al. (2012), Downs et al. (2014), and Zenner et al. (2019) distinguished passive and active observers/spectators/audience. Paay et al. (2017) focused in their study on a specific group of attending people, the engaged bystander, which they in turn subcategorized according to their relationship to the user. In a study from the video game field, the authors identified nine spectator roles or personas, specifying who they are and why they watch (Cheung & Huang, 2011). Downs et al. (2015) defined the roles of a bystander and audience members, which reflect how involved or engaged these persons are in gameplay.

All in all, HCI literature lacks a clear and consistent terminology for the present others. Most of the studies provide insufficient definitions or none at all. Not only have terms been used inconstantly across different studies, but the studies also vary greatly in how detailed the (role of the) attendant is

described. Thus, a clear conceptualization is needed, also enabling a better operationalization of the construct in future research.

RQ3. How do attendants (co-)experience public technology interaction?

So far, HCI research on technology experience mainly focuses on the user perspective. There are numerous models on the user's experience or acceptance of technology, while the attendant is mainly considered to be an influential factor – if at all. Thus, there is no theory or model to relate to when it comes to understanding the attendant experience. Studies explicitly exploring how people feel or react when co-experiencing a user interaction with technology are scarce (e.g., Dalsgaard & Hansen, 2008; Denning et al., 2014; Reeves et al., 2005).

Most studies addressing the attendant perspective ultimately aim at (improving) the user experience or (generating) engagement with technology. This might explain why often only negative aspects of the experience, such as discomfort, disturbance, or embarrassment (e.g., Galván et al., 2013; Koelle et al., 2020; Ling, 2002), are captured. However, studies show that the experience of attendants can also be positive, e.g., entertaining, amusing, or motivating (e.g., Eiband et al., 2017; Gugenheimer et al., 2017; Mauriello et al., 2014). Unlike in user research, however, there is no body of research studies that can be referred to when it comes to evaluating or predicting positive experiences, e.g., which needs are most relevant to fulfill. Not only can the attendant differ from the user experience (e.g., Alallah et al., 2018; Eiband et al., 2017; Sethumadhavan et al., 2021), but the experience of attendants can vary as well. Studies show that attendants can take on several roles and, thus, differ in their perception and demands of public technology interactions (e.g., Dix & Sas, 2010; Greuter et al., 2022; Wouters et al., 2016).

However, there are no validated or popular measures of the attendant experience, i.e., when watching or listening to a technology interaction. Analogous to research on user experience (e.g., Hassenzahl & Tractinsky, 2006; Partala & Kallinen, 2012; Robert & Lesage, 2017), we suggest that, among other factors, emotions and psychological needs also play a central role in the (co-)experience of attendants.

RQ4. Which action and design strategies can improve the attendant experience of public technology interactions?

User-centered design (UCD; Abras et al., 2004) emphasizes user collaboration throughout the product lifecycle in various industries. It ensures that products meet the user's needs and expectations and has become standard practice. While we know a lot about how to enable positive user experience, e.g., how to design technology or how attendants should behave so as not to be an intrusion or limitation, there are hardly any suggestions for improving the attendant experience that do not relate to reducing or minimizing the invasion or (direct) participation. For example, recommended actions for users of mobile technologies often refer to protecting or at least not violating the attendant's privacy. Asking for permission is only one option of many (Denning et al., 2014). And when it comes to design strategies that acknowledge the attendant perspective, popular approaches are oriented toward social acceptability and recommend that design meets the aim of unobtrusiveness (e.g., Flammer, 2016; Hsieh et al., 2016; Lee et al., 2018). There are also a number of studies that provide design recommendations for creating or fostering attraction and engagement in attendants. In such studies, the attendant role is often viewed as being sub-optimal or a state that needs to be changed or overcome to achieve the ideal state of "using" (e.g., Finke et al., 2008; Tang et al., 2008; Wouters et

al., 2016). However, when co-experiencing technology usage in public in everyday life, attendants often do not want to or cannot get “active” and participate (i.e., become a user) but rather they want or have to stay “passive” (i.e., remain an attendant).

Reeves et al. (2005) developed a categorization for public interfaces and performances to understand how they are perceived and affect attendants. Moreover, they identified four strategies for “designing the spectator experience” (p. 741), namely secretive, expressive, magical, and suspenseful interfaces. However, they focused on how others should experience the user-technology interaction, mainly taking the user or designer perspective (Uhde et al., 2023), instead of actually addressing the attendant’s needs and demands.

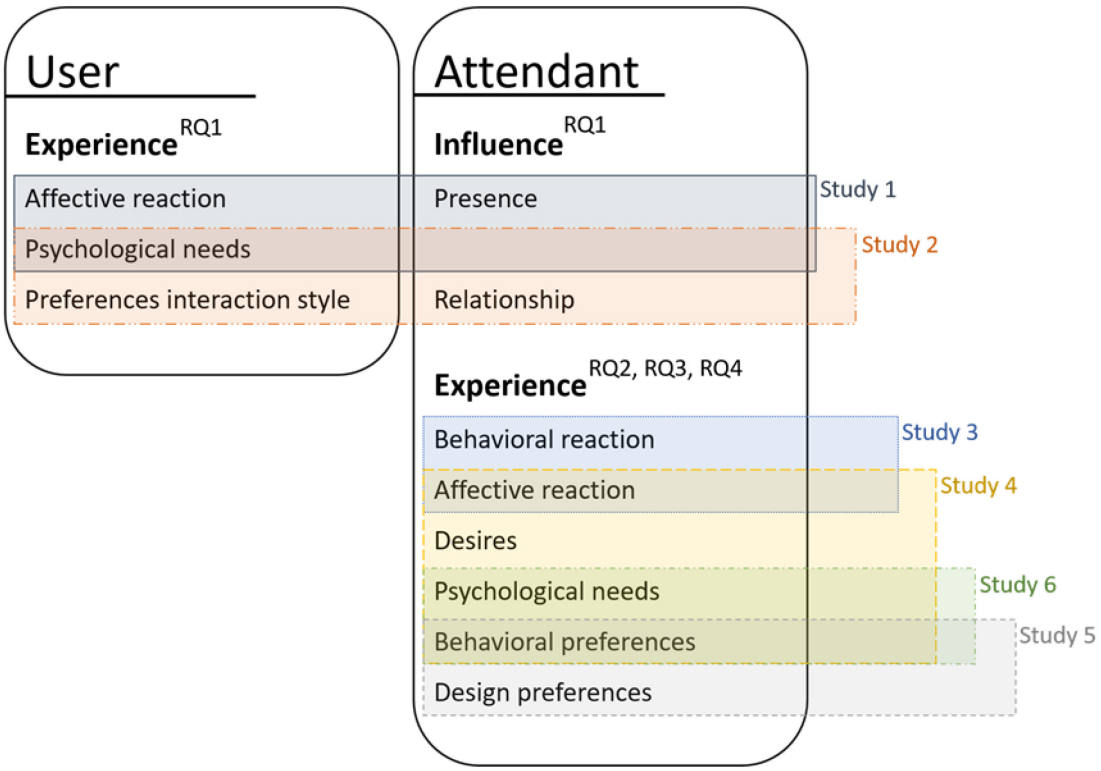
In general, attendants often have no reaction or control possibilities, and although there are voices that advocate or highlight (greater) attendant consideration, there are only a few practical recommendations for design and actions, and these refer to a specific technology. We therefore first need explorative studies that are aimed at generating ideas for technology-independent or trans-technological recommendations.

3. Theoretical Background

This section presents the research approach of the thesis, including the key research objects (see Figure 1) and methodology (see Table 1). It also explains the relevant concepts and describes related work, i.e., the most significant theoretical and empirical studies that provided the basis for the present work. A comprehensive theoretical introduction of the particular studies included in this thesis can be found in the appended manuscripts.

Figure 1

Illustration of the research approach of this thesis including the relevant research objects of the empirical studies



3.1. Research Approach

Seeking to better understand and analyze positive technology-mediated experiences in public settings, this thesis moves the attendant into the focus of attention. The first two studies (study 1 and study 2) explored positive technology-mediated experiences from the user perspective and the impact of attendants in these experiences. Specifically, we investigated the effect of the presence of others (private vs. public, study 1) and their relationship with the user (close vs. unknown, study 2) on the user experience, i.e., need fulfillment (study 1 and study 2), positive affect (study 1 and study 2), and preferred interaction style (study 2). The studies went beyond merely examining user experiences, capturing contextual differences (in study 1 and study 2) as well as understanding underlying psychological mechanisms (study 2). In study 1, the participants reported memorable user experiences

with all kinds of technology. Whereas in study 2, participants were asked to assess their experience with a specific technology, a service robot, with the help of vignettes (i.e., textual and pictorial descriptions of hypothetical scenarios). The questionnaire used in study 1 collected both qualitative and quantitative data, while study 2 provided only quantitative data.

The subsequent studies (studies 3-6) explored the attendant perspective in public technology interactions. Specifically, we conducted an interview study (study 3) to collect positive and negative experience reports and evaluated these experiences using qualitative content analysis. This study aimed to gain insights into attendants' behavior and experience in everyday situations. Additionally, we tested a previously developed "role model" to see if it reflects actual attendant experiences. The next step (study 4) was to investigate in more detail, experimentally, whether and how the technology experience of different attendant types deviates from each other in a specific use case, listening to music in public. We used vignettes to manipulate the attendant type and collected quantitative (e.g., ratings of affective reactions and desires) and qualitative data (e.g., participants' ideas on improving the attendant experience). Study 3 examined general attendant experiences, while study 4 focused on type-specific differences and particularities.

Last but not least, we developed a tool (card set) for mapping the attendant perspective in the research and design process and used it in two application and refinement studies, study 5 and study 6. Specifically, we asked experts to apply and evaluate the cards in an online study (study 5). Based on the experts' feedback, we then reworked the cards and used them in a workshop with students (study 6). The expert survey and workshop aimed to test and improve our tool and to generate further explorative insights (based on qualitative data) into the attendant experience. For example, in study 5, participants were asked to describe an ideal attendant experience, attendant (re-)action possibilities, and useful technological features and functions. In study 6, workshop participants evaluated and discussed differences and similarities between the types with regard to need fulfillment, user contact, social acceptability, etc. Table 1 gives an overview of the empirical work conducted within the framework of this doctoral thesis.

Table 1

Characteristics of the studies included in this thesis

Study	Sample Size	Method	Data	Considered Technology	Manipulation	Research Question
Study 1	184	Online Experiment, Critical Incidents	Qualitative and Quantitative	Various	Attendant Presence (private vs. public)	RQ1
Study 2	228	Online Experiment, Vignettes	Quantitative	Service Robot	Attendant Relationship (unknown vs. close)	RQ1
Study 3	20	Interviews, Guideline-based	Qualitative	Various	-	RQ2, RQ3
Study 4	181	Online Experiment, Vignettes	Qualitative and Quantitative	Headphones, Loudspeaker	Attendant Type: Voluntariness (forced vs. voluntary) and Conspicuousness (secret vs. obvious)	RQ2, RQ3, RQ4
Study 5	13	Online Survey, Closed and Open Questions	Qualitative and Quantitative	Various	-	RQ3, RQ4
Study 6	5	In-person Workshop, Individual Tasks and Group Discussions	Qualitative	Smartphone	-	RQ3

3.2. Relevant Concepts and Related Work

3.2.1. (Positive) Technology-Mediated Experiences

The goal of technology design has changed in recent decades – away from problems of use toward user experiences. In other words, nowadays, it's about designing for a world of opportunities rather than simply solving predefined issues. This trend was significantly influenced by the rise of Positive Psychology (Burmester et al., 2017), and new design approaches have emerged in recent years, such as Positive Computing (Calvo & Peters, 2014), Positive Design (Desmet & Pohlmeyer, 2013), and Experience Design (Hassenzahl, 2010). The focus is on promoting well-being by emphasizing the positive and possibilities (Desmet & Hassenzahl, 2012). Diefenbach (2018) stated that "every designed

object can be understood as an intervention and a possibility to promote well-being" (p. 3). And research highlights the central role of need fulfillment and positive emotions in positive technology-mediated experiences (e.g., Hassenzahl & Diefenbach, 2012; Hassenzahl et al., 2010; Hassenzahl et al., 2015).

Self-Determination Theory (SDT; Ryan & Deci, 2000) originally outlined three fundamental psychological needs: autonomy, competence, and relatedness. Autonomy involves pursuing self-determination, making choices, and having control over one's life. Competence addresses the importance of feeling effective and capable of mastering challenges. And relatedness pertains to the need for connection and relationships with others. While autonomy, competence, and relatedness can be considered fundamental psychological needs and are well-supported by empirical evidence, subsequent research explored seven additional needs that influence positive or negative experiences: self-actualization – meaning, money – luxury, physical thriving, popularity – influence, security, self-esteem, and pleasure – stimulation (Sheldon et al., 2001). Importantly, there is no hierarchy in needs; their prioritization is suggested to be context-dependent, indicating that not all needs are universally applicable in every situation. Based on these ten needs, different sets of needs are proposed for technology-mediated experiences. For example, Hassenzahl et al. (2013) identified the following six needs as particularly relevant: relatedness, popularity, competence, security, stimulation, and autonomy. Several studies have already used this selection (e.g., Eckoldt et al., 2013; Hassenzahl et al., 2015; Klapperich et al., 2020). Another approach introducing "13 fundamental needs and 52 sub-needs" comes from Desmet and Fokkinga (2020). Yet, no mutual agreement exists regarding which needs (selection) should be used. As diverse as the selection of investigated needs may be, so too are the application contexts or domains of investigation, such as driving (e.g., Eckoldt et al., 2013), self-service (e.g., Leung & Matanda, 2013), healthcare (e.g., Hohm et al., 2022), music listening (e.g., Lenz et al., 2012), etc. Furthermore, a couple of studies examined the relationship between need fulfillment and positive experience independently of a specific technology (e.g., Hassenzahl et al., 2015; Partala & Kallinen, 2012; Tuch et al., 2016).

In sum, these findings show the link between positive (and negative) technology-mediated experiences and need fulfillment and affect. More specifically, need fulfillment can be understood as a primary source of positive technology-mediated experiences or in the words of Hassenzahl and Diefenbach (2012): "Any positive experience eventually stems from psychological need fulfillment." (p. 1).

3.2.2. Users: The Center of Attention

Understanding the mechanisms of technology adoption and usage is at the heart of HCI research. The most prominent frameworks used to address these mechanisms are technology acceptance and user experience models (Hornbæk & Hertzum, 2017).

Regarding technology adoption, several theories and models have been developed from the Theory of Reasoned Action (TRA, Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and the Theory of Planned Behavior (TPB, Ajzen 1985, 1991) over time. The Technology Acceptance Model (TAM, e.g., Davis et al., 1989) is one of the most used and cited. Researchers created multiple variations of the TAM to address specific applications, integrate additional influential factors, account for cultural differences, leverage methodological advancements, and respond to critiques or limitations (e.g., TAM2, Venkatesh & Davis, 2000; UTAUT, Venkatesh et al., 2003). TAM suggests that people adopt and use technology based on two factors: how useful it is and how easy it is to use. Perceived usefulness refers

to the belief that a system enhances job performance, while perceived ease of use is the belief that using the system requires minimal effort (Davis et al., 1989). According to TAM, these perceptions influence an individual's attitude toward using the system, shaping their intention to use it and, ultimately, determining whether they use it.

User Experience (UX) models aim to provide a structured approach to understanding and improving the multifaceted aspects of technology experience, ensuring that products and services meet user needs and expectations. Commonly, these models explore the user's experiences during the interaction, the outcomes of those experiences, and how experience and outcome are connected. Thus, they consider factors such as users' perceptions of products, emotional responses, and changes in behavior. While UX models can differ in the details, they also have things in common. For example, emotions play a crucial role in several UX models (e.g., Hassenzahl et al. 2010; Thüring & Mahlke, 2007). To summarize, TAM focuses on users accepting and adopting technology based on factors like usefulness. Whereas UX models consider a broader range of elements, including aesthetics and emotions, to capture the overall user experience beyond acceptance. In other words, TAM is specific to technology adoption, whereas UX models offer a more "holistic" exploration of users' interactions with products.

While early models neglected the role of social context in technology adoption and usage, newer or revised versions of TAM and UX models now take social factors into account – more or less. For example, Malhotra and Galletta (1999) expanded the TAM to include "social influence" or Venkatesh and Bala (2008), incorporating "subjective norm" and "image" as explanatory factors for perceived usefulness. However, researchers have criticized that technology acceptance and user experience models still seem underdeveloped regarding the impact and integration of social aspects (Graf-Vlachy et al., 2018; Hornbæk & Hertzum, 2017). Furthermore, these aspects are only considered to be influencing factors. The actual perception and reaction of the present others is not addressed.

3.2.3. Present Others: The Forgotten Ones

Overall, there is a lot of systematic research on the mechanisms that shape the adoption and usage of technology. However, these studies and theories focus on the primary user of technology, while the attendant perspective plays a minor role (as an influencing factor) or no role at all. Thus, we still know little about the co-experience of watching or listening to another person's interaction with technology (see quantity and quality of user vs. attendant research). Undoubtedly, this is partly due to the unclear and inconsistent terminology, which makes a systematic assessment difficult. There are various terms for the present others in public technology interactions such as observer, spectator, bystanders, non-wearer, receiver, third-person/party, audience (members), eavesdropper, viewer, and passer-by, to name but a few. Some authors also used several terms seemingly synonymously or without explaining them in more detail or distinguishing them from one another. For example, Profita et al. (2016) write observer and bystander. Gentile et al. (2017) refer to users as passers-by and subdivide attendants into passive vs. active audiences. They also mention a bystander, but it remains unclear who or what is meant by this. Koelle et al. (2020) also use several synonyms. They initially use the term spectator but later switch between observer and bystander. Montero et al. (2010) and Alallah et al. (2018) are also inconsistent in their choice of terms. There are even studies referring to users with (interested) bystanders (Yousuf et al., 2019). Only a few studies explained and justified the terms used (e.g., Eghbali et al., 2019; Paay et al., 2017; Wouters et al., 2016).

Since the terminology in HCI is incoherent and ambiguous, we decided on a new term, attendant, to refer to present others who co-experience the technology interaction of (unknown) users in public space. It was important to us to choose a term that is neutral, i.e., without valuing, and one that is not yet used in HCI research so that it evokes as few preconceptions or expectations as possible. Furthermore, the emphasis was on using an "inclusive" term, avoiding a focus on one specific sense, like overhearer or viewer.

Overall, there is no systematic investigation into the co-experience of attendants, i.e., how they perceive or react to the use of technology. In most of the research on public technology usage, the social context or present others appear as an (irrelevant) side-factor or black box. In the relatively few studies that address the attendant perspective, the focus is usually still on the user role or experience. Attendants are often seen as potential interrupters or constraints and, thus, studies aim at understanding and mitigating their impact, for example, to enhance the primary users' experience, concentration, or task performance (e.g., Günay et al., 2014; Mai et al., 2018; Mansour et al., 2023). In other words, the experience of attendants is primarily perceived as a means to an end when focusing on how to improve the user experience, for example, by ensuring the social acceptability of interactions or products (e.g., Koelle et al., 2020), preventing (physical and social) collisions (e.g., Ng et al., 2021), or minimizing interference (e.g., Toch et al., 2020). Other studies consider the attendant only as a potential future user and assume that there is an ideal state, that of the active technology user, and a suboptimal state, that of the attendant. Here, understanding the attendant perspective and experience is supposed to help turn attendants into users, i.e., by creating engagement and involvement (e.g., Chen et al., 2014; Lösch et al., 2017; Paay et al., 2017).

Flammer (2016) summarizes the issue: "Compared to users, bystanders are often considered a second-order phenomenon; in other words, 'human-centered design' really applies only to the user." (p. 73). Therefore, rather than understanding social context as just an additional variable within TAM or UX models, it or, respectively, the present others in human-technology interactions should be treated as a valuable research objective by itself.

3.2.4. Public Technology Interactions

In the field of HCI, Goffman's impression management framework (1959) is a frequently utilized theoretical lens through which to describe and analyze how people interact with technology in social contexts (e.g., Dalsgaard & Hansen, 2008; Koelle et al., 2020; Rico et al., 2010). According to Goffman (1959), social interactions resemble a theater performance; individuals in everyday life take on the actors' roles on a stage, while the audience comprises present others observing and reacting to the performance. One of the key messages of Goffman's work is that the opinion of others is essential to people. Consequently, their perspective on or experience of the "performance" plays a central role for the user and their experience.

Other people co-experiencing the technology interaction can affect the user in various ways. For example, Reeves et al. (2005) demonstrated that attendants' influence on users can be positive (e.g., encouraging the user) as well as negative (e.g., fear of embarrassment). Similarly, Rae et al. (2015) noted that in their field study, some participants appreciated the attention drawn to them by wearing a new, noticeable device, while others experienced social awkwardness. Little and Briggs (2009) revealed that people experience stronger stress reactions when personal information is considered in a crowded setting vs. being alone. Others, such as Wiethoff et al. (2015), support the idea that the

presence of others can also be perceived positively; their participants found the interaction in public enjoyable, expressing that performing on stage provided a remarkable and impressive user experience. Present others can also impact the fulfillment of users' needs. For example, Hassenzahl et al. (2015) showed that social situations, i.e., when at least one other person was present during the user's interaction with technology, are associated with the need for relatedness and popularity.

Attendants not only influence how users experience a technology interaction but also how they interact. For example, Günay et al. (2014) showed that the presence of other people affects the users' feelings and satisfaction when using a self-service kiosk, as well as their task performance, e.g., a negative impact on the duration of use or number of mistakes. The findings of Gentile et al.'s (2017) field study point in the same direction. They revealed decreasing interaction times when using public displays while others are around and found that some users even interrupted their interaction to return later when no one was present. Sergeeva et al. (2017) describe their observation that "onlookers' inferences, judgments, and reactions trigger users to reflect on consequences and adjust the use in front of others" as the onlooker effect. Meanwhile, a major field of research addresses the topic of social judgment, the social acceptability research (Koelle et al., 2020). These studies investigate how socially acceptable specific technologies (e.g., wearables) or technology interactions (e.g., control gestures) are perceived – from the viewpoint of users and attendants. Such studies highlight the relevance of the (imagined) perception and opinion of attendants on the user or their usage (intention).

However, while attendants impact the user, attendants are also influenced by the user. Co-experiencing can have positive as well as negative consequences for the attendant. For example, attendants might enjoy watching others because they find spectating engaging (Williamson et al., 2017) or perceive a specific technique as fun or magical (Paay et al., 2017). From watching others, attendants can also learn how to use a technology themselves (e.g., Hespanhol, 2016; Wouters et al., 2016; Ylikauppila et al., 2014). On the other hand, the interaction of users with technology can be perceived as an (unwanted) distraction or disturbance. For example, Cecchinato et al. (2017) explained that smartwatches can be perceived as a distraction not only by the user but also from an attendant's perspective. Studies on public phone calls show how using technology in public can stress present others, e.g., by embarrassing them (Ling, 2004). Even though most people act without malicious intent when shoulder-surfing smartphone users, reading along can trigger negative feelings in the attendants (Eiband et al., 2017). Nuñez et al. (2020) underline the negative consequences of phubbing (i.e., choosing one's phone over face-to-face social interactions; Chotpitayasunondh & Douglas, 2016; Karadağ et al., 2015) by showing that it is not only the person getting phubbed who experiences stress, but uninvolved third parties observing the situation do as well.

The experience of a public technology interaction can differ between the user and attendant perspectives. Phone use in public is a good everyday example. While people see some benefits in using mobile phones in public places (e.g., De Souza e Silva & Frith, 2012; Foley et al., 2007; Hampton & Gupta, 2008), from the perspective of an attendant, co-experiencing can be rather disturbing (e.g., Campbell, 2007; Galván et al., 2013; Kumar et al., 2016). Furthermore, user-attendant differences are widely explored and discussed in studies on head-mounted displays (HmD) like virtual reality (VR) and augmented reality (AR) headsets. For example, Koelle et al. (2015) found that the use of data glasses, in general, is perceived critically but more positively by the user compared to the attendant. Eghbali et al. (2019) noted a divergence in perception between users and attendants regarding isolation and

recording concerns; attendants disliked being isolated from the user, unlike most users, who enjoyed the sense of isolation and the feeling of virtually being somewhere else while physically co-present. Other studies revealed role-specific differences regarding the preferred form or style of interaction. For example, users assessed subtle input modalities as more acceptable than attendants (Alallah et al., 2018). Similar results can be found for other devices. For example, Paay et al. (2017) investigated different interaction techniques for public displays. The feedback collected from users and attendants showed that although most users feel comfortable with what they are doing, the interaction techniques can seem embarrassing from the attendant's perspective. Baier and Burmester (2019) investigated the public use of voice control and found that the experience was more positive from the perspective of the user compared to the attendant.

As the above examples of using smartphones or more innovative products such as smart glasses can illustrate, finding oneself in the role of an attendant, i.e., "just" watching or listening, often feels worse than using the technology. While users have the benefits and control, whether it is, for example, being able to talk to their partner at any time thanks to their smartphone or recording their personal life with smart glasses to relive those moments later, attendants get left behind. They have to bear the potential risks of privacy violation when recorded by the users' data glasses (e.g., Koelle et al., 2017) or annoyance when drawn into a user's private phone call (e.g., Norman & Bennett, 2014). Therefore, when it is about the experience of technology interactions in public, it should not be only about users. Previous studies came to the same conclusion. For example, Flammer (2016) called for "bystander-centered design" (p. 73) of wearables or Baier and Burmester (2019) stated it is "not just about the user" (p. 349). There are a couple of studies on the benefits and possibilities of considering the attendant perspective in product development and design. For example, Zenner et al. (2019) and Eghbali et al. (2019) addressed the issue of attendants feeling left out in VR experiences and presented possible solutions. Jarusriboonchai et al. (2016) demonstrated how a display on the back of a smartphone could not only encourage more careful or conscious usage behavior but could also trigger interaction with attendants and, thus, enable the fulfillment of social needs for both users and attendants. In summary, a positive experience for attendants should receive greater interest not only because attendants might be prospective users (Murray, 2022; Shin & Dai, 2022) or shape the user interaction and experience as a "social influence", but because a positive attendant experience or attendants' well-being has or rather should have value in itself.

4. Overview of Publications

The following chapter provides an overview of the publications related to this dissertation, involving four research articles (empirical) and a book chapter (non-empirical).

4.1. Original Research

The following section summarizes the original research papers included in this thesis and the corresponding empirical studies. There is a subsection for each paper presenting the research motivation and the subordinate research questions, followed by a short description of the study paradigm, sample and procedure, results, and research contribution.

Table 2 presents details for the four papers. Next to the corresponding studies, it lists the respective publication status of the papers, the authors, the authors' contributions according to the Contributor Roles Taxonomy (CRediT; Brand et al., 2015), and the addressed research questions. The table also shows data availability statements.

The research studies included in this thesis follow the Ethical Principles of Psychologists and Code of Conduct (American Psychological Association, 2024). All participants have given informed consent in accordance with the Declaration of Helsinki (World Medical Association, 2013). Furthermore, all study designs were reviewed and approved by the ethics committee of the faculty for mathematics, computer science, and statistics of LMU Munich before implementation.

Table 2

Overview of papers corresponding to the studies included in this thesis

Paper Title	Study	Addressed Research Question	Authors Contributions	Data Availability Statement	Status
Technology-Mediated Experiences and Social Context: Relevant Needs in Private Vs. Public Interaction and the Importance of Others for Positive Affect.	Study 1	**RQ1.** How do positive experiences with technology in public settings emerge, and what role do attendants play?	**Pia von Terzi:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project Administration **Stefan Tretter:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Writing – Review & Editing **Alarith Uhde:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Writing – Review & Editing **Marc Hassenzahl:** Resources, Writing – Review & Editing, Supervision, Funding Acquisition **Sarah Diefenbach:** Resources, Writing – Review & Editing, Supervision, Funding Acquisition	Preregistered on AsPredicted, Data available on OSF, Open Access	Published Article; Frontiers in Psychology
How Present Others Shape the User Experience of Service Robots.	Study 2	**RQ1.** How do positive experiences with technology in public settings emerge, and what role do attendants play?	**Stefan Tretter:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Writing – Original Draft, Project Administration **Pia von Terzi:** Conceptualization, Methodology, Validation, Writing – Original Draft, Writing – Review & Editing **Sarah Diefenbach:** Resources, Writing – Review & Editing, Supervision, Funding Acquisition	Preregistered on AsPredicted, Data available on OSF	Unpublished Manuscript (currently under review)

Paper Title	Study	Addressed Research Question	Authors Contributions	Data Availability Statement	Status
The Attendant Perspective: Present Others in Public Technology Interactions.	Study 3	**RQ2.** How to specify and analyze the attendant perspective in public technology interactions? **RQ3.** How do attendants (co-)experience public technology interaction?	**Pia von Terzi:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project Administration **Sarah Diefenbach:** Conceptualization, Resources, Writing – Review & Editing, Supervision, Funding Acquisition	Preregistered on AsPredicted	Published Article; Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems
	Study 4	**RQ2.** How to specify and analyze the attendant perspective in public technology interactions? **RQ3.** How do attendants (co-)experience public technology interaction? **RQ4.** Which action and design strategies can improve the attendant experience of public technology interactions?			
The Attendant Card Set: A Research and Design Tool to Consider Perspectives of Attendants versus Users When Co-Experiencing Technology.	Study 5	**RQ3.** How do attendants (co-)experience public technology interaction? **RQ4.** Which action and design strategies can improve the attendant experience of public technology interactions?	**Pia von Terzi:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original draft, Writing – Review & Editing, Visualization, Project Administration **Sarah Diefenbach:** Conceptualization, Validation, Resources, Writing – Review & Editing, Supervision, Funding Acquisition	Data available on OSF, Open Access	Published Article; Multimodal Technologies and Interaction
	Study 6	**RQ3.** How do attendants (co-)experience public technology interaction?			

4.1.1. Study 1

Von Terzi, P., Tretter, S., Uhde, A., Hassenzahl, M., & Diefenbach, S. (2021). Technology-mediated experiences and social context: relevant needs in private vs. public interaction and the importance of others for positive affect. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.718315

In order to create technology that feels good for people, it is first necessary to understand how positive experience is composed under different conditions. In HCI, several UX models build on need theories, such as Self-Determination Theory (SDT, Deci & Ryan, 1985; Ryan & Deci, 2000). SDT has become one of the most extensively applied and validated theories within HCI research (Ballou et al., 2022). It emphasizes three fundamental psychological needs that drive intrinsic motivation and well-being. Building on this, Sheldon et al. (2001) later presented a set of ten universal psychological needs, which in this or a "slimmed-down" version is commonly used in user research (e.g., Hassenzahl et al., 2010; Partala & Saari, 2015; Tuch et al., 2016). Consequently, and in line with previous research on well-being, we understand psychological need fulfillment as the source of positive experience.

However, systematic research on experience-oriented aspects of technological products explicitly taking contextual factors into account is still rare (Lenz et al., 2014; Ross & Wensveen, 2010), and models on technology use and experiences still need to improve regarding the incorporation of social context (Hornbæk & Hertzum, 2017). Some studies show that technology experience can differ in public and private settings (e.g., Efthymiou & Halvey, 2016; Eghbali et al., 2019; Pandey et al., 2021), but the question of how positive technology-mediated experiences are shaped by the social context, i.e., absence (private context) or presence (public context) of others, needs further exploration.

Thus, study 1 addresses this research gap and focuses on the research question of (RQ1) How do positive experiences with technology in public settings arise, and what role do attendants play?

4.1.1.1. Study Paradigm

Previous studies (Hassenzahl et al., 2010; Hassenzahl et al., 2015) have examined need fulfillment and affect in technology-mediated experiences. Even though these studies found differences in need fulfillment for experiences rated as social (i.e., when participants explicitly mentioned other people) vs. non-social (i.e., when this was not the case), they lack experimental control over the social context as the experience reports were retrospectively classified by the researchers.

To allow statements regarding causal inferences, the present study therefore experimentally manipulates social context to compare need fulfillment in public vs. private (between-subject comparisons). More specifically, we asked each participant to report either a public or private technology-mediated experience from their past and then to rate their experience in these situations. In accordance with Hassenzahl et al. (2010, 2015), we hypothesized that relatedness and popularity fulfillment are higher in public vs. private contexts. Furthermore, building on Goffman's (1959) idea that interacting in public is a performance where individuals aim to create a specific (positive) impression, we suggest that in situations with fewer external forces, i.e., other people, the need fulfillment of autonomy is lower than in public contexts. The same should apply to competence and security as Hassenzahl et al. (2010) showed lower need fulfillment of competence and security in social experiences vs. non-social experiences.

To address potential confounding effects in previous studies (Hassenzahl et al., 2010; Hassenzahl et al., 2015), the present study was implemented as a mixed design with social context (public vs. private) between-subject, and experience type (recalled vs. imagined) as a within-subject factor. After each participant recalled and assessed their technology-mediated experience in its initial form, i.e., either an experience in a public or a private context, the participants were instructed to imagine their experience in a modified form. Depending on whether their initial report concerned an experience in a public or private context, participants imagined the same interaction with or without others present (within-subject comparisons). In doing so, we could analyze participants' assessments of the technology interaction under different social conditions, i.e., while there are other people present and while being alone. In other words, the study tested the hypotheses of a causal relationship between the presence of others and need fulfillment. We expected that need fulfillment for relatedness and popularity would be higher for experiences in public contexts than for the same technology interactions without any other people present. In contrast, we predicted the need fulfillment for autonomy to be higher in private contexts compared to when other people are present.

Furthermore, we expected that these modifications, i.e., the changes in social context, would have a negative impact on affect. Assuming that modifying social context leads to lower need fulfillment and given the association between need fulfillment and positive affect (Hassenzahl et al., 2010; Hassenzahl et al., 2015), positive affect should decrease when there is a change in social context. Specifically, if positive experiences in public stem mainly from the fulfillment of social needs (i.e., relatedness and popularity) and in private contexts from autonomy, a modification of contexts is expected to result in lower positive affect. Importantly, supporting the above-described hypotheses on need fulfillment is a prerequisite for the decrease in positive affect.

4.1.1.2. Sample and Procedure

184 people aged between 18 and 71 (*M* = 27, *SD* = 26.30; 67.4% female, 32.1% male, 0.5% non-binary) participated in study 1.

The questionnaire collected qualitative and quantitative data. First, we instructed the participants to report a memorable positive experience with technology from their past in either public (i.e., while other people were present) or private (i.e., while the person was alone) context and to specify where it occurred. The participants then rated their experience in the described situation using various statements on the key variables, affect and need fulfillment, and some exploratory variables, e.g., social acceptability and relationship to present others. In the second part of the study, the participants were asked to imaginatively add or remove other people from/to their originally private or public experience. Again, they rated their experience using the same set of questions. Consequently, all measures were collected twice, after the participants were asked to recall their initial experience and then again after imagining it in a modified version.

4.1.1.3. Summary of Results

Study 1 revealed differences in the experience of technology users in public vs. private contexts. The descriptive statistics demonstrated a wide range of technology used and diverse locations; interestingly, participants in the public condition stated in only 9.7% of cases that the present others were strangers. In line with our hypotheses, results showed the psychological needs for relatedness and popularity are particularly relevant and better fulfilled in public than private contexts (between-

subject comparisons). In addition, as hypothesized, there was a decrease in need fulfillment for relatedness and popularity when participants imagined performing an initial public technology interaction without other people present (within-subject comparisons). However, we couldn't find evidence in our data to support our hypotheses regarding a relationship between social context and the fulfillment of the need for autonomy, competence, and security. Our results revealed that participants didn't score significantly higher for these needs in the private compared to the public context.

Supporting our hypothesis, the within-subject comparisons of the participants' scores regarding need fulfillment in the recall vs. imagined condition showed that imaginatively adding other people to a formerly private technology interaction can decrease the need fulfillment of autonomy. And since participants experienced less positive affect when they imagined performing the same interaction but in a modified form, i.e., with (in case of a recalled private experience) or without (in case of a recalled public experience), the results support our hypothesis that context changes have a negative effect on participants' affect.

4.1.1.4. Research Contribution

The present study found that positive technology-mediated experiences in public contexts mainly stem from relatedness and popularity. It therefore supports the idea of social needs, i.e., needs that are especially relevant or fulfilled in public contexts (Hassenzahl et al., 2010; Hassenzahl et al., 2015). However, contrary to our assumption, the need for competence, security, and autonomy did not reveal typical private, non-social needs. The study results not only suggest that the source of positive experience can depend on the social context, i.e., whether other people are present or not, but also that context changes negatively affect the user's experience. We explain the decrease in positive affect when hypothetically removing or adding other people to initially public or private experiences through a mismatch of context and technology interaction. These findings replicate earlier research, indicating a connection between social context, need fulfillment, and positive affect and underlining the risk of performing a technology interaction that is incompatible or even inappropriate for a specific social context. Therefore, an essential contribution of our study lies in its methodological implementation, i.e., the experimental design. Previous studies had already described positive technology experiences (in work and leisure contexts) in which other people were present or involved (e.g., Tuch et al., 2016; Zeiner et al., 2018; Hassenzahl et al., 2015). Yet their role or what effect their presence had remained unclear, as the social context was assessed retrospectively and not investigated experimentally in these studies.

However, like previous studies on technology experience (e.g., Hassenzahl et al., 2010; Hassenzahl et al., 2015; Tuch et al., 2016), our results are based on self-reporting and recollections. The study procedure of (retrospectively) assessing need fulfillment based on qualitative narratives is well-established in HCI research (e.g., Desmet & Fokkinga, 2020; Partala & Kallinen, 2012; Tuch et al., 2013). Our quantitative approach allowed systematic exploration of differences between public and private experiences with technology, but field observations would be a useful addition, for example, to avoid self-reporting biases or any misunderstanding of items (Paulhus and Vazire, 2007; Remillard et al., 2014).

A dichotomous classification of social context as we applied in the present study can also be viewed critically, as it is relatively simplistic. Previous studies specified the social context according to the

relationship with the user (e.g., Efthymiou & Halvey, 2016; Rico & Brewster, 2010). Other approaches referred to the involvement of the present others and based their differentiation, for example, on attendants' interest or insights into the technology interaction (e.g., Greuter et al., 2022; Wouters et al., 2016) or interaction with the user (e.g., Koelle, 2019; Nuñez et al., 2020). In our study, only a fraction of the reports in the public context concerned experiences with unknown people. Thus, more research is needed to investigate the influence of different attendants. Another limitation of the present study is that only the user perspective was recorded. However, deviations in the technology experience between the user and attendant are likely. For example, research on technology acceptance showed differences between the two stakeholders (e.g., Alallah et al., 2018; Koelle et al., 2015; Lucero & Vetek, 2014). Future research should, therefore, also capture the attendant perception, e.g., what they think or desire.

Overall, by experimentally exploring the sources of positive experiences with technology in public (i.e., when others are present) and private (i.e., when being alone) settings, study 1 overcame previous studies' theoretical shortcomings, enhancing the understanding of technology use in different social contexts. Our findings advocate for a more socially oriented perspective in HCI research and design, moving beyond the individual experience in a social vacuum or neutral, static social environment. For example, product development should implement features that enable interactive products to adapt to contextual changes such as a smartphone offering multiple "modes" depending on the level of publicness one desires for their interaction, or systems that respond intelligently to changes in the environment (Colley et al., 2016). Furthermore, technology usage/adoption models should (better) acknowledge the central role of social context and need fulfillment for positive experience (Hornbæk & Hertzum, 2017).

Study 1 contributes to the research question regarding (RQ1) the constitution of positive experiences with technology in public settings and the attendants' role. In sum, study results show that positive technology-mediated experiences in public stem from the need fulfillment of relatedness and popularity. These can be considered social needs as they are more important in public compared to private contexts. Furthermore, it appears that positive user experience in public technology-mediated experiences is closely tied to the presence of others as imagining the same technology interaction without the present others is associated with a less positive affect. However, further research is needed to clarify how different attendants (e.g., friend vs. stranger) affect the user experience or what the needs and demands of present others might be.

4.1.2. Study 2

Tretter, S., Von Terzi, P., & Diefenbach, S. (unpublished manuscript). How present others shape the user experience of service robots.

