Personalized Reality: Challenges of Responsible Ubiquitous Personalization

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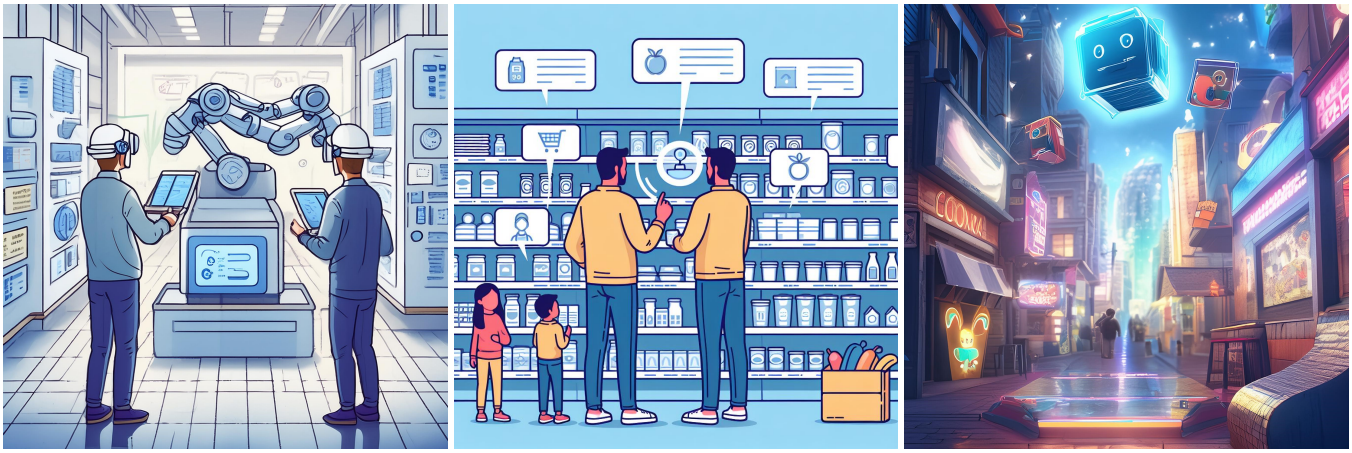

(a) (b) (c)

Figure 1: Personalized Reality enables people to benefit from personalized services ubiquitously in their lives, from personalized interaction with robots on industrial shop floors (a), to personalized help for healthier and more informed grocery shopping (b), to entertainment companies that may personalize users' perceived reality corresponding to a movie (c).[1]

Abstract

The expanding capabilities of Mixed Reality and Ubiquitous Computing technologies enable personalization to be increasingly integrated with *physical* reality in all areas of people's lives. While such ubiquitous personalization promises more inclusive, efficient, pleasurable, and safer everyday interaction, it may also entail serious societal consequences such as isolated perceptions of reality or a loss of control and agency. We present this paper to initiate a discussion towards the *responsible* creation of ubiquitous personalization experiences that mitigate these harmful implications while retaining the benefits of personalization. To this end, we present the concept of *Personalized Reality* (PR) to describe a perceived reality that has been adapted in response to personal user data. We provide avenues for future work, and list open questions and challenges towards the creation of responsible PR experiences.

CCS Concepts

• **Information systems** → **Personalization**; • **Human-centered computing** → **Mixed / augmented reality**; **Ubiquitous computing**.

Keywords

altered reality, societal implications, extended reality, responsible computing, future technologies, pervasive personalization

1 Introduction

In their daily lives, people encounter different types of personalization, such as personalized music [9] or video [3] recommendations, social media feeds [15], shopping experiences [2], or online advertisements [8]. Benefits of such personalization include, e.g., higher interaction efficiency and comfort for users, reduction of information overload [10], enhancement of experiences and communication [66], better preference matching [67], and provision of equal access to users with diverse capabilities and interaction requirements [34]. While the term *personalization* is used differently in different fields of research and practice (cf. [10, 19, 59, 66, 67]), it commonly refers to the processing of personal data by a system as input, the adaptation of the system's functioning in response to personal data, or the personalized content that such a system

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[1] The images were generated with Adobe Firefly.

outputs. The term *personal data* has been defined by the European Union's General Data Protection Regulation (GDPR) as "[...] any information relating to an identified or identifiable natural person [...] who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural, or social identity