Building on the findings of the previous study, in study 2 our aim was to investigate how different attendants affect the user experience in public usage situations. Social needs, i.e., relatedness and popularity, play a central role in public technology-mediated experiences, but we assumed differences depending on who is attending. Specifically, we were interested in the impact of the relationship between the user and the attendant.

Although both social needs are fed from the presence of others, they are still different. Relatedness refers to the human need for connection and belonging, i.e., experiencing some connection or relationship with other people. The psychological need for popularity refers to an individual's desire for social recognition, approval, or positive attention, i.e., it is more about a favorable self-presentation than creating a feeling of community.

According to Goffman (1959), public technology interaction is comparable to a performance. The user (as a performer) will strive to control and shape the impression the attendants (as the audience) will form of them. This performer-audience relationship shapes the technology interaction in terms of if, how, and where. In a public space, all human actions have a performative aspect, even when they are not intentionally a performance (Hansen et al., 2011). In addition to the unobtrusiveness of technology interactions, some studies also emphasize the advantage of designing candid, i.e., more observable, interactions (Koelle, et al., 2020). Research showed that the relationship to the present others can impact the user's behavior and preferences. For example, Efthymiou and Halvey (2016) showed that the audience or location affects the likelihood of performing a voice-based (vs. text) search with a smartphone or smartwatch. Other studies such as Ahlström et al. (2014) or Alallah et al. (2018) found that these factors can also impact the user preference regarding gesture size or notability of the interaction. Holthöwer and van Doorn (2022) showed that social presence can be a source of discomfort, whereas Delgosha and Hajiheydari (2021) showed that social presence can enhance the perceived trustworthiness of robots. Public interactions may evoke positive or negative feelings, e.g., some interaction styles can be perceived as embarrassing, others can be perceived as cool (Koelle et al., 2020), but they also may provide the opportunity for favorable self-presentation or connection with others.

All in all, previous research has shown that attendants can affect the technology experience of users in many ways (e.g., need fulfillment or which form of interaction is preferred). Consumer research has also confirmed that the presence of others can influence the consumer's thoughts, feelings, and behaviors (e.g., Argo, 2020; Argo et al., 2005; He et al., 2012). However, it is still unclear how different attendants affect the user needs and demands in public usage situations, for example, when interacting with a service robot (Holthöwer & van Doorn, 2022).

Thus, study 2 addresses this research gap and focuses on the research question regarding (RQ1) the constitution of positive technology-mediated experiences in public settings, and the attendants' role.

4.1.2.1. Study Paradigm

This study explored how people imagine an ideal interaction with a service robot, depending on whether they are watched by a person close to them (i.e., an acquaintance) or unknown (i.e., a stranger). Therefore, we compared users' need for relatedness and popularity as well as their preference for an expressive, thus notable, interaction.

Previous research suggests that we are driven by distinct psychological motives when dealing with people who are more or less psychologically close to us, namely self-enhancement with distant others and a protective instinct with close others (Dubois et al., 2016). Thus, we hypothesized that depending on the relationship to the attendant (close vs. unknown attendant), people's need for relatedness and popularity differ; if the attendant is an acquaintance, then the need for relatedness is more critical, and in the case of a stranger, the need for popularity would be more important.

Fulfillment of social needs implies the presence (and attention) of others, which is why the expressivity of an interaction, i.e., that others can easily observe it, matters. Research findings indicate that when people feel like they can make a good impression on others, they are less concerned about talking to robots and may even tolerate privacy violations (Hedaoo et al., 2019). Furthermore, a meta-analysis in the context of self-service technologies (SSTs) showed that the negative effect of anxiety on the acceptance of SSTs is not generally stronger in public contexts than in private contexts. People may even see (emotional) support in others (Blut et al., 2016). We therefore hypothesized that a higher need for relatedness and popularity is associated with the preference for an expressive interaction.

Building on our previous argument that people's need for relatedness is higher with close attendants and that the need for relatedness is associated with a preference for (greater) expressivity, we further hypothesized that relatedness mediates the effect of the attendant relationship on expressivity. With close attendants, we expect people to seek a shared experience or connection and, therefore, a more expressive interaction.

Regarding popularity, we suggest a more complex model. We consider popularity to be one of several factors that can influence the effect of attendant relationship on expressivity. Inspired by the Control-Value Theory of Achievement Emotions (Pekrun, 2000, 2006) and recent findings emphasizing the role of performance expectations (Fan et al., 2020; Tojib et al., 2022) and blame attributions (Belanche et al., 2020; Fan et al., 2020), we also suggest that interaction success (i.e., success expectation) and perceived personal responsibility for that success (i.e., success attribution) are additional factors that moderate this mediation. In other words, popularity is expected to mediate between attendant relationship and expressivity, with this mediation being moderated by an interaction effect between success expectation and external attribution.

4.1.2.2. Sample and Procedure

228 people aged between 18 and 73 (*M* = 40.28; *SD* = 12.47; 58% males, 42% females, and one person identified as non-binary) participated in study 2.

The study was an online experiment with a between-subjects design including two conditions, an interaction with a service robot in a café involving either a close or unknown attendant. Participants had to assess one of two scenarios (presented as vignettes), both consisting of a short text description and schematic sketch, which were randomly assigned. More specifically, each participant was asked to take the user perspective and to provide ratings on their immersion ability (i.e., how well they could imagine themselves in the situation), statements reflecting their ideal experience (i.e., how they imagine a "best-case" interaction), success expectation (i.e., whether participants anticipate struggling with the interaction of the robot or not), and attribution (i.e., if they found themselves or the robot responsible in the event of an interaction failure). Statements reflecting participants' ideal experience included measurements of the need for relatedness and popularity (based on Hassenzahl et al., 2010; Sheldon et al., 2001) as well as expressivity (i.e., participants' desired level of visibility for their interaction). Exploratory items covered diverse aspects such as additional needs or social acceptability of the interaction.

4.1.2.3. Summary of Results

Our analyses confirm the hypotheses that people express a stronger need for relatedness with a close attendant and that a higher need for relatedness is associated with the preference for a more expressive interaction. Additionally, in line with our hypothesis, we found that relatedness moderates the effect of attendant relationship on interaction preference.

Contrary to expectations, participants did not express a higher need for popularity with unknown attendants compared to close ones. However, within-subject analyses showed that participants assigned to the unknown attendant scenario scored significantly higher on the need for popularity than relatedness. And the opposite was the case in the scenario with the close attendant. Furthermore, confirming our hypothesis, we found a positive correlation between the need for popularity and expressivity preference. As regards the mediation model with two potential moderators, we could only find support for some of the hypotheses, namely the three-way interaction of the mediator, need for popularity, and the two moderators of success expectation and external attribution. Contrary to our hypotheses, there was no indirect or direct mediation effect of the need for popularity on attendant relationship and expressivity.

4.1.2.4. Research Contribution

Service robots are frequently placed in public spaces, exposing users to social influences. However, existing research often neglects the interaction contexts. Our experimental vignette study builds on previous results such as the meta-analysis conducted by Blut et al. (2016) that revealed differences when using public vs. private self-service technologies. While vignette studies offer a valid means of systematically examining effects in a controlled environment (Aguinis & Bradley, 2014), participants' decisions are guided solely by the hypothetical scenario described. There might be a discrepancy in responding to a hypothetical scenario and the actual experience (Alexander & Becker, 1978). Our investigation also distinguishes from previous studies on self-service technology, predominantly focusing on failure prevention and negative experiences when considering the impact of present others (e.g., Fan et al., 2015; Qiu et al., 2018; Weber et al., 2016). We address this research gap by exploring how the presence of others can positively enrich the service experience.

The results of the present study offer insights into the effect of the attendant relationship on psychological needs and the desired expressivity, i.e., how noticeable and, thus, whether it can be observed by others. In our study, we specify the attendants based on relationships as being close (e.g., acquaintance) or unknown (e.g., stranger), which is just one of many ways to specify the audience in public technology interactions. Furthermore, we focused on the user experience. The attendant perspective of the service robot interaction is not assessed and consequently, we do not know what needs they have and whether these are compatible with the user needs.

Results showed that with a close compared to an unknown attendant, people express a higher need for relatedness, attributing it to the pleasure derived from sharing experiences with people that are especially important to a person. This conclusion is further supported by the fact that the need for relatedness also correlates with a preference for expressive interactions. Notably, the psychological need for relatedness mediates the link between the attendant relationship and the user's preference for an expressive interaction. With unknown attendants observing, we found that people were not significantly more motivated to present themselves favorably during an interaction with a service

robot compared to close attendants. However, people expressed a higher need for popularity than for relatedness, indicating that particular social needs are more or less important depending on the attendant relationship.

We also found support for our assumption that popularity is positively associated with the preference for expressive interaction, as visibility is essential for self-presentation. Furthermore, study results show that the association between attendant relationship and expressivity preference is more complex for popularity than for relatedness. While interactions that do not proceed as intended can still fulfill one's need for relatedness, there are additional prerequisites for making a good impression on others to fulfill the need for popularity, namely that the interaction is successful and this success is attributed internally. Our results confirm that the need for popularity when observed by unknown attendants is associated with a preference for expressive interactions, especially when users anticipate success and attribute it to themselves rather than external factors.

The finding that regardless of whether people seek relatedness or popularity, they prefer an expressive interaction supports the notion that a fit of interaction reason (i.e., the why) and interaction form (i.e., the how) creates positive experiences (Diefenbach et al., 2013). Furthermore, our findings support the idea that expressivity of interactions can be a "good thing" (i.e., positive user experience). In doing so, this study contributes to the research strand that considers candid interactions a reasonable design goal and thus, represents a kind of counter-movement to socially acceptable design, which focuses on not disturbing or embarrassing others (Koelle et al., 2020). Findings underline the importance of social needs for positive experiences (design). However, they also highlight the importance of theoretically distinguishing between the social needs that are addressed by an interaction. Depending on the attendants involved, users may prioritize the fulfillment of needs through a shared experience and connection (relatedness) or the creation of a positive impression (popularity). While the former is straightforward, the latter requires consideration of at least two situational factors. Specifically, success expectation and external attribution affect whether users aiming for a good impression on present others desire an expressive interaction. This extends the application of the control-value-theory of achievement emotions (Pekrun, 2000, 2006) to a new context but also underscores the importance of context-sensitive design to enable or foster positive user experiences.

To address the moderating effects of success expectation and external attribution, technology design should allow or support the possibility of adjusting the expressivity of an interaction. Although expressivity can also be a source of positive experience in situations with strangers, a potential challenge in such scenarios is the risk of errors during the ordering process, potentially causing embarrassment for the user. Moreover, this emphasizes the significance of designing service robots or interactions that enhance the likelihood of success and positive attribution, particularly in interactions with strangers. Overall, the study highlights the potential of considering present others as a valuable resource to enhance user experience. It also underlines the context-dependency of user's need fulfillment, i.e., specific social needs are more or less relevant depending on who the present others are.

These study findings therefore contribute to the research question on (RQ1) how positive experiences with technology in public settings arise, and what role attendants play. In sum, the presence of different attendants, whether close or unknown to the user, emphasizes distinct psychological needs. These, in turn, affect the user's expressivity preference, i.e., how observable they want their

technology interaction to be. Although we did not find significant differences between unknown and close attendants regarding the need for popularity, results show the need for popularity exceeds relatedness in scenarios with unknown attendants.

4.1.3. Study 3 and Study 4

Von Terzi, P., & Diefenbach, S. (2023). The attendant perspective: present others in public technology interactions. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-18). ACM. https://doi.org/10.1145/3544548.3581231

As outlined in the theoretical background of this thesis, many models and studies in HCI research focus (exclusively) on the experience of the primary user of technology, neglecting the perspective of present others. Even though the HCI community increasingly recognizes the importance and value of considering the attendant perspective, so far there is still a lack of attendant research. And the research that considers the attendant perspective reveals weaknesses. For example, it uses unclear and inconsistent terminology, and the attendant (experience) is usually only considered to be a means to an end or an influencing factor for the (positive) user experience (e.g., Colley et al., 2020; Hornbæk & Hertzum, 2017; Koelle et al., 2017). Many of the studies, or their recommended design and actions, aim to minimize the "impact" of present others on user interaction or experience. Thus, it is more about the user than the actual attendant experience. The attendant perspective has so far received little attention, not only in research but also in design practice (Flammer, 2016), although the added value, especially for many newer technologies such as VR glasses or voice assistants, cannot be denied.

Research showed that the role of present others in the public technology interactions of users, for example, if they are "actively" or "passively" attending (e.g., Candello et al., 2019; Gentile et al., 2017; Gugenheimer et al., 2017), affects the user experience. However, the attendants' experience can also differ depending on the roles they take or the phase they are in (e.g., Downs et al., 2014; Greuter et al., 2020; Hepperle et al., 2020). Previous studies suggest differences in perceived control and/or visibility while watching or listening to public technology interactions (e.g., Eiband et al., 2017; Puikkonen et al., 2011; Wagenknecht, 2018). However, it is unclear what attendants need or want when co-experiencing public interactions with technology in general, i.e., regardless of which specific device or system is involved, let alone through which actions or design strategies this could be achieved. Therefore, a better conceptualization and operationalization of the attendant perspective (trans-technologically) is needed to improve the understanding of attendants and their experience.

Study 3 and study 4 address this research gap and focus on the following research questions: (RQ2) How to specify and analyze the attendant perspective in public technology interactions? (RQ3) How do attendants (co-)experience public technology interaction? And (RQ4) Which action and design strategies can improve the attendant experience of public technology interactions?

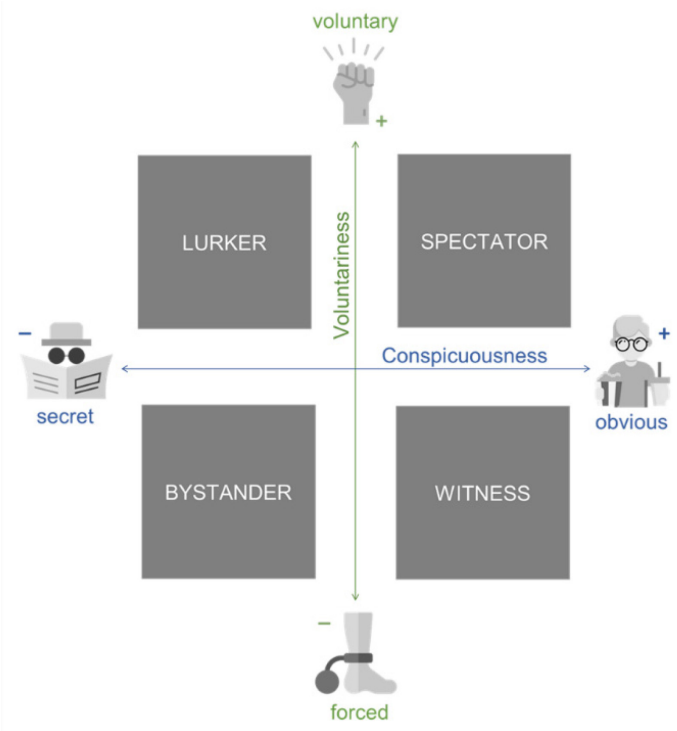
4.1.3.1. Study Paradigm

The idea was to develop a role model to (better) describe and analyze the attendant experience and thus, support systematical investigations in future research studies. There are no models or frameworks analogous to TAM or UX models that we can build on when capturing the attendant perspective. Therefore, in an iterative process including literature research, interviews (study 3), mini-

pretests, and feedback from research colleagues, we developed a typology that specifies the attendants in public technology interactions (see Figure 2). More specifically, it determines four types using two criteria, voluntariness of attending the user interaction (forced vs. voluntary) and conspicuousness of attending the user interaction (secret vs. obvious). The criterion voluntariness refers to the degree of perceived self-determination, indicating whether co-experiencing the technology interaction is the attendant's decision or whether they feel compelled to do so. Conspicuousness relates to the level of attention the attendant thinks they receive from the user, i.e., whether they believe the user recognizes them as an "observer" or not. The resulting four types are: lurker (voluntarily and secretly attending), spectator (voluntarily and obviously attending), bystander (forcedly and secretly attending), and witness (forcedly and obviously attending).

Figure 2

Attendant typology classifying four types by two criteria



A test of the typology (study 4) was supposed to show whether a nuanced distinction of the present others is reasonable, i.e., if and how the types differ in their experience. We also suggest that one-size-fits-all solutions are inadequate when designing public technology (interactions) as they do not reflect the complexity of the attendant perspective, i.e., as a diverse group of stakeholders. For this reason, we also collected some qualitative data regarding design and reaction recommendations.

Study 3 followed an explorative approach to gain initial insights into the attendant experience. In particular, we interviewed people about situations in which they found themselves in the role of an

attendant and asked them to describe positive as well as negative experiences from their past. We were interested in their feelings, thoughts, and behavior in particular situations.

In study 4, we experimentally manipulated the attendant type and explored people's experiences in a concrete use case: a user listening to music in public. We expected that the experience of the attendant types, i.e., lurker, spectator, bystander, or witness, reflect the differences in the criteria dimensions, conspicuousness and voluntariness. Inspired by previous user research, the present study examined factors including participants' emotional responses (Agarwal & Meyer, 2009) and demands or expectations (Goffman, 1959). More specifically, we suggest that an obvious observation is associated with a stronger affective reaction, whereas secretly co-experiencing is less "thrilling" and, therefore, less activating. Since obvious attendants believe they are noticeable, they might feel they deserve (more) respect from the user, i.e., the user should consider their presence and adjust the interaction with technology accordingly. Secret attendants think the user does not notice them. Consequently, the attendants do not expect the user to change their behavior to make the technology interaction more transparent or acceptable for them. If attendants feel forced to co-experience, it could lead to stronger emotions and a sense of powerlessness or loss of control. We also link the feeling of being forced with less interest and understanding of personal responsibility. Attendants who therefore willingly choose to watch or listen to technology interaction might be more interested in the user's goals or motives and attribute the responsibility for their experience primarily to themselves rather than the user.

To sum up, in study 4, we hypothesized that participants in the obvious compared to the secret conditions experience higher arousal and a stronger desire for transparency and consideration. Moreover, participants in the voluntary, compared to the forced conditions, experience lower arousal, higher dominance, a stronger desire for transparency and a weaker desire for consideration.

4.1.3.2. Sample and Procedure

In study 3, we interviewed 20 people aged between 19 and 62 (M = 26.25, SD = 11.35; 60% female, 40% male). In study 4, 181 participants aged between 19 and 69 (M = 30.56, SD = 9.40; 39.8% female, 56.9% male, 1.7% non-binary, 1.6% no answer) took part.

The semi-structured interviews of study 3 were conducted in German. In the first part of the interviews, participants reported a positive attendant experience from their past, and a negative attendant experience in the second part. After each report, we asked a few questions to collect some details about the user's technology interaction (which technology, how, and where it has been used), the "observation" (reason and goal, strategy, consequences), the conditions (environmental, social), the experience (perception, feelings, thoughts), and a general evaluation (user, product).

In study 4, participants were randomly presented with one of four vignettes, in which we varied the voluntariness and conspicuousness of attending the user interaction (here: listening to music). In other words, each participant assumed the role of a particular attendant type: lurker, spectator, bystander, or witness. Following the manipulation, we asked the participants to assess their perception of the situation, i.e., what they (imagine to) feel and desire. Besides the emotional response, arousal and dominance, and the desire for consideration and transparency, the questionnaire also included some additional variables for explorative reasons. Most importantly, we asked participants to share some ideas on what the user or the attendant themselves could or should do to make the situation more

pleasant for the attendant, to later derive specific design and action recommendations from the results.

4.1.3.3. Summary of Results

In study 3, we collected detailed descriptions of attendant situations, positive and negative. They provided interesting insights into characteristics to distinguish and categorize different attendant experiences. The descriptive statistics revealed that participants co-experienced an interaction with a mobile device (e.g., smartphone or headphones) in 22 cases, with fixed or public devices (e.g., ATM or ticket vending machine) in 10 cases, and the usage of transport vehicles (e.g., e-scooter or car) in eight cases. Moreover, curiosity/pastime, intrusion, waiting, information search, preparation for action, and indignation were identified as reasons for observation. The analysis of the participants' answers regarding which feelings the observation evoked identified tension, attraction, joy, relief, security, surprise, anger, guilt, pity, and incomprehension as prevailing emotional states. In addition to descriptive statistics, the application of typology also provided essential findings. Specifically, we were able to categorize all experience reports based on the two criteria of voluntariness and conspicuousness, i.e., each story could be assigned to a specific type. Moreover, our results showed that both positive and negative experiences were assigned to each type.

Study 4 was aimed at expanding on these findings by experimentally exploring whether and how the experience of the particular types differs in a concrete use case. Analyses of quantitative (for hypotheses testing) and qualitative data (for exploratory analyses) revealed type-specific differences. Firstly, analyzing the mean scores of the key variables of arousal, dominance, desire for consideration, and desire for transparency, in the four conditions primarily supports our hypotheses. The results showed that conspicuousness is associated with arousal and voluntariness with arousal, dominance, transparency, and consideration. In particular, we found that obvious attendants experienced higher arousal than secret attendants. In addition, voluntary compared to forced attendants experienced lower arousal, higher dominance, a stronger desire for transparency, and a weaker desire for consideration. Secondly, the exploratory analyses of the participants' answers regarding ideas for potential actions the user and attendant could take also revealed some differences between the four types (as well as a few commonalities). Depending on the conditions they had been assigned to, participants suggested that the attendants should, for example, either *"*shield*"* themselves or talk to the user. Interestingly, directly intervening or abruptly terminating the interaction was, apart from isolated references, not an option for the participants in any of the conditions.

For users, participants' ideas included changes in the technology or interaction style, turning away, enabling participation, or friendly gestures.

4.1.3.4. Research Contribution

All in all, the two studies showed that it is possible and reasonable to have a nuanced conception or distinction of the present others. Rejecting an oversimplification of present others as (social) context or "everything else" (Kuutti & Bannon, 2014), our study provides novel and nuanced insights into the diverse aspects of the attendant experience, including type-specific differences in the experiential patterns.

The findings of study 3 concerned diverse reports of positive and negative experiences regarding everyday observation situations. Our results not only gave the first insights into the attendant experience, e.g., feelings, thoughts, and motivation, they also showed that typology or our choice of types can be considered to be realistic and useful. Each of the experience reports could be assigned to a type, and all types reappeared in the data. Interestingly, each type was assigned to both positive and negative experiences. However, it is important to note that we do not claim that the typology or criteria and types are exhaustive. Therefore, further research could explore additional criteria and extend the typology.

Study 4 provides empirical evidence for the assumptions of type-specific differences in the experience of the attendant types. Specifically, analyses supported most of the expected associations of experiential qualities, such as affect and desires, and attendant types, or the conspicuousness and voluntariness of attending a user-technology interaction. Moreover, to the best of our knowledge, study 4 is the first to experimentally examine the emotional and psychological attendant experience in public usage situations. The overall goal was to explore whether differences between types are likely, i.e., whether it is reasonable to specify present others, and to support this with empirical evidence, which we largely succeeded in doing. The fact that we could not find support for some hypotheses could also be due to the dependent variables we chose or their operationalization, respectively. As yet, there are no valid measurements for attendant experience and so we mainly used items from research on the user (and adapted them accordingly). Future research should aim at developing and validating measurements of the attendant experience. Furthermore, the choice of our use case could also have played a role; in situations involving more personal or sensitive matters, conspicuousness might be more important because exposure in such scenarios may involve more significant social risks – for both the attendant and the user. Our study built on previous research that emphasized the importance of considering different attendants (e.g., Dix & Sas, 2010; Gentile et al., 2017; Greuter et al., 2022) and on the explorative findings of our interview study. Introducing and testing the typology in an experimental study not only demonstrated that our typology is a helpful way to more accurately describe and operationalize present others in public technology interactions but can also be considered a crucial step toward systematic research into understanding the attendant perspective.

Qualitative insights regarding (re-)action possibilities for users and attendants revealed a broad and diverse range of ideas concerning how to improve the attendant experience in the specific observation situation. The answers clarified similarities and differences between the conditions/types that need to be considered, thus emphasizing the relevance of (social) context-sensitive design solutions or a good context-interaction fit. Thus, the results of study 4 illustrate an additional value of the typology, inspiring the development of concrete action and design recommendations, e.g., notifications to improve user awareness, rotating seating with high walls, which can act as a kind of cocoon or bubble, or encouraging shared experiences like the exchange of music tips via a public display, to name a few. Ideas regarding behavioral strategies to improve the attendant experience included looking for distractions, initiating social interaction with the user (for attendants), or critically questioning the impact of their technology use in public spaces (for users).

Other studies have already shown how considering the attendant perspective can inspire innovative product development (e.g., Jarusriboonchai et al., 2016; Mauriello et al., 2014; Pearson et al., 2015). However, neither the general nor a specific attendant experience per se has yet been an explicit

(design) objective of empirical research. Since our recommended strategies are derived from exploratory analyses, they require further systematic and experimental validation. For example, the development of personas (Cooper, 2004) based on typology could be a promising approach to support the design of innovative interactive products or product ideas in practice.

Overall, by developing and testing the attendant typology, we have contributed to a greater or more accurate operationalization of social context and systematic exploration of the attendant perspective in future research studies. Results revealed insights into the attendant experience in general and type-specific differences, thus providing a deeper understanding of the attendant perspective in public technology interactions. Based on the qualitative input collected in study 4, we also derived some design and action recommendations for the different types.

The findings of studies 3 and 4 therefore address the research questions regarding (RQ2) the conceptualization and operationalization of the attendant perspective as well as (RQ3) the attendants' co-experience of public technology interactions. Additionally, study 4 addresses the research question of (RQ4) action and design strategies to improve the attendant experience. In sum, results showed associations between attendant type and attendant experience, i.e., affective reaction and demands. However, we did not find all hypothesized associations, which may be due to methodological reasons such as the measurement of attendant experience or the choice of scenario. The derived design and action recommendations, first and foremost, were supposed to highlight the existence of type-specific differences or preferences. They can serve as guidance and inspiration for future work; they demonstrate how taking the perspective of different types generates diverse ideas for design and action strategies. However, a lot of (explorative) research still needs to be done in order to better understand the attendant experience in general and further investigate type-specific experiences, as well as more concrete design and action recommendations.

4.1.4. Study 5 and Study 6

Von Terzi, P., & Diefenbach, S. (2023). The attendant card set: a research and design tool to consider perspectives of attendants versus users when co-experiencing technology. *Multimodal Technologies and Interaction*, *7*(11), 107. https://doi.org/10.3390/mti7110107

After the previous studies provided initial insights into type-specific differences and similarities, further information was collected to deepen the understanding of the attendant perspective in public technology interactions. This is important for establishing the construct in HCI. In contrast to user experience, where a whole range of models can be used to derive recommendations for action and design (Peters, 2023), there are rather isolated, context-specific recommendations regarding the attendant experience. These primarily not only relate to a specific usage scenario but also aim to avoid or reduce negative experiences rather than create or promote positive ones (e.g., Denning et al., 2014; Koelle et al., 2015; McDaniel & Wesselmann, 2021).

Other studies have already demonstrated that specifying different roles in public technology interactions provides added value when evaluating and designing technology (interactions). For example, Greuter et al. (2022) describe different user and attendant roles (they call them users in the peripheral frame, in the audience frame, in the performance frame, and the orchestrator frame) for

public VR installation and suggested role-specific design tactics. They conclude: “Our design space reminds designers that multiple [stakeholder] roles exist, each with their own expectations, demands, and needs.” (p. 804).

So far, there is hardly any systematic research on the general or specific attendant experience, i.e., we do not know enough about what attendants need or want, and user-centered design that focuses only on users often ignores the role of bystanders (Flammer, 2016). Yet, there is a lack of general/trans-technological design and action recommendations or guidelines explicitly addressing a positive experience from the perspective of (different) attendants. Study 3 and study 4 laid the groundwork for a systematic exploration. However, further research is needed into what attendants need and want when co-experiencing diverse everyday user-technology interactions.

Thus, study 5 and 6 address this research gap and focus on the research questions regarding (RQ3) attendants (co-)experience of public technology interaction, and (RQ4) action and design strategies that improve the attendant experience.

4.1.4.1. Study Paradigm

The aim of these studies was to make the results of study 3 and study 4 or the typology more “tangible” and enable a broader application beyond (online) experiments. Personas and design cards are popular methods for visualizing research results and gaining new insights (see e.g., privacy mediation cards of Koelle and Boll, 2019; design card set of Ringfort-Felner et al., 2022; persona cards of Lee et al., 2021). Card sets represent a well-established and versatile tool in the field of HCI, considered “tangible idea containers, triggers of combinatorial creativity, and collaboration enablers” (Lucero et al., 2016, p. 75). Literature, including reviews by Aarts et al. (2020) and Roy and Warren (2019), describes them coming in various styles and serving different purposes across various application domains, such as repository tools or support in participatory design. They can encourage perspective-taking, communication, empathy, and collaboration between designers and users or address specific design challenges (Wölfel & Merritt, 2013). Personas likewise offer numerous benefits (Nielsen, 2019; Salminen et al., 2022) and are therefore also a valuable tool for product design and development. They are hypothetical representations of potential users or derived from data of real users, effectively making their perspectives tangible and comprehensible. Personas enable a deeper understanding and empathy for the users (Goodman et al., 2007; Winter et al., 2012).

We decided to translate our typology into a combination of design cards and personas, the Attendant Card Set (ACS). It shares conceptual parallels with personas, delineating roles rather than personalities. The card set consists of a total of five cards, with one card per attendant type and one introduction card. During the development process, we followed the suggestions of Hsieh et al. (2023) on how to enhance the design and use of cards. For example, the cards include textual descriptions and visual representations, ensuring intuitive comprehension without professional support. We see great potential in the broad and straightforward application of our typology in the research and development process with the help of the ACS to offer more significant consideration and establishment of the attendant perspective in the HCI community. However, whether the ACS works, is usable, and valuable still has to be substantiated with empirical findings. Therefore, we conducted two application and refinement studies, testing and improving the card set in a practical setting and collecting further insights regarding the attendant experience and possible design and action recommendations.

4.1.4.2. Sample and Procedure

Thirteen participants aged between 23 and 38 (*M* = 29.62, *SD* = 4.33; 69.2% females, 30.8% males) took part in study 5 (expert survey). Five participants aged 22 to 38 (*M* = 26.20, *SD* = 6.65; 80% females, 20% males) participated in study 6 (student workshop).

The expert survey included two parts. In part A, participants tested the cards by using them for specific research and design tasks, namely reflecting on an ideal attendant experience, how to assert the attendant interests, and promising features and functions. In part B, we asked some closed questions (quantitative data) and open questions (qualitative data) to collect participants' feedback on the cards, e.g., their usefulness or engagement potential. Since all participants were randomly assigned to one of the four types at the beginning of the study, each participant only used and evaluated one card during the survey.

The workshop comprised three parts: a warm-up, theoretical input, and practical tasks. More specifically, participants were first asked to tell us about an attendant experience from the past, gaining familiarity with the attendant perspectives and raising awareness of different roles one can take as an attendant. After introducing the typology and card set, each participant was assigned an attendant type and was handed the corresponding card. Each participant used their designated card for the workshop's final phase, which involved solving practical tasks such as (1) creating sketches of smartphone interactions to visualize the attendant perspective, (2) analyzing psychological needs, (3) reflecting on user behavior and contact as well as acceptable attendant behavior, and (4) assessing the relevance of civil inattention (i.e., engaging in deliberate actions to convey to others, "I am not paying attention to you."; Goffman, 1963). The participants solved all of these tasks, first individually, and then their ideas were discussed in a group. In doing so, participants identified differences and similarities among the attendant types.

4.1.4.3. Summary of Results

Regarding study 5, experts' responses in part A suggested some promising design and action strategies. For example, participants in the lurker condition recommended acting disinterested by faking focus on other activities when asked about good behavior for attendants that would enable them to protect or satisfy their interests. When asked about a technological feature or function that would improve the attendant experience, participants came up with various ideas for the technology design, e.g., some kind of gadget enabling attendants to signal their needs to the user without verbalizing them (spectator condition). Analyses of quantitative and qualitative data of part B revealed positive expert assessments overall and that they see a value in the ACS. For example, participants appreciated the sketches, typology overview, background information, example situations, and quotes in the cards. The experts suggested the distribution of the information on both sides of the cards, a more straightforward layout, and additional instructions to improve the design and usability of the card set. Even though some of the experts had former experience with other card sets or design tools, none of them knew of an alternative for capturing social context in technology interactions. The experts described various potential or future use cases such as product evaluation, UX assessment, prototyping, user testing, interviews, or game design.

Regarding study 6, the analyses of the qualitative workshop data provided some further insights into the attendant experience and behavior. First, the (differences in) participants' sketches of smartphone

interactions from the perspective of the assigned type (task 1) showed that all of them could be immersed in a specific attendant role with the help of the cards. Furthermore, the group discussion revealed some parallels as well as differences between the attendants co-experiencing the interaction of a user with a smartphone. The group discussion focused on the importance of needs (task 2), optimal user behavior and contact, socially acceptable attendant behavior (task 3), and the relevance of civil inattention (task 4). Through this discussion, attendants discovered some similarities and differences in the way they, or rather their assigned type, experienced user interactions with a smartphone. For example, participants explained that there are needs that are relevant for one particular type (e.g., competence for lurkers) as well as needs that are essential for all types (e.g., stimulation). Regarding user behavior and contact, it was discussed that user attitude seems to differ between types. Eye contact, on the other hand, was described as a frequent form of user contact of obvious types and thus represented a commonality according to the participants. In addition, participants identified giving the user enough space as a critical socially acceptable behavior for obvious types, whereas, for example, initiating social interaction seems to be more or less acceptable depending on the specific type. Regarding civil inattention, the participants agreed that it can be an essential strategy for all types except spectators. However, they stated that the reasons for this differ between the types.

4.1.4.4. Research Contribution

The contribution of study 5 was two-fold. On the one hand, part A data analysis provided more and detailed insights into the attendant perspective, showing that the ACS can inspire creative thinking. Furthermore, findings expand on the insights from study 3, namely that diverse positive experiences (with all kinds of technological products or systems) are also possible for attendants of user-technology interactions. The diversity of participant answers across the conditions supported findings from our earlier studies, namely that the experience can differ between the types and thus, specification of present others is reasonable. Participants' responses also inspired the improvement of the ACS, for example, we included participant ideas regarding how to enable a positive experience for the particular types on the corresponding cards. On the other hand, the experts' feedback regarding the design, usability, and practical relevance of the cards (part B) underlined and helped us further improve the applicability and utility of the ACS. The experts' diverse input on ideal attendant experiences and ideas for useful technology features, as well as attendant actions to achieve those positive experiences, offer further information on what attendants want and need from observation situations (with a broad range of technologies), and what technological design solutions could look like. Furthermore, the experts' innovative suggestions demonstrate the value of extending the target group and focusing on the attendant for a new and different perspective on public technology interactions and thus challenge the current UCD practices in the HCI community.

With the student workshop (study 6), we tested the applicability of the ACS in a situation we consider to be a common and realistic setting in practice, namely working on-site with people without specific professional knowledge. The findings of study 6 relate to understanding and analyzing the implications of different types. The cards supported the participants in perspective-taking, i.e., delving into the experience of a specific type. They also served as a basis for discussions, whereby differences and similarities were identified between the attendant types regarding the importance of psychological needs, desired level of user contact and user behavior, social acceptability of attendant behavior, and relevance of civil inattention. Overall, participants' ideas and solutions for the practical tasks and the group discussions provided some further information on the (variance of) attendant experience.

Findings relating to the relevance of the needs can be a starting point for further quantitative research examining differences experimentally. Since psychological need fulfillment has proven central to positive technology-mediated experience (for users, e.g., Hassenzahl et al., 2013; Hassenzahl et al., 2015; Hornbæk & Oulasvirta, 2017), this is an essential next step when it comes to the development of design solutions that are intended to enable a positive experience for all stakeholders. Additionally, first insights into user-attendant interdependencies, e.g., the (desired) form and extent of social interaction, were gained. These can serve as orientation for how to behave as a user and attendant to ensure the attendants' interests are protected or supported. However, further research is necessary as the study results are exploratory.

Our studies are not without limitations. For example, the sample sizes are quite small, but this is not critical for qualitative research (O'Reilly & Parker, 2013). If larger samples are available, (exploratory) findings from the present studies can be extended using statistical analyses. A greater diversity in the samples, for example, regarding cultural or educational peculiarities, could provide insights into the generalizability of the findings. Field observation would also be a valuable addition, for example, to gain insights into user-attendant dynamics and potentially extend the ACS. Analogous to the previous note regarding the fact that we do not claim exhaustiveness for types or criteria of the attendant typology (see study 3 and study 4), it also applies that it is possible to extend the ACS. In alignment with Aarts et al.'s (2020) recommendation for developing open-ended card sets, the capacity to expand the ACS by including emerging research insights allows for ongoing flexibility and advancement.

All in all, findings imply that the ACS enables and fosters conscious reflection on the attendant perspective. Like other design cards it can inspire creative thinking and ideation and foster communication and empathy in designers/researchers (e.g., Kwiatkowska et al., 2014; Lucero & Arrasvuori, 2010; Wölfel & Merritt, 2013). It is considered user-friendly and widely applicable. For example, no specific prior knowledge is required, neither professionals (study 5) nor laypersons (study 6) had problems using the cards in our studies, and application is quick and can be done without much preparation. The ACS can fulfill various goals, e.g., for ideation, design, or evaluation. Its utility extends to both explorative scenarios, where the cards act as a kind of catalyst for delving into attendant experiences, and directed scenarios, where the focus is on addressing specific usage situations. Furthermore, the ACS is unique in mapping the social contexts or present others in public technology usage as there is no comparable tool to our (and the experts') knowledge.

Thus, study 5 and study 6 contribute to the research questions of (RQ3) attendants (co-)experience public technology interaction, and (RQ4) action and design strategies that can improve the attendant experience. In sum, with the two studies, we gained a better understanding of attendant characteristics and differences as well as commonalities in the experience of attendants. In addition, they demonstrate how overcoming shortcomings of the prevailing UCD practice, namely forgetting or neglecting the attendant perspective, can inspire context-sensitive design solutions and behaviors. The publicly available card set is a simple way to make people aware of the role and experience of the attendants. However, further research is needed to implement the attendant perspective in the research and design practice. A combination or integration with other methods in design, e.g., design thinking (Camacho, 2016) or cognitive walkthrough (Polson et al., 1992), is easily conceivable.

4.2. Book Chapter

Von Terzi (2022). Technisierte Öffentlichkeit: Einflüsse der Digitalisierung auf den öffentlichen Raum als Ort der Begegnung. In S. Diefenbach & P. Von Terzi (Eds.), *Digitale Gesellschaft neu denken: Chancen und Herausforderungen in Alltags- und Arbeitswelt aus psychologischer Perspektive* (pp. 96-132). Kohlhammer. https://doi.org/10.17433/978-3-17-041191-3

The book chapter with the title "Technisierte Öffentlichkeit: Einflüsse der Digitalisierung auf den öffentlichen Raum als Ort der Begegnung" (engl., "Technified public sphere: the impact of digitalization on public space as a place of encounter") has been published in an anthology entitled "Digitale Gesellschaft neu denken" (engl., "Rethinking the digital society"). It discusses the connection or interdependencies between digitalization, i.e., omnipresent technology, and public life, i.e., people's perception and behavior in public spaces.

Due to technological advances such as mobile technologies or ubiquitous computing environments, the boundaries between the private and public space are becoming blurred or must be redefined. I outline this development as the technified public sphere, whereby a distinction is made between the communal and private technified public sphere. The communal technified public sphere is formed through the automation of services and the development of innovative products meant to make our environment "intelligent". Thus, this kind of technified public sphere is created through technology that is used by the general public and can be considered a part of the public space, such as ordering terminals or service robots. On the other hand, the private technified public sphere is created by people using personal technology in the public space. With the rise of mobile devices such as smartphones or tablets, the private enters the public space.

The development summarized as technified public sphere poses individual and societal risks. For instance, the widespread use of mobile devices has made it easier to invade users' privacy by observing their screen content (e.g., Saad et al., 2021; Eiband et al, 2017). At a societal level, there is the risk of a (digital) division of society where some members may be left behind due to their inability or unwillingness to use technology. This could result in discrimination, as those who cannot or do not want to use technology may miss out on certain benefits, such as time savings and lower prices (Kelly & Lawlor, 2021). A survey conducted by Lühr et al. (2020) highlighted that people fear the possibility of such a social division.

However, the book chapter also presents concrete design implications and recommendations for action on how to meet these and other challenges, i.e., how to overcome the status quo and pave the way for a "better" technified public sphere. For example, privacy concerns when using personal mobile devices in public can be addressed by distorting or individualizing information such as images or texts (e.g., Eiband et al., 2016; Von Zezschwitz et al., 2016). To prevent a (perceived) division of society into users and non-users, "vulnerable persons", e.g., older people (Peine & Neven, 2019), need to receive support. If the reason for not using a specific technology is unwillingness rather than inability, effective ways to avoid interaction should be implemented (Williamson & Sundén, 2015). The appropriate strategy for dealing with non-users depends on why they are not using the technology (Oostveen, 2014).

In general, research can provide multiple starting points to uncover and minimize the risks associated with digital transformation of the public space. However, this can only be achieved with support on an individual and societal level. Coping with the challenges of a technified public sphere requires a certain level of self-reflection and flexibility. More research is needed, especially on the psychosocial consequences. Only then can we overcome the current status quo and fully realize the potential of a technified public sphere.

5. General Discussion

Technology integrates further and further into the public space, i.e., public technology interactions are now part of our everyday life. Public space implies the presence of others and so there are other stakeholders besides the user who need consideration: attendants co-experiencing the user-technology interaction, i.e., "just" listening or watching. These present others influence and are influenced by the users.

Imagine your partner calling you on your smartphone. How would you feel or react when answering while sitting on your couch? And what about when sitting on a train? Now, imagine the perspective of the person sitting next to someone starting a phone call with their partner on a train. As an involuntary listener, you might feel annoyed or maybe slightly amused. The whole situation might feel different if you voluntarily put yourself in such a situation; you are walking through the train wagons looking for a seat and pick up the first snippets of a spicy phone call. Positioning yourself close to the person talking on the phone to follow the conversation for a while might be far more entertaining than just staring out the window to kill time. Attending a public technology interaction like a phone call obviously or secretly can trigger different feelings and thoughts; wouldn't it be great to sometimes be able to join in another person's conversation, but secretly spying on someone talking on the phone can also be appealing, can it not?

In the field of HCI, there is now an increased focus on the social context of technology use. However, it is not clear what (positive) role present others can play in technology interactions beyond being "intruders" or "victims". There is also a lack of research that explicitly explores the experiences of attendants, i.e., how they perceive public technology interactions, and what their expectations and needs are. Therefore, taking a human-centered approach should also consider the perspective of attendants to be crucial for enabling positive technology-mediated experiences in public settings.

5.1. Summary of Research Findings

This thesis explores the following four research questions; (RQ1) How do positive experiences with technology in public settings emerge, and what role do attendants play in this?, (RQ2) How to specify and analyze the attendant perspective in public technology interactions?, (RQ3) How do attendants co-experience such interactions?, and (RQ4) Which action and design strategies can improve the attendant experience?

The first question regarding the emergence of positive technology-mediated experiences in public and the role of attendants (RQ1) was addressed with two experimental studies focusing on the user experience. According to the relevance of need fulfillment for positive experience in general (Ryan & Deci, 2000; Sheldon et al., 2001) and of technology in particular (Hassenzahl et al., 2010; Hassenzahl et al., 2015), we examined user's need fulfillment in both studies, study 1 and study 2. In study 1, we experimentally manipulated the social context of positive experiences with technology and compared the fulfillment of different needs in public (i.e., other people present) vs. private (i.e., alone) usage situations. Our results suggest that the need fulfillment for relatedness and popularity is more relevant in public contexts, and imaginatively removing the present others in these situations diminished positive affect. The findings therefore imply that positive public technology experiences are primarily characterized by feelings of relatedness and popularity and are closely tied to the presence of other people. Building on this, study 2 examined – also from the user perspective – the impact of different

attendants. We manipulated the relationship with the attending person (close vs. unknown) and compared users' need fulfillment and preference regarding the expressivity of the technology interaction. The results imply that with close attendants, the user's need for relatedness is stronger and so they favor an expressive interaction. When the attendant is unknown, the need for popularity prevails over the need for relatedness, with popularity also being linked to a preference for expressive interaction. This preference is even stronger when users perceive the interaction to be a self-attributed success. Overall, insights highlight that positive public experiences primarily stem from what we refer to as social needs, relatedness, and popularity. However, the importance of the need for relatedness and popularity can differ depending on who is watching or listening. Consequently, contrary to the prevailing view, attendants can be a source of positive experience. If users are seeking opportunities for favorable self-presentation and connection with others, expressive interactions can be a great way to achieve this.

The second question on the conceptualization and operationalization of the attendant perspective (RQ2) was addressed qualitatively (study 3) and quantitatively (study 4), focusing on the attendant experience. Since there is still a lack of systematic research or theoretical foundation for the attendant experience, we first conducted an interview study to exploratively examine people's self-experienced attendant situations (study 3). This was followed by a mainly quantitative investigation of participants' thoughts and feelings in a hypothetical attendant scenario (study 4). Our findings suggest that specifying four different types of attendants (lurker, spectator, bystander, and witness) is a reasonable way to describe and analyze the attendant perspective. For example, all experience reports in study 3 were covered by our typology, and each type could be assigned to both positive and negative experiences. The results of study 4 revealed type-specific differences in the experience of technology interaction and so support our assumption that it is not sufficient to consider the present others in technology interactions as a "homogenous unit". Consequently, a specification of the social context in research studies seems necessary because a finer distinction enables a more precise understanding of the attendant experience.

The third research question on attendants' co-experience (RQ3) was addressed through interviews (study 3), an online experiment (study 4), an expert survey (study 5), and a workshop (study 6). All four studies explored differences and similarities between the attendant types with regard to multiple psychological aspects such as motivation, emotions, and thoughts. In particular, the qualitative interview study provided insight into attendants' reasons for observing, their emotions, and an evaluation of the user and the product. Through the experimental study, we expanded our understanding of the association between the conspicuousness and voluntariness of attending the user interaction and the attendant's affective reactions and demands. The survey results, or specifically the experts' diverse descriptions (concerning different technologies) of ideal attendant experiences, underline the fact that various positive technology-mediated experiences are also possible from an attendant perspective. In the workshop, which involved individual tasks and group discussions, comparisons of the different attendant perspectives revealed that the relevance of psychological needs and the evaluation of social interaction with the user can differ but that there are some commonalities as well. Overall, these findings improve our understanding of the attendant experience and provide insights into type-specific experiential patterns and general attendant experience characteristics. They also highlight that attendants can have positive experiences with all kinds of technology.

The final research question referred to the action and design strategies that can support a positive attendant experience (RQ4) and was addressed through qualitative analyses in two studies (study 4 and study 5) focusing on the perspectives of the different attendant types. While the experimental online study (study 4) used the attendant typology to compare the four types, the ACS was used in the workshop (study 5) for perspective-taking and as a basis for discussion. In study 4, participants described possible user and attendant actions to promote a positive attendant experience. Participants' responses suggest that there are several ways to achieve this goal, specific to the type of attendant and surprisingly, abruptly terminating the interaction was not a popular claim. Moreover, the derived design recommendations illustrate context-sensitive design solutions, not only for technology but also regarding the environment/public space. Therefore, the findings imply that there are other means of supporting and protecting the interests of the attendants beyond altering user interaction or technology. In study 5, experts shared their ideas on ideal experiences for attendants and suggested diverse technological features and functions, both existing and fictional. They also reflected on concrete actions that attendants themselves can take to promote a positive experience. The study findings imply that type-specific solutions (regarding attendant actions and technological features) are needed but also more general strategies are possible. For example, expressing (dis-) interest in a product or interaction through non-verbal signals is a promising approach. Overall, the studies reveal that specifying different attendants, in the form of the attendant typology (study 4) or ACS (study 5), can inspire and promote positive technology experiences in public. Considering the attendant perspective in the design or research process does not necessarily mean limiting or interfering with user interaction or technology. The explorative findings imply different design approaches for a positive technology experience in the public space: user technology, attendant technology, and public space. In addition, they underline the importance of people critically reflecting on their actions because the user's and attendant's behavior and experience are closely linked. They should act thoughtfully and be aware of their role and the role of others – and technology could support this.

5.2. Theoretical Implications

Broadly, the theoretical implications of this thesis can be categorized into two areas; on the one hand, it contributes to the large field of user experience research, and on the other hand, it provides initial insights and the basis for further systematic research into the perspective of the attendants. While the appended manuscripts offer more detailed explanations of the theoretical implications of the particular studies, the following section places the thesis's essential findings in the context of current research, starting with the results of the user experience research.

Firstly, many studies that consider the attendant (influence) focus on discomfort or failure to use technology in public (e.g., Dao et al., 2021; Fan et al., 2015; Qiu et al., 2018; Weber et al., 2016). Therefore, our user studies (study 1 and study 2) explicitly addressed positive experiences or ideal interactions. This allowed for a more detailed examination of other aspects of the user experience in line with current insights that suggest technology adoption is influenced by avoiding failure and positively framed achievement motivations (Tojib et al., 2022). In the field of user experience research, an influential theory suggests that positive and meaningful interactions stem from fulfilling psychological needs relevant to the given context (Hassenzahl et al., 2021; Lenz et al., 2017). Results of study 1 and study 2 support a connection of needs and positive or ideal experiences. Furthermore, we validated the existence of social needs (see study 1), which was previously suggested, e.g., by

Hassenzahl et al. (2010, 2015), but had not yet been experimentally tested. Diefenbach et al. (2013) stated that considering the how and why of an interaction is important for promoting positive technology-mediated experiences. Therefore, how an interaction is performed should align with the intended experience. The results of study 2 are consistent with this notion. They suggest that users favor expressive interaction, regardless of whether they value experiencing relatedness or popularity. Additionally, the user's need for relatedness and popularity vary for different attendants. In particular, when an attendant is unknown, popularity appears to be more important, whereas with a close person, relatedness takes precedence. In gaming research, there is another study that compared people's need fulfillment in situations with friends vs. strangers, which suggested similar; it demonstrated that users experience greater relatedness when playing video games with people they know well (Vella et al., 2015).

Furthermore, we have added to research strands that offer an alternative perspective to the often-applied social acceptability lens in studying public technology interactions. Socially acceptable design primarily focuses on minimizing the potential drawbacks of public interactions, such as avoiding discomfort for others or preventing awkwardness (Koelle et al., 2020). However, we build on the premise of present others as a resource for positive user experience. Previous studies suggest that users might appreciate social support (Blut et al., 2016) or serendipitous interaction (Jarusriboonchai et al., 2016). By regarding public interactions to be performances, researchers have shown that users can also enjoy entertaining others (Gugenheimer et al., 2017) or appreciate the opportunity for a favorable self-presentation toward others (Leary, 1996/2019). Additionally, studies suggested that using technology in public can create a sense of shared experience that could result in positive psychological effects such as increased motivation (Mauriello et al., 2014). Our results revealing a connection of social needs and expressivity preference support these findings, highlighting the positive potential of expressivity, i.e., interactions that can (easily) be co-experienced by others.

Various researchers have already stated how important it is to consider the attendant perspective. However, most of their work has focused solely on enhancing the user's experience or engagement of (potential) users in a specific usage context or with a specific technology (e.g., smartphone, HmD, public displays, SSTs, smartwatch, autonomous vehicle, etc.). Therefore, our work addresses this research gap by considering the attendant experience as a research objective on its own merits. In other words, it was not only about considering the attendant influence (study 1 and study 2) but also about taking the attendant perspective (study 3-6). We faced several challenges when conceptualizing and operationalizing the present others in public technology interactions. With regard to the attendant perspective, the terminology in the HCI literature is unclear and inconsistent, and there is also a lack of systematic research as well as models and theories. To better describe and analyze the social context in future research studies, we have developed a (trans-technology or technology-independent) role model, the attendant typology. Other researchers have already made attempts to specify the people attending a public technology interaction (e.g., Dix & Sas, 2010; Finke et al., 2008; Gugenheimer et al., 2017; Wagenknecht, 2018; Wouters et al., 2016). However, such classifications have often been made in the context of a particular technology, typically involving public displays or HmDs.

The findings of our attendant studies testing the typology supported our choice of criteria, voluntariness and conspicuousness of attending the user interaction. For example, our typology covered all positive and negative experience reports on everyday attendant situations from the interviews (study 3). We extended the findings of the qualitative study with a mainly quantitative

exploration of the attendant experience, revealing differences in the attendant experience between the types. Previous research indicated this by dividing the attending experience into phases of observation or roles and showing that different, individual design interventions are worthwhile (e.g., Downs et al., 2014; Greuter et al., 2022; Wouters et al., 2016). Research studies also showed that changing technology in a way to "involve" or engage with present others can be received positively or negatively by them (e.g., Jarusriboonchai et al., 2016; Kleinman et al., 2015). This is consistent with our findings, which suggest that different types of attendants have different demands, e.g., for transparency or consideration. Our study, however, to the best of our knowledge, was the first to experimentally examine the emotional and psychological experiences of different attendants.

To support a broad and straightforward application of the typology (beyond common online experiments) and thus implementation in HCI, we have translated it into a tool for ideation, evaluation, and design – the attendant card set (ACS). As study results (study 5 and study 6) show, our cards are suitable for perspective-taking and collecting additional insights into the attendant experience. Besides, the diversity in the answers using different cards/types underlines the significance of a more nuanced conceptualization and operationalization of present others. Although we have demonstrated the relevance of attendants or considered their perspective and experience across different use cases, e.g., various technologies (e.g., robot, smartphone, loudspeaker, etc.) and settings (open, given: café or waiting hall), the construct "attendant experience" (AX) still needs to be grounded in theory. It would not only be important to develop new, extra AX models analogous to TAM or UX models (e.g., "attitude toward experiencing" instead of "attitude toward using") to explain psychological mechanisms and predict attendant behavior or motivation, integrating the attendant perspective into existing user experience models would also be an essential next step. Therefore, future studies should focus on implementing and establishing the attendant typology/ACS in theory and practice and, thus challenge the current user-centeredness of HCI, which often overlooks the attendants (and their influence).

Last but not least, the mixed measures approach or combination of qualitative and quantitative methods can be highlighted as a strength of our work. This procedure allowed us to test whether assumed differences or associations were statistically significant (quantitative), explore new connections (qualitative), and gain deeper insights (qualitative). Qualitative insights are especially valuable in the early stages of research when there is little empirical evidence on a topic, as in the case of attendant research.

5.3. Practical Implications

The appended manuscripts provide specific design and/or action recommendations that can serve as inspiration and orientation for improving existing or creating new technologies for public settings. Meanwhile, this section describes more general practical contributions for product development and individuals.

What are the key takeaways that designers and developers can derive from the research findings of this thesis? First, need fulfillment is crucial for positive technology-mediated experiences. Consequently, psychological needs should be at the center of technology design. Regarding technology that is also or exclusively used in public, the focus should be on the need for relatedness and popularity. It is essential to specify the social context as this may result in additional requirements (e.g., how to deal with the possibility of failure). Second, an understanding that attendants are a valuable resource

rather than a constraint needs to be established. Since the positive experience of public technology interaction is closely tied to the presence of others, designing for more expressive interaction, i.e., an interaction that can be clearly or easily co-experienced by others, can have advantages. It can be a good way to present yourself favorably to others or to connect with others (emotionally). Third, one-size-fits-all design solutions are inappropriate for public contexts or places where different stakeholders meet. Not only should the needs of users and attendants be considered (as they can differ), but it is also important to specify the stakeholder group of attendants (as the experience of different attendants can deviate as well). Our attendant typology and ACS can help designers understand and analyze different perspectives. This approach considers all stakeholders in public technology-mediated experiences, promoting a more holistic, human-centered design.

Regarding the relevance of our work for individuals, our findings highlight the importance of critically reflecting on one's behavior in public when using technology and attending its use. In the past, scientists and technologists debated about who should be held responsible for the potential negative consequences of their inventions (Koepsell, 2010). Nowadays, responsibility has shifted to the user as it is up to them when and how to interact with (new) technology. The designer's choice cannot override the user's decisions. For example, a smartphone can be used as a mirror, a television, or a music player, depending on the user's imagination. Therefore, all technology can be used in a disruptive manner. However, attendants also have some power and influence on the user; it can depend on the present others how and whether the user interacts or is willing to interact with the technology. The attendants can also behave disruptively, e.g., intruding on a user's interaction or mocking them. Thus, people need to act in way that is reflective of today's world of the technified public sphere. Our work highlights the "responsibility" of the individual (user and attendant). For example, it showed that the same technology interaction, i.e., performed under comparable circumstances, can result in either a positive or negative experience for attendants. Similarly, attendants or having one's interaction co-experienced by others can be a risk as well as a source of positive user experience.

Individuals can take specific steps to achieve positive experiences with technology in public. Firstly, realize that as an attendant, you are not bound to passivity; one can "serve" as a supporter and a serendipitous encounter. As a user, do not shy away from expressivity as it can be a way of impressing or connecting with others. Secondly, even though our findings regarding the attendant experience are mainly based on exploratory investigations, they illustrate that individuals (as users and attendants) have various options to (re-)act or get (pro-)active and thus improve the experience of the public technology interaction themselves. It is therefore the responsibility of users and attendants not only to consider the other party's experience but they also can "co-design" their own. Admittedly, reflecting or reflective acting is a challenge. Providing standards or guidelines can make it easier for individuals. How about, for example, a kind of etiquette manual of dos and don'ts when using or co-experiencing technology in public? In reaction to the people's issues with the first-generation Google Glass, Google introduced a list of rules for not acting like a "glasshole" (CBS News, 2014), wouldn't something like this be possible for technologies in general? And shouldn't we consider going even a step further and enacting laws that define user and attendant rights in public technology usage, supplementing existing regulations like the General Data Protection Regulation? Additionally, establishing guidelines to regulate the use of technology in specific areas or guide the design of new technologies could contribute to a more comprehensive legal framework. Reflecting on this, in 2022, former US president Barack Obama emphasized the symbiotic relationship between regulation and innovation, asserting

that they are not mutually exclusive (Hendrix, 2022). Drawing parallels to the United States' history of regulating various technologies for public safety, he pointed out that while companies often initially resist regulations, a well-structured regulatory environment tends to spur innovation by raising standards for safety and quality.

5.4. Limitations and Future Research Directions

The research findings of this thesis contribute to understanding the (positive) experience of technology in public contexts. However, it is also important to acknowledge its limitations. The more general limitations are described below, while study-specific limitations can be found in the appended manuscripts. Next to suggestions on how future research could address these limitations, possibilities to expand the scope of application, i.e., the potential that could lie in our research findings for other domains and current HCI issues, are discussed.

First, we do not claim that our attendant typology is exhaustive. Even though the criteria we proposed for specifying the present others are supported by our findings, there may be other relevant criteria that we have not considered. On the contrary, we believe expanding the typology by including additional factors is possible and valuable. For example, physical closeness to the user (e.g., Gentile et al., 2017) or comprehension of the interaction (e.g., Profita et al., 2016) would be interesting starting points. In addition, we intentionally excluded relationship aspects so future studies could investigate how including this factor affects the attendant's experience when observing user-technology interactions.

Another limitation refers to the operationalization of the attendant experience and, thus, how we measured it, often with self-constructed items or items adapted from user research. Based on our literature research, we considered affect, desires or needs, and social acceptability to be relevant aspects of the attendant experience. Since the attendant experience is not (yet) a popular construct in HCI like user experience, no common and validated measures are available. Therefore, future research should address this gap and aim at developing AX measurements analogous to existing UX measurements such as UEQ (Laugwitz et al., 2008), WEAR scale (Kelly & Gilbert, 2016), AttrakDiff (Hassenzahl et al., 2003), and the interaction vocabulary (Diefenbach et al., 2010; Diefenbach et al., 2013). Further inspiration could be drawn from the performing arts. For example, the Arts Audience Experience Index (Radbourne et al., 2009) distinguishes between four components that make up a performing arts experience: authenticity (i.e., is it truthful and believable?), collective engagement (i.e., does it encourage social interaction?), knowledge (i.e., is it comprehensible?), and risk (i.e., is it worth the money and does it align with one's self-image?).

Furthermore, our studies only considered the perspectives of users or attendants. However, to address interdependencies between user and attendant, future studies (laboratory and field experiments) should include user and attendant ratings. The findings of our studies suggest that user reactions to the attendant (behavior) and vice versa can shape technology-mediated experiences in positive and negative ways. Not only can the user behave "rightly" or "wrongly" from the attendant's point of view (see social acceptability of interactions), but exploratory findings in the workshop study suggest that the social acceptability of co-experiencing can also vary, depending on the type or behavior. A combination of user and attendant perspectives is needed when it comes to the development and evaluation of action or design intervention aimed at positive technology-mediated experience in public. Our studies already outline initial ideas for technological features or behavioral strategies that

need further development in future studies and evaluation regarding their suitability for everyday use and effectiveness. Since the research conducted on attendants, in particular, was exploratory, it is necessary, and thus a logical next step, to carry out field experiments to test and replicate the associations found (under real-world conditions). This will help overcome the weaknesses of, for example, self-reporting or vignettes.

One topic that has not yet received much attention in our studies is the transition from one type to another. Role transformations, e.g., switching between the user and attendant role, have already been research objectives in several studies (e.g., Chen et al., 2014; Fischer & Hornecker, 2012; Wouters et al., 2016). These studies emphasize that one-size-fits-all design solutions are inappropriate as we face multiple stakeholders and thus have multiple design tasks. Explorative field observations could provide initial insights into the reasons, possibilities, and consequences of attendant type-switching. They would also be helpful for investigating more complex use cases, i.e., multi-user and -attendant scenarios. Since we used "simple" designs with a single attendant, exploring how the presence of multiple attendants (types) influences the technology experience on both the user and attendant side could be an interesting future research direction.

Regarding the methodological limitations of our work, last but not least, the generalizability of our results needs to be discussed because most studies (except the expert survey) used a German or German-speaking sample. An application of the attendant typology or ACS in studies with people from other nationalities could provide insights into possible cultural differences (Sturm et al., 2015). Comparisons regarding user and attendant experience of public technology interactions in individualistic vs. collectivistic cultures would also give more information about the generalizability of our results. Cultural differences could be incorporated into an extension of the typology or ACS, or different cultural versions of the ACS are also conceivable.

Extending the application scope may provide interesting directions for future research. Transferring the attendant types to other domains could help to look at ("old") issues in HCI and beyond, literally from a new perspective(s) and thus might open up new possibilities. For example, techno-stress, i.e., adverse psychological and physical effects experienced by individuals due to the (over-)use of technology, has been a popular topic in HCI for several years. There is already a lot of research on how much is a good level of technology use in everyday life and how to reduce digital stress (e.g., Curran et al., 2017; Hartmann, 2022). However, what about the stress that technology can cause in the physical world, such as the incessant ringing of phones, glowing displays, flying drones, and talking robots? The attendant perspective or types could be a valuable approach to determine whether physical techno-stress is an issue and identify practical countermeasures. Urban planning is another area outside of HCI where considering the attendant perspective could bring added value. To pick up on the suggestion of one of our experts in the survey study, architects could use the ACS in ideation sessions for planning (smart) cities and public spaces. The attendant perspective has the potential to provide new insights for reshaping the public space into a realm of social encounters, also taking into account the preferences and needs of attendants. The focus in urban planning should shift toward designing spaces that enable people to engage in activities that involve technology and providing opportunities for others to co-experience these activities.

6. Conclusion

> "In fact, bystanders are crucial in this public context – one might say that they're the 'public' in 'public space'."
> – Flammer (2016, p. 73)

This thesis is dedicated to exploring public technology interactions, focusing on the user and attendant perspectives. According to the theoretically and empirically grounded understanding of needs as a source of positive technology-mediated experiences, our user studies demonstrated the existence of social needs, relatedness and popularity, which are especially relevant to the user experience in public settings. In addition, the present work illustrates that a positive experience in public is closely tied to the presence of others. And it makes a difference who is attending, as people are then either more inclined to experience connection with others or experience favorable self-presentation. Present others are not alike, and so it is not adequate to consider them to be one homogenous unit or group of stakeholders. Our attendant studies show that the present others in public technology interactions can be specified; we have developed and tested a role model that distinguishes four types based on two criteria (conspicuousness of attending and voluntariness of attending).

This work contributes to HCI by opening up new perspectives on public technology usage, those of different types, and challenging user-centered practices in research and design. With the attendant typology and ACS, we provide means for implementing the attendant perspective in theory and practice, aimed at a more holistic and inclusive approach. Theoretical and practical implications are supposed to serve as inspiration and orientation for future work, promoting context-sensitivity of interactive products or interaction styles. Technology should not dominate or intrude in public spaces. Instead, it should support and connect people, not only in the sense of social interaction but also in the sense of harmonization, i.e., (enabling us) to consider and, if necessary, adjust to the needs and demands of others. Then, a positive experience with/through technology is possible for all stakeholders in public space, users and attendants.

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8. Appendix

Study 1	Von Terzi, P., Tretter, S., Uhde, A., Hassenzahl, M., & Diefenbach, S. (2021). Technology-mediated experiences and social context: relevant needs in private vs. public interaction and the importance of others for positive affect. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.718315
Study 2	Tretter, S., Von Terzi, P., & Diefenbach, S. (unpublished manuscript). How present others shape the user experience of service robots.
Study 3 Study 4	Von Terzi, P., & Diefenbach, S. (2023). The attendant perspective: present others in public technology interactions. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-18). ACM. https://doi.org/10.1145/3544548.3581231
Study 5 Study 6	Von Terzi, P., & Diefenbach, S. (2023). The attendant card set: a research and design tool to consider perspectives of attendants versus users when co-experiencing technology. *Multimodal Technologies and Interaction*, *7*(11), 107. https://doi.org/10.3390/mti7110107

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Technology-Mediated Experiences and Social Context: Relevant Needs in Private Vs. Public Interaction and the Importance of Others for Positive Affect

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Technologies, such as smartphones or wearables, take a central role in our daily lives. Making their use meaningful and enjoyable requires a better understanding of the prerequisites and underpinnings of positive experiences with such technologies. So far, a focus had been on the users themselves, that is, their individual goals, desires, feelings, and acceptance. However, technology is often used in a social context, observed by others or even used in interaction with others, and thus shapes social dynamics considerably. In the present paper, we start from the notion that meaningful and/or enjoyable experiences (i.e., wellbeing) are a major outcome of technology use. We investigate how these experiences are further shaped by social context, such as potential spectators. More specifically, we gathered private (while being alone) and public (while other people are present) positive experiences with technology and compared need fulfillment and affective experience. In addition, we asked participants to imagine a change in context (from private to public or public to private) and to report the impact of this change on experience. Results support the idea of particular social needs, such as relatedness and popularity, which are especially relevant and better fulfilled in public than in private contexts. Moreover, our findings show that participants experience less positive affect when imaginatively removing the present others from a formerly public interaction, i.e., when they imagine performing the same interaction but without the other people present. Overall, this underlines the importance of social context for Human-Computer Interaction practice and research. Practical implications relate to product development, e.g., designing interactive technologies that can adapt to context (changes) or allow for context-sensitive interaction sets. We discuss limitations related to the experimental exploration of social context, such as the method of data collection, as well as potential alternatives to address those limitations, such as diary studies.

Keywords: human-computer interaction, psychological needs, need fulfillment, social context, public space, positive affect, user experience, social acceptability

INTRODUCTION

Technologization of our everyday lives progresses rapidly. Smartphones, laptops, wearables, and the like accompany us everywhere. Together with their human users, they co-constitute the socio-technical ecosystems we live in (i.e., "mutual constitution" of humans and technologies, Sawyer and Jarrahi, 2014). We are constantly surrounded by technology and permanently interact with it. One major individual outcome of this interaction is experiences, that is, meaningful and enjoyable moments (i.e., wellbeing) mediated through technology use (User Experience, UX; Experience Design, see Hassenzahl, 2010). The present study explores how subjective wellbeing is made through technology (e.g., Desmet and Hassenzahl, 2012; Calvo and Peters, 2014). The user experience of an interactive product is highly context-dependent. It is an ever-changing result of the interplay between the user, technology (i.e., devices), other individuals, and the environment as a whole (Forlizzi and Ford, 2000; for a conceptual distinction from usability, see Hassenzahl and Tractinsky, 2006; Law et al., 2009; Cruz et al., 2015). Thus, it is necessary to consider social dynamics and contextual factors when developing interactive products – especially if they are meant for use in public, such as many mobile devices. For example, imagine you are waiting at a crowded bus station and want to check if there is news regarding the arrival time of your already delayed bus. How would it feel like to use the voice assistant of your smartphone in that situation? Being watched by two people standing close to you, would you prefer using the keyboard of your smartphone instead? Would there be a change in your feelings, thoughts, or behavior if it was only you waiting for the bus? A previous study (Easwara Moorthy and Vu, 2015) on the effect of public vs. private usage contexts showed a higher willingness to use voice assistants in private than in public but showed no difference in preferences regarding keyboard use. This example is only one of many, which demonstrate that social context plays an important role in shaping the way people interact with technology and how they experience technology (e.g., Roto, 2006; Rico and Brewster, 2010; Ens et al., 2015; Grubert et al., 2016; Sergeeva et al., 2017). Interestingly, technology is often insensitive to differences in social context, which is also why Human-Computer Interaction (HCI) experts identify "Human-Environment Interactions" as one of "Seven HCI Grand Challenges" (Stephanidis et al., 2019).

Since social context, i.e., present others, is likely to impact technology experience and use, a better understanding of this influence is necessary. Therefore, the present study addresses the question of how positive experiences with technology differ between private and public contexts. In the following, we give a brief overview of the theoretical concepts of social context and technology-mediated experiences, with an emphasis on the relevance of psychological need satisfaction and subjective wellbeing. We then present an empirical examination of the effect of the presence of other people on need fulfillment and affect. In doing so, we offer deep insights into the emergence of technology-mediated experiences and confirm the existence of social needs, i.e., needs that are more relevant in public contexts. Since we assess a broad spectrum of psychological needs, we draw a more complete picture of technology interactions than previous studies (e.g., Hassenzahl et al., 2010; Tuch et al., 2013; Peters et al., 2018). In conclusion, we discuss the reported observations and implications for further research, product development, and design. Overall, our study results support a positive, need-based approach on designing meaningful (public) interaction experiences.

THEORETICAL BACKGROUND

Social Context in HCI

In HCI research, Goffman (1959) framework is a popular and widely used theoretical framework when it comes to describing and analyzing how people experience technology in social contexts (e.g., Campbell, 2007a; Dalsgaard and Hansen, 2008; Rico and Brewster, 2010; Colley et al., 2020). Goffman depicted a dramaturgical interpretation of social life, comparing social interaction to theater. According to him, all public action can be understood as performance. People try to manage the impression they make on others by acting in a certain way. Analogous to actors on stage, people play roles to fit the expected social context. More specifically, how people present themselves depends on the audience, the context, and the expectations of their audience's reactions. Consequently, technology interactions in public spaces should account for the presence of others, i.e., actual or potential spectators, to allow for a pleasant "performance." Present others can take up different roles depending on their interaction with the system or relationship with the user (e.g., Wouters et al., 2016; Gentile et al., 2017). However, in the present study, social context, i.e., the others present, is not further defined and only general distinction is made between public (someone is present) and private (no one is present) contexts.

The importance of social context and its alleged impact on people's experience and behavior is widely acknowledged. However, there has been little systematic research on experience-oriented aspects of interactive products explicitly taking contextual factors and social dynamics into account (e.g., Ross and Wensveen, 2010; Lenz et al., 2014). Thus, an adequate theoretical model that includes social context when describing or predicting positive technology use and experience is still missing.

Positive Technology-Mediated Experiences (in Public)

Previous research on positive technology-mediated experiences understands it as positive affectivity, which emerges from the fulfillment of psychological needs (Sheldon et al., 2001; Hassenzahl et al., 2010). In line with the central role of psychological needs for wellbeing in general (Ryan and Deci, 2000), the notion of psychological needs as a source of positive experiences has a tradition in the field of HCI and UX (e.g., Hassenzahl, 2008a; Hassenzahl et al., 2010; Hassenzahl and Diefenbach, 2012; Tuch et al., 2013; Peters et al., 2018). In fact, any positive experience with technology can usually

ultimately be traced back to the fulfillment of a psychological need (Hassenzahl and Diefenbach, 2012). Thus, need fulfillment is understood as a main source of positive experiences with interactive products. Positive design approaches acknowledge the key role of psychological needs and take the users' experiences to the fore.

However, the few approaches that consider technology interactions as socially embedded often treat social context as a potential source of problems – with the goal to avoid disturbing others (Koelle et al., 2020). Accordingly, interactions are designed to be socially acceptable. This social acceptability is "typically defined through negation, or an absence of negative judgment" (Koelle et al., 2020, p. 6). It encompasses both, the way other people perceive the use of a technical device and the way the user does so him- or herself (Montero et al., 2010). A lack of social acceptability could impact the user's self-perception as well as other people's perception (Goffman, 1959), influence the overall user experience (Williamson, 2012), and carry the risk of misperceptions (Shinohara and Wobbrock, 2011) and negative judgment through others (Kleinman, 2007; Koelle et al., 2015; Schwind et al., 2018). So, there is no doubt that social acceptability plays an important role when it comes to the development and design of technology for public application. However, research on social acceptability needs to account for the complexity of social context to overcome theoretical shortcomings (Uhde and Hassenzahl, 2021). Thus, social acceptability might be necessary but is not sufficient to create positive experiences due to the negative, problem-driven perspective. Actually, such problem-driven approaches only aim for eliminating problems or reducing unhappiness rather than promoting happiness (Desmet and Pohlmeyer, 2013). In order to design technology that feels good – instead of not bad – to interact with, it is not enough to ensure social acceptability. One must also understand what makes a technology interaction a positive experience in different social contexts. Previous studies on technology experience in public (and private) are a first step by revealing differences in acceptance and perception of interactive products in public vs. private space (e.g., Rico et al., 2010; Pearson et al., 2015; Hsieh et al., 2016; Lopatovska and Oropeza, 2018; Pandey et al., 2021). The current study contributes to this research and explores the source, i.e., the relevant needs, of positive experiences with technology in public and private contexts.

RESEARCH FOCUS AND HYPOTHESES

All in all, social context has mostly been neglected in HCI research so far. On the one hand, most design approaches in the fields of HCI, Ergonomics, or Interaction Design predominantly focus on the immediate interaction of user and technology, thereby downplaying the impact of social context. On the other hand, social context (if it is even considered) is yet conceptualized mainly from a restricted, problem-oriented perspective. Our study aims to expand this view on social context. Besides a focus on preventing problems in public interactions, we also consider present others as a potential source for the creation of positive experiences. Hereby, the main emphasis is less on technology type but rather on general, context-specific requirements. The present study explores positive experiences with technologies in public and private contexts and identifies potential differences regarding fulfilled psychological needs. By this means, we reveal whether and how interactions with all kinds of interactive products are shaped by the social context, i.e., absence (private context) or presence (public context) of others. In the following sections, we derive specific hypotheses regarding need fulfillment and affect in private vs. public contexts and highlight our study's advancements beyond previous research.

Previous studies (Hassenzahl et al., 2010, 2015) already scrutinized the relationship between technology use and need fulfillment on positive affect for social and non-social experiences. In both studies, the presence or absence of other people was associated with differences in need fulfillment. Specifically, Hassenzahl et al. (2010) found that relatedness fulfillment was higher in public situations, i.e., other people had been explicitly mentioned. In contrast, competence, security, and meaning fulfillment were lower in public compared with private situations. Hassenzahl et al. (2015) found relatedness and popularity to be fulfilled to a greater extent when at least one other person was present (i.e., social situations) while meaning was fulfilled to a lower degree. In both studies, however, the presence of other people was not experimentally controlled for, so causal inferences cannot be drawn. Thus, we conduct an experimental between-subjects manipulation of social context to directly compare need fulfillment in public vs. private. In line with Hassenzahl et al. (2010), we hypothesize that need fulfillment for relatedness and popularity is higher in public than in private contexts (H1a and H1b).

> *H1*: Need fulfillment is higher in public compared to private contexts for,
> *H1a*: Relatedness (between-subjects comparison).
> *H1b*: Popularity (between-subjects comparison).

Goffman (1959) described interacting in public as a performance and that people strive to create a specific impression in the minds of others. Therefore, we suggest that in situations with fewer "external forces" (here: other people), the need fulfillment of autonomy is higher than in public contexts. Moreover, Hassenzahl et al. (2010) showed that need fulfillment for competence, security, and meaning is lower in social experiences than in non-social experiences. Accordingly, we hypothesize a lower need fulfillment for competence, security, and autonomy in public compared to private contexts (H2a, H2b, and H2c).

> *H2*: Need fulfillment is lower in public compared to private contexts for,
> *H2a*: Competence (between-subjects comparison).
> *H2b*: Security (between-subjects comparison).
> *H2c*: Autonomy (between-subjects comparison).

In the previous studies (Hassenzahl et al., 2010, 2015), comparisons between social vs. non-social context included various types of experiences; participants reported interactions with different products and in different contexts, and thus, confounding effects cannot be excluded. In order to control for that in our study, we implemented a study design which allowed for within-subject comparisons of the very same interaction in a public and private context. Thus, we can compare participants' perceptions and evaluations of the same technology interaction in different social contexts, i.e., when other people are present and no one is around. We hypothesize a causal relationship between the presence of others and need fulfillment, specifically, a positive effect for relatedness and popularity (H3a and H3b) and a negative effect for autonomy (H4a).

H3: Need fulfillment is higher for positive experiences in public context than for the same technology interaction without the other people for,
H3a: Relatedness (within-subject comparison).
H3b: Popularity (within-subject comparison).
H4: Need fulfillment is higher for positive experiences in private context than for the same technology interaction with other people present for,
H4a: Autonomy (within-subject comparison).

Furthermore, we expect that context changes, i.e., a modification of social context, have a negative effect on positive affect as well. Since a change of social context presumably leads to lower need fulfillment and need fulfillment is associated with positive affect (Hassenzahl et al., 2010), positive affect should decrease when social context is modified. More specifically, if positive experiences in public mainly arise from need fulfillment of social needs (i.e., relatedness and popularity) and in private contexts from a feeling of autonomy, a switch of contexts should, in turn, lead to lower positive affect (H5a and H5b). However, support for hypotheses on need fulfillment (H3a, H3b, and H4a) has to be found first as a prerequisite for the corresponding affect alterations.

H5: Positive affect is lower in a modified social context.
H5a: Positive affect is lower when removing present others from originally public interactions.
H5b: Positive affect is lower when adding other people to originally private interactions.

MATERIALS AND METHODS

The study was pre-registered on the Open Science Framework prior to data collection and analysis. It was realized *via* an online questionnaire and announced as a study on the subjective experience of technology interactions in public and private contexts. All materials were presented in German.

Participants

Overall, 198 participants who were recruited *via* university mailing lists, snowball sampling, and social media platforms completed the survey. After a first screening of their answers, 14 individuals were excluded from the study on the basis of missing data (e.g., answered central questions with "X") or an experience that obviously did not fit our criteria (e.g., indicated that "nobody" was present although they had been instructed to recall an interaction occurring in public context). The 184 participants (67.4% female, 32.1% male, and 0.5% diverse) were aged 18 to 71 years ($M = 27$, $SD = 26.30$). As an incentive for their participation, four gift coupons of 25 euros were raffled among all participants. Besides, students could register their participation for course credit. The preconditions for participation were a good knowledge of German.

Procedure

In the present study, we asked participants to evaluate technology experiences and systematically varied the configuration of the situations through short text vignettes. More specifically, we varied the factors "social context" (public vs. private context, varied between-subjects) and "experience type" (recalled vs. imagined, varied within-subjects), see **Table 1**.

Participants were randomly assigned to one of the two experimental conditions, i.e., pub→prv condition ("recalled public interaction, followed by imagined private interaction") or prv→pub condition ("recalled private interaction, followed by imagined public interaction") after reading an introduction and giving consent agreement. Depending on which group they were in, we instructed participants to recall and describe either a positive technology interaction in *public* or *private* (see **Table 1** for the detailed instructions). Participants were asked to provide positive experiences with an interactive product in the broadest sense, such as smartphones, kitchen devices, or e-scooters. After having described the experience, participants evaluated their recalled (public or private) experiences. Subsequently, participants were instructed to reimagine their reported experience in the opposite context. Thus, participants who recalled an experience in public context were now asked to imagine the same experience in private. Again, they were asked to evaluate the imagined experience. Participants rated the recalled and imagined experiences with regard to a variety of measures: affect, need fulfillment, attribution (i.e., what causes the positive experience), relationship to present others, other people's role, publicness of interaction, impact of context modification (from public to private or private to public), and overall social acceptability of interaction (see "Measures"). Finally, participants in both experimental conditions provided some demographic information (gender, age, and occupation). Except for affect and needs which were assessed after each vignette, i.e., two times, all measures were acquired once. In both experimental conditions (pub→prv condition and prv→pub condition), the same selection of items was presented to participants – in a different sequence. The study procedure is visualized in **Figure 1**.

Experience Reports

Participants were instructed with the following text to describe their positive technology interactions: "Please report your

TABLE 1 | Experimental conditions and corresponding instructions to elicit and modify experiences.

Condition[a]	Group[b]	Vignette	Text
pub→prv	recalled public	vignette 1a	Please take a moment to recall a specific, positive experience in which technology in the broadest sense was involved. This should be an experience in which you interacted with a technical product, which one is up to you (e.g., cell phone, robot, food processor, e-scooter, etc. - really any kind of electronics or technology). The interaction should have taken place in public, i.e., one or more other persons were present. Thus, above all it's important that you had company during your technology interaction and that you experienced this interaction as positive. The other person(s) may also have interacted with the technology, or may have just been present
prv→pub	recalled private	vignette 1b	Please take a moment to recall a specific, positive experience in which technology in the broadest sense was involved. This should be an experience in which you interacted with a technical product, which one is up to you (e.g., cell phone, robot, food processor, e-scooter, etc. - really any kind of electronics or technology). The interaction should have taken place in private, i.e., no other person was present. Thus, above all it's important that you did not have company during your technology interaction and that you experienced this interaction as positive
pub→prv	imagined private	vignette 2a	Now please try to imagine that no one else would have been present during the product interaction you described earlier, so you would not have had any company. In some situations, this may seem strange or difficult to imagine because another person was directly involved in the original product interaction. Nevertheless, please try to place yourself in the modified situation as best you can
prv→pub	imagined public	vignette 2b	Now please try to imagine that additionally someone else had been present during the product interaction you described earlier, so you would have had company. In some situations, this may seem strange or difficult to imagine. Nevertheless, please try to place yourself in the modified situation as best you can

[a]*n* = 96 (pub→prv condition), *n* = 88 (prv→pub condition).
[b]*Each group comprises a specific combination of factor levels of "social context" and "experience type."*

product experience as accurately and in detail as possible, trying to be as specific as possible. You can use as many words as you like. Outsiders should be able to easily understand your experience with the help of this description." Participants' experience reports were collected with the help of an open text question. Overall, 96 participants (52%) were assigned to the public condition and, consequently, recalled and described a positive experience in public. Another 88 participants reported a positive experience in private. Participants were further asked to specify the location of the experience by choosing one of eight options (i.e., in my own home, in the home of friends or acquaintances, at work, in a public building or in a stranger's home, on a (motor)bike/in a car/bus/train/plane, in the street or another public space, in a natural setting, and other; selection is based on Scherer et al., 2001). The coding process for the open text question consisted of two steps. First, categories were defined for the type of product (e.g., smartphone) and the interaction's main function (e.g., entertainment). In a second step, two independent coders were asked to categorize the participants' reports according to the defined categories (product types: Krippendorff's $\alpha = 0.73$; function: Krippendorff's $\alpha = 0.73$). Multiple assignments were allowed in both cases.

Measures

Need fulfillment and affect are the two key variables used for testing the hypotheses and were assessed two times in both conditions, once after each experience report. This resulted in four measurements for affect and need fulfillment, respectively. Therefore, internal consistencies of the key variables are given in ranges in the following. Additional measures on attribution, social acceptability, present other(s), shape of interaction, and contextual setting were measured once per condition, i.e., there are two measurements for the whole sample. Internal consistencies for the additional measures are provided separately for both experimental conditions.

Affect

Most definitions of wellbeing assume an affective component (e.g., Diener et al., 1985; Hassenzahl et al., 2010; Martela and Sheldon, 2019). Thus, we administered the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988; German translation by Krohne et al., 1996) to assess this facet of subjective wellbeing. It has been found to be a reliable and valid measure (Crawford and Henry, 2004) and is well established in HCI and UX research (e.g., Hassenzahl, 2008b; Partala and Kallinen, 2012; Anderson et al., 2017; Klapperich et al., 2020). Another reason for choosing PANAS over other measures was the fact that it allows for capturing positive and negative emotions separately. Consequently, PANAS was selected as the emotion assessment method for the current research. The scale consists of 20 verbal descriptors of different facets of affective experiences (e.g., scared, nervous, inspired, and proud) and covers positive as well as negative valence of affect through two subscales with 10 items each. Participants were asked to rate how well each of these 20 attributes described their affect during the respective experience on a 5-point scale ranging from 1 (not at all) to 5 (extremely). Even though we explicitly asked participants to provide positive experiences only, we included negative affect for exploratory analyses. Positive affect (PA) and negative affect (NA) scores were calculated in the present study by averaging the responses to the 10 affect descriptors for each valence. Internal consistency of positive and negative affect was good (PA: $\alpha = 0.82$–0.83; NA: $\alpha = 0.75$–0.92; see **Table 2**). Inter-scale correlations were mainly small and insignificant ($r = -0.01$–-0.38).

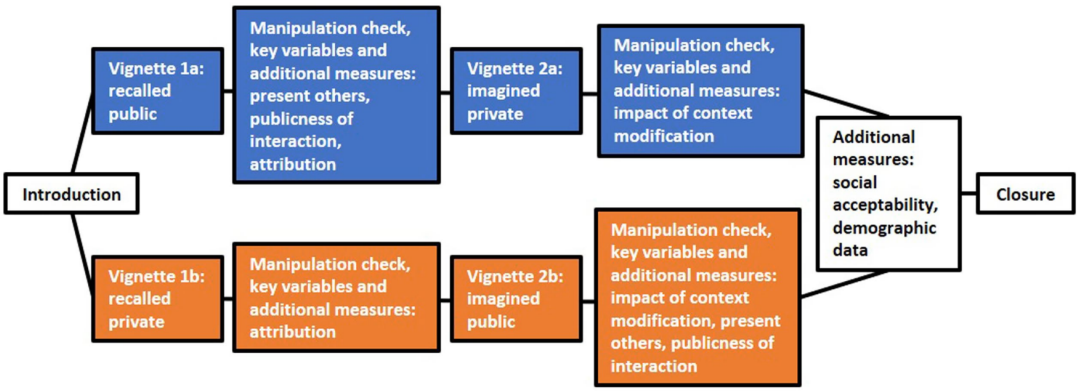

FIGURE 1 | Procedure of the study. The same selection of items was presented to participants of both experimental conditions (in a different sequence). Key variables = need fulfillment and affect.

Need Fulfillment

Fulfillment of different needs was measured with the questionnaire of Sheldon et al. (2001; German translation by Diefenbach and Hassenzahl, 2010) except for self-esteem which we consider an outcome of need fulfillment rather than a need itself (Hassenzahl et al., 2010). General need fulfillment was computed by averaging the scores of all nine needs. Participants were asked to assess the following needs on a 5-point scale ranging from 1 (not at all) to 5 (extremely): relatedness (e.g., Item 2: "I felt close to people who are important to me"), popularity (e.g., Item 1: "I felt like a person whose opinion is valued by others"), competence (e.g., Item 1: "I felt that I was successfully completing difficult tasks"), security (e.g., Item 2: "I felt that I have a comfortable set of routines and habits"), autonomy (e.g., Item 2: "I felt that things can be done in my own way"), luxury (e.g., Item 3: "I felt that I got plenty of money"), stimulation (e.g., Item 3: "I felt that I was experiencing new sensation and activities"), physical striving (e.g., Item 2: "I felt that my body was getting just what it needed"), and meaning (e.g., Item 1: "I felt I was becoming who I really am") – with three items each. However, we only used the first five needs for hypotheses testing (i.e., relatedness, popularity, competence, security, and autonomy) and included the latter four in exploratory analyses.

Overall, the internal consistency (Cronbach's alpha) was acceptable for most of the needs with exception of popularity, luxury, and security. Since the criterion of 0.70 (according to Nunnally, 1975) has not been reached in both conditions, we performed item reduction for each respective scale. Thereby, we achieved a substantial improvement of Cronbach's alphas for luxury [$\alpha = 0.73–0.81$; Item 2 ("I felt that I have nice things and possessions") excluded] and security [$\alpha = 0.65–0.79$; Item 3 ("I felt safe from threats and uncertainties "excluded)], but not for popularity ($\alpha = 0.67–0.83$). Cronbach's alphas and scale inter-correlations of the needs relevant for hypotheses testing are in **Table 2**.

Additional Measures

Manipulation Check

After each vignette, we first asked participants to indicate how well they could immerse themselves in the situation using a 5-point scale (1 = not at all and 5 = extremely). Besides, we offered participants to declare if they had difficulties with the imagined context modification the second vignette asked for. Experience reports of participants with a score lower than three for the manipulation checks were examined and excluded if necessary. Finally, our sample includes 14 participants with such low scores.

Attribution

We asked participants to assess the extent to which the product caused the experience on a 5-point scale (1 = very small and 5 = very large).

Social Acceptability

We used two questions, adapted from Koelle et al. (2018), to assess social acceptability of the technology interaction. Participants were asked to indicate "How comfortable would you feel performing this product interaction in a public setting?" and "How acceptable would it be to perform this product interaction in public?" on a 5-point scale (1 = not at all and 5 = extremely). Internal consistency (Cronbach's alpha) was acceptable to good (pub→prv condition: $\alpha = 0.83$; prv→pub condition: $\alpha = 0.79$).

Present Others

We used two questions to clarify the relationship with and involvement of person(s) present during public experiences. First, participants indicated their relationship by selecting one or more options from a list of different categories: "nobody," "a friend or partner," "a colleague or acquaintance," "several friends or acquaintances," "one or more unspecified persons," "large crowd," and "other" (selection is based on Scherer et al., 2001). Second, they were asked about the

TABLE 2 | Inter-correlation of key variables need fulfillment and affect for recalled (in brackets: imagined) experiences. The diagonal (bold) displays internal consistencies (Cronbach's alpha) for each scale.

Measures	1		2		3		4		5		6		7	
	Pub	Prv	Pub	Prv	Pub	Prv	Pub	Prv	Pub	Prv	Pub	Prv	Pub	Prv
1. Relatedness	**0.91 (0.93)**	**0.92 (0.95)**												
2. Popularity	0.26* (0.66**)	0.58** (0.60**)	**0.67 (0.83)**	**0.77 (0.81)**										
3. Competence	0.00 (0.19)	0.24* (0.34**)	0.42** (0.34**)	0.42** (0.62**)	**0.74 (0.87)**	**0.73 (0.79)**								
4. Security	0.15 (0.32**)	0.34** (0.33**)	0.60** (0.52**)	0.37** (0.41**)	0.40** (0.41**)	0.49** (0.50**)	**0.65 (0.71)**	**0.68 (0.79)**						
5. Autonomy	0.24* (0.22*)	0.41** (0.51**)	0.57** (0.38**)	0.56** (0.63**)	00.33** (0.51**)	0.34** (0.52**)	0.38** (0.50**)	0.46** (0.64**)	**0.70 (0.81)**	**0.71 (0.72)**				
6. Positive Affect	0.16 (0.23*)	0.17 (0.26*)	0.32** (0.43**)	0.43** (0.52**)	0.45** (0.52**)	0.51** (0.66**)	0.33** (0.33**)	0.38** (0.43**)	0.34** (0.53**)	0.39** (0.43**)	**0.83 (0.89)**	**0.82 (0.88)**		
7. Negative Affect	−0.10 (0.11)	0.00 (−0.03)	0.01 (0.14)	0.03 (0.02)	0.15 (0.09)	−0.09 (0.04)	−0.07 (0.04)	−0.20 (−0.21*)	−0.17 (−0.08)	−0.15 (−0.21*)	−0.02 (−0.03)	−0.06 (−0.22)	**0.75 (0.85)**	**0.75 (0.92)**

Pub, pub→prv condition ($n=96$); Prv, prv→pub condition ($n=88$); $^{*}p < 0.05$; $^{**}p < 0.01$.

involvement of those present others in the interaction itself on a 5-point scale (1 = passive and 5 = active).

Publicness of Interaction

We created four items to measure participants' perceived publicness of technology interaction: "I (would have) felt like I was being watched," "I (would have) cared what other people might think," and "During my product interaction, I would have been/was at the center of attention of the other person/s." Participants indicated their agreement with each item on a 5-point scale (1 = not at all and 5 = fully). The average of all three scores serves as an indicator of how public the situation was subjectively experienced by each participant. Originally, we created four items; however, inter-item correlations were at least questionable in both conditions. Thus, we excluded one item ["I (would have) experienced the interaction as public"] which leads to a slightly improvement of Cronbach's alphas (pub→prv condition: $\alpha = 0.59$; prv→pub condition: $\alpha = 0.70$).

Impact of Context Modification

One quantitative and one qualitative question captured the impact of the within-subject manipulation of social context, i.e., when people were added or removed to the recalled experience. First, participants quantified how the interaction would feel like in the modified context compared to the original one by rating the valence on a 5-point scale from "worse" to "better" (with the midpoint indicating no change). Second, participants were supposed to elaborate on the effects of the presence (prv→pub condition) or absence (pub→prv condition) of others on their feelings, thoughts, and behavior in an open-ended answer.

RESULTS

All analyses were conducted with SPSS (IBM Statistics Version 26).

Experience Reports

An example of a technology experience (i.e., a recalled interaction in public context) described in the pub→prv condition reads as follows, "*I was at Legoland with my family. There were robot arms that whirled you through the air, similar to a roller coaster ride. However, you could choose the movements of the arm yourself.*" The other half of the sample recalled positive technology interactions in private context, i.e., while being alone. An exemplary report from the prv→pub condition was, "*When the new album of one of my favorite artists came out, I immediately listened to it with my Bluetooth headphones and the experience - hearing it for the first time - was indescribable. At that moment I was indeed happy about the technology and digitalization that conquers the whole world nowadays.*" **Figure 2** provides an overview of the obtained technology reports.

Participants' answers regarding locations of recalled technology interactions were quite equally distributed across the provided options. In the pub→prv condition, 19% of the (recalled public)

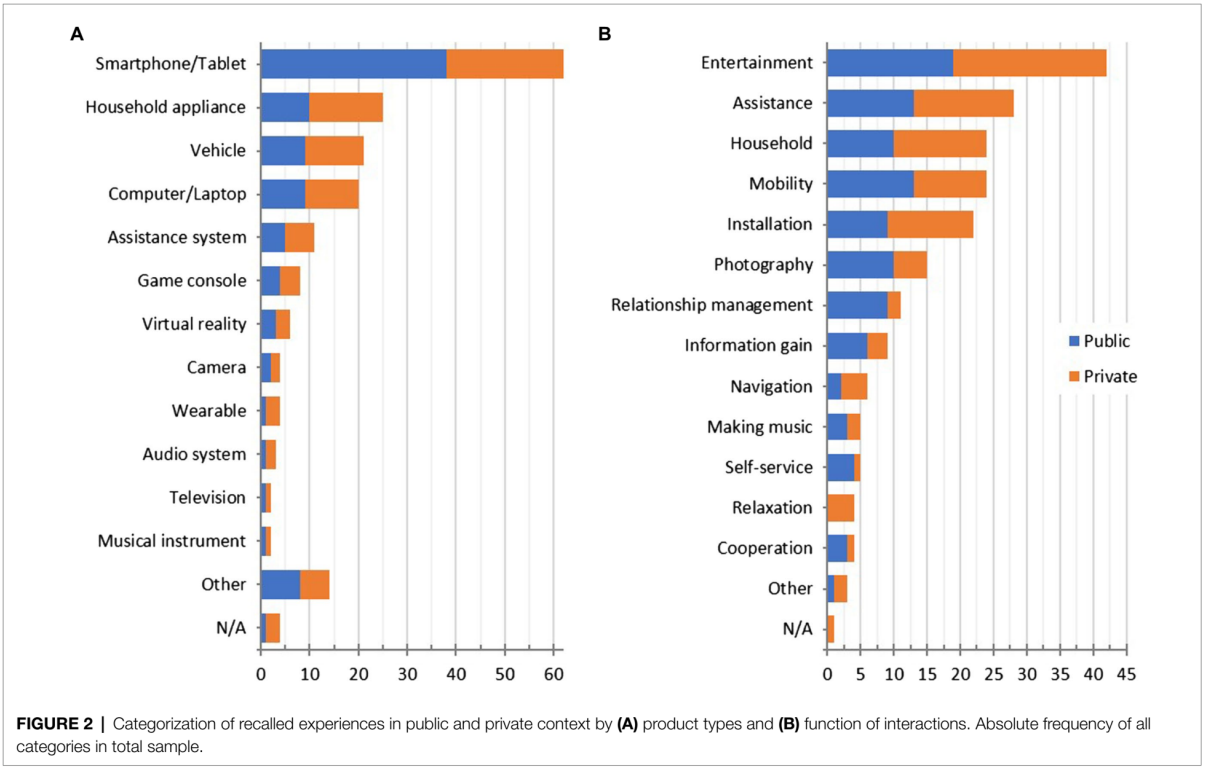

FIGURE 2 | Categorization of recalled experiences in public and private context by **(A)** product types and **(B)** function of interactions. Absolute frequency of all categories in total sample.

interactions took place "on the streets or another public place," 18% "in my own home," 14% "in the home of friends or acquaintances," and 14% "in a natural setting." However, a different picture emerged in the prv→pub condition (for interactions in private); most of the participants' recalled experiences (67%) took place in their own homes. Participants' answers to the question of how their thoughts, feelings, or behavior change through the modification of context provided further insights into the effect of the presence or absence of others. For example, when a participant in the pub→prv condition was asked to imagine their originally public interaction without other people being present, they described the change as follows, "*I can try everything as long as I want, have no stress, can take the time I need and I am relaxed. But I also have a smaller sense of achievement when no one is there to watch.*" A representative example for the prv→pub condition is, *"Alone, you could do everything according to your own wishes and ideas and be proud of having actually done it alone, however, there is also no one with whom you can share the joy. Conversely, in the presence of another person, you have a shared sense of achievement and can rejoice together. However, you do not feel quite as free in your application and may adapt to the other person's opinion or feel more pressure because you want it* [the product] *to work when someone is watching you.*"

In order to check if public and private contexts were inherently different with regard to positive affect, we conducted a one-way ANOVA. Results showed no effect of "social context" (public vs. private context) on positive affect [$F(1, 182) = 0.41$, $p = 0.523$]. Thus, there were no systematic differences to be further considered.

Hypotheses Testing

One-way ANOVAs were conducted to allow between-subjects comparisons of recalled experiences, i.e., actually experienced interactions, with regard to social context, i.e., public vs. private context. We assumed an effect of "social context" on need fulfillment for relatedness and popularity; particularly, we expected higher scores for relatedness (H1a) and popularity (H1b) when participants recalled experiences in public compared to private contexts. The opposite was assumed for competence, security, and autonomy (H2a, H2b, and H2c). All reported effect sizes were calculated using the partial eta square (η_p^2), with 0.01, 0.06, and 0.14 considered small, medium, and large effects, respectively (Lakens, 2013). **Table 3** shows means and standard deviations of the relevant five needs and positive affect (PA), and results of between- and within-subject comparisons.

Results supported our first two hypotheses by showing that participants experienced more need fulfillment of relatedness (H1a) and popularity (H1b) in public than private contexts. First, "social context" (public vs. private) had a significant effect on relatedness [$F(1, 182) = 43.24$, $p < 0.001$, $\eta_p^2 = 0.19$] and popularity fulfillment [$F(1, 182) = 19.11$, $p < 0.001$, $\eta_p^2 = 0.10$]. Relatedness was significantly higher for recalled experiences in public ($M = 3.28$, $SD = 1.30$) compared to private ($M = 2.05$, $SD = 1.24$). Second, popularity was

TABLE 3 | Means (*M*) and standard deviations (*SD*) of need fulfillment and significance of statements on between-subjects and within-subject group differences.

Measure	Experimental Group								Analysis	F^c	η_p^2
	recalled public[a]		recalled private[b]		imagined public[b]		imagined private[a]				
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Relatedness	3.28	1.30	2.05	1.24	2.98	1.37	1.63	1.03	H1a	43.24***	0.19
									H3a	136.90***	0.59
Popularity	2.83	1.03	2.18	1.00	2.64	1.09	1.93	0.99	H1b	19.11***	0.10
									H3b	81.67***	0.46
Competence	3.01	1.02	3.15	0.98	3.03	1.01	2.84	1.18	H2a	0.86	0.01
Security	2.64	1.12	2.92	1.14	2.80	1.20	2.38	1.22	H2b	2.82	0.02
Autonomy	2.97	0.97	3.16	0.96	2.74	1.02	2.77	1.16	H2c	1.78	0.01
									H4a	20.75***	0.19
Positive Affect	3.69	0.66	3.63	0.68	3.47	0.80	3.34	0.83	H5	29.21***	0.14

[a]*pub→prv condition (n = 96)*
[b]*prv→pub condition (n = 88)*
[c]*F(1, 182) for hypotheses 1, 2, and 5; F(1, 95) for hypotheses 3; and F(1, 87) for hypothesis 4*
***$p < 0.001$.

significantly higher in public context ($M = 2.83$, $SD = 1.03$) compared to private context ($M = 2.18$, $SD = 1.00$). In contrast, our hypotheses regarding competence (H2a), security (H2b), and autonomy (H2c) have to be rejected as "social context" had no effect on the need fulfillment of competence [$F(1, 182) = 0.86$, $p = 0.354$], security [$F(1, 182) = 2.82$, $p = 0.095$], and autonomy [$F(1, 182) = 1.78$, $p = 0.183$]. Overall, we found support for relatedness and popularity being social needs, i.e., needs especially relevant for public contexts, but no indication that competence, security, and autonomy could be labeled typical private, non-social needs.

Previous analyses of recalled experiences in public vs. private compared experiences with different products between people. To reduce potential confounding effects, we formulated hypotheses on within-subject comparisons and conducted one-way repeated-measures ANOVAs. Similar to the effect of "social context" in the between-subjects comparison, we expected to find an effect of context modification, i.e., "experience types" (recall vs. imagination), on need fulfillment. More specifically, we hypothesized that fulfillment of relatedness, popularity, and autonomy differs for "experience types" with higher values for recalls, i.e., interactions that participants actually experienced, than for imagination, i.e., when adding or removing others to/from the recalled experiences. Regarding relatedness (H3a) and popularity (H3b), the conducted ANOVAs revealed a significant main effect for "experience type" [relatedness: $F(1, 95) = 136.90$, $p < 0.001$, $\eta_p^2 = 0.59$; popularity: $F(1, 95) = 81.67$, $p < 0.001$, $\eta_p^2 = 0.46$]. Thus, in the pub→prv condition, the context modification, i.e., imaginatively removing present others, led to a decrease in need fulfillment of relatedness and popularity as need scores were lower in imagined (relatedness: $M = 1.63$, $SD = 1.03$; popularity: $M = 1.93$, $SD = 0.99$) compared to recalled (relatedness: $M = 3.28$, $SD = 1.30$; popularity: $M = 2.83$, $SD = 1.03$) experiences.

Regarding autonomy (H4a), one-way repeated-measures ANOVA revealed a significant effect of "experience type" [$F(1, 87) = 20.76$, $p < 0.001$, $\eta_p^2 = 0.19$] in the prv→pub condition as fulfillment of autonomy differed for recalled ($M = 3.16$, $SD = 0.96$) and imagined ($M = 2.74$, $SD = 1.02$) experiences. More specifically, autonomy was fulfilled less when imaginatively adding other people to a formerly private interaction.

Overall, within-subject comparisons (between recalled and imagined experiences) revealed a positive causal relationship between the presence of other people and need fulfillment for relatedness and popularity, and a negative one for autonomy. Since need fulfillment and positive affect are linked, we expect positive affect to be lower in imagined compared to recalled experiences. Thus, on the one hand, we suggested that experiences in public context are perceived less positively when no others are present (H5a). On the other hand, we proposed a decrease in positive affect when other people are added to formerly private interactions (H5b). Prerequisites (H3a, H3b, and H4a) are fulfilled as need fulfillment decreases when modifying social context through the imaginative addition (or removal) of other people. Consequently, we conducted a two-way mixed ANOVA and results showed significant main effect of "experience type" for positive affect [$F(1, 182) = 29.21$, $p < 0.001$, $\eta_p^2 = 0.14$]. In addition, we found a significant interaction between "experience type" and "social context" [$F(1, 182) = 4.24$, $p = 0.041$, $\eta_p^2 = 0.02$] and no significant main effect of "social context" [$F(1, 182) = 0.10$, $p = 0.752$]. More specifically, overall positive affect scores were higher in recalled experiences (pub→prv condition: $M = 3.69$, $SD = 0.66$; prv→pub condition: $M = 3.63$, $SD = 0.68$) compared to the modified versions, where people were imaginatively removed or added (pub→prv condition: $M = 3.34$, $SD = 0.83$; prv→pub condition: $M = 3.47$, $SD = 0.80$). Thus, hypotheses 5a and 5b were supported.

Exploratory Analyses

We conducted further exploratory analyses to gain deeper insights on the underpinnings of positive technology experiences in public space and the impact of present others.

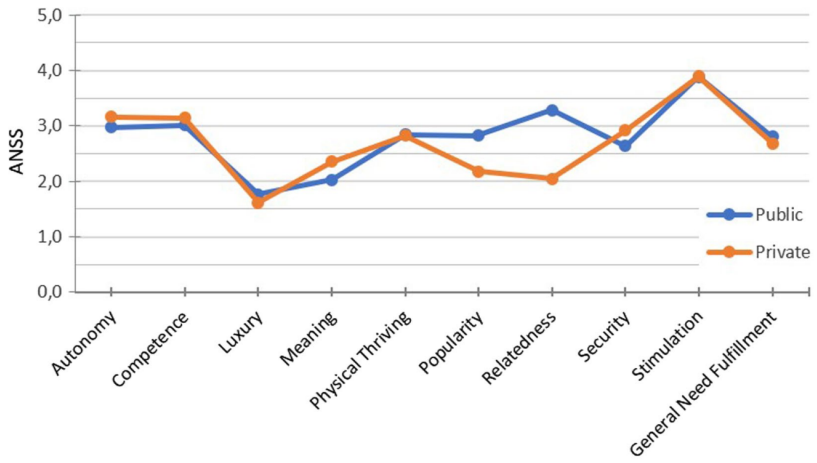

FIGURE 3 | Needs profiles for recalled experiences in public and private context. ANS, average need fulfillment score.

Need Profiles

Initially, we extended our focus to all nine measured needs to draw a more complete picture of the need fulfillment in technology experience. We created need profiles by comparing the need fulfillment for the initially given (i.e., recalled) public and private experience (see **Figure 3**). The detected need profiles are quite similar and show no significant differences besides those in relatedness and popularity reported above. An additional analysis of general need fulfillment showed that in both conditions general need fulfillment was equally high (public: $M = 2.81$, $SD = 0.65$; private: $M = 2.68$, $SD = 0.71$).

Needs and Affect

Furthermore, we explored relationships between our key variables, i.e., need fulfillment and affect. To this end, we pooled the recalled and imagined experiences, resulting in a dataset of 368 experiences (two for each of the 184 participants). Means, standard deviations, and Pearson correlations of the respective variables are illustrated in **Table 4**. Our analyses showed that high values for all needs are associated with high values for PA, $r(366) = 0.23–0.69$. In contrast, NA only correlated negatively with two needs: autonomy [$r(366) = -0.17$, $p < 0.01$] and physical thriving [$r(366) = -0.17$, $p < 0.01$]. However, such correlations can be considered rather low, especially when compared to the strong correlations between PA and general need fulfillment, $r(366) = 0.61$, $p < 0.001$.

Additional Factors

In order to reveal differences in how socially acceptable interactions in public and private contexts are, we conducted an exploratory one-way ANOVA. Social acceptability ratings differed between private ($M = 3.23$, $SD = 1.15$) and public context ($M = 4.01$, $SD = 0.97$; $F(1, 182) = 24.70$, $p < 0.001$, $\eta_p^2 = 0.12$). Thus, people seem to perform less socially acceptable technology interactions in private compared to public situations. In addition, we conducted an exploratory analysis of bivariate correlations between social acceptability and the key variables to investigate if and how social acceptability is linked to need fulfillment and affect. Results showed a strong correlation with NA but not PA, such that higher values for social acceptability come with lower values for NA, $r(182) = -0.24$, $p < 0.01$.

Furthermore, participants were asked to indicate the valence of context modification, i.e., if they perceive the same interaction as "better" or "worse" when adding or removing others. Results of exploratory one-way ANOVAs revealed differences between the two experimental conditions, $F(1, 182) = 13.70$, $p < 0.001$, $\eta_p^2 = 0.07$. Apparently, participants in the prv→pub condition assessed the addition of other people to formerly private interactions rather neutral ($M = 2.93$, $SD = 1.27$). In comparison, participants in the pub→prv condition indicated that the imagined experiences, i.e., formerly public interactions without others being present, would feel worse ($M = 2.30$, $SD = 1.04$). In fact, only 23.4% of all participants experienced the context modification as improvement, i.e., chose four or five on a 5-point scale, with the majority of these people (32 of 43 participants) reporting imagined experiences in public contexts. More specifically, in the prv→pub condition, 40.9% of the participants indicated that they experienced the imagined presence of others as negative (scoring lower than three on the 5-point scale), whereas 62.5% in the pub→prv condition claimed that their experience was worse when imagining performing the same interaction in private context.

We also assessed how active (vs. passive) present others were in the public interactions and explored if this influenced reported affect. There was a medium positive correlation between the involvement of others in the technology interaction and PA [$r(182) = 0.34$, $p < 0.001$]; a more active role of present others was correlated with higher PA values for public interactions regardless if it was a recalled or imagined experience. Besides, present others played a more active role in recalled

TABLE 4 | Means (*M*), standard deviations (*SD*), and correlations of need fulfillment, positive, and negative affect.

Measures	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. Autonomy	2.91	1.04	–											
2. Competence	3.00	1.06	0.44**	–										
3. Luxury	1.66	0.89	0.28**	0.13*	–									
4. Meaning	2.10	1.07	0.68**	0.43**	0.33**	–								
5. Physical Thriving	2.69	1.16	0.56**	0.40**	0.22**	0.61**	–							
6. Popularity	2.39	1.09	0.49**	0.43**	0.30**	0.48**	0.45**	–						
7. Relatedness	2.49	1.41	0.29**	0.18**	0.13*	0.33**	0.36**	0.58**	–					
8. Security	2.68	1.18	0.50**	0.45**	0.33**	0.50**	0.52**	0.46**	0.27**	–				
9. Stimulation	3.66	1.06	0.45**	0.42**	0.25**	0.40**	0.44**	0.37**	0.22**	0.23**	–			
10. General Need Fulfillment	2.62	0.75	0.77**	0.63**	0.46**	0.78**	0.76**	0.76**	0.59**	0.71**	0.61**	–		
11. Positive Affect	3.53	0.76	0.45**	0.54**	0.23**	0.36**	0.47**	0.43**	0.23**	0.37**	0.69**	0.61**	–	
12. Negative Affect	1.30	0.45	−0.17**	0.05	0.06	0.02	−0.17**	0.04	−0.01	−0.10	−0.06	−0.06	−0.12*	–

N = 368; *$p < 0.05$; **$p < 0.01$.

($M = 3.43$, $SD = 1.46$) compared to imagined ($M = 2.65$, $SD = 1.43$) experiences, $F(1, 182) = 13.37$, $p < 0.001$, $\eta_p^2 = 0.07$. Consequently, when participants recalled public interactions, present others were perceived as active in contrast to imagined public interactions in which participants assign them a more passive role.

Additionally, an analysis of the perceived publicness of the interaction showed that people in the pub→prv conditions ($M = 2.76$, $SD = 1.05$) and the prv→pub conditions ($M = 3.31$, $SD = 1.06$) rated the publicness of their interactions surprisingly different, $F(1, 182) = 12.49$, $p = 0.001$, $\eta_p^2 = 0.06$. Since a public context implicates the presence of other people during technology interactions, i.e., potential spectators, we expected to find a left-skewed distribution of scores. However, scores were nearly equally distributed over all answer options. In fact, only 17 of 96 participants in the pub→prv condition rated their experiences as strongly public (i.e., values higher than four on a 5-point scale). For participants in the prv→pub condition, this trend was even larger; 39.8% (35 of 88 participants) stated that their imagined experience would feel strongly public to them (i.e., score of four or higher).

DISCUSSION

The present study aimed to investigate how positive experiences with technologies emerge in (non-)social contexts. In addition to context-dependent differences in need fulfillment, we were interested in the direct impact of present others on users' subjective experiences. We predicted that there are needs particularly relevant in public context, as well as needs that are fulfilled more in the private context. In fact, we assumed that the fulfillment of such needs is causally linked to the presence or absence of others. Consequently, in the very same interaction, certain needs play a more or less important role depending on social context. Following up on this, we suggested a positive relationship between need fulfillment and positive experience and predicted a lower positive affect for modified contexts, i.e., when people were removed from interactions in public or were added to interactions in private contexts.

Our results support hypotheses 1a, 1b, 3a, and 3b by showing that the fulfillment of relatedness and popularity is higher in recalled public interactions compared to recalled private interactions (H1a and H1b) and when people are imaginatively added to a formerly private situation (H3a and H3b). We could not find support for hypotheses 2a, 2b, and 2c, as we found similar need fulfillment for competence, security, and autonomy in public and private contexts. However, results support hypothesis 4a and show that imaginatively removing people from formerly public situations while performing the same interaction resulted in greater autonomy fulfillment. Therefore, we conclude that there is a category of "social needs" that are particularly relevant in public contexts and whose fulfillment depends on the presence of other people. But on the other hand, there are apparently no equivalent "non-social needs" that specifically pertain to private contexts. Competence and security did not differ between contexts and we could only find inconclusive results for a higher need fulfillment of autonomy

when being alone. In line with Hassenzahl et al. (2015), we found context-dependent differences in need fulfillment only for popularity and relatedness but not for security and competence. Thus, we could not replicate the findings of Hassenzahl et al. (2010) showing that competence and security were significantly less salient in social situations. Apparently, the presence of others did not automatically limit the experience of feeling competent, secure, or autonomous. Possible explanations for the absence of these effects are described in the following.

Regarding competence, one could argue that this need also plays a central role in public contexts as people strive to give the impression of being capable. Remember our example from the introduction, waiting at a bus station while using the voice assistant of your smartphone. In the case of smooth and successful speech interaction, your feeling of competence probably would not be negatively affected by present others. Taking it even one step further, perhaps it would feel good to master the speech interaction precisely because other people are watching you? However, since our data neither showed significant differences between public and private context nor between recalled and imagined experience, one might conclude that the fulfillment of the need for competence is not exclusively arising from social context.

Security does not seem to be mainly relevant for technology interactions in private context either. Participants' need fulfillment did not differ significantly between the recalled experiences in public and private contexts. Screening of participants' experience reports suggests that the need for security can also be fulfilled in public contexts as others may support feeling "safe and in control of your life" (Sheldon et al., 2001). For example, one participant described the preparation of coffee with an electronic machine together with their mother as a pleasant ritual. Furthermore, by taking a closer look at the answers of participants in the prv→pub condition on how a modification of social context (i.e., removal of other people) would affect them, some users conceived present people as potential sources of support. Thus, present others do not necessarily make life more unpredictable and could even function as supporters, e.g., when having experience or expertise with the particular technology. Given that only 12.5% of the people attending the technology interactions in public context were unknown persons, the possibility of receiving help from known others might have contributed to feeling secure and thus to similar security fulfillment in recalled private and public situations. This illustrates how complex the influence of "social contexts" can be.

Contrary to our expectation, the need for autonomy was not fulfilled to a higher extent in private contexts. Even though autonomy fulfillment was lower when people were imaginatively added to what was originally a private interaction, it should not be concluded that performing the same interaction while being alone awakes a greater feeling of autonomy compared to being surrounded by others. We can think of the following possible explanations for the contradictory results regarding the feeling of autonomy (H2c and H4a). On the one hand, even when interacting with technology in a public context, the user is still the one in control of the interaction, regardless of whether someone is present. On the other hand, a decrease in autonomy fulfillment could be caused by the experimental manipulation. People might have perceived our instruction to imagine a change to their previously recalled experience as an intrusion of their autonomy, since "external forces or pressure are the cause of (their) action" (Sheldon et al., 2001, p. 339), and therefore assessed the fulfillment of autonomy lower in response. However, social desirability (Grimm, 2010) could serve as a possible explanation as well. Since low need fulfillment for competence, security, and autonomy seems undesirable in social situations, participants could have adapted their response patterns.

Our results support hypotheses 5a and 5b as we detected a decrease of positive affect when context was modified. For example, removing other people from a recalled public interaction led to less positive affect. This second key finding of our study is in line with previous research (e.g., Hassenzahl, 2010), which showed a correlation of social context and need fulfillment as well as a correlation of need fulfillment and positive affect. In our view, the most compelling explanation for the difference in positive affect between recalled public and imagined private interaction is a (missing) compatibility of social context and technology interaction. By showing that the modification of social context, i.e., removal of present others, had a negative impact on the experienced effect of participants, our study stresses the risk of performing an interaction in an "unsuitable" context. For example, imagine using your smartphone to listen to your favorite song after a long day of work. In order to relax, you put on earphones and start dancing and singing along. For some people, the presence of other people might disturb this experience. Results of our exploratory analyses also support this potential explanation; only 23.4% of all participants indicated that the modification of social context would lead to an improvement of their technology experience. Hereby, participants in the prv→pub condition, i.e., imaginatively adding other people to a formerly private interaction, make up the majority of this group. We conclude that the context modification in form of adding people to a private situation was perceived as neutral or even as a potential gain. In contrast, removing present others from public situations was experienced as negative or as a loss.

Another important finding is the (non-)correlation of social acceptability and need fulfillment with experienced affect. General need fulfillment only correlated with positive but not negative affect. But the opposite is true for social acceptability, which correlated with negative but not positive affect. Thus, a lack of social acceptability can be detrimental, but positive experience may arise independently through the fulfillment of needs. We conclude that a conceptual distinction between the preventative social acceptability view and a positive, need-based perspective on designing meaningful technology experiences is reasonable and necessary. Parallels can be drawn with previous research (Hassenzahl et al., 2010) which, inspired by Herzberg (1959) two-factor theory, distinguished "hygiene factors" and "motivators" when it comes to explaining the emergence of positive technology experience. Hassenzahl et al. (2010, p. 359, 361) described motivators as "the product's perceived ability

to create positive experience through need fulfillment" and hygiene factors as instrumental aspects of interactive products "dampening negative affect but not being a source of positive experience in itself." Moreover, results of exploratory analyses also support the idea of context-interaction fit by revealing higher social acceptability of recalled experiences in public compared to private contexts and linking social acceptability to negative affect. Formerly, public interactions were basically perceived as socially acceptable. But positive private technology interactions turned out to be potentially "unacceptable" when adding others to the situation. Since low social acceptability is associated with negative affect, interacting with an interactive technology insensitive to changes in social context bears the risk of not only receiving negative reactions from others but also experiencing the interaction more negatively oneself.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Taken together, we showed that the sources of positive experience differ systematically depending on the social context (i.e., presence or absence of other people) and that context changes from public to private or vice versa can have a substantial impact on how people experience interactive technologies.

Our results support the causality assumption of the effect of social context on need fulfillment. Thus, they underline the importance of extending theoretical frameworks with a notion of social context that accounts for its positive potential for technology experiences (instead of its constraints). For example, two of the most widely applied models of technology use are Technology Acceptance Model (Venkatesh and Bala, 2008) or Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2016). However, these models mainly consider subjective norms, social influences, and facilitating conditions of contexts as shaping merely the acceptance of technologies. As we laid out before, these considerations are in line with a negative social acceptability view on context effects, i.e., more of an ought-to than a want-to perspective. This implies an extrinsic motivation to technology use, but the presence of others might also boost users' intrinsic motivation since those others contribute to the positive user experience. Hornbæk and Hertzum (2017 p. 26) who investigated previous literature on technology acceptance and user experience already stated that the experiential component in HCI is still not well recognized. In accordance with our approach, they emphasized that the concept of psychological needs would help to analyze and understand the motivation for technology adaption and use and criticized that, currently, "accounting for social aspects of use and incorporating them into modeling of experiences (still) seems underdeveloped". Besides, the finding of social acceptability as a "hygiene factor" (i.e., reducing negative affect but not supporting positive affect) highlights the relevance of a shift in focus to the creation of positive public interactions through deliberate need fulfillment. However, to create a "context-sensitive" model which considers wellbeing as a result of need fulfillment in dynamic social contexts for describing and predicting positive technology experience, further research is needed because social context is more complex than the distinction in private and public context (see "Limitations and Future Research Directions").

Regarding practical implications, our study emphasizes the importance of considering contextual aspects and psychological needs when designing interactive technologies. For example, design approaches for public space should consider ways to establish relatedness to present others and/or foster a popular impression of the user toward them. Re-designing smartphones by adding a display on their backs allows counterparts or spectators, respectively, to gain insights into what exactly the user is doing when interacting with their smartphone (Jarusriboonchai et al., 2016). By informing or even involving the counterpart in one's phone activities, a greater feeling of relatedness in user and spectator could be generated (Beukeboom and Pollmann, 2021). Concrete design implications for technologies that address a varying social context could be drawn from, for example, context-aware devices, i.e., systems which are aware of their surroundings and respond intelligently to environment changes (Colley et al., 2016). Interactive products which offer two (or more) "modes" for the context of use depending on its publicness might be good solutions. A simple example is the "silent mode" of smartphones; if users find themselves in a public situation where talking on the phone or even a ringing smartphone would be a distraction or disturbance (for the user or present others), turning on silent mode is a way to avoid these negative effects. However, such solutions rely on users recognizing if an interaction could have negative consequences for themselves or others and adjusting their behavior. This means that there is a dependence on the user's assessment of the context-interaction fit and willingness (and ability) to react to it. Here, dynamically changing contexts (Dix et al., 2000) and the fact that people sometimes interact with technology, e.g., mobile phones, out of habit or even implicitly (Humphreys, 2005) pose a challenge. In these situations, people may not be aware of when and how their use impacts themselves and others and will not make a deliberate decision for or against an interaction (type). Thus, designers and researchers must face the challenges which arise in the rapidly evolving landscape of interactive technologies and develop adaptive, intelligent products which serve people – users and present others – well (Ens et al., 2015; Grubert et al., 2016). Since our analyses showed that active involvement of present others in participants' experiences is linked to positive user affect, another practical implication for the design of interactive technologies may lie in the deliberate engagement of spectators in users' technology interactions – if desired. Previous research on (social) engagement and collaboration *via* interactive products (e.g., Fails et al., 2010; Lucero et al., 2011) can be used as orientation and inspiration for such studies.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The present study has several limitations that should be addressed in future research. First, some limitations need to be acknowledged with regard to the research methods. With the questionnaire method, we chose a quantitative research approach because the

main focus was on exploring general differences between public and private experiences with technology in a systematic and experimental way. This has certain limitations, such as a self-report bias or a risk of misunderstanding items (e.g., Paulhus and Vazire, 2007; Remillard et al., 2014). In the future, field studies (e.g., in cafés or airports) are planned to complement findings from subjective self-reports with objective observations. Another methodological limitation concerns the fact that all analyses are based on recalled or imagined experiences, which yields the question of how representative these mental references are for real-life interactions. Though the here applied method to assess (retrospective) need fulfillment with a questionnaire or based on qualitative narratives is well established in HCI research (e.g., Hassenzahl et al., 2010, 2015; Partala and Kallinen, 2012; Partala and Kujala, 2016) and has proven as a valuable source of insights, future studies could complement retrospective approaches by a daily diary approach, such as experience sampling (Hektner et al., 2007). This *in-situ* method aims at measuring behavior, thoughts, and feelings of participants related to certain experiences or activities throughout their daily life and, thus, overcomes shortcomings of post-hoc techniques like recall errors. In doing so, this may deliver deeper insights into the source of positive affect, the purpose of interaction, and relevant context factors by instructing participants to report their daily experience with a specific kind of technology (e.g., virtual reality glasses) or technology interaction (e.g., voice control) over a longer period of time. Moreover, a qualitative research approach allows for the personalization of instruments, which facilitates more detailed addressing of sample characteristics (e.g., Zhang and Rau, 2015; Bolaños et al., 2021).

A second limitation concerns the experimental manipulation of context for the within-subject comparisons; it can be challenging to imagine your own feelings and behavior in fictional scenarios. Occasionally, participants' recalled experiences that were difficult to imagine in an opposite context. For example, one person reported taking a picture of their family with a camera. Although we excluded participants who stated being unable to imagine their technology interaction in the modified context. Future studies could address this limitation by prescribing concrete technology interactions to ensure that the interaction is applicable to private and public contexts or concentrate on the interaction styles (e.g., touch-, voice-, or gestures-controlled). However, since the type of technology may influence the experience, it is recommended to shift the focus for examination from context-specific requirements to a specific technology type in future studies.

Third, the dichotomous classification of contexts as public and private constitutes a challenge. Participants' ratings of how observed they felt during their experiences varied remarkably (in private and public). Moreover, interacting with a specific kind of technology can even feel more or less public when being surrounded by others. For example, two participants who recalled using VR glasses in public assessed the publicness of their interaction completely differently; while one participant reported that they felt strongly watched using VR glasses in a museum, the other participant did not feel observed at all during interacting in a gaming center. Presumably, potential spectators do not necessarily lead to a stronger feeling of being watched. Additionally, ubiquitous technologies blur the boundaries between private and public (Reeves, 2011), a clear distinction of public and private context is becoming increasingly difficult (Hatuka and Toch, 2016). Our study provides a coarse comparison between public and private that should be investigated in more detail in the future. Since most of the recalled and imagined public interactions were with familiar others in the present study, future studies could rely on the subjectively perceived publicness of interaction or focus on specific components of the social context (e.g., place of interaction, relationship to present others, and their involvement). It is presumed that the user experience of a given technology (interaction) may differ depending on whether present others are familiar or strangers (e.g., Williamson, 2012; Ahlström et al., 2014). Furthermore, since our original four-item publicness scale needed adjustments, we consider the development and validation of a scale to measure perceived subjective publicness of interactions an important topic.

Fourth, while our study on positive technology experience was limited to the experiences of users, future research should also involve the spectator's perspective. More specifically, differences between users' and spectators' experiences of the very same technology interaction provide an interesting research subject. Previous studies that surveyed both, users and spectators, suggest that variations or deviations in acceptance ratings of technology between the two groups are likely (e.g., Lucero and Vetek, 2014; Koelle et al., 2015; Alallah et al., 2018). For example, while people enjoy using mobile phones in public or semi-public places (Hampton and Gupta, 2008), present others may be disturbed by forced-noticing of the user's conversation (Campbell, 2007a,b). This public-private paradox (Jarvenpaa et al., 2005) should be further explored in experimental studies to deduct practical implications on how to design technology interactions that support users' need fulfillment without negatively affecting present others – or even fulfilling their needs, too. Moreover, it could be interesting to investigate user-spectator dyads in further studies to explore potential differences in the technology experience of users and spectators depending on the extent of the spectator involvement in the technology interaction (e.g., Maurer et al., 2014; Gugenheimer et al., 2017; Humphreys and Hardeman, 2020). Such studies would contribute to a better understanding of socio-technical ecosystems by revealing, analyzing, and predicting interactions between user, spectator, and technology. Specifically, future studies could investigate how different forms of interaction (e.g., control *via* voice vs. touch) for a particular technology affect the social environment or present others, respectively, and how present peoples' reactions, in turn, affect the user's interaction process. Varying the role (i.e., active vs. passive involvement into user interaction) of the present others could provide further interesting insights.

Finally, the target sample is a German-speaking population; thus, generalizations to other cultural backgrounds have to be made with caution. Social contexts vary greatly within and across cultures. Comparative studies in different cultural contexts are needed to develop a more comprehensive picture (Sturm et al., 2015).

CONCLUSION

Nowadays, many interactive products are still insensitive to our social surroundings or do not account for (sudden) contextual changes and, thus, are insufficiently adaptive to the socio-technical ecosystems we live in. As a consequence, these systems might be impaired in serving their intended purpose. Our work underlines the importance of adaptive technologies by showing that need fulfillment is dependent on social context and that people experience the same technology interaction less positive if this context is altered. In fact, our study is congruent with the findings of Hassenzahl et al. (2010, 2015) who found relatedness and popularity to be fulfilled to a greater extent in public contexts. However, we could not find support for the expected higher fulfillment of competence, security, and autonomy in private contexts, i.e., when being alone. Furthermore, need fulfillment of relatedness and popularity as well as positive affect significantly declined when originally present others were imagined absent. Thus, we conclude that positive experiences in public are mainly shaped by feelings of relatedness and popularity and are closely tied to the presence of other people. In addition to that, exploratory findings indicate that less negative affect is associated with higher social acceptability of the interaction, while positive affect is related to the overall fulfillment of psychological needs. Taken together, the technology experience differs systematically depending on the social context, which emphasizes the importance of considering contextual aspects in the design of interactive technologies. For example, design approaches for social contexts should consider ways to establish relatedness to present others and foster a popular impression of the user among them. While many research and design approaches focus on user and machine in a contextual vacuum, the dissemination of interactive products into everyday life calls for a more socially oriented perspective to create positive user experiences.

We hope that our work will stimulate further investigation into the role of social context for technology-mediated positive experiences. Existing models to describe and explain technology-mediated positive experiences focus mainly on the individual experience of the interactant. Neither do these models incorporate the impact of social context on individual experience, nor do they attempt to describe social context in detail. The present study demonstrates the impact of social context on individual experiences and is thus a first step toward the development of an expanded model that describes how social context shapes the relevance of different needs, their fulfillment, and ultimately subjective wellbeing. Therefore, future research should take a more fine-grained perspective on interaction in social context, for example, by including the spectator perspective, exploring dyad-interaction, and investigating further qualitative differences between different types of social contexts (see Uhde and Hassenzahl, 2021). In addition, further research methods, such as diary studies, should complement the present approach taken. At this point, our study already contributed to the understanding of the emergence of positive technology experiences in public situations in several regards. First and foremost, we experimentally manipulated the presence of others and thereby confirmed the existence of needs, which are paramount to public contexts. Second, we assessed a broad spectrum of psychological needs and could thus draw a more complete picture of public (as well as private) technology-mediated experiences. Finally, we provided evidence for a conceptual distinction between a rather preventative social acceptability view on technology use and a positive, need-based perspective on designing meaningful public technology-mediated experiences.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/s45v8/?view_only=9d4dbb6694094fd8a13db4dbfc9d25a2.

ETHICS STATEMENT

Ethical review and approval were not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

PT, ST, and AU conceived and carried out the study and performed the data analyses. PT wrote the first draft of the manuscript. ST and AU revised the manuscript. SD and MH edited the drafts and provided feedback on the project and the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.718315/full#supplementary-material

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How present others shape the user experience of service robots

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Abstract

In the age of mobile technology and self-service technologies (SSTs), human-computer interaction (HCI) often takes place in public settings. From a psychological perspective, such interaction can be considered as performance before others, whereby the relationship with potential observers may affect user preferences for concrete interaction styles. While particular interaction styles could be rather embarrassing or disturbing for others, others may provide the opportunity for favorable self-presentation or connection with others. The present study investigated how the presence of different observers (i.e., acquaintance, stranger) highlights different psychological needs and in turn, affects preferences for more or less expressive interaction with a service robot. Results show that participants' need for relatedness was higher when imagining a robot interaction with a close observer and preferred a more expressive interaction, whereby the effect of the observer type on interaction preference was fully mediated by relatedness. With an unknown observer, the need for popularity dominated over relatedness, and popularity was associated with a preference for expressivity if the interaction was considered an internally attributed success. Our research provides valuable insights into the role of the observer in public HCI and can inspire designers to view present others as an opportunity for creating positive user experiences.

Keywords: service robot, HRI, observer, public space, expressivity, psychological needs, user experience

1. Intro

A major theme of modern life is our increasing reliance on technologies. In addition to the myriad of personal devices that shape our private lives, we also encounter more and more innovative and unfamiliar technologies in public spaces. Companies are already using ticket machines, ordering terminals, or self-checkouts to replace human staff and empower the customer, while the service robot market is predicted to grow by a multiple in the next few years (Tojib et al., 2022).

Accordingly, users increasingly interact with more or less unfamiliar devices while other people are around, potentially witnessing, judging, or even joining them. Therefore, those interactions become akin to public performances. Such performances may evoke feelings of embarrassment or pride, depending on whether we struggle or succeed, but they may also create a sense of shared experiences. Those feelings are grounded in the basic psychological needs for popularity and relatedness, two inherently social needs, whose fulfillment during product interactions supports positive and meaningful user experiences (Hassenzahl et al., 2010).

Research addressing human-computer interaction (HCI) in public space or context often treats the present others as potential risk or problem as they can disturb or be disturbed by the user interaction. Thus, social acceptability often dictates the design of public technologies (Koelle et al., 2020), resulting in subtle or covert interaction patterns. However, we propose that the presence of others can also be a source of positive experiences in public, if they provide the opportunity to fulfill needs that require other people, like popularity or relatedness. But in order for those needs to be fulfilled, others have to witness our interactions, which is why their expressivity, i.e., how extensive and noticeable they are, becomes paramount. At the same time, when interactions are expressive, and thus may be witnessed by others, how we relate to those others becomes increasingly important. We suppose that individuals place greater importance on gaining acceptance and recognition (need for popularity) with strangers, i.e., observers they don't know, while prioritizing building and maintaining relationships (need for relatedness) with acquaintances, i.e., people who are emotionally closer to them.

To examine this, we conducted a vignette study on how the relationship with an observer shapes the user experience (UX) with a service robot in a café. More specifically, participants were asked to reflect on what would be important for an ideal interaction with the robot when being observed by a person either close or unknown to them. Preferences for the fulfillment of different psychological needs (i.e., relatedness and popularity) and expressivity (i.e., how extensive, obvious, and/or noticeable the interaction should be) were assessed, as well as people's cognitive evaluations of the expected encounter (i.e., success expectation and its attribution).

The following literature review juxtaposes research on the use of robots in private against public contexts, challenges against opportunities that come with it, and pragmatic against experiential service robot qualities. By doing so, we emphasize the relevance and significance of analyzing the impact of "passive" observers on the user experience and adopting a positive and experiential approach that considers the observer as a kind of resource and focus on the experiential value of an interaction.

2. Related Work and Research Gaps

2.1 Private vs. Public Use Contexts

Self-service technologies (SSTs) such as check-out terminals, ticket machines, and also service robots are often situated in public spaces, where users are exposed to social influences. However, pertinent research often lacks consideration of interaction contexts, although meta-analytic comparisons for SSTs show differences in public and private settings (Blut et al., 2016). For example, ease of use, previous experience with the product, and perceived risk are stronger predictors of acceptance for public than for private settings. Additionally, technological anxiety becomes even more pronounced when users feel crowded and time-pressured (Gelbrich & Sattler, 2014) – a circumstance that applies to many public spaces.

Research on contextual factors in the acceptance of service robots is even scarcer. While numerous empirical studies cover a diverse set of service settings (Holthöwer & van Doorn, 2022; Mende et al., 2019), there are hardly studies comparing different settings yet. One such study, conducted by Park et al., provides initial evidence that the context in which a service robot is implemented affects users' psychological processes (Park et al., 2021). Tojib et al. (2022) also demonstrate that different psychological motivations can drive the preference toward human staff or service robots. Furthermore, by comparing human with robot service encounters, Holthöwer and van Doorn (2022) report across several studies that social presence can be a source of discomfort for consumers in embarrassing situations. In uncertain situations though, social presence can also enhance the perceived trustworthiness of service robots (Delgosha & Hajiheydari, 2021).

As these studies considered the role of present others as individuals (actively) involved in the interaction, we were explicitly interested in their impact as observers. Furthermore, previous research has shown that social entities who are not partaking in an interaction can affect the service experience in many ways (Argo, 2020; Argo et al., 2005; He et al., 2012), but there is no research yet on how different observers might affect user needs and demands regarding the service robot interaction (Holthöwer & van Doorn, 2022).

2.2 Challenges vs. Opportunities of Public Interactions

As humans, we have an innate human desire for a positive self-image (in terms of approved social attributes) that we want others to share (Goffman, 1955). We constantly engage in so-called impression management behaviors to get others to see us the way we want them to (Goffman, 1959). Accordingly, even if impression management is not our main concern, the use of technologies

in public spaces constantly poses a risk, but also an opportunity, for our favorable self-presentation toward others (Leary, 2019).

Research on public technology interactions, however, predominantly revolves around the potential risk of negative social evaluation (Koelle et al., 2020). It explores, when people feel (dis)comfort in public interactions, why they do, and how to improve them. Public interactions are assessed according to their so-called social acceptability, which is "typically defined through negation, or an absence of negative judgment" ((Koelle et al., 2020), p. 6). Given this conception and designers' traditional focus on solving problems, most approaches aim at avoiding negative experiences by either hiding interactions or at least reducing their "intrusiveness" to not disturb others or be exposed to their judgment.

Little attention has yet been paid to the positive side of others witnessing those interactions, beyond superficial benefits like looking cool, fancy, or stylish (Koelle et al., 2020). This is quite surprising given the fact that UX research has identified numerous instances where the social aspect of a technology interaction satisfies a fundamental psychological need that primarily motivates its use (Desmet & Fokkinga, 2020; Hassenzahl et al., 2010). To design ideal interactions that are enjoyable and meaningful, the what and how of an interaction should align with its why (Diefenbach et al., 2013). Therefore, by considering not only the user of a technology but also those (passively) attending, we can gain a deeper understanding of how to design positive interactions that fulfill the needs of all "stakeholders" involved in those situations (Von Terzi & Diefenbach, 2023).

2.3 Pragmatic vs. Experiential Qualities in Service Robots

Service robots may be considered a subtype of SSTs, as they are ''technological interfaces that enable customers to produce a service independent of direct service employee involvement'' ((Meuter et al., 2000), p. 50). A large part of research on SSTs revolves around what makes users accept those devices and how to support their adoption (Blut et al., 2016). One of the most prolific models in this endeavor is the so-called Technology Acceptance Model (TAM), which poses a pragmatic view that highlights perceived usefulness and ease of use as the main contributor to technology acceptance (Davis, 1989).

However, when it comes to the acceptance of service robots, the application of SST research might fall short. SSTs are largely low-autonomous, non-intelligent, less-sophisticated devices, and thus differ fundamentally from service robots (Mende et al., 2019; Tojib et al., 2022). Their ideal is to deliver the intended outcome by providing usefulness and ease of use. Service robots are expected to perform high on those pragmatic measures by default, but research has just recently begun to incorporate not only functional but also hedonic determinants as essential drivers for service robot use (Alotaibi et al., 2022; Lu et al., 2019; Molinillo et al., 2022). Within the predominant TAM-perspective in service robot research (Tojib et al., 2022), aspects at the core of UX models have fallen short. On the one hand, the TAM is directed at the prediction of acceptance as an aggregate-across-episodes, while UX models build on episodes-of-use (Hornbæk & Hertzum, 2017). The latter allows for a better consideration of social influences in a particular situation. On the other hand, the TAM employs a quite utilitarian approach, with cognitive arguments like a product's usefulness as the most decisive factor, while UX models also pronounce the experiential component of product use, with affective arguments like hedonic motivation (Hornbæk & Hertzum, 2017).

The importance of incorporating the experiential value of an interaction shows in a wide array of recent works: hedonic motivation is a considerably larger predictor than performance expectancy of the intention to use conditionally automated cars (Nordhoff et al., 2020) or AI robotic devices in hospitality services (Lin et al., 2020); a satisfying experience is not less important for utilitarian SSTs than for hedonic SSTs (Blut et al., 2016); the adoption of service robots in shopping malls is

determined by their capability to be useful as well as entertaining (Niemelä et al., 2019); and perceived enjoyment has a stronger effect on attitude towards technologies than perceived usefulness or ease of use (Hornbæk & Hertzum, 2017). Consequently, latest models in service robot literature call for the inclusion of cognitive and affective factors (Lin et al., 2020; Shi et al., 2021) and we aim to contribute to the recently growing interest in robot-related, individual-related, social, and contextual factors in service robot adoption compared to the TAM (Tojib et al., 2022).

A service robot that can be interacted with via voice or tablet interface (Pandey & Gelin, 2018) can illustrate how following the user's needs can mean to either prevent negative experiences or create positive ones. For example, imagine a hotel guest asking the robot for a nearby dermatologist to inspect an unpleasant rash. Of course, that person would probably prefer a textual interaction over the risk of letting others overhear their conversation. Conversely, imagine a travel group searching for a restaurant recommendation. They might enjoy a conversation so that everybody can join in and share a common experience. Or someone may even find pleasure in showcasing their nonchalant dialogue with this futuristic technology in front of other guests. A medium-sized touch display would deeply constrain these opportunities for pleasure.

3. The Present Study

The aforementioned example of a service robot highlights how underlying needs may have different implications for how expressive an ideal interaction should be. Together with the outlined research gaps regarding experiential qualities and social context, we set out to investigate the public interaction with service robots in a study that integrated the three basic pillars of service robot implementation (Belanche et al., 2020b): robot design (here: the degree of expressivity of an interaction), customer features (here: the users' dominant psychological needs), and service encounter characteristics (here: the relationship to observers).

Consumer research on social influences suggests two types of non-informational, positive factors: affiliation-related rewards and the enhancement of the self in the eyes of others (Argo, 2020). The first compromises the need for social support, interpersonal attachment, or belonging (i.e., relatedness), while the latter describes the need for recognition or positive evaluation (i.e., popularity). Both needs, need for relatedness and need for popularity, find themselves in user experience research as they have been shown to be an integral part of positive technology interactions in public (von Terzi et al., 2021). While each of these "social needs" feeds from the presence of other people, they are yet quite different. For example, many experiences may be shared with others, but only some will affect how they think of us. On the other hand, our performances are less indicative of our individual capabilities, when others were actively involved instead of passively witnessing.

3.1 Observer Relationship and Need Fulfillment

Psychological research indicates that the relevance of relatedness and popularity may vary depending on our relationship to present others. For example, positive experiences are amplified when they are shared with psychologically proximate compared to distant others (Boothby et al., 2016). Perceived closeness even affects the social motives behind sharing experiences. While we are inclined to protect others when they feel close, we are driven by an underlying motive to self-enhance with distant others (Dubois et al., 2016). A common distinction of social presence in service settings is one between in-group members, i.e., acquaintances or friends and family, and out-group members, i.e., strangers (He et al., 2012; Qiu et al., 2018). Depending on the observer, we assume that people place a different emphasis on either relatedness or popularity when asked about their ideal interaction with a service robot.

- **H1a**: Users express a higher need for relatedness when interacting with a service robot in presence of a close person (compared to an unknown person).
- **H1b**: Users express a higher need for popularity when interacting with a service robot in presence of an unknown person (compared to a close person).

3.2 Need Fulfillment and Expressivity

As laid out before, designing public technology interactions often revolves around guaranteeing social acceptability, which often leads to subtle, covert, and unobtrusive interactions. A complementary strand of research however deals with the analysis and design of performative interactions, i.e., interactions that are affected by the spectacle resulting from the interaction itself, the public setting, or the presence of an audience (Williamson et al., 2014). Every human action in public spaces, even if not intentionally a performance, has a performative aspect (Hansen et al., 2011). This means users are not only operators anymore but also performers as well as observers of their own interactions (Dalsgaard & Hansen, 2008; Rico & Brewster, 2010).“Performative” in that sense describes “an action that one is aware may be witnessed by others – and that awareness may affect the nature of the action, the perception of that action, and/or an evaluation of the self who is undertaking that action” ((Spence, 2016), p. 5), though scholars may put different emphasis on the actions themselves or the effects they have (Dix et al., 2006; Saltz, 1997). Therefore, we use the term “expressivity” as the degree to which an interaction is noticeable and thus its probability to be witnessed by others.

Avoiding human interaction is one of the reasons people use SSTs, a tendency that might be rooted, for example, in anxiety, privacy concerns, or a feeling of autonomy and self-efficacy (Blut et al., 2016; Oh et al., 2013). Such reasons, as well as simply habits, may explain why people are apt to use touchscreens rather than talking to service robots (Mende et al., 2019; Pinillos et al., 2016). But research already indicates that people are less concerned about robots talking to them and even accept privacy violations as long as they make a good impression in the process (Hedaoo et al., 2019). Moreover, meta-analytic analyses on SSTs do not show generally more anxiety in public compared to private settings, people may even appreciate the social support (Blut et al., 2016). And user reports from positive public interactions highlight the fulfillment of social needs like relatedness and popularity (von Terzi et al., 2021). Therefore, we assume that people, who seek fulfillment of those needs in public service robot interactions, also appreciate a higher level of expressivity.

- **H2a**: A higher need for relatedness is associated with a higher preference for expressivity.
- **H2b**: A higher need for popularity is associated with a higher preference for expressivity.

3.3 Observer Relationship, Relatedness, and Expressivity

Following our previous arguments that people want to experience more relatedness with close others and that relatedness is associated with a higher preference for expressivity, we propose a mediating role of relatedness between the relationship to an observer and expressivity. When people are with close others, we expect them to favor a shared experience and thus a more noticeable interaction.

- **H3**: The need for relatedness mediates the effect of relationship to the observer on expressivity.

3.4 Observer Relationship, Popularity, and Expressivity

Finally, we also expect a mediating role of popularity but in a more complex model. While an expressive interaction is sufficient for sharing an experience and thus a sense of relatedness, it is only one prerequisite for experiencing popularity. Additional conditions may also be a successful

interaction and personal responsibility for the success, which we both consider to moderate the mediation of popularity on the association of observer relationship and expressivity.

According to the control-value-theory of achievement emotions, the emotions that people experience in anticipation of a task are the result of an appraisal process that incorporates subjective value and control (Pekrun, 2000, 2006). In our case, popularity is a basic human need that inherently provides subjective value. Control, in turn, is a result of expectancies and attribution processes, i.e., do I expect success and will it be my own merit (Pekrun et al., 2007). Similarly, we expect people that strive for popularity only to experience anticipatory joy and therefore a preference for expressivity, if they (1) expect a successful interaction (i.e., success expectation) and (2) if that success is not due to external sources (i.e., external attribution). If one does not expect to be successful or if an interaction will not influence the impression toward others, there is no reason to prefer an expressive interaction.

These theoretical considerations are also in line with recent research highlighting the role of performance expectations (Fan et al., 2020; Tojib et al., 2022) and blame attributions (Belanche et al., 2020a; Fan et al., 2020) in service robot research. Therefore, we assume that people want others to notice their interaction to fulfill their need for popularity particularly when they are confident that they are successful and if this success is not externally attributed. This results in a mediation model with two potential moderators outlined in the following.

- **H4**: A moderated mediation model adequately describes the relationship between observer, popularity, success expectation, external attribution, and expressivity:
    - (**a**) Mediation: The need for popularity mediates the effect of relationship to the observer on expressivity.
    - (**b**) Moderation: The effect of need for popularity on expressivity is moderated by success expectation.
    - (**c**) Moderation: The moderation of the effect of need for popularity on expressivity by success expectation is in turn moderated by external attribution.

The model of H4 as well as all other hypotheses are summarized in Figure 1.

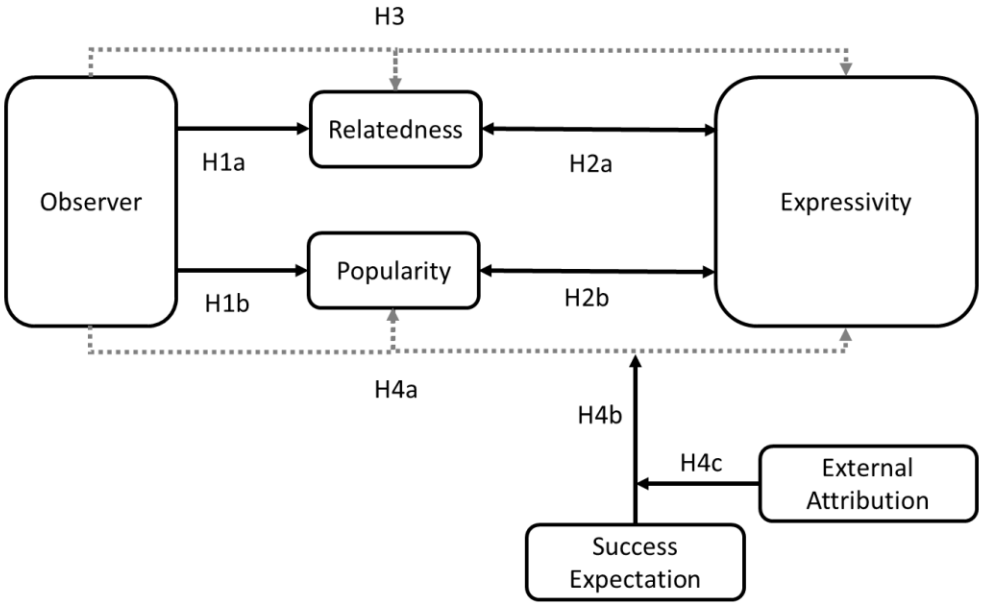

Figure 1. Summary model of study hypotheses.

4. Method

4.1 Participants

The initial sample consisted of 367 German-speaking participants from Germany, Austria, and Switzerland, who were compensated with 0,80€ for their participation of approximately 5 minutes. A pre-registered exclusion of participants who either failed the attention check (i.e., a question on the situation they ought to imagine), expressed trouble imagining the situation (i.e., a rating of less than four on a seven-point scale), or fell out of the admissible time to completion (i.e., below 180 or above 720 seconds) led to a final sample of 228 people. Of those, 58% were male, 42% female, and one person identified as non-binary. The average age was 40 years (M = 40.28; SD = 12.47; Med = 38), with the youngest participants being 18 and the oldest 73 years old.

4.2 Experimental Design and Procedure

The experiment was conducted online as a between-subjects design with two conditions, close vs. unknown observer. Consequently, participants read one of two vignettes, describing the encounter with a talking service robot in presence of either a close or unknown person. This situation was additionally illustrated with a schematic sketch to support imagination and establish a common notion among participants (Figure 2). We chose a café as it is a relatable public service setting that is not primarily associated with pragmatic concerns like privacy and performance (e.g., hospitals, offices) but foremost with experiential qualities like social exchange, leisure, and pleasurable goods (Hedaoo et al., 2019; Park et al., 2021).

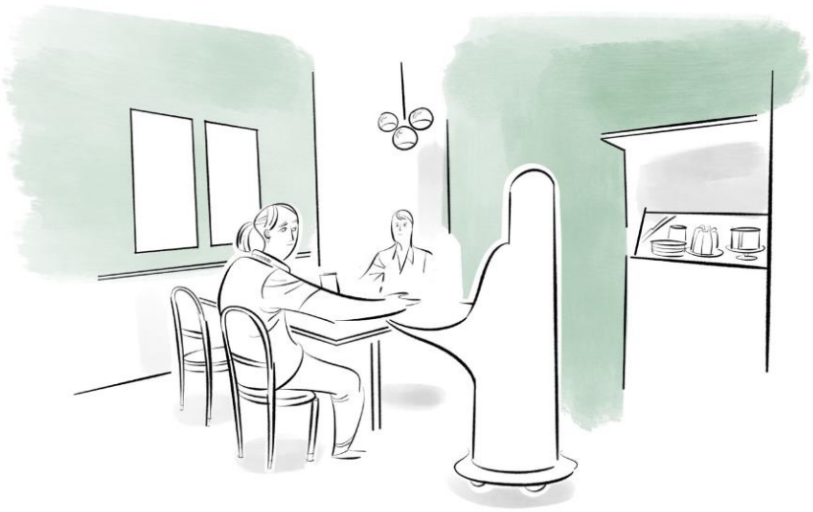

Figure 2. Schematic sketch of the described situation.

After giving a consent agreement according to data protection laws, participants were asked to imagine one of the following two situations with a service robot in public.

Close observer condition

> *You are in a café, where orders are taken by a talking robot. You are there in company, because a person close to you (e.g., a friend) is sitting at the table with you. S/he watches with interest as the robot approaches you, stops in front of you and asks, "May I take your*

order?". Please take a moment to put yourself in the situation as you talk to the robot while being watched by the person close to you.

Unknown observer condition

You are in a café, where orders are taken by a talking robot. You are there alone, but a person unknown to you is sitting at the opposite table. S/he watches with interest as the robot approaches you, stops in front of you and asks, "May I take your order?". Please take a moment to put yourself in the situation as you talk to the robot while being watched by the stranger.

First, participants rated their ability to put themselves in this situation, and how much they expect a successful interaction with the robot. Subsequently, participants had to rate various statements according to how much they describe their ideal experience in that situation, i.e., the interaction experience they wish for. Then participants rated the situation according to who they would attribute an interaction failure to, themselves or the robot. Those central measures were the basis of the later analysis. Further exploratory items capturing additional needs, hedonic interaction qualities, comfort and social acceptability, impact of the observer, and alternative services, as well as attention check items are included in the openly available data set (see Transparency Statement).

4.3 Key Measures

All items were measured on a seven-point scale. Needs for relatedness and popularity in the imagined scenario were measured with four items adapted from previous works (Hassenzahl et al., 2010; Sheldon et al., 2001). Expressivity, i.e., how noticeable participants would like their interaction to be, was also measured with four items (e.g., “Others shall experience how I interact with the robot”). Success expectation was assessed by means of three statements, for example, “I think the interaction with the robot will cause me no problems”. Participants’ tendency for external attribution was measured with three items (e.g., “It is not my fault if the order fails”). Appendix A provides an overview of these variables and corresponding measurement items. Corresponding descriptive statistics can be found in Table 1.

5. Results

5.1 Preliminary Analyses

Internal scale consistencies (Cronbach’s alpha) as well as means and standard deviations for the measured variables, in each condition and overall, are displayed in Table 1. All scales met the pre-registered requirements and showed good to excellent internal consistency according to common conventions.

Table 1. Overview of internal scale consistencies and means (standard deviations).

Variable	Cronbach’s alpha	Overall	Close Observer	Unknown Observer
Relatedness	.89	3.98 (1.49)	4.44 (1.42)	3.49 (1.40)
Popularity	.86	3.74 (1.46)	3.75 (1.51)	3.73 (1.40)
Expressivity	.92	3.29 (1.36)	3.45 (1.41)	3.11 (1.29)
Success Expectation	.88	5.56 (1.03)	5.66 (0.99)	5.46 (1.06)
External Attribution	.84	4.48 (1.23)	4.49 (1.27)	4.48 (1.20)

5.2 Group Comparisons and Correlations (H1 & H2)

First, we conducted an independent samples t-test to examine whether users in the close person condition express a higher need for relatedness (H1a). We found support for this assumption ($t(226) = 5.09$, $p < .001$, $d = 0.67$). Conversely, we expected them to express a lower need for popularity than people in the unknown person condition (H1b), which has not been the case ($t(226) = 0.06$, $p = .95$, $d < 0.01$). However, when conducting a within-subjects comparison with dependent sample t-test, people within the unknown person condition expressed a higher need for popularity than relatedness ($t(109) = -2.63$, $p = .01$, $d = 0.25$), while people within the close person condition expressed a higher need for relatedness than popularity ($t(117) = 6.36$, $p < .001$, $d = 0.59$).

Furthermore, we also found support for our second set of hypotheses that the needs for relatedness (H2a) and popularity (H2b) are associated with the preference for a more expressive interaction. The desired expressivity of the interaction significantly correlates with the need for relatedness ($r(226) = .39$, $p < .001$) as well as popularity ($r(226) = .38$, $p < .001$), see Table 2.

Table 2. Correlations between variables.

Variable	Relatedness	Popularity	Expressivity	Success Expectation	External Attribution
Relatedness	–				
Popularity	.67*	–			
Expressivity	.39*	.38*	–		
Success Expectation	.11	.09	.31*	–	
External Attribution	.04	.07	.00	.06	–

* $p < .001$

5.3 Mediation and Moderation Analyses (H3 & H4)

Building on the former observations that the need for relatedness differed between conditions and is associated with higher expressivity, we continued by investigating our assumption that it serves as a mediator between the relationship to the observing person and expressivity preference. For this, we used the “PROCESS" macro, version 4.0, model 4 (Hayes, 2022) with bias-corrected 95% confidence intervals and 5000 bootstrap samples. A graphical depiction of the resulting mediation model can be found in Figure 3.

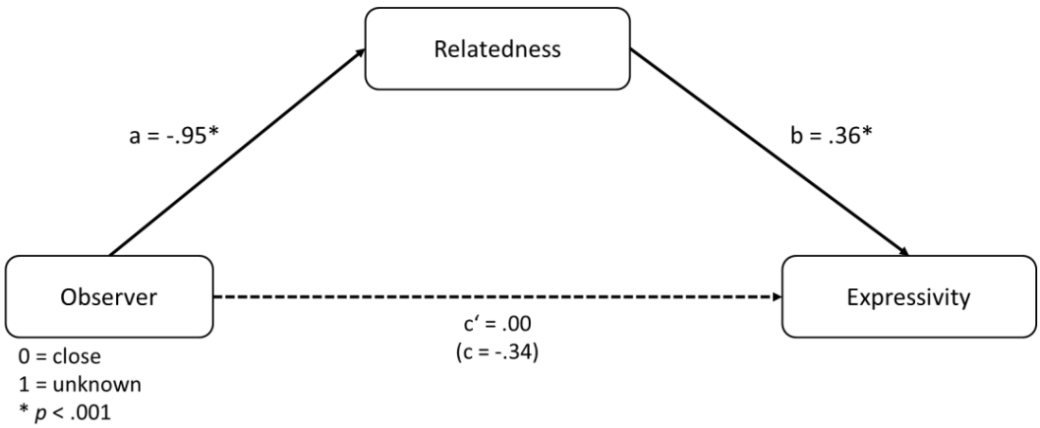

Figure 3. Mediation model according to H3.

The analysis showed no total effect of observer relationship on expressivity (B = -.34, SE = .18, t = -1.89, p = .06), which also applies to the direct effect within the mediation model (B = .00, SE = .18, t = 0.02, p = .99). More importantly, analyzing the indirect effects, relatedness significantly mediates the effect of observer relationship on expressivity, supporting H3 (B = -.34, SE = .10, 95% CI [-.55, -.18]). Dissecting the indirect path also corroborates the hypotheses H1a and H2a, since relatedness is significantly lower with unknown observers (B = -.95, SE = .19, t = -5.09, p < .001) and relatedness positively affects expressivity (B = .36, SE = .06, t = 6.07, p < .001).

We also expected popularity to mediate between observer relationship and expressivity (H4a), but this mediation or the path between popularity and expressivity to be moderated by an interaction effect between success expectation (H4b) and external attribution of the outcome (H4c). In other words, we assumed that the user's need for popularity is higher with an unknown observer. However, whether this popularity need also leads to a preference for expressivity is mainly dependent on, first, whether one expects to succeed in this situation and, second, whether one feels responsible for it (Figure 1). To this end, we applied the according model 18 in PROCESS (Hayes, 2022), again with bias-corrected 95% confidence intervals and 5000 bootstrap samples.

Inevitably, this led to a rather complex model, which is why we report all results in Table 3 and concentrate here on the core results as well as a visual inspection of the relationships among the plenty of variables. In sum, the model explains over 25% of the variance in expressivity (R^2 = .26, MSE = 1.43, F(8,219) = 9.51, p < .001). There was neither a significant direct effect (B = -.28, SE = .16, t = -1.77, p = .08), nor an indirect mediation effect on any inspected level of the moderators. However, as expected, there is a significant three-way interaction between the mediator, i.e., need for popularity, with the moderators success expectation and external attribution, partially supporting H4.

Table 3. Results for the regression model (H4) with expressivity as criterion.

	B	*SE*	*t*	*p*
(Intercept)	7.36	-3.71	1.99	.05
Observer[a]	-.28	.16	-1.77	.08
Popularity (POP)	-1.71	.93	-1.84	.07
Success Expectation (SUC)	-.73	.64	-1.15	.25
External Attribution (EXT)	-1.57	.73	-2.14	.03
POP * SUC	.33	.16	2.13	.03
POP * EXT	.47	.18	2.54	.01
SUC * EXT	.25	.12	1.99	.05
POP * SUC * EXT	-.08	.03	-2.50	.01

[a] close = 0; unknown = 1

As can be seen in Table 3, there are also two-way interactions between the mediator and moderators as well as a main effect of external attribution. But given the significant higher order three-way interaction, those lower order effects have to be interpreted in context. To this end, a visual inspection of interaction plots at different levels of the predictors is pertinent to gauge the direction and magnitude of effects.

5.4 Visual Inspection of Moderated Moderated Mediation Effects (H4)

We used the code generated by PROCESS to visualize interactions and plotted three graphs with need for popularity on the x-axis and expressivity on the y-axis (Figure 4). Each of those graphs is based upon a different level of external attribution and contains three lines, each for one level of

success expectation (PROCESS divides those moderators at the 16th, 50th, and 84th percentiles). This allows us to visually inspect tendencies that do not reveal themselves right away from the complex three-way interaction effect.

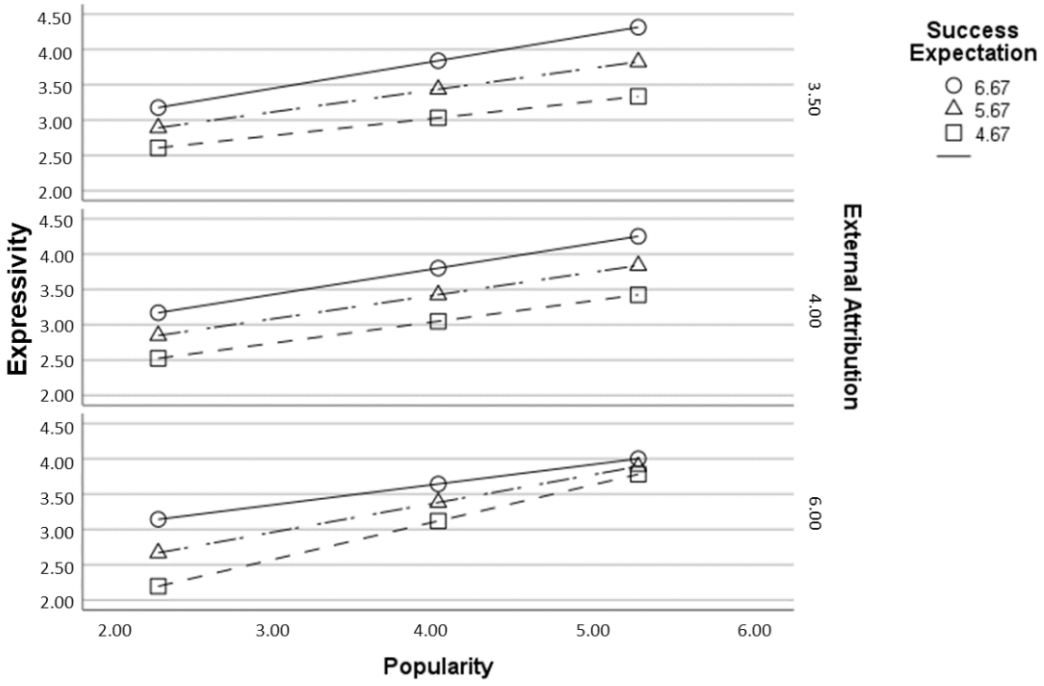

Figure 4. Graphical depiction of the moderated moderated mediation model of H4.

Figure 4 provides three observations that stand out and call for interpretation. First, all lines rise from left to right, indicating that, regardless of moderators, popularity is already positively related to expressivity, which is in line with H2b.

Second, looking at the individual lines representing different degrees of success expectation, there tends to be a clear order with the circle line (high expectation) surmounting the triangle one (medium expectation), and the triangle line surmounting the square one (low expectation). This implies a higher preference for an expressive interaction at higher success expectations – in most ranges of popularity and at different degrees of external attribution.

Third, however, this observation does not apply when there is a high need for popularity and external attribution is relatively high, as there is a near overlap of lines in the bottom graph at the right. Here, the lines seem to approach each other, indicating less of an influence of success expectation under these conditions. This aligns with the notion behind the whole interaction model: A higher need for popularity might lead to a higher preference for expressivity. However, if the outcome is externally attributed, success or failure probably have less influence on the user's impression towards others, which attenuates the effect of success expectation on expressivity. In other words, those who do have lower success expectations have less reason to fear a suboptimal public interaction, and those with higher success expectations have a lower incentive to display their achievement. This is corroborated by the circle lines (displaying high success expectation), whose slope increases from the bottom to middle to top graph, i.e., with lower degrees of external attribution.

In sum, the assumed moderation of popularity need's effect on expressivity by success expectation and external attribution is found within the data and supported by visual inspection.

6. Discussion

This research is motivated by the question of what the ideal interaction with service robots in public settings should look like. Our study shows that the expression of two different social needs varies with the relationship to the observer (close vs. unknown), which is in turn associated with the preference for the interaction's expressivity. Depending on the respective need, however, this association may be moderated by certain preconceptions about the success and attribution of an interaction.

In line with our proposition, people express a higher need for relatedness when imagining an ideal interaction with a service robot in the presence of a (emotionally) close person compared to a stranger. We attribute this to the fact, that the presence of another person is a necessary but not sufficient prerequisite for drawing pleasure from a shared experience. As expected, the expressed need for relatedness also correlates with the preference for expressivity, i.e., an interaction that is noticeable and can be witnessed by others. Both observations point towards the conclusion that people are aware of the potential value of co-experiencing a fairly new technology with a close other and therefore appreciate an interaction that involves more than themselves. In accordance with these observations, we could show that it is the psychological need for relatedness that mediates the effect between the relationship with the observer and the user's wish to engage in an expressive interaction.

Regarding unknown observers, we assumed that the key source of a positive experience is the opportunity to present oneself favorably, leading to a higher need for popularity. Contrary to our proposition, participants did not express a higher need for popularity with an unknown observer compared to a close one. In other words, people were just as keen to present themselves favorably towards close others as they were towards strangers. However, when comparing the two needs within instead of between both experimental groups, results indicate that relatedness and popularity play different roles based on the relationship with the observer. When observed by strangers, people express a higher need for popularity than relatedness when asked about their ideal interaction. Moreover, we found support for our assumption that popularity as well is positively associated with the preference for an expressive interaction, as a perceivable interaction is a necessity to present oneself to others.

We anticipated that the connection between observer relationship and expressivity preference is not as simple when it comes to popularity compared to relatedness. While an interaction can fulfill one's need for relatedness even if it doesn't go as planned, the need for popularity requires a successful interaction to make a good impression on present others. Our findings support the assumption that the need for popularity resulting from being observed by a stranger mainly manifests in the preference for an expressive interaction if the user (1) tends to expect a successful interaction and (2) does not attribute this to external factors. This theoretical model accounted for more than 25% of the variance in expressivity, which seems like a moderately high share, given the fact that human behavior in social settings is subject to a myriad of potential factors.

In summary, the present study highlights the influence of the observer relationship on psychological needs and desired expressivity during service robot interactions. Understanding these dynamics can enhance the design and implementation of innovative technologies in public spaces.

7. Theoretical Contributions

Our research contributes to the current literature in several regards. First of all, we investigated the effect of observer relationship for a service experience from an ideal, positive perspective. Studies on how different in- and outgroup members affect service experiences are still limited and they mostly consider instances of service failure (Fan et al., 2015; Qiu et al., 2018; Weber et al., 2016). On the contrary, we addressed a research gap by examining how those present others might enrich the service experience, which puts a new spin on this field of research and service robot encounters in particular. This also counterbalances the predominant pragmatic, aggregate-across-episodes approach to technology adoption represented by the TAM (Hornbæk & Hertzum, 2017). While its utilitarian focus on arguments like a product's usefulness is indisputably valuable, our study adds to an increasing amount of current literature focus on hedonic determinants in service robot use (Alotaibi et al., 2022; Lu et al., 2019; Molinillo et al., 2022).

Moreover, the experiential approach applied by us instead of a pragmatic focus can serve as an example and inform further research, as it is better suited to some kinds of service environments. Usefulness has been shown to be a significant factor in people's attitude toward service robot adoption in credence settings, e.g., hospitals, but not in service settings with an experience attribute, e.g., cafés (Park et al., 2021). As soon as service robots are able to provide the same quality of service a human would, the additional experiential value of interacting with an innovative technology might be a decisive factor in their adoption, especially if pragmatic considerations are not paramount.

By building on the premise that present others can also positively contribute to the experience of a service robot interaction, we added to strands of research that provide a counterpart to the often-applied social acceptability lens on public technology interactions (von Terzi et al., 2021). Socially acceptable design is to a large degree centered on reducing the negative effects that might come with public interactions, like disturbing others or looking awkward (Koelle et al., 2020). These concerns about how one's technology use might affect others become even more relevant in service settings, like hotels, restaurants, or cafés, as they typically take place in public spaces (Qiu et al., 2018). Our study, however, emphasizes that the interaction expressivity, i.e., its capacity to be witnessed by others, is not inherently bad. On the contrary, while there are definitely concerns about one's own impression toward others, as seen in the need for popularity, the fulfillment of those needs is a source of positive experiential value from a meaningful interaction (Hassenzahl et al., 2010). This contrasts the avoiding perspective implicitly dominant in social acceptability approaches and is in line with current insights on how not only failure avoidance but also positively framed achievement motivations can affect service robot adoption (Tojib et al., 2022).

Our study on service robot interaction also contributes to the larger field of user experience research. One pertinent theory of user experience builds on the proposition that a positive, meaningful interaction originates from the fulfillment of psychological needs that the respective context brings to the fore (Hassenzahl et al., 2021; Lenz et al., 2017). This fulfillment can emerge from the way an interaction is performed, i.e., if how it is done fits why it is done (Diefenbach et al., 2013). Our study is a well-fitting example of this approach and provides evidence for this theory. Regardless of whether people were more inclined to experience relatedness or popularity (i.e., the why), they also expressed a higher preference for expressivity (i.e., the how) when asked for an ideal interaction. This supports the notion that congruency between the reason for an interaction and the way it is performed creates positive experiences.

We also provided evidence that highlights the importance of theoretically differentiating the social needs an interaction responds to. Depending on the person present, people either prioritize need fulfillment from a shared experience or a favorable impression. While the former is straightforward,

the latter calls for the consideration of circumstantial conditions. For popularity, in line with control-value-theory of achievement emotions (Pekrun, 2000, 2006), we could show that there are at least two circumstantial factors (i.e., success expectation and external attribution), which shape whether people, who wish to present them favorably, actually want their ideal interaction to be expressive. This not only supports control-value theory within a new application context but also highlights the relevance of context-sensitive design for creating positive user experiences.

8. Practical Implications

The implications for context-sensitive design of service robots are one of the main contributions of our empirical exploration. Context sensitivity in this case is twofold: first, it demands awareness that the social environment affects user experiences from outside the typical interaction paradigm between user and technology. Second, it implies that there are factors within that social environment that people may react to differently. This in turn calls for customizable interactions, as service robots mostly operate in environments with a variety of potential users, observers, and thus user requirements, and it is still unclear how those interactions can be designed accordingly (Kong et al., 2018). Service robots provide the sophisticated, specific skills needed to enable such customized interactions that reflect the customers' needs and demands (Belanche et al., 2020b), but research is still focused on individual characteristics that may shape their general acceptance (Belanche et al., 2019). We aim to shed light on the importance of considering the social context in the design of public interactions and the potential to create more engaging, satisfying, and meaningful experiences – even if the people around us are strangers. In response, our study promotes expressivity as a key design factor that characterizes public interaction with a robot. This provides implications for how robots in service settings should be designed. The service robot in our café scenario may react to whether the customer is sitting alone or in company and may adapt the expressivity of an interaction accordingly. For example, Pepper, a popular robot for social purposes (Pandey & Gelin, 2018), usually speaks with its users but may also communicate through texts on a display mounted on its chest. These modalities are inherently different in how expressive and therefore noticeable corresponding interactions are, which allows adjusting expressivity to whether the customer is alone or in company. Interventions with expressivity in mind could also be more fine-grained. Font size and graphics of a terminal could be enhanced to be visible from afar. Displays could be curved to be visible to people not directly in front of it. Or the volume of voice interfaces could be regulated situationally. As soon as it is clear that people may embrace the fact that their interaction is noticeable, this results in a range of conceivable design implications.

The possibility to adjust the expressivity of an interaction (or at least the opportunity to opt out of a spoken dialogue) seems especially important as we identified not only relatedness with known others but also popularity in front of unknown observers as a source of positive experiences. Even if one may enjoy a service alone, they might still be inclined to let others witness their interaction. A potential pitfall in this situation, however, can be the possibility of something going wrong while ordering and thus embarrassing the user, which is reflected in the moderating effects of success expectation and its external attribution. But within this insight, there also lies a solution through considerate interaction design. In the pilot phase of introducing service robots, their adoption could be fostered by letting the robot take accountability. We suppose that people will be less concerned about the expressivity of their interaction if the service robot approaches them by explaining that they are still in the early stages of their training and therefore apologize in advance for any inconvenience. This can take pressure off the user by fostering external attribution (also for the people within earshot) and may even enhance the feeling of personal achievement if everything goes as expected. All in all, the study results stress the importance of designing service robots

(interactions) that facilitate success and positive attribution, especially when interacting in front of strangers.

9. Future Research and Limitations

Limitations of the current study and resulting further research questions refer to two broader aspects. The first aspect concerns the study's design. We conducted a vignette study to explore the fundamental notion of the positive potential of expressivity in a public service robot interaction. Even though vignette studies are a valid source of systematically investigating effects in a controlled manner (Aguinis & Bradley, 2014), the hypothetical nature of our survey calls for more realistic follow-up studies where people actually encounter the pros and cons of interacting in a public setting. Furthermore, we asked for psychological need fulfillment in an ideal interaction with rating scales, which allowed people to rate relatedness and popularity independently. However, this may not fully account for practical limitations in the design of interactions, as the fulfillment of one need may inhibit that of another (Hassenzahl et al., 2010). A response format that asks for rankings could prevent people from rating both needs equally high, thereby enforcing prioritization and a clear target need. Similarly, the topic of incommensurability may also apply to user and observer needs. Future research should additionally measure the observer's needs in the respective situation, since the fulfillment of a user's need for relatedness, for example, may inhibit an observer's need for autonomy.

The second aspect relates to the generalizability of results. There are several ways our applied scenario may vary in a real-life setting and those variations have to be further examined. Although we previously laid out why we focused on a café as an experiential setting instead of a credence setting like a hospital, it is still questionable whether the shown effects also apply to instances where the interaction is less about the process (e.g., having a nice time) and more about the result (e.g., getting treatment). We also did not consider individual, intrapersonal factors in our study. Previous research has shown that, e.g., the emotional state of a user, influences how satisfied they are with the service of a robot (Lajante et al., 2023). Therefore, future studies could investigate the influence of user factors on the associations we found.

Furthermore, audiences may vary and we don't know yet how this affects the optimal user experience. We applied a stripped-down design with a single observer (whose presence can already have decisive effects; Guerin & Innes, 1984) and manipulated the user-observer relationship. However, users may be accompanied by someone they barely know, or by several people, or the place may be crowded with strangers, which influences the ratio of close to unknown observers. People may also differ, for example, in their age, gender, appearance, or cultural background, and may therefore behave differently in the examined service setting (Fan et al., 2015). It seems promising here to focus less on the sheer endless number of possible combinations but on the strength of emerging psychological needs. For example, applying social impact theory (Latané, 1981), future research could focus on how the need for relatedness and popularity is a function of the strength (i.e., importance), number (i.e., how many persons), and immediacy (i.e., proximity) of the social source or the potential audience (Qiu et al., 2018).

10. Conclusion

The current research explored the ideal interaction with a service robot in a public setting from a performative perspective. It provided support for the notion that an expressive, thus noticeable interaction is not necessarily unpleasant but may allow people to fulfill their basic psychological needs of relatedness or popularity, depending on who witnesses their interaction. At the same time, we discovered potential pitfalls and design implications that must be addressed when people seek to

draw pleasure from presenting themselves favorably when interacting with a public technology. While our focus was on service robots, these insights on HCI in a public setting may also encourage fellow researchers and designers to explore expressivity in the interaction with other innovative technologies, considering the presence of others less as a constraint and more as a resource of positive user experiences.

Data Availability

This study was pre-registered at https://aspredicted.org/ZL6_Q9G. All data is available at https://osf.io/v54qk/?view_only=135340be64b34c03b0257b50b5452423.

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Appendix

Relatedness (I want to have a sense of …)
… relatedness with people around me.
… building a connection with those around me.
… sharing a common experience with someone.
… close intimacy with the people I am with.
Popularity (I want to have a sense of …)
… being someone, others look to for guidance.
… making a good impression on others.
… being admired by others.
… inspiring others with my behavior.
Expressivity
Others shall experience how I interact with the robot.
Others should be able to have a share in my interaction with the robot.
I want others to notice what I do.
I want others to witness how I interact with the robot.
Success expectation
I think the interaction with the robot will cause me no problems.
I am sure that I can handle the robot.
I think I will succeed at ordering without any problems.
External attribution
It is not my fault if the order fails.
The robot is to blame, if the order goes wrong.
It's not up to me if the order doesn't work out.

The Attendant Perspective: Present Others in Public Technology Interactions

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ABSTRACT

Technology interactions found their way into public space and present others attend what users are doing. However, in HCI research, the attendant perspective has often been neglected or considered only vaguely in the sense of "social context". Aiming at a better understanding of different types of attendants and their experiences, we developed a typology of four types based on two differentiating criteria (conspicuousness and voluntariness of attending the user interaction). An experimental vignette study (N = 181) tested the typology and revealed typical experiential patterns (e.g., need fulfillment, emotions, desire to join the technology interaction) related to the four types based on quantitative and qualitative data. Our research provides various contributions to HCI theory and design. For example, the typology can be used analytically in UX research. Moreover, it can be used generatively to design positive technology experiences in public for all stakeholders, namely, users and attendants.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); HCI theory, concepts and models; Human computer interaction (HCI); Empirical studies in HCI.

KEYWORDS

Technology experience, Public space, Attendant, Typology

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1 INTRODUCTION

Nowadays, when leaving the house, being accompanied by technical equipment has become the rule rather than the exception. For example, the fitness tracker has become an integral part of the morning run. The smartphone assists us with different tasks and needs and has even become a prerequisite when visiting a restaurant in times of the COVID-19 pandemic. Consequently, private activities such as calling your partner or listening to your favorite band's new album are no longer confined to your own four walls but increasingly take place in public spaces. In this, the public space, which typically presented a place of social (human-human) encounters [69], is now where human-human-technology encounters occur.

The public space implies a social context, i.e., present others[1]. Technology that is also or exclusively used in public should, therefore, ideally not only be tailored to the needs of immediate users but also consider or at least not violate the needs of present others. In other words: technology should be designed in a way that it enables positive experiences for all "stakeholders", users and present others. Consequently, there is an urgent need to expand the research focus and to systematically examine the perspective of present others in more detail.

Although HCI (Human-Computer Interaction) research has recognized the relevance of social context by now, it plays a subordinate role in most of the previous research, which primarily focuses on the user (experience). Social context or co-present others are usually understood and depicted as "background noise" or influencing factors (e.g., see "social influence" in the unified theory of acceptance and use of technology [74]). Though there are probably wide variations in the specific roles, motives, needs, and experiences of present others, these are often not further considered. Instead, present others rather appear as an irrelevant side-factor – an anonymous mass or black box. In sum, while numerous models focus on the experience of the primary user of technology [45], the perspective of these present others and potential interdependencies with the user are insufficiently studied [75]. Neither are social aspects adequately covered in theories or models on technology experience [30]. In our present research, we aim to address this gap and particularly focus on the social context, meaning the present others in public technology interactions. More specifically, we aim to answer the following research questions:

- RQ1: Who are these present others, i.e., how to specify and operationalize different types of attendants?
- RQ2: How do different types of attendants experience technology interactions in public?

In order to answer these questions, we developed an "attendant typology", which aims at a more detailed specification of the construct social context to depict the present others in their complexity. It distinguishes four types of present others (or attendants what we call them) depending on whether the co-present person is unwittingly cast into the role of an audience member or by choice, and whether they believe that the user notices them watching or not. We then implemented the typology in an experimental online study (N = 181) by means of a specific use case that is probably well

[1]We use both terms synonymously, i.e., whenever social context is mentioned in this text, we mean other people.

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known to all of us: *someone is listening to music in public*. The aim was a practical test of our typology. Next to detailed information regarding how the four types differ in their technology experience or how conspicuousness and voluntariness in attendants affect their anticipated perception, reaction, and demands, respectively, our study results provide ideas to make listening to music in public more pleasant or even a positive experience for present others.

In sum, our typology can be used analytically to better understand the attendant perspective and generatively improve or create new experiences for the attendants of public technology interactions. More specifically, the major contributions of our research work are:

1. Specification and operationalization of the social context (future research)
2. Implications and recommendations for what to consider (product development) and how to use (individual) technology in public space

In the following sections of this paper, we provide an overview of the current state of research on the role of social context in HCI, underlining our work's relevance. We then explain our concept and the process of developing the attendant typology, followed by a detailed description of the experimental study and its most important results. Finally, the present study's limitations and theoretical and practical implications are discussed.

2 RELATED WORK

This section clarifies the relevant terminology and presents related work on public technology interactions to establish a basis for understanding how present others affect the technology experience. It also explains the added value of extending or shifting the research focus away from the user toward the present others.

2.1 Present Others

In HCI literature, numerous terms exist for the present others in public technology interaction: passer-by, bystander, audience member, spectator, reflector, and observer (e.g., [23, 60, 61, 79]), to name a few. Even the rather vague term social context is often used to describe present others. The lack of generally applicable definitions not only leads to the use of different terminology in research studies to describe the same "construct". For example, what Paay et al. [53], consider an observer, Tang et al. [71] name the engaged bystander. Some studies even use several synonyms (e.g., [3, 14]). The fact that different studies use the same term but mean different things also represents a challenge. For example, Eiband et al. [15] refer to a bystander as a person who observes a shoulder surfing attack, whereas in other studies [18, 66] a bystander is someone who executes a shoulder surfing attack themselves. In addition, the extent or the level of detail in which studies describe the (role of) present others differs as well (e.g., [16, 64, 79]).

It is a fact that a large number of different terms impede the conceptualization and operationalization and, thereby, hinder systematic research on the social context or the perspective of present others, respectively, in public technology interactions. In order to support a clearer terminology and more conscious perspective on this issue, we systematically explore different sub-types of present others and use "attendant" as an umbrella term for present others. Our intention was to choose a term that is quite neutral and not yet used in HCI research, to evoke as few preconceptions or expectations as possible (although we are aware that the term may have different meanings in daily language). In addition, the denotation attendant should also overcome another weakness of some of the conventional terminology for present others like overhearer, which limit the experience to a certain sense (here the perception through hearing). Therefore, the present research defines attendants as (unknown) present others who experience technology interaction of (unknown) users in public space and, as explained in more detail in the following chapter, can be divided into four types.

2.2 Experience of Public Technology Interactions

Various studies demonstrated that social context plays an important role in shaping how people interact with and experience technology (e.g., [20, 67, 75]). In everyday life, the present others attending technology interactions in public are mostly unknown with little or no possibility to react, let alone assert control over users or technology, i.e., are exposed to the users and their technology (interactions) [19, 76]. Negative consequences, such as violation of privacy (e.g., [11, 56]), social exclusion (e.g., [10, 44]), disturbance (e.g., [8, 72]), annoyance (e.g., [15, 46]) and distraction (e.g., [9, 42]) are not uncommon. Thus, when designing technology, the perspective of present others should definitely be considered [5, 19, 48, 58, 75].

Present others can take up different roles depending on their "interaction" with the system[2], e.g., how much attention they pay, what they know about the process, or interest they have and can accordingly differ in their perception or experience of the technology [20, 23, 79]. Such studies underline the importance of specifying the social context, as the experience of present others can differ depending on their role. Who is not familiar with these or similar situations: you are walking in the street, sitting in a café, or traveling by train, and another person nearby is making a private phone call. In such a situation, one sometimes feels disturbed or uncomfortable, but other times a phoning neighbor is no problem or even entertaining (e.g., [51, 73]). In sum, not only the mere presence of other people in public technology interaction (here attendants) matters but also the role they play (here attendant type) in this. Previous studies underpin this assumption by showing that it makes a difference whether a technology interaction is forced on someone or self-chosen. For example, enforced technology usage can evoke a negative experience such as low satisfaction with technology [41, 62]. The same could be the case for enforced "passive interaction", i.e., not interacting with technology but watching others. Besides, since visibility in public space is a two-way process, i.e., attendants not only see but could also be seen, we suggest that it also makes a difference whether one can secretly or subtly watch a user or is "caught" doing so [22, 40].

[2]At this point, it should be mentioned that there is another approach to studying social context, pursued by Rico Williamson and Brewster [64] or Efthymiou and Halvey [13], namely a distinction based on the personal relationship with the user. However, since we are explicitly interested in typical, everyday usage situations in public spaces and thus situations where strangers meet, we exclude the relationship aspect in our work.

3 RESEARCH MOTIVATION AND APPROACH

In order to pave the way to evaluating or even predicting the attendant experience in public technology interactions, firstly, a clear conceptualization and operationalization are required. Currently, not only is clear terminology missing but also theories or models on the attendant experience that support systematic research. Therefore, our goal was the specification of different types of attendant perspectives (RQ1) and to analyze and better understand the experiences of different types of attendants (RQ2).

Our solution approach for enabling a precise description and specification of the attendant perspective is categorizing different attendant types using a kind of role model, the so-called attendant typology. More specifically, we distinguish between the four types by means of the two criteria conspicuousness of attending the user interaction (secret vs. obvious) and voluntariness of attending the user interaction (forced vs. voluntary). The difference between forced vs. voluntary attendants lies in the feeling of self-determination. For example, regarding voluntariness, someone waiting in line at the supermarket checkout while the person waiting behind him is recording a voice message is more or less forced to attend the interaction. They have no other choice than to listen to the interaction as distancing themselves from the situation would be tied to negative consequences (in the supermarket scenario: being unable to pay for the purchases). In contrast, someone stopping by while taking a walk in a public park to listen to another person recording a voice message is voluntarily attending the interaction as they could easily avoid the observation situation by not stopping, but instead, they decide to devote their attention to the user (interaction). The difference between secret and obvious attendants lies in the imagined visibility of attendants. For example, in the park scenario, someone secretly eavesdropping from a further distance or pretending to look elsewhere, i.e., observing in such a way that the user (presumably) does not notice that they are being watched, is a secret attendant. An obvious attendant, in contrast, would place themselves close to the user and show or communicate their interest, e.g., by starting a conversation.

Based on these dimensions, we distinguish four types of attendants: the lurker (voluntary-secret), spectator (voluntary-obvious), bystander (forced-secret), and witness (forced-obvious). In our choice of terminology, we drew inspiration from previous HCI studies, i.e., these terms have been used before for describing present others. For example, in naming voluntary-secret attendants, we got inspired by social media research. Here lurker describes someone who "play[s] a passive or silent role" and "belong[s] to a community but remain[s] quite unnoticed while watching, reading or, in general, benefiting from others' information or services without significantly giving back to the community" ([70], p. 215). We named the voluntary-obvious attendant spectator, inspired by a definition of Popovici et al. [59]: "A spectator is someone who wants to attend the experience, and can freely communicate and interact with all other participants in the environment. This way, the spectator may influence the experience evolution." (p. 199). In the context of smart home studies, bystander refers to "people who are not the primary users of technology but are nevertheless exposed to it" ([78], p. 4) wherefore we chose this term to describe forced-secret attendants. The term witness for forced-obvious attendants refers to the Oxford Dictionary definition of witnessing: "[to] have knowledge of (a development) from observation or experience" [52]. In order to address the aforementioned problem of lacking generally accepted and clear terminology (see "2.1 Present Others"), we list definitions for all types, i.e., as they are understood in our research, in Table 1.

The attendant typology was developed in an iterative process, starting with a literature review. In the beginning, we used three criteria (physical proximity, flexibility, anticipation) to distinguish five and, later, seven attendant types. However, we decided to focus on pivotal and distinctive criteria resulting in the typology version described above. It is important for us to stress that we do not claim exhaustiveness for this typology, or the criteria and types, respectively. Rather, the criteria are characteristic of everyday attendant experiences and allow us to cover a large number of cases. In a preliminary interview study, we asked 20 people (40% male, 60% female; age: $M = 26.25$, $SD = 11.35$) about recent positive and negative experiences from the perspective of an attendant of public technology interactions and verified whether each experience report could be assigned to one of the four types. In 22 cases participants observed a user interacting with a mobile device (e.g., smartphone or headphones), ten reports concerned interactions with fixed or public devices (e.g., ATM or ticket vending machine), and eight times the usage of transport vehicles (e.g., e-scooter or car). An analysis of the experience reports revealed curiosity/pastime, intrusion, wait, information search, preparation for action, and indignation as reasons for the observation. Participants reported feeling tension, attraction, joy, relief, security, surprise, anger, guilt, pity, or incomprehension in the observation situation. We categorized all experience reports based on the two criteria, voluntariness and conspicuousness, and thus assigned each story to a specific type. Results revealed that positive as well as negative experiences are possible for each of the four types. Consequently, it should be examined more closely whether and how exactly the experience of the particular types differs in a concrete use case as a next step.

4 METHOD

The aim of the present study, which is described in more detail in the following section, was a first practical implementation and test of our attendant typology and to reveal possible differences and commonalities between the types. So-called vignettes, i.e., short descriptions with the aid of which participants are supposed to put themselves into a certain setting and empathize with a person or situation [2, 4], formed the core of our study. Since it's a common public usage situation, we decided for the use case *someone is listening to music in public* (see "4.4 Scenarios" for further details).

The study was pre-registered[3] prior to data collection and analysis. It was realized via an online questionnaire and all materials were presented in German. A university-internal ethics committee classified the study as ethically unproblematic.

4.1 Hypotheses

We assumed that the attendant types differ primarily in their emotional response and that each type also has certain expectations

[3] https://aspredicted.org/QCT_BDH

Table 1: Experimental conditions and corresponding instructions

Attendant Type	Criteria		Definition	Scenario	
	Voluntariness	Conspicuousness		Textual Vignette	Pictorial Representation[a]
Lurker	voluntary	secret	a person who is given the choice of watching or listening to another person's technology interaction and does so imperceptibly	You are sitting in an airport waiting lounge, and you notice another passenger (hereafter referred to as "user") a few meters away. He is holding a smartphone, wearing Bluetooth headphones, and moving his head rhythmically - probably a good music track. The user's face is turned away from you, and he cannot see you watching him.	a
Spectator	voluntary	obvious	a person who is given the choice of watching or listening to another person's technology interaction and does so openly	You are sitting in an airport waiting lounge, and you notice another passenger (hereafter referred to as "user") a few meters away. He is holding a smartphone, wearing Bluetooth headphones, and moving his head rhythmically - probably a good music track. The user's face is turned towards you, and he can see you watching him.	b
Bystander	forced	secret	a person who feels forced to watch or listen to another person's technology interaction and does so imperceptibly	You are sitting in an airport waiting lounge, and another passenger (hereafter referred to as "user") a few meters away catches your attention. He is holding a smartphone and Bluetooth speaker and is rhythmically moving his head to the music sounding from the loudspeaker. The user's face is turned away from you, and he cannot see you watching him.	c
Witness	forced	obvious	a person who feels forced to watch or listen to another person's technology interaction and does so openly	You are sitting in an airport waiting lounge, and another passenger (hereafter referred to as "user") a few meters away catches your attention. He is holding a smartphone and Bluetooth speaker and is rhythmically moving his head to music sounding from the loudspeaker. The user's face is turned towards you, and he can see you watching him.	d

[a] see Appendix A.1

or wishes in the usage situation, i.e., the differences in the criteria dimensions (conspicuousness: secret vs. obvious; voluntariness: forced vs. voluntary) should also be reflected in the attendant experience.

However, to our knowledge, there are yet no studies explicitly addressing the operationalization of attendant emotional and psychological experience in public technology. Since research shows that emotional response is an integral part of user experience [1] and participants of our preliminary interview study reported diverse feelings (as attendants in similar situations) we decided to experimentally examine the affective reactions of the four attendant types. More specifically, we captured the participants' ratings regarding arousal, i.e., stimulation or activation, and dominance, which refers to a feeling of control, to explore possible type-specific differences. Furthermore, when HCI literature addresses the attendant, it is often about what or how much attendants are allowed or need to know about the user interaction, e.g., its cause or goal (e.g., [16, 32, 61]), or why to consider the attendant perspective in the first place (e.g., [7, 19, 21]). Thus, in order to reveal type-related preferences regarding attendants' desires in a specific usage situation, we also captured the participants' desire for transparency (i.e., how much they want to know about the interaction) and consideration (i.e., how much attention they wish from the user).

We expect conspicuousness to induce a stronger affective activation, while the secret observation is likely to be less activating as the "thrill" is less. In addition, conspicuousness could lead to a greater claim in attendants concerning their presence being respected (by the user). When attendants think of themselves as secret observers they assume that a user does not notice them and thus see no need in adapting their behavior to make it more transparent or acceptable (for other people). Involuntariness, i.e., if the attendant feels that the observation situation or the users' technology interaction is forced upon them, could be related to a stronger affective activation and a feeling of powerlessness. Furthermore, we associate involuntariness with less/no interest and anticipated personal responsibility. In other words, we suggest that attendants who freely decide to experience an interaction are more interested in the goals or motives of a user (interaction) and see the responsibility for their experience rather with themselves and not with the user. More specifically, we formulated the following hypotheses:

H1: Conspicuousness is associated with the attendants' affective reactions.
- **H1a:** Obvious attendants experience higher arousal than secret attendants.

H2: Voluntariness is associated with the attendants' affective reactions.
- **H2a:** Voluntary attendants experience lower arousal than forced attendants.
- **H2b:** Voluntary attendants experience higher dominance than forced attendants.

H3: Conspicuousness is associated with the attendants' desires.
- **H3a:** Obvious attendants experience stronger desire for transparency than secret attendants.
- **H3b:** Obvious attendants experience stronger desire for consideration than secret attendants.

H4: Voluntariness is associated with the attendants' desires.
- **H4a:** Voluntary attendants experience stronger desire for transparency than forced attendants.
- **H4b:** Voluntary attendants experience weaker desire for consideration than forced attendants.

Apart from hypotheses testing, we planned some exploratory analyses to gain more insights about the attendant perspective. Thus, in addition to our key variables arousal and dominance, participants were supposed to rate the positive and negative valence of their experience, i.e., the affective quality relating to the goodness or badness of a situation. Moreover, we also captured the desire for involvement, the social acceptability of the interaction, the relevance of different psychological needs as well as participants' ideas for improving the attendant experience.

4.2 Participants

Overall, 212 participants who were recruited via Prolific.co completed the survey. The preconditions for participation were a good knowledge of German, i.e., fluent or first language level, the capability of giving consent, and being over 18 years of age. Participation was compensated with 1.80 GBP (approximately 2.13 EUR).

We excluded 31 individuals from the study as they met the exclusion criteria (see "4.5.1 Attention Check and Method Control"). The remaining 181 participants (39.8% female, 56.9% male, 1.7% diverse, and 1.7% no answer) were aged 19 to 69 years (M = 30.56, SD = 9.40).

4.3 Procedure

After reading an introduction and giving consent agreement participants were randomly assigned to one of four experimental conditions: voluntary-secret (i.e., attendant type "lurker"), voluntary-obvious (i.e., attendant type "spectator"), forced-secret (i.e., attendant type "bystander") or forced-obvious (i.e., attendant type "witness"). More specifically, we presented one of four scenarios (a combination of text vignette and pictorial representation, see "4.4 Scenarios" for a detailed description) to the participants and ask them to take the attendant perspective in the public technology interaction. Depending on which conditions they were in, the participant's role in the scenario was that of a secret or obvious and forced or voluntary attendant.

Following this manipulation, all subjects receive the same questionnaire. Firstly, they had to deal with the manipulation check and method control followed by questions on their affective reactions (regarding the valence of experience, arousal, and dominance) and desires (for consideration, transparency, and involvement). Then participants were asked to rate the importance of different needs (i.e., competence, relatedness, popularity, stimulation, security, and autonomy) and the overall social acceptability of the technology interaction described in the specific scenario. Before providing some demographic information (technical affinity, age, gender, and highest educational attainment), participants could propose ideas on how the user (i.e., optimization possibilities) or themselves in their role as attendant (i.e., reaction or control possibilities) could improve the attendant experience in the specific situation or scenario.

4.4 Scenarios

By means of vignettes, consisting of a short text and image, all four scenarios described how a person (= user) is listening to music in an airport waiting hall while being observed by another person (= attendant). The structure and length of the text vignettes, as well as the way the images are displayed, were similar for all four scenarios. However, the conditions differed in the specific attendant perspective, or the degree of voluntariness (forced vs. voluntary) and conspicuousness (secret vs. obvious) of the attendant in the particular scenarios, respectively, see Table 1. A pretest ($N = 61$) showed that the vignettes or textual descriptions and pictorial representations of the four scenarios differed significantly according to the criteria.

4.5 Measures

The following sections describe the questionnaire and measures in more detail. In addition, Appendix A.2 lists the exact items and internal consistencies.

4.5.1 ***Attention Check and Method Control.*** The questionnaire started with an attention check and method control to ensure that only participants who correctly understood the scenario (attention check) and could immerse themselves in the situation (method control) were included in the analyses. The attention check consisted of two items per criteria, and participants' scores on these items were used as exclusion criteria. For example, participants in secret conditions should rate the item "The user is aware that I am looking at him." (1 = not at all agree, 5 = totally agree) low and therefore became excluded from further analyses with a score of 4 or higher. In total, 31 participants were excluded because of the attention check. In addition, participants were supposed to indicate how well they could immerse themselves in the situation using a 5-point scale (1 = not at all, 5 = extremely). However, all participants scored ≥ 3; thus, no further participants had to be excluded.

4.5.2 ***Affective Reactions.*** We collected affective reactions with the Self-Assessment Manikin (SAM), "an easy method for quickly assessing reports of affective response in many contexts" [6] because it is a reliable and valid measure [47, 49]. Originally, the scale consists of three sub-scales arousal, dominance, and pleasure/valence; however, we only adopted the first two which participants assessed on a Likert-type scale ranging from 1 (arousal: I am calm, relaxed, sleepy; dominance: It is not in my control. I cannot affect it.) to 5 (arousal: I am excited, activated, vigilant; dominance: It is in my control. I can affect it.). Since the preliminary interviews study showed that positive as well as negative experiences are possible for each type, we decided to capture the positive and negative valence of the experience separately. SAM uses semantic differential scales to measure participants' (dis-)agreement with the statements on valence, arousal, and dominance. We assessed the valence of experience with the following question: "If you think about the situation that was described to you: How would you feel?" and asked the participants to rate the positive valence (i.e., "positive") and the negative valence (i.e., "negative") on a 5-point scale (1 = not at all, 5 = extremely) to avoid an either-or choice between positive and negative valence.

4.5.3 ***Desires.*** Besides transparency and consideration (please see "4.1 Hypotheses"), another popular topic in HCI literature explicitly addressing the attendant is the degree and possibilities of attendant involvement (by the user) in public technology interactions, i.e., how much participation they prefer (e.g., [24, 29]). To our knowledge, there are no reliable and validated scales for the attendant desire for consideration, transparency, or involvement. Therefore, we used the following self-constructed items and asked participants to indicate their approval on a 5-point Likert scale: "I would like to get more insights into the user's technology interaction." (transparency), "It is important to me that the user shows consideration for me while they interact with the technology." (consideration), and "I would like to be more involved in the user's technology interaction." (involvement).

4.5.4 ***Additional Measures.*** When it comes to designing public technology interactions social acceptability is an important aspect [36, 48]. Social acceptability, i.e., whether a technology interaction is considered acceptable (by others), has an impact on the user [63] and attendant experience [14]. In the present study, social acceptability was assessed with two items adapted from Koelle et al. [34]. More specifically, participants were asked to take a user's perspective and indicate how comfortable and acceptable they rate performing the technology interaction themselves in the specific setting on a 5-point scale (1 = very uncomfortable/completely unacceptable, 5 = very comfortable/completely acceptable).

Research shows that positive experience emerges from the fulfillment of psychological needs [68]. More specifically, need fulfillment is understood as a main source of positive experiences with interactive products (e.g., [25, 57]). Therefore, we asked the participants to assess the importance of different psychological needs described by Hassenzahl, Diefenbach, and Göritz [26] on a 5-point scale ranging from 1 (not at all) to 5 (extremely). We used the six needs most relevant for technology interactions [27]: relatedness, popularity, competence, security, stimulation, and autonomy. This selection has also been used in previous, comparable studies on UX with interactive products (e.g., [12, 33]).

Finally, we assessed some qualitative data on participants' ideas regarding user's optimization possibilities (open question 1: "How could/should the user behave to make the situation more enjoyable for you?") and attendant's reaction or control possibilities (open question 2: "What could you do to make the situation more pleasant for yourself?") in the scenarios.

5 RESULTS

All analyses were conducted with SPSS (IBM Statistics Version 28). All reported effect sizes were calculated using the partial eta square (η^2_p), with 0.01, 0.06, and 0.14 considered small, medium, and large effects, respectively [39].

5.1 Hypotheses Testing

In order to analyze the impact of conspicuousness (secret vs. obvious) and voluntariness (forced vs. voluntary) on the attendants' experience of public technology interactions, we conducted two-way ANOVAs. This allowed us between-subjects comparisons of the different attendant types' affective reactions and desires depending on each type's specific degree of conspicuousness and

Table 2: Means (M) and standard deviations (SD) of arousal, dominance, transparency, and consideration and results of the hypotheses testing[a]

Measure	Conspicuousness					Voluntariness				
	Secret *M* (*SD*)	Obvious *M* (*SD*)	Analysis	*F* (1, 177)	η^2_p	Forced *M* (*SD*)	Voluntary *M* (*SD*)	Analysis	*F* (1, 177)	η^2_p
Arousal	2.85 (1.06)	3.15 (0.90)	H1a	4.83*	.027	3.56 (0.83)	2.56 (0.89)	H2a	60.91***	.256
Dominance	2.85 (1.17)	2.97 (1.04)				2.51 (0.83)	3.22 (1.19)	H2b	20.99***	.106
Transparency	1.67 (0.92)	1.84 (0.90)	H3a	1.78	.010	1.61 (0.81)	1.87 (0.97)	H4a	3.80	.021
Consideration	3.35 (1.39)	3.37 (1.33)	H3b	0.01	.000	4.35 (0.79)	2.59 (1.19)	H4b	128.80***	.421

[a] Statistical significance levels: *$p < .05$, **$p < .01$; ***$p < .001$

voluntariness. Table 2 shows the means and standard deviations of the key variables and results of between-subject comparisons.

The two-way ANOVA of the effect of conspicuousness and voluntariness on affective reaction regarding arousal showed a significant main effect for both conspicuousness, $F(1, 177) = 4.83$, $p = .029$, $\eta^2_p = .027$, and voluntariness, $F(1, 177) = 60.91$, $p < .001$, $\eta^2_p = .256$. More specifically, participants experienced more arousal in the obvious scenarios ($M = 3.15$, $SD = .90$) than in secret ($M = 2.85$, $SD = 1.06$), and less arousal in the voluntary ($M = 2.56$, $SD = .89$) compared to forced conditions ($M = 3.56$, $SD = .83$). In line with our hypotheses, results show that attendants experience greater arousal when it is obvious that they are watching then when it is not (H1a) and attendants experience greater arousal when a technology interaction is imposed than when it is voluntary (H2a).

Corresponding to H2b, results showed that voluntariness is associated with attendants' affective experience regarding dominance, $F(1, 177) = 20.99$, $p < .001$, $\eta^2_p = .106$. As such, participants in the voluntary conditions ($M = 3.22$, $SD = 1.19$) gave higher scores on the SAM dominance sub-scale than in the forced ($M = 2.51$, $SD = .83$). Besides, results showed a significant interaction effect of conspicuousness and voluntariness, $F(1, 177) = 4.22$, $p = .041$, $\eta^2_p = .023$. Thus, the impact of voluntariness on dominance was significantly different in obvious and secret attendants. More specifically, participants in the voluntary-obvious condition (spectator; $M = 3.42$, $SD = 0.97$) scored higher compared to voluntary-secret (lurker; $M = 3.02$, $SD = 1.35$) but in the forced conditions it is the other way around, i.e., secret attendants (bystander; $M = 2.63$, $SD = 0.84$) reached higher scores on the dominance sub-scale than obvious (witness; $M = 2.38$, $SD = 0.81$).

Referring to H3a and H4a, we examined the relationship between conspicuousness and voluntariness and the attendants' desire for transparency. Participants assessed the desire for transparency higher in the voluntary condition ($M = 1.87$, $SD = .97$) compared to forced condition ($M = 1.61$, $SD = .81$), however, the difference was only marginally significant, $F(1, 177) = 3.80$, $p = .053$. Regarding conspicuousness, we also did not detect a significant main effect ($F(1, 177) = 1.78$, $p = .184$) and the means were nearly the same for obvious ($M = 1.84$, $SD = .90$) and secret attendants ($M = 1.67$, $SD = .92$). Consequently, neither conspicuousness nor voluntariness was associated with the reported degree of transparency desire and therefore, H3a (conspicuousness) and H4a (voluntariness) have to be rejected.

Finally, we analyzed the effects of conspicuousness (H3b) and voluntariness (H4b) on the desire for consideration. Contrary to H3b, we couldn't find a significant main effect of conspicuousness and participants' scores were similar in obvious ($M = 3.37$, $SD = 1.33$) and secret conditions ($M = 3.35$, $SD = 1.39$), $F(1, 177) = 0.01$, $p = .918$. In line with H4b, results suggest a statistically significant main effect of voluntariness on how strongly participants stated their desire for consideration, $F(1, 177) = 128.80$, $p < .001$, $\eta^2_p = .421$, as voluntary attendants ($M = 2.59$, $SD = 1.19$) experience a weaker desire for consideration than forced attendants ($M = 4.35$, $SD = .79$).

5.2 Exploratory Analyses

The following exploratory analyses are aimed at gaining further information about the attendant perspective in the specific use case, as well as deeper insight into how to enable a (more) positive experience for the different attendant types. The means and standard deviations of the exploratory variables are illustrated in Table 3. Pearson correlations for all variables are listed in Appendix A.3.

Table 3: Attendant types' means (M) and standard deviations (SD) of positive affect, negative affect, involvement, and social acceptability

Additional Measures	Lurker		Spectator		Bystander		Witness	
	M	SD	M	SD	M	SD	M	SD
Positive Affect	3.67	0.81	3.38	0.81	2.20	0.82	2.18	0.82
Negative Affect	1.81	0.89	2.40	0.86	3.83	0.87	3.64	0.99
Involvement	1.52	0.87	1.68	0.87	1.78	0.92	2.00	1.12
Social Acceptability	3.95	0.82	3.79	0.94	1.75	0.65	1.56	0.56

5.2.1 ***Quantitative Data.*** First, to dig deeper into how experiences related to different levels of conspicuousness (secret vs. obvious) and voluntariness (forced vs. voluntary), we analyzed differences regarding positive and negative valence, desire for involvement, and social acceptability between the four scenarios. The results of exploratory two-way ANOVAs revealed significant main effects of voluntariness but not conspicuousness. More specifically, participants in voluntary conditions scored higher in positive valence (M = 3.53, SD = 0.82) and social acceptability (M = 3.87, SD = 0.88) than in the forced conditions (positive valence: M = 2.19, SD = 0.82; social acceptability: M = 1.66, SD = 0.61), $F(1, 177)$ = 119.95, p < .001, η^2_p = .404 and $F(1, 177)$ = 363.36, p < .001, η^2_p = .672. The opposite was true for negative valence and involvement, $F(1, 177)$ = 146.40, p < .001, η^2_p = .453 and $F(1, 177)$ = 4.16, p = .043, η^2_p = .023. Here voluntary attendants assessed the negative valence of the experience (M = 2.10, SD = 0.92) and their desire for involvement (M = 1.60, SD = 0.87) weaker than participants in the forced conditions (negative valence: M = 3.73, SD = 0.93; desire for involvement: M = 1.89, SD = 1.03). Figure 1 illustrates the significant differences between the voluntary and forced conditions regarding the explorative variables.

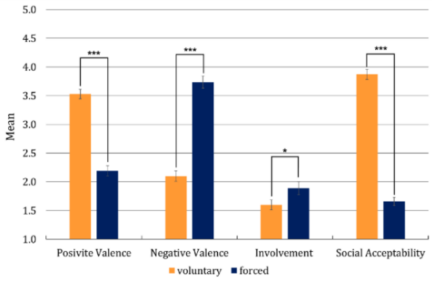

Figure 1: Voluntary and forced attendants' means and standard errors of positive valence, negative valence, involvement, and social acceptability ($^*p$ < .05; $^{***}p$< .001).

No significant interaction between voluntariness and conspicuousness was found apart from negative valence, $F(1, 177)$ = 8.31, p = .004, η^2_p = .045. Here, participants in the forced-secret condition (M = 3.83, SD = 0.87) scored higher compared to forced-obvious (M = 3.64, SD = 0.99) but the opposite was found to be the case when comparing voluntary-secret (M = 1.81, SD = 0.89) and voluntary-obvious (M = 2.40, SD = 0.86) attendants. Additionally conducted Bonferroni post-hoc tests revealed significant differences not only for voluntary vs. forced attendants (lurkers and bystanders: p < .001, M_{Diff} = -2.02, 95%-CI[-2.52, -1.51]; lurkers and witnesses: p < .001, M_{Diff} = -1.83, 95%-CI[-2.34, -1.33]; spectators and bystanders: p < .001, M_{Diff} = -1.43, 95%-CI[-1.93, -0.92]; spectators and witnesses: p < .001, M_{Diff} = -1.24, 95%-CI[-1.75, -0.73]) but also between voluntary attendants, i.e., lurkers vs. spectators (p = .006, M_{Diff} = -0.59, 95%-CI[-1.07, -0.12]).

We created need profiles for all four attendant types to aim a first impression of whether and how the different types vary in their needs. The need profiles illustrate which psychological needs were rated more or less important by each attendant type (see Figure 2). An additional one-way ANOVA revealed significant differences among the attendant types for competence ($F(3, 177)$ = 6.03, p < 0.001, η^2_p = .093), stimulation ($F(3, 177)$ = 7.13, p < 0.001, η^2_p = .108), security ($F(3, 177)$ = 9.89, p < 0.001, η^2_p = .144), and autonomy ($F(3, 177)$ = 5.62, p = 0.001, η^2_p = .087). As Figure 2 shows, the detected need profiles partly overlap, the greatest for lurker and spectator, and bystander and witness. Besides, post-hoc comparisons with Bonferroni correction on social acceptability of the interaction revealed significant differences for lurkers and witnesses (p < .001, M_{Diff} = 2.39, 95%-CI[1.95, 2.83]), lurkers and bystanders (p < .001, M_{Diff} = 2.20, 95%-CI[1.77, 2.64]), spectators and witnesses (p < .001, M_{Diff} = 2.23, 95%-CI[1.78, 2.67]), and spectators and bystanders (p < .001, M_{Diff} = 2.04, 95%-CI[1.60, 2.48]). On contrary, no significant differences were found between lurkers and spectators (M_{Diff} = 0.16, 95%-CI[-0.25, 0.57]) or bystanders and witnesses (M_{Diff} = 0.19, 95%-CI[-0.28, 0.65]).

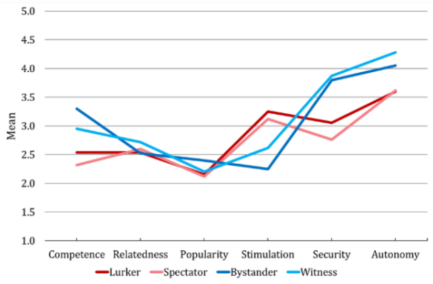

Figure 2: Attendant types' mean scores of different needs.

5.2.2 ***Qualitative Data.*** As described in the method section, we asked each participant to reflect on possibilities for improving the attendant experience in the respective scenario for the user (open question 1) and the attendants themselves (open question 2). Participants' text responses to both questions were coded and evaluated in several steps in sense of qualitative content analysis [43].

First, an inductive categorization was performed for both questions, resulting in seven main categories (MC) and ten subcategories (SC) for the user's possibilities and ten MC and seventeen SC for the attendant's possibilities. Two independent coders were asked to categorize the participants' answers according to the defined categories. The degree of agreement or consensus in encoding is indicated by Krippendorff's alpha. While 0 means total disagreement, a value of 1 implies perfect agreement [28]. Generally, the reliability between the two coders was good (question 1 MC: Krippendorff's α = .96; question 1 SC: Krippendorff's α = .93; question 2 MC: Krippendorff's α = .84; question 2 SC: Krippendorff's α = .76). Multiple assignments concerning MC or SC were allowed for the participants' answers to both questions. A list of the main and sub-categories used to evaluate participant responses, including the corresponding frequencies, can be found in Appendix A.4 and A.5.

In order to provide deeper insights, an analysis of the answers to the open questions, subdivided in type, i.e., lurker, spectator, bystander, or witness, and criteria, i.e., voluntary vs. forced or obvious

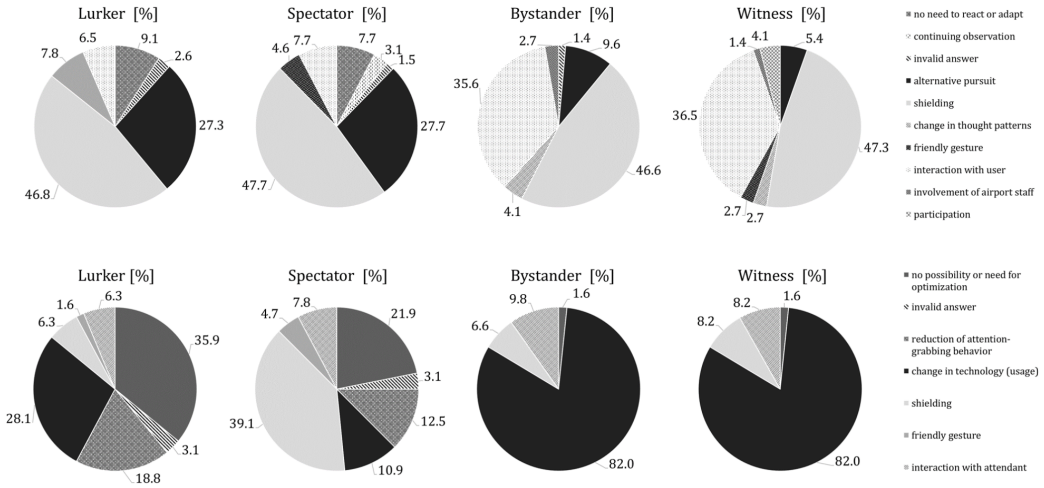

Figure 3: Main categories regarding action possibilities of attendant (first row) and user (second row) to improve the attendant experience per attendant type.

vs. secret, was conducted. Figure 3 illustrates the type-specific differences regarding the frequencies of the particular main categories. The most interesting findings are reported in the following, starting with insights on what attendants themselves could do to improve their experience.

The analysis of participants' answers regarding the attendant's possibilities shows a similar picture for all four attendant types; *shielding* is the most frequent category, followed by *interaction with user* for forced attendants (bystanders and witnesses) or *alternative pursuit* for voluntary attendants (lurkers and spectators). Finding oneself in the role of a lurker, a good way to control or react to the technology interaction of the user would be *shielding*. For example, participant 263 suggested a *change of location*: "If it gets too uncomfortable, I could go somewhere else or find another seat farther away.". Another lurker stated to shield oneself by *turning away*: "If I feel disturbed, I would turn away or position myself in a way that I could no longer see the user." (participant 113). As the most frequent sub-category of *alternative pursuit*, the coping strategy *changing the focus of attention* is another popular recommendation for attendants in the role of a lurker. The following statement is exemplary for answers assigned to this category: "If it would bother me, I always have the option to look away and observe my surroundings more closely." (participant 135). Regarding the group of spectators, similar recommendations were given. More specifically, most participants stated that *turning away* would improve the attendant experience. Again, *change of location* (e.g., participant 193: "If it really bothered me, I could walk away.") and *changing the focus of attention* (e.g., participant 167: "I could look for another fixing point in the area.") are one of the most frequent sub-categories. In the group of bystanders and witnesses, *shielding* or *change of location*, respectively, was the top category. However, participants in these conditions also suggested *using headphones themselves* quite often to shield themselves from the interaction and improve the experience, e.g., participant 240 (bystander): "I can put on my own headphones and drown out the sounds with my own music.". *Interaction with the user* or *behavior change proposal* and *pointing out disturbance*, respectively, are the next frequent recommendations. For example, participant 221 suggested that attendants in the role of bystanders should ask the user "to turn off the device and use headphones instead", and according to participant 96, witnesses should make the user aware of the fact that "he uses his technology in public". Moreover, the analysis revealed an interesting insight into type-specific differences depending on conspicuousness; unlike secret attendants (i.e., lurkers and bystanders), obvious attendants (i.e., spectators and witnesses) noted that showing a *friendly gesture* towards the user might improve the attendant experience, e.g., participant 163 (spectator): "I make the other person the gift of a smile". Furthermore, exclusively participants in forced conditions mentioned *involvement of airport staff* and *participation*. For example, participant 240 (bystander) declared that they wanted to transfer responsibility to an airport employee: "I could call the airport staff, tell them the situation and ask for resolution.". Only test persons that had to imagine the role of a witness suggested an involvement for themselves, e.g., "I could move my foot along with the beat." (participant 281).

When asked about possibilities for the user to improve the attendant experience, participations came up with the following ideas. For example, forced attendants, i.e., witnesses and bystanders, suggested *change in technology (usage)* the most by far, followed by *interaction with attendant* and *shielding*. Statements like "Here, manners call for headphones." (participant 133, bystander) from the sub-category *headphone use or noise canceling*, or participant 198's (witness) suggestion, "If he doesn't have any headphones with him, but still insists on listening to music, he should turn the music down low enough so that others present don't feel bothered."

(assigned to *volume regulation*) were typical for the group of bystanders and witnesses. *Change in technology (usage)* is found to be a frequent category in voluntary attendants as well; however, *shielding* is more common in the group of spectators. Actually, only spectators noted that the user *turning away* (sub-category of *shielding*) would improve their experience. Besides, a few lurkers and spectators suggested a *reduction of attention-grabbing behavior* on the side of the user, e.g., "Don't make exuberant movements. Not making sounds like rhythmic tapping or humming would also be good." (participant 144, lurker). Interestingly, 35.9% of the lurkers and 21.9% of spectators stated *no possibility or need for optimization*, and *interaction with attendant*, e.g., *ask for permission* (mainly assigned to forced attendants), was mentioned but not as often as one might expect.

6 DISCUSSION

In the following, we first summarize the most important findings and theoretical and practical implications. Then we highlight the limitations of the present study and how they could be addressed in future research studies.

6.1 Theoretical Contributions

As an extension to previous research in HCI, our typology not only enables the operationalization of social context or present others but is also an essential step towards systematic research of the attendant perspective. So far, strongly simplified as "context" or "everything else" [38], our study additionally offers new and detailed insights into the variance of the attendant experience and the specific experiences of a particular type.

We hypothesized that variations in the attendant experience can be associated with the different levels of conspicuousness (secret vs. obvious) and voluntariness (forced vs. voluntary) of attending the user interaction. In line with our expectations, there was an association between conspicuousness and the attendants' experienced arousal, as well as voluntariness and the attendants' experienced arousal, dominance, and desire for consideration. More specifically, obvious attendants experience higher arousal than secret attendants (H1). Voluntary attendants experience lower arousal and higher dominance than forced attendants (H2), and voluntary attendants experience a weaker desire for consideration (H4b). However, other than expected, there was no association between conspicuousness and attendants' desire for transparency and consideration (H3) and also no stronger desire for transparency among voluntary attendants (H4a). Though we did not find not all the expected associations to experiential qualities, conspicuousness and voluntariness showed as relevant dimensions to describe different types of attendant experience.

The found associations to the measured experiential qualities and categories of the qualitative statements provide a broader picture of the different perspectives of different types of attendants, e.g., those voluntarily attending an interaction in public or being forced into it. For example, as one would intuitively assume, voluntary attendants experience more positive and less negative affect. Also, the social acceptability of scenarios with voluntary attendants was rated higher than with forced attendants. Regarding the need profiles, stimulation showed as more relevant for voluntary attendants, whereas safety, competence, and autonomy were rated higher for forced attendants.

6.2 Practical Implications

Besides a better theoretical understanding of the attendant experience, our work also explored the potential for design and individual behavioral strategies to support more positive technology experiences in public spaces – for users and attendants. In this regard, especially the qualitative statements provide interesting starting points, i.e., participants' ideas regarding what attendants themselves and users can do to improve the attendant experience in the particular scenarios. While some of the recommendations are specific to the example of listening to music in public, most of them are transferrable to other interactions in public.

Overall, the analyses of our qualitative data show that participants don't see a problem with the act of listening to music in public and that it is something they also like to do themselves. Consequently, participants suggest that the attendants could listen to music themselves as a distraction, or the user could adjust the type of music to make the situation more comfortable for the attendants. So, it is less about preventing someone from listening to music in public and rather about responding to the individual needs of attendants and finding ways to improve their experience. This insight also allows basic recommendations for technology design, more or less suitable depending on the type. For example, when designing headphones or portable loudspeakers in the public space, a notification could warn the user when using technology that others might feel disturbed by the selected volume (in forced and voluntary conditions). When designing the architecture of public spaces, one should ensure that a "change of location" is possible, e.g., by separating areas from one another or creating walls for noise and sight-protections. If spatial separation is not feasible, placing (rotatable) chairs similar to one-person cabins that allow users and attendants to shield themselves could be a good solution (especially for voluntary attendants). Another option is to construct extra technology areas, where social interactions about or through technology are promoted (for voluntary attendants and witnesses). For example, researchers have already used a public display as a platform for users to share their own media content with present others [55]. One could try the same with sharing music, i.e., installing a public display that can be used by anyone with a smartphone to listen to music together in public space or even exchange music tips.

Besides serving as starting points for design, the qualitative data also highlighted some behavioral strategies, i.e., what individuals themselves could do to improve the experience. Interestingly, direct intervention in or termination of the user interaction was not suggested by any attendant types, apart from isolated mentions. Thus, attendants' coping strategies were more about distracting themselves or constructive exchange. For example, we suggest the following action strategies for the different types of attendants (when a change of location is not possible). Volunteer attendants, i.e., lurkers and spectators, should bring tools to have the option to occupy or distract themselves when moving in public space (e.g., noise-canceling headphones). A more creative strategy for improving one's technology experience, especially for obvious attendants,

i.e., spectators and witnesses, is friendly gestures such as smiling at the user. Forced attendants are advised to be proactive by interacting with the user, e.g., by making concrete suggestions for a change in behavior or pointing out the disturbance to the user, thereby making them aware of the potential conflict lying in their technology interaction. Users in public spaces should bear the potential invasiveness of their technology interaction in mind and keep it as low as possible, e.g., by reducing the volume, using headphones or noise canceling, or reducing attention-grabbing behavior such as large gestures. If the other people present are spectators, or forced attendants (bystanders and witnesses), turning away to signal that one does not wish to disturb (in case of spectators) or looking for ways to interact with the attendant like asking for permission (in case of forced attendants) is also a good solution. Seeking interaction with attendants isn't necessary, but it probably will not do any harm either.

The derived design and action recommendations are primarily intended to underline the existence of type-specific differences or preferences. Moreover, they are supposed to give a first impression of the added value that a consideration of the attendant perspective could bring to the design process when reworking/optimizing existing products or developing new, innovative product ideas.

6.3 Limitations and Further Work

There are four main limitations to our work that can form the focus of future research.

First, we want to highlight that our typology is not meant to be exhaustive. Rather it is a first attempt to specify present others in public technology interactions and gain an impression of type-specific differences in the experience of the attendants. However, an extension and further development of the typology through finer gradations, additional dimensions, or deeper insights into related experiential qualities are conceivable. Regarding the latter, we are currently planning a study that examines other types of desires (besides transparency and consideration), which could be differently related to the attendant types. Inspired by the participants' responses to the open questions of our questionnaire, we suggest, e.g., desire for shielding (i.e., attendants want to be able to distance themselves physically and/or psychologically), desire for politeness (i.e., attendants place importance to friendly gestures in their encounter with a user) or instead of desire for consideration a desire for non-consideration (i.e., attendants prefer being ignored by user). Furthermore, we plan to capture multiple facets of emotions, e.g., through the Positive and Negative Affect Schedule (PANAS, [77]) or Layered Emotion Measurement Tool (LEMtool, [31]), since the here applied SAM measures only two affective dimensions with single-item subscales. Though in the present study, most of the found differences in experiential qualities were associated with the voluntariness dimension, a more fine-grained investigation of emotional reaction might also reveal more differences associated with the conspicuousness criterion, as could the testing of alternative use cases. More specifically, we wonder if in usage situations regarding more personal or sensitive issues such as eavesdropping on private telephone calls, the conspicuousness of attending plays a greater role because being exposed entails more social risks, e.g., embarrassment for oneself or the user. Further studies on more "complex" use cases can help to understand the attendant perspective even better.

Second, our research was focused on the attendant experience, and most measures exclusively asked for their perspective. However, the assessment of a technology (interaction) will likely differ between users and attendants (e.g., [3, 35]). Therefore, in the sense of a holistic approach, future research could include the perspectives of users and attendants in parallel and compare them to one another.

Third, attendants' need profiles and recommended action strategies for users and attendants are based on exploratory analyses. Therefore, further systematic and experimental research is needed to verify and extend our results. For example, by manipulating or varying the satisfaction of specific needs, one could analyze, e.g., if a voluntary attendant experiences a technology interaction designed to enable the satisfaction of the need for stimulation vs. one that is supposed to fulfill their need for security (vs. a "neutral" interaction) more positive and pleasant. Likewise, our recommendations for users and attendants should not be understood as a code of conduct but rather as a first draft that needs to be further developed, tested, and evaluated in future studies. This also applies to our design implications. Further experimental studies should investigate whether and how the proposed design recommendations influence the attendant experience, e.g., do people who receive a notification to behave thoughtfully in public space use technology in a more prudent way? The attendant typology cannot only be used for the development and evaluation of design recommendations but also as a kind of tool, e.g., to create personas that can in turn be used in design workshops to generate innovative interactive products or product ideas. The value of personas for product development is manifold [50]. For example, current research emphasizes the added value of persona with needs or needs persona as "a starting point for creative brainstorming in the context of experience-oriented design" ([37], p. 1).

Last but not least, our research method of an experimental vignette study comes with certain inherently-related risks and limitations, e.g., report bias [54] or discrepancy between actual vs. imagined experience [17]. Although none of our participants reported having difficulty putting themselves in the scenario, in-situ methods, which capture participants' behavior, thoughts, and feelings related to particular experiences or activities, would also be an interesting extension. Field studies could complement findings from subjective self-reports with objective observations. Another limitation regarding the vignette methodology is that our findings might have been affected by the wording of the vignettes. The aim was to create (four versions of) a vignette that was neither too detailed, nor too vague. Thus, we presented explanatory as well as contextual factors which were supposed to lead to more realistic and plausible scenarios. Hereby, there is a risk of potentially "leading" formulations, e.g., through adjectives like good. We evaluated the vignettes in a pretest and ensured similar lengths and levels of detail in the four scenarios. Nonetheless, other methodologies and vignette studies on other use cases should be used to extend and support the present study's findings.

7 CONCLUSION

In this paper, we build on research that acknowledge the role of present others in public technology interactions. We advance previous perspectives with several novel contributions and promote a deeper understanding of the attendant perspective. More specifically, we developed a typology that allows an operationalization of social context; and that can be used in future research to analyze or evaluate technology interactions and as a framework for designing technology (experiences) for attendants in public spaces. A first test of the typology in the form of an experimental vignette study has shown that a more specific distinction of different attendant types is necessary as it reveals differences in the experience of attendants relating to the level of conspicuousness and voluntariness. Thus, our study dismisses overly simplistic "one size fits all" notions of social context by emphasizing the variance in the attendants' experience. In addition, the exploratory conducted qualitative data also provided interesting insights about expectations and opportunities for improving the technology experience of the attendants or the experience of attending a user listening to music (with headphones or speaker) in public, respectively. We expect our attendant typology to be extended with several practical design implications for interaction concepts to improve or create new technology experiences in public. Further studies could test the typology in other contexts or use cases and with an adapted set of dependent variables or experience scales, e.g., other kinds of feelings or desires to explore distinct differences regarding the conspicuousness of attendants. All in all, our study is one of the few to put the attendant, a group of stakeholders so far playing a minor role in HCI research, in the center of attention, and further illustrates the potential of the attendant perspective for ideation and product development.

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A APPENDICES

A.1 Pictorial representations of the different scenarios

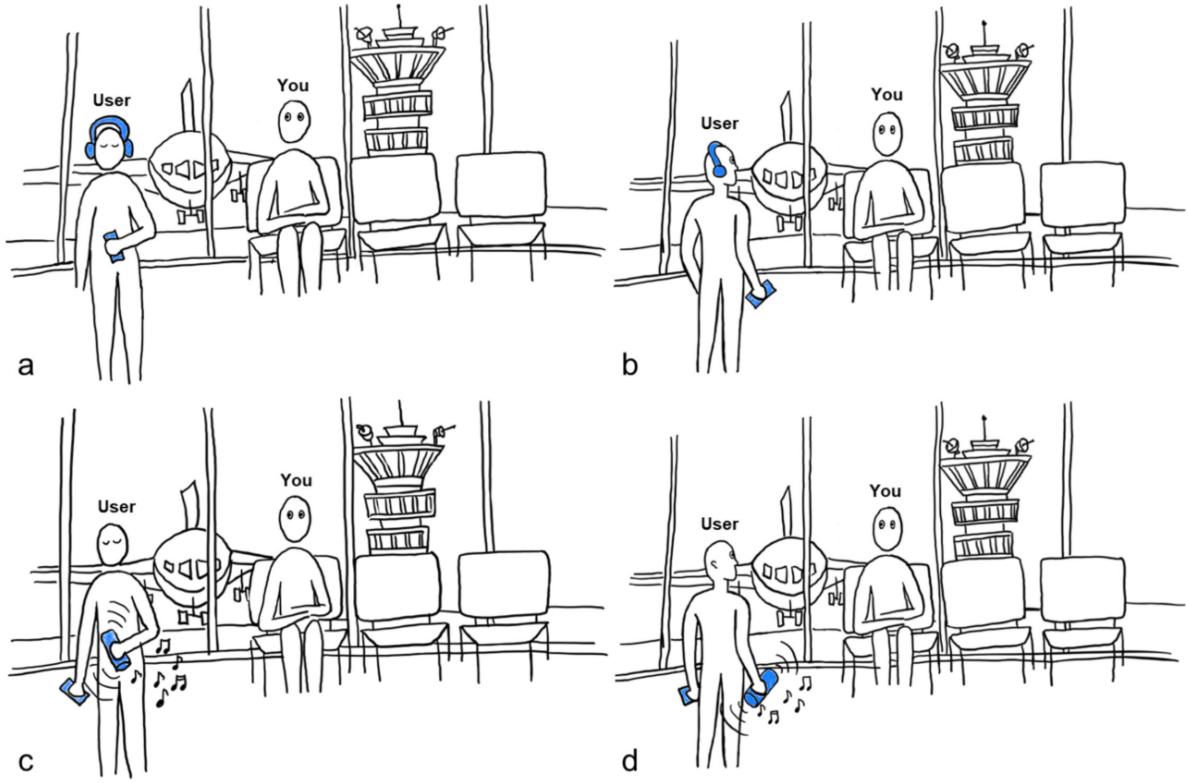

Figure A1: Pictures used in lurker (a), spectator (b), bystander (c), and witness (d) condition.

A.2 Questionnaire

Table A1: All items used in the questionnaire and, if applicable, internal consistencies of the scales

Measure	Items	Internal Consistency[a]
Affective Reaction: Arousal	I am calm, relaxed, sleepy. / I am excited, activated, vigilant.	
Affective Reaction: Dominance	It is not in my control. I cannot affect it. / It is in my control. I can affect it.	
Desire: Transparency	I would like to get more insights into the user's technology interaction.	
Desire: Consideration	It is important to me that the user shows consideration for me while they interact with the technology.	
Attention Check	V-item 1: I can voluntarily decide whether I pay attention to the user and their technology. V-item 2: I unintentionally get to see how the user interacts with the technology. C-item 1: The user is aware that I am looking at them. C-item 2: I can follow unnoticed how the user interacts with the technology.	V-items:.64 C-items: .89
Method Control	All in all, how well can you put yourself in the scenario?	
Affective Reaction: Positive Valence	If you think about the situation that was described to you: How negative would you feel?	
Affective Reaction: Negative Valence	If you think about the situation that was described to you: How positive would you feel?	
Desire: Involvement	I would like to be more involved in the user's technology interaction.	
Need: Competence	Refers to the need to face and overcome challenges. The experience of success and self-efficacy plays an important role.	
Need: Relatedness	[. . .] to feel close to others, especially people who are important to you. It is about the feeling of social inclusion and closeness.	
Need: Popularity	[. . .] to be recognized by others, to be someone others emulate and find interesting. Fame, responsibility, power and influence play an important role.	
Need: Stimulation	[. . .] to get to know new things. Curiosity, variety, entertainment or distraction often play an important role.	
Need: Security	[. . .] to be able to plan things and to be safe from threat and uncertainty. It is about a sense of relaxation through predictability and structure.	
Need: Autonomy	[. . .] to be able to decide things freely. Self-determination, autonomy and independence play an important role.	
Social Acceptability	SA-item 1: How comfortable would you feel performing the described technology interaction in the described public setting? SA-item 2: How acceptable do you evaluate the performance of the described technology interaction in the described public setting?	.89
User's Optimization Possibilities (Open Question 1)	How could/should the user behave to make the situation more enjoyable for you?	
Attendant's Reaction or Control Possibilities (Open Question 2)	What could you do to make the situation more pleasant for yourself?	
Demographic Information: Age	How old are you?	
Demographic Information: Gender	Which gender identity do you most identify with?	
Demographic Information: Highest Educational Attainment	What is your highest school-leaving qualification?	
Demographic Information: Technical Affinity[b]	I feel positive regarding the utilization of technologies. Overall, I like using technologies.	.89

[a] Internal consistency was measured with Spearman-Brown split half. [b] Items inspired by Salloum et al. (items ATT1 and ATU4, [65]).

A.3 Correlations

Table A2: Inter-correlations of all quantitative variables (Pearson correlation[a])

Attendant Experience	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Arousal	1													
2. Dominance	-.08	1												
3. Transparency	.02	.22**	1											
4. Consideration	.47**	-.23**	-.07	1										
5. Positive Valence	-.42**	.25**	.28**	-.54**	1									
6. Negative Valence	.47**	-.33**	-.19*	.55**	-.75**	1								
7. Involvement	.13	.04	.50**	.16*	-.01	.11	1							
8. Competence	.20**	.12	.17*	.34**	-.09	.13	.22**	1						
9. Relatedness	-.01	.11	.32**	.01	.25**	-.19*	.22**	.36**	1					
10. Popularity	.06	-.03	.30**	.08	.10	.02	.22**	.30**	.49**	1				
11. Stimulation	-.15*	,17*	.36**	-.28**	.43**	-.39**	.09	.17*	.50**	.31**	1			
12. Security	.25**	-.00	.00	.47**	-.17*	.22**	.17*	.53**	.26**	.18*	-.05	1		
13. Autonomy	.22**	-.10	.00	.37**	-.20**	.29**	.14	.40**	.10	.09	.00	.50**	1	
14. Social Acceptability	-.51**	.30**	.16*	-.66**	.67**	-.66**	-.09	-,22**	.07	-.05	.33**	-.33**	-.29**	1

[a] Statistical significance levels: *$p < .05$; **$p < .01$

A.4 Participants' ideas regarding possibilities for action on the side of the user

Table A3: Frequencies of the main and sub-categories per attendant type

Main category	Sub-category	Lurker	Spectator	Bystander	Witness	Overall
no possibility or need for optimization		23	14	1	1	39
invalid answer		2	2	0	0	4
reduction of attention-grabbing behavior		12	8	0	0	20
change in technology (usage)		18	7	50	50	125
	headphone use or noise canceling	4	0	30	25	59
	volume regulation	13	7	11	13	44
	adaptation of the music (genre)	1	0	2	6	9
	termination of interaction	0	0	7	5	12
	no classification possible	0	0	0	1	1
shielding		4	25	4	5	38
	change of location	4	6	4	5	19
	turning away	0	19	0	0	19
friendly gesture		1	3	0	0	4
interaction with attendant		4	5	6	5	20
	ask for permission	1	1	6	4	12
	provide explanation	1	0	0	0	1
	enabling participation	2	4	0	1	7

A.5 Participants' ideas regarding possibilities for action on the side of the attendant

Table A4: Frequencies of the main and sub-categories per attendant type

Main category	Sub-category	Lurker	Spectator	Bystander	Witness	Overall
no need to react or adapt		7	5	0	0	12
continuing observation		0	2	0	0	2
invalid answer		2	1	1	0	4
alternative pursuit		21	18	7	4	50
	reading	2	1	1	1	5
	smartphone usage	0	2	0	0	2
	listen to music themselves	5	5	5	2	17
	changing the focus of attention	9	7	0	0	16
	other	5	3	1	1	10
shielding		36	31	34	35	137
	change of location	18	11	23	25	77
	turning away	17	20	4	1	43
	arbitrary termination of technology use	1	0	1	1	3
	using headphones themselves	0	0	6	8	14
change in thought patterns		6	0	3	2	11
	positive emotions	4	0	2	2	8
	self-reflection	2	0	0	0	2
	negative emotions	0	0	1	0	1
friendly gesture		0	3	0	2	5
interaction with user		5	5	26	27	63
	behavior change proposal	0	2	16	13	31
	pointing out disturbance	3	0	8	11	22
	seek conversation	2	3	0	2	7
	destructive communication	0	0	1	1	2
	other	0	0	1	0	1
involvement of airport staff		0	0	2	1	3
participation		0	0	0	3	3

Multimodal Technologies and Interaction

MDPI

Article

The Attendant Card Set: A Research and Design Tool to Consider Perspectives of Attendants versus Users When Co-Experiencing Technology

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Abstract: Although many of our interactions with technology nowadays take place in public places (e.g., using a mobile phone in public transportation), research and design on Human-Computer Interaction (HCI) has paid little attention to how this kind of technology usage affects others present—and vice versa. To illustrate the perspective of the attendant, i.e., a person who is not interacting with technology themselves but co-experiencing it as listener or viewer, we developed the so-called Attendant Card Set (ACS). In two studies, an expert survey and a student workshop, we tested its practical applicability and usefulness. It showed not only that experts assess the cards positively, i.e., helpful, informative, and relevant, but also that the cards can be used with laypersons for perspective-taking, creative ideation, and discussions. Thus, analyzing and/or comparing the experience of different types with the help of the ACS provides a unique approach to the consideration of the attendant perspective in the research and development process. Limitations of the present research and opportunities for future tool applications are discussed. In addition to establishing this concept in HCI, we also see potential in the transferability to other areas and contexts such as the design of public space or non-technological products.

Keywords: Human-Computer Interaction; technology experience; attendant; user; card set; research and design tool; public space; social context

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1. Introduction

Due to the rapid rate of innovation and widespread integration of technology, technical products are nowadays have become intertwined with our daily experiences. Interactions with technology have become an inherent part of numerous activities in the public space from moving around or working to communicating with people. Even when we are not users of the technology ourselves, i.e., we do not directly interact with the technology, we are, nonetheless, affected by its presence as passive viewers or listeners. Thus, it is important to recognize that designing only for the needs and preferences of users is insufficient. To truly enhance or shape public technology experiences in a positive way, a human-centered design approach is essential. This includes another group of stakeholders in public technology interactions: the attendants, i.e., individuals who are co-experiencing another user's interaction with technology [1].

The first launch of the Google Glass is a good example of how neglecting to consider the attendants' perspective can lead to design and product failures. Attendants reported issues such as privacy invasion and interference with social interactions [2,3]: "The Google Glass feature that (almost) no one is talking about is the experience—not of the user, but of everyone other than the user." [4]. The term "Glasshole" for users of this early AR glasses product spread quickly in public and in the media, underlining the importance of considering the perspective of those co-experiencing the use of a particular technological device.

Some even argue that attendants represent "the largest stakeholder group" [5] (p. 2377). Neglecting the perspective of a group that is affected by technology (interactions of users) to such an extent is concerning and calls for a critical reflection of the user-centered design practice in Human-Computer Interaction (HCI) research. The present research questions the popular design practice of only or mainly focusing on the needs and preferences of primary users by explicitly considering the attendant perspective. The overall aim is to enable positive experiences with/through technology for those (un-)voluntarily and (un-)apparently attending. To this end, a set of cards was developed to facilitate the description and analysis of attendant experience in the research and development process. The so-called Attendant Card Set (ACS) is supposed to stimulate critical thinking and encourage discussions and can thereby serve as a tool for design, evaluation, and ideation. We tested and optimized the ACS with the help of two studies: an online survey with experts and an in-person workshop with students. Results, such as the overall positive feedback of the experts and the fruitful discussions in the workshop, demonstrate the practical relevance and significance of the ACS. Ideas for further research directions are also presented. We start by explaining the importance of understanding and considering the attendant perspective in public technology interactions in the following chapter.

2. Theoretical Background

2.1. Attendant Role

First of all, why should we care about the attendant experience at all? To take up the example from the beginning, users reported how the experience of others present affected their own experience with the Google Glass: "Again and again, I made people very uncomfortable. That made me very uncomfortable." [6]. This is only one example of many illustrating an interdependency or connection of user and attendant experience. In fact, there are various studies showing that attendants both influence and are influenced by the user (technology interaction). For example, Gentile et al. [7] presented some insights on how others present can discourage users of public displays, and Von Terzi et al. [8] suggested that formerly public interactions with technology were experienced less positive when imagining the same interaction but without other persons present. Other authors investigated the effects of user interactions on attendants and revealed annoyance (e.g., [9,10]), disturbance (e.g., [11,12]) distraction (e.g., [13,14]), and embarrassment (e.g., [15,16]) as potential consequences.

So far, there is no systematic research on the attendant experience. HCI literature uses various terms for attendants of technology interactions, such as bystander (e.g., [17]), spectator (e.g., [18]), observer (e.g., [19]), passer-by (e.g., [20]), audience member (e.g., [7]), or Non-HMD (Head-Mounted Displays) user (e.g., [21]). Some authors, like Montero et al. [22], even utilize multiple terms within a single paper. The relatively few studies explicitly addressing the attendant perspective have a "narrow" research focus and can be grouped into two categories. The first category includes studies about the assessment and improvement of the technology or technology interaction, e.g., through social acceptability (e.g., [19,23]), but these are less about the attendant experience or its improvement. Those studies that explicitly address the attendant experience focus mainly on negative aspects, i.e., reducing or preventing violation of privacy (e.g., [5,24]). In the second category are studies concerned with turning attendants into users, i.e., by causing attraction or engagement (e.g., [25,26]). Indeed, previous research studies identified and tested various psychological effects in the context of user attraction and engagement [27], but what about those who cannot or do not want to participate, who cannot or do not want to be users?

We expand the focus of investigation and put the attendant in the center of our research work. For this, it is necessary to first understand who the attendants are in order to be able to better describe and analyze their experience in a next step.

2.2. *Attendant Typology*

Through an iterative development process, we created the Attendant Typology (AT) for a more precise operationalization of the social context or the others present in public technology interactions [1]. The typology distinguishes four types of attendants by means of two criteria. The two criteria are voluntariness of attending the user interaction (forced vs. voluntary) and conspicuousness of attending the user interaction (secret vs. obvious). The criterion of voluntariness describes the degree of felt self-determination, i.e., whether watching and listening to the technology interaction is the attendant's choice or they feel like the interaction is forced upon them. The criterion of conspicuousness describes the level of attention that is given to the attendant, i.e., whether or not they believe they can be identified as an "observer" by the user while watching or listening in on the technology interaction. The resulting four types are lurker, spectator, bystander, and witness (see Figure 1).

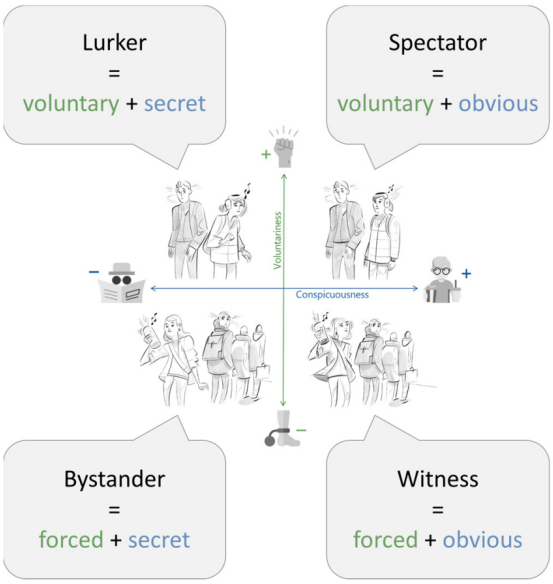

Figure 1. Overview of the four attendant types based on Von Terzi & Diefenbach [1].

In an online vignette study (N = 181) we ran a first experimental test of the typology. Participants were randomly assigned to one of four conditions or attendant types and were asked to evaluate their experiences in the imagined scenario. The study revealed notable differences in the experience patterns, emphasizing the need for design solutions that address the specific requirements of each attendant type [1]. Since we used a fictional use case in this first study, we were interested in whether the typology would also be applicable in the actual everyday experiences of people. Consequently, we conducted an explorative, qualitative interview study (N = 17) where we asked participants to recall a past attendant experience, followed by a few questions to help specify what aspects made this experience positive or negative. Lastly, each participant had to choose the attendant type that best described their role in the recalled experience. All four types were chosen multiple times (lurker: six, spectator: four, bystander: four, witness: three) underscoring the importance of differentiating the attendant perspective.

All in all, these studies not only provide valuable first insights into the attendant experience in public technology interactions but also stress the inadequacy of "one size fits all" design solutions. By recognizing and addressing the variations in experience patterns among different attendant types, researchers and designers can create technologies that meet the specific needs and preferences of individuals in different social contexts.

3. Attendant Card Set

As outlined in the previous chapter, considering the attendant perspective in contrast to the user perspective is an important topic in HCI research and practice. However, adequate tools and methods are still rare. To facilitate an easier and broader application of the developed attendant typology, we translated it into a card set (ACS, short for Attendant Card Set, see Figures A1–A4 in Appendix A for the final version). The card set is intended to enable the use of the typology in formats with greater practical orientation like workshops, focus groups, etc.

Card sets are an established, light-weight form of research and design tools in the HCI community. There are numerous types of card sets for different purposes and application domains, e.g., as repository tool or for participatory design (see literature reviews on design card sets of Aarts et al. [28] or Roy and Warren [29]). Many authors have commented on the value of such card sets, for example, Lucero et al. [30] naming them "tangible idea containers, triggers of combinatorial creativity, and collaboration enablers" (p. 92). As argued by Bekker and Antle [31], "[C]ard sets are a form of design tool that can be used to make conceptual information accessible to designers and can be used to support designers how they work in practice." (p. 2533). More specifically, they can inspire and enhance creativity in the design process [32]. They can encourage designers to take different perspectives, foster communication, empathy, and collaboration between designers and users, and can be used to solve a specific design issue [33].

The ACS (see Figure 2 for an example card) uses both, text and images, to illustrate the idea and characteristics of the attendant types so people can intuitively relate to the concepts. As with other card sets like Need Cards [34], PLEX Cards [30], Privacy Mediation Cards [35], or Wellbeing Determinant Cards [36], no specific professional or methodical know-how is needed to use the cards. Besides, the preparatory work is minimal, as participants can be introduced to the concept of AT with help of the introduction card (see Appendix A Figure A1). This can be done by a moderator or by the participants themselves. Our ACS bears a certain similarity to the method of personas, i.e., descriptions of prototypical users of a product through specific characters or profiles [37], which are frequently used in various fields such as marketing, product design, or software development. The difference is that in our case it is not about personality but role. To put it in the words of Ringfort-Felner et al. [38]: "While a personality describes general traits as they are, roles imply certain behaviors and conventions independent of the actual personality [. . .]. For example, mothers are expected to care, no matter whether they have a warm and caring personality or not; in the same way, a waiter is supposed to be friendly, no matter whether he is an introvert or has a bad day. Roles are more crucial to shape emerging relationships and expectations than personality." (p. 3).

The ACS offers a practical tool for gaining a deeper understanding of the complexities of attendant roles and for incorporating the attendant perspective into the research and development process. Typical usage scenarios we have in mind are, for example, analyzing and comparing a public technology (interaction) from the perspective of the different attendant types, or exploring ways to improve or create innovative technological product ideas by considering the perspective of a specific attendant type. In other words, the ACS can serve as an evaluation, design, or ideation tool, promoting social and context-aware design solutions or technologies. Concrete examples of use cases for the cards include applying the ACS to design mobile technology interfaces that support or help to avoid the "participation" of attendants in the user interaction. Another example is using the ACS to inform users of public displays about the perspective of different attendants on their interaction and explore appropriate interaction forms to fulfill social needs for popularity or relatedness. Broadly, the ACS can be used in two ways:

1. explorative: e.g., by using the cards as impulses, to plunge into the attendant's world of experience, or to invent new product concepts based on attendant types not yet considered

2. directed: by starting from a specific technology (interaction) or usage scenario and exploring the solution or design space with the help of the cards

The ACS was developed in an iterative process in which we critically reviewed and improved its applicability with the help of two studies. These studies are described in more detail in the following.

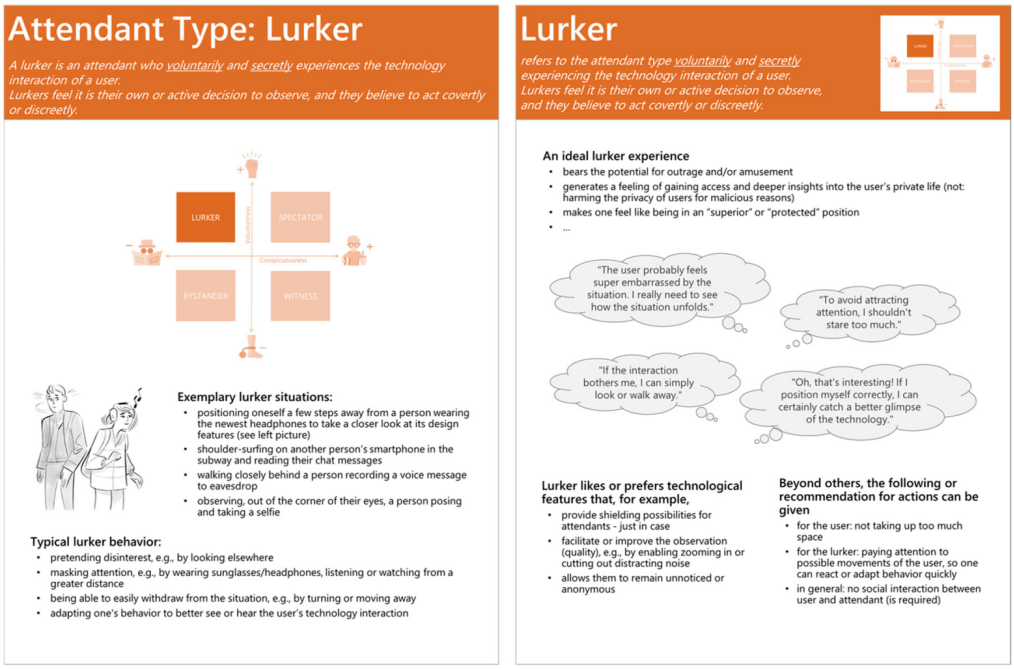

Figure 2. Front (**left**) and back (**right**) side of the lurker card.

4. Application and Refinement Studies

We first conducted an expert study (N = 11) to test and optimize the ACS, followed by a student workshop (N = 5) with the revised version of the ACS. In this chapter, we present the procedure and results of the two studies, i.e., discuss how the ACS was used and adapted.

4.1. Expert Survey

We structured the expert study into two parts: solving a specific research/design task (part A) and giving feedback on the card set (part B). With this structure, we hoped to not only gain a first impression of whether the card set would work and in which way it worked, but we also hoped to identify improvement potential and assess the practical relevance of our ACS.

4.1.1. Method

The questionnaire combined open (qualitative) and closed (quantitative) response formats. Except for the demographic question about gender, the closed format used a 5-point scale ranging from 1 (low/disagreement) to 5 (high/agreement). Thirteen participants were recruited via email, four males and nine females aged between 23 and 38 years (M = 29.62, SD = 4.33). These practitioners had experience and expertise in HCI (M = 4.31, SD = 0.95), psychology (M = 3.54, SD = 1.33), design (M = 3.31, SD = 1.25), and research (M = 4.38, SD = 0.65).

The study employed a randomized design wherein each participant was assigned to work with one type/card. The procedure consisted of two parts: part A involved testing and using the cards, while part B focused on gathering feedback related to the participants' user experience with the cards. More specifically, in part A the participants were instructed the make themselves familiar with their card and then reflect on how an ideal experience would look like, how they could satisfy or protect their interests in the role of that specific type, and which technological features and functions might enable a positive attendant experience. The expert feedback in part B included an assessment of the ACS quality on a 5-point scale, but also open-ended questions such as if and what information the participants did miss or which aspects of the cards they disliked or found difficult. Lastly, we asked participants to provide some demographic information. The complete questionnaire can be found in Supplementary Materials (see Table S1). The completion of the online questionnaire took the experts approximately 45 min.

4.1.2. Results

The analysis of the qualitative data collected in part A provided some valuable insight. First, all participants were able to solve all tasks or answer all three questions with the help of the cards (i.e., no missing data). Second, the content of the participants' answers differed between the conditions. For example, participants working with the card of an obvious attendant type, witness, emphasized that being recognized was ideal because it allowed them to directly interact with the technology user in question: "[. . .] I did not have to intervene explicitly by saying that she is really loud and asking her to calm her voice. [. . .] she understood the way I looked at her". Participants in the lurker condition, on the other hand, emphasized that remaining unnoticed was of central importance when asked about an ideal experience: "[. . .] I would be much more comfortable, not worrying about the need to explain myself [. . .]". This shows that the cards provide diverse insights into the attendant perspective and thus emphasizes that a nuanced distinction between the other participants in the technology interaction is necessary. Since the participants' answers to the three open questions also provided deeper insights into the attendant experience, they were consequently used as inspiration for improving the ACS. For example, we included participant ideas regarding technical features that would enable a positive attendant experience in the revised version of the ACS.

Analyses of the qualitative and quantitative data from part B of the questionnaire showed an overall positive experts' assessment of the ACS. All of eight items capturing the cards' utility received mean scores of $\geq$3 on a 5-point Likert scale ranging from 1 (strongly disagree/not at all) to 5 (strongly agree/extremely). This shows that the experts liked the cards, see Figure 3.

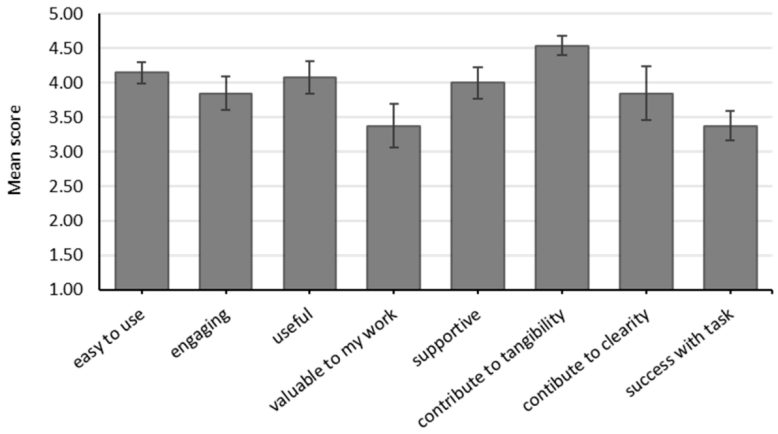

Figure 3. Mean scores of all eight items to show the quality of the ACS. Error bars show standard errors.

This impression is further reinforced by participants' answers to the open questions regarding what they found particularly helpful, missed, or disliked in the cards. Experts stated, for example, that they especially appreciated the sketches, the overview of the types, the background information regarding the typology, the concrete and non-obvious example situations, as well as the quotes. Eight of the thirteen participants found nothing amiss when using the cards. The input of the other five experts corresponded to their responses when asked about possibilities for improvement and the features they disliked or found difficult. For example, one participant missed the perspective of the primary user and suggested to include their perspective. Another expert asked for sample scenarios in virtual environments. Most of the experts' improvement suggestions related to visual or design aspects like less text, reducing the quantity of information, a more aesthetic font, or an alternative arrangement of the elements on the card.

For the revision of our card set, we did not only include the explicit suggestions for improvement but also examined all participant responses from part B carefully and applied them as far as considered reasonable. In the end, the following changes were made to improve design and ease of use: (1) information on the front and back side of each card, (2) a clearer layout, and (3) additional information. To improve the layout of the cards, we changed the font and rearranged the sketches, quotes, and text blocks. The newly added information included, for example, an instruction card that gives an overview of all four types and explains how to use the ACS and textual descriptions of the sketches.

Further interesting insights relate to the experts' experience with similar tools. Eight participants have worked with a card set before, for example, in the context of design thinking, collaboration, creative imagination, scrum process, or card-sorting tasks. These experts had used card sets like Need Cards [34], Interaction Vocabulary Cards [39], or the digital card set "Laws of UX" (User Experience) [40]. However, none of the experts knew a tool to capture the social context in (public) technology interactions. Furthermore, when asked about work situations where they might use the cards in the future, nearly all experts could think of potential use cases like evaluation of a product idea or UX of a technology, prototyping, user testing, interviews, categorization of user groups, in ideation process for architects or designer, or game design—just to name a few. One expert suggested that the ACS not only can be used to take and understand the perspective of the attendant but also to assess a technology/interaction from a user perspective when a specific attendant type is present.

4.2. Student Workshop

The student workshop was designed with the aim of testing the cards' applicability in a face-to-face setting with people who have no specific practical know-how, i.e., under conditions that we consider typical and realistic in practice.

4.2.1. Method

The five participants of the workshop (four females, one male; aged between 22 and 38 years, M = 26.20, SD = 6.65) were all psychology students in a master's program and had no design or research expertise. The workshop lasted for about 75 min and was divided into the following phases: warm-up, theoretical input, and practical tasks.

In the beginning, participants were asked to report and reflect on their most memorable experiences in an attendant role, i.e., when they listened to or watched the technical interaction of a stranger and why. In doing so, participants were expected to become acquainted with the topic and aware of differences in the attendant perspectives. Following the warm-up, we explained the idea of the AT and ACS to the participants. Then, each of the participants was assigned to one specific attendant type and given some time to familiarize themselves with the corresponding card.

The last phase of the workshop consisted of several practical tasks which the participants performed individually. First, we asked the participants to take the perspective of their assigned attendant type and think about how a user interaction with a smartphone

might be experienced from this perspective. The scenario could be fictional or a situation from their own experience. Each participant created a sketch of this experience and later explained it to the group. This allowed us to make sure that all participants had read their cards carefully. For the second task, participants had to analyze which psychological needs (i.e., autonomy, competence, meaning, popularity, relatedness, security, stimulation) would be most important for their attendant type and why. They had a few minutes to make some notes and then, one by one, put sticky dots on a flipchart after the corresponding needs and were asked to explain their reasoning. The third task was related to user behavior and contact. We asked participants to reflect on (a) how a user would behave in a scenario where they were surrounded by their attendant type, (b) the conceivable user-attendant contact, and (c) how the specific type should behave so that their behavior would be experienced as positive or pleasant for primary users. Last but not least, participants assessed the relevance of Civil Inattention (CI) for their respective type; CI being the practice of signaling people that you have noticed them but are not particularly interested in them or what they are doing in order to keep a polite distance [41].

After each task, participants were instructed to discuss their impressions and ideas. By comparing the four types in a group discussion, participants explored differences and similarities in the attendant types regarding needs, desired level of user contact, and socially acceptable attendant behavior.

4.2.2. Results

Task 1 was aimed at immersion into the perspective of the respective types to appreciate possible thoughts and behavior. On this base, participants created sketches of a user interaction with a smartphone from the perspective of their type using the assigned cards. For example, one participant described their sketch to the group as a situation where they sit on the train and were happy to secretly read the "spicy messages" of another person.

In task 2 and task 3, participants first analyzed the perspective and experience of their type individually, and afterwards engaged in a group discussion to compare the different types. This allowed them to identify differences and similarities in the scenario of attending a user's smartphone interaction in public. In task 2, participants determined the needs relevant to their attendant type. For example, participants in the lurker condition stated that, for their type, competence is the most relevant need and could be satisfied by secretly gathering information about the user, thereby gaining a sort of knowledge advantage. For the spectator, in addition to autonomy and stimulation, one of the participants mentioned relatedness as a relevant need. In their opinion, the observation situation felt like a shared experience, something that the user and attendant experienced together. As bystander, the need for security can play an important role. Since most usage situations seem unpredictable to them, gathering information through secret observation was seen as a way to assess the user and enable an appropriate reaction. In addition to the satisfaction of the need for stimulation and relatedness, participants explained that autonomy is important. According to them, as a bystander, the need for autonomy is violated because one cannot freely decide what one sees or hears. The participant in the witness condition declared relatedness, stimulation, and security as relevant needs. The need for security, was explained as being certain of not doing something unwanted when observing the user or their interaction since the user was aware of the witness's observation and could just adapt the technology interaction accordingly. The group discussion on the participants' choices revealed that some of the need-type assignments were considered critical. For example, regarding the need for relatedness, the participants concluded that for the secret types, lurker and bystander, it is rather a kind of one-way relatedness. In such situations, since the user is unaware that the attendant acquired private knowledge about them, the feeling of relatedness cannot be mutual. Regarding the need for stimulation, participants discussed that this aspect mainly motivates the voluntary types whereas, for forced types, stimulation only plays a role in making the situation more bearable.

In Task 3, participants reflected on user behavior and contact and described with the help of their card what socially acceptable attendant behavior might look like. The group discussion revealed user attitude to be one of the most important differences in user behavior towards the four types. For example, participants discussed that the user would act "clueless" in a lurker situation, whereas, in a spectator situation, the user simply might not care enough to hide or change their behavior. Furthermore, participants agreed that even with forced attendant types, the users often don't act with a bad intention of imposing themselves or their technology interaction but, for example, "do not pay attention to what the others present are doing" (witness) or "do their thing" (bystander). Participants suggested that depending on the attendant situation, the user might actively ignore any witnesses, as opposed to simply being too absorbed to notice any bystanders. Regarding user contact, participants agreed that even though interaction with secret types would be rare, attendants would be open to step in, if necessary. For obvious types, eye contact was deemed the most common form of interaction between user and attendant. In the discussion on socially acceptable attendant behavior, participants identified some differences between types but also similarities. For example, as spectator, it would be important not to act too intrusively and to give the other person enough space, i.e., to signal openness for social contact only through facial expressions and gestures. Similarly, as witness, one should not stare too much. In case the user or their technology is disturbing, the witness might communicate it to the user while keeping this social interaction as short as possible. For both obvious types, it seems to be important not to take up too much of the user's time and space. The question of which party could or should initiate the verbal contact was answered differently for each type. While it was deemed okay for a witness to approach the user directly, a spectator should wait for the user to make the first move. In case of a bystander, the user should not be disturbed in their technology interaction and even eye contact should be avoided. For lurkers, participants stressed the importance of the attendant apologizing and explaining if caught observing. Lastly, participants discussed the relevance of CI for the different types and concluded that signaling to the user "I see, but I am not watching you" might be helpful or important for all types except the spectator. For instance, one participant suggested that lurkers might be more successful in observing a user, i.e., following their technology interaction undisturbed, by pretending not to be interested. For the witness, CI is relevant for another reason. By making brief eye contact with the user and (mutually) confirming that one has noticed the other, witnesses can ensure that contact is possible in case necessary, e.g., if the technology interaction became disturbing.

5. Discussion and Future Work

The results of the application and refinement studies show that the ACS provides a valuable approach to exploring the attendant perspective. Its value and usefulness are not only affirmed by the overall positive feedback (mean scores ≥ 3) of the experts on the ACS but also by their creative ideas on ideal experiences, attendant (re-)action possibilities, as well as technological features and functions. The results of the workshop show that the cards can be used for imagining the perspective of an attendant (type) and, thereby, analyze type-specific characteristics and preferences. They can also be used for comparing types to uncover similarities and differences, e.g., with regard to needs, social acceptability, etc. That way, the ACS can serve both as a design tool and a research tool. As a design tool it might serve as inspiration or to help ensure the explicit consideration of the attendant experience(s) in the design of a technology or technology interaction. As a research tool, it enables reflection on the role and perspective of attendants in technology interactions.

The ACS can be used by both experts and laypersons for assessing, improving, or creating public technology experiences. For example, in the expert survey, participants not only reported that it was engaging and easy to use but also that it allowed them to successfully complete the design/research tasks. No difficulties were observed when the card set was used by the laypeople in the workshop.

We suggest that the ACS offers a unique approach to mapping the social context or other people present as none of our experts knew about a similar (design) tool. Moreover, they suggested a couple of example scenarios for how they could use the ACS in their everyday work—beyond the use cases we described in the online study. The analysis of the quantitative data also shows that the experts think of the ACS as useful, supportive, and informative.

When talking about the opportunities to enhance the design and use of design cards, Hsieh et al. [42] stated that "[. . .] we need to explore ways to better communicate the value of design cards and lower barriers for using these cards." (p. 13). Therefore, we consider the fact that the value and contribution of the ACS to the HCI community is precisely described in this work as well as on the instruction card a major strength of our ACS. Besides, the cards are not only engaging and easy to use (see expert study), they also require no prior knowledge (ACS was used in workshops by laypersons without any problems). Lastly, using the ACS needs minimal preparatory work. For instance, it took less than 10 min to introduce the idea of the ACS to the workshop participants. In the expert study, a brief written introduction was sufficient.

This research comes with a few limitations that need to be addressed. First, we used relatively small sample sizes in our application and refinement studies as we followed a qualitative (workshop) and mixed (expert survey) approach. However, this is not uncommon, nor are large sample sizes considered critical for such formats, see [43]. A suggestion for an experimental study with a larger sample size could be to explore statistically significant group differences between the four attendant types. For example, by instructing participants to take the perspective of a specific type with the help of the ACS and assess a technological product with the help of quantitative measures, such a study could show if a technology is more or less "suitable" for particular types. Furthermore, the focus on European participants with higher educational levels may limit the generalizability of the results. Thus, conducting studies with a more diverse sample of individuals with varying backgrounds and experiences (e.g., engineers or marketing experts) and exploring how the ACS can support the later design stages (e.g., prototyping and implementation) would be logical next steps. Future research could also explore the application of the ACS in diverse cultural contexts, and thereby assess if cross-cultural differences exist or if modifications or supplemental types/cards would be needed for other cultures. Moreover it is very likely that in the real world, attendants will not only find themselves in the role of one single type but could be expected to transition from one type to another (see e.g., "roles are dynamic" [38]). Therefore, field experiments or observations investigating the transition from one type to another and its impact on the attendant experience are an interesting future research direction. Last but not least, we do not address interdependencies between attendants and users in our ACS. Future studies exploring user perception and emotions regarding a specific type of attendant are needed to allow an integration and expansion of the ACS with user-attendant dynamics. Moreover, experimental and observational studies should also explore more complex usage situations with multi-user and/or multi-attendant situations in the future as interdependencies might change or differ when there are multiple stakeholders.

We see great potential in the ACS, for two main reasons: (1) the systematic implementation of the attendant construct into HCI theory and practice and (2) the transferability of the ACS to/in other fields; from which we derive further recommendations for future research directions. First, a wider application of the ACS would support successfully establishing the construct in HCI. For example, future studies could integration and combine the ACS in and with other design methods (e.g., design thinking or role-play) or tools (e.g., need cards). Furthermore, the ACS can be extended by additional types/cards in accordance with the typology (see [1]). Following Aarts et al. [28] suggesting the creation of open-ended card sets, the possibility to expand the ACS in line with new research insights enables continuing flexibility and progress. Second, the transfer of the ACS to other fields, such as hybrid collaboration or urban planning, presents exciting opportunities. For example, one could

consider the attendant as an additional stakeholder (next to users) when developing video conference systems, or one might explore the role and perspective of attendants in smart cities or Pervasive Computing Environments (PCEs). Analyzing the attendant experience in such environments might lead to, e.g., new insights regarding non-use or techno-stress in physical spaces.

Since we focus exclusively on technology, testing the applicability of ACS for non-technical interactions, such as the act of riding a bike, could be an interesting distinction in user versus attendant perspective. By considering non-technical interactions and acknowledging the user-attendant dynamics within them, a more comprehensive understanding of public experiences with products of all kinds could be achieved.

6. Conclusions

People co-experiencing, i.e., watching or listening, both influence and are influenced by the user interaction with technology. As technology becomes increasingly embedded in public spaces, it is essential to adopt a human-centered design approach that also acknowledges the role and experience of the attendants in public technology interactions. This research has presented the so-called Attendant Card Set as a valuable tool for stimulating conscious reflection and consideration of the attendant perspective in the research and design process. Results of the application and refinement studies show, for example, overall positive feedback from experts regarding the ACS and its use. The card set also facilitated fruitful discussions and interactions between laypersons in an in-person workshop. More specifically, experts not only rated the ACS as, inter alia, easy to use and supportive. They also saw the potential of using the cards for their work and suggested a couple of interesting future use cases for the cards. Furthermore, the ACS enabled students to take and compare the perspectives of the four attendants, thereby identifying similarities and differences, e.g., regarding need satisfaction or socially acceptable attendant behavior. The present work challenges how we currently design technology in HCI. However, it can only be the first step. Future studies, on the one hand, should focus on the establishment in HCI theory and practice, e.g., by using the ACS in experimental studies with greater sample sizes or prototyping sessions in companies. On the other hand, the transferability and application of the ACS in other domains and contexts, e.g., urban planning or multi-user workspaces, are promising research directions. Considering the attendant perspective will lead to more holistic and inclusive design practices—in all kinds of areas.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/mti7110107/s1, Table S1: All Items of the expert survey.

Author Contributions: Conceptualization, P.v.T. and S.D.; methodology, P.v.T.; validation, P.v.T. and S.D.; formal analysis, P.v.T.; investigation, P.v.T.; resources, S.D.; data curation, P.v.T.; writing—original draft preparation, P.v.T.; writing—review and editing, S.D. and P.v.T.; visualization, P.v.T.; supervision, S.D.; project administration, P.v.T.; funding acquisition, S.D. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data presented in this study are openly available in an OSF repository at https://osf.io/vaw6p/?view_only=370006a0011849f69af7c33a0a8d0702 (accessed on 18 October 2023).

Conflicts of Interest: The authors declare no conflict of interest.

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Appendix A

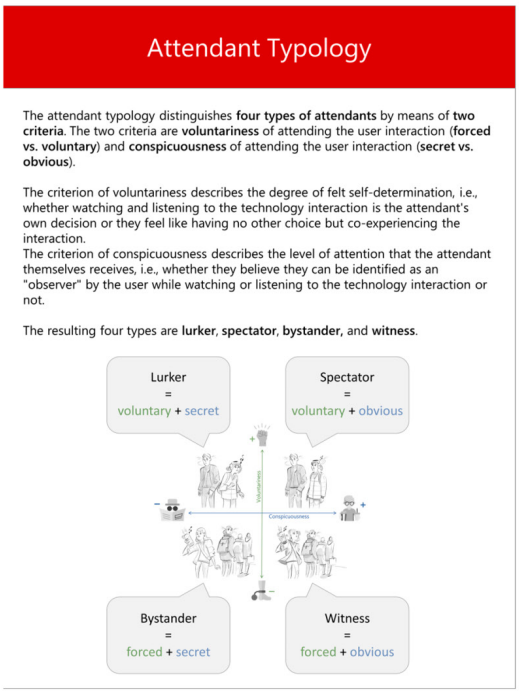

Figure A1. Introduction card of the ACS.

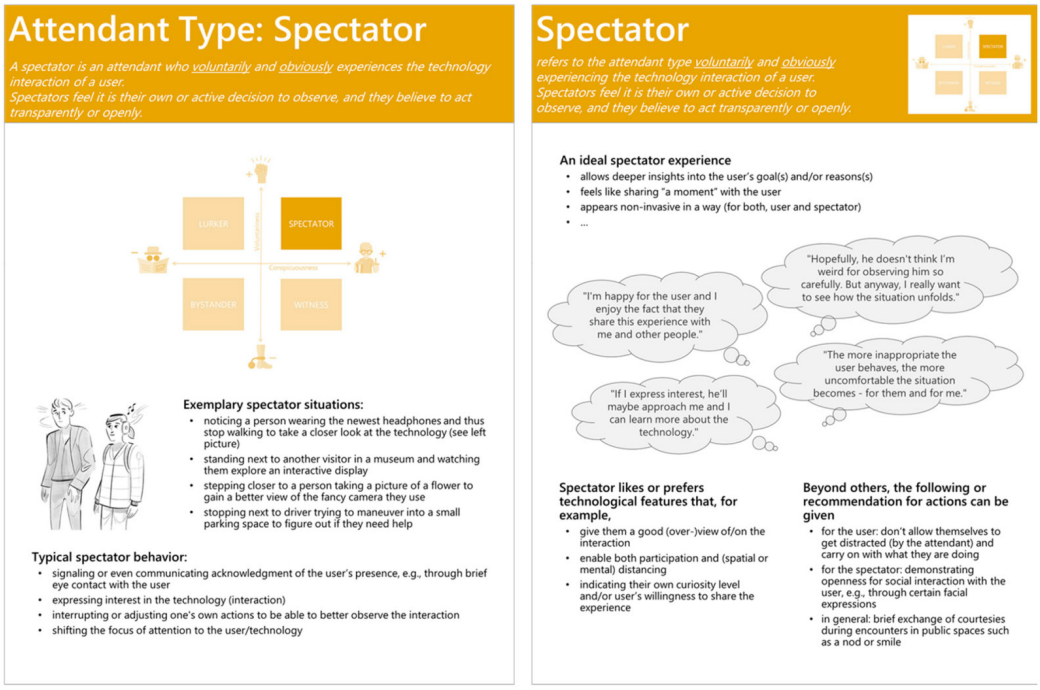

Figure A2. Front (**left**) and back (**right**) side of the spectator card.

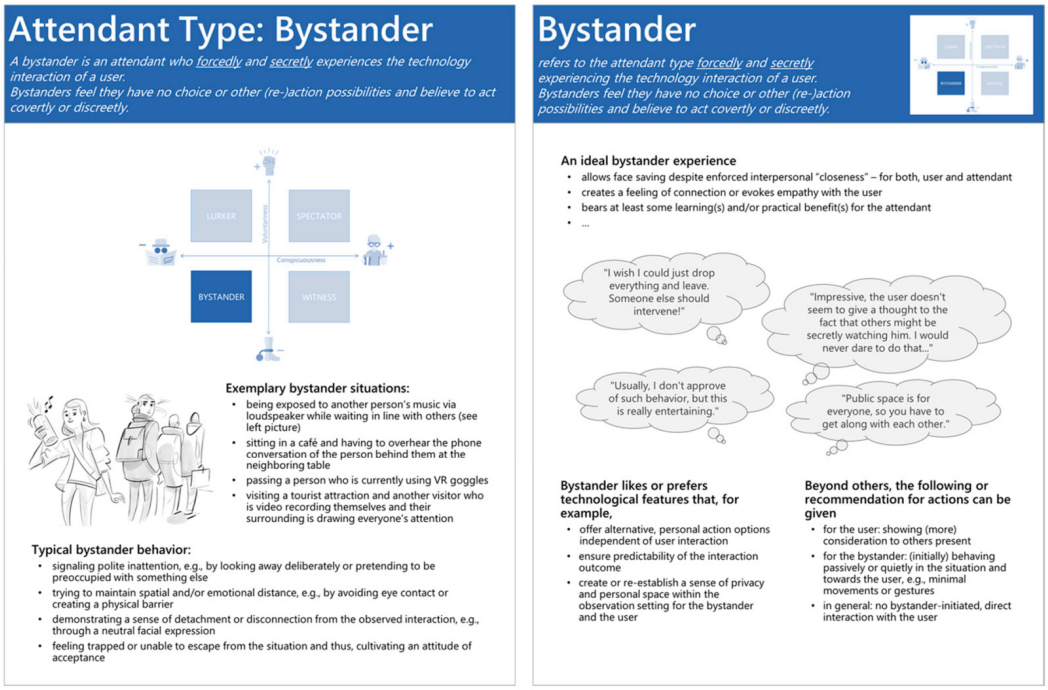

Figure A3. Front (**left**) and back (**right**) side of the bystander card.

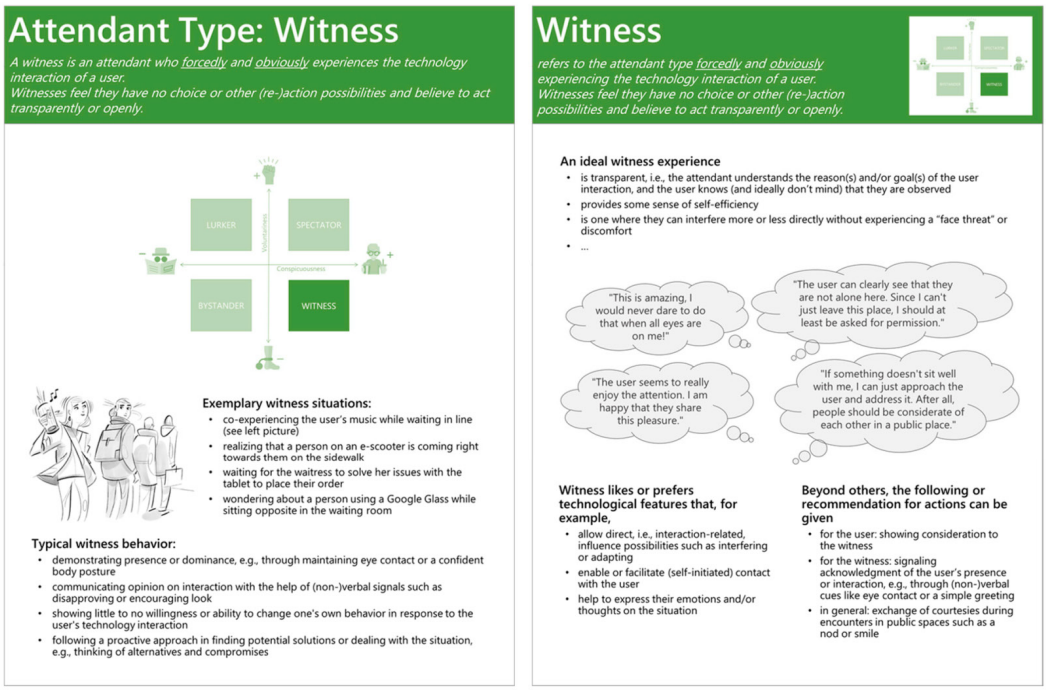

Figure A4. Front (**left**) and back (**right**) side of the witness card.

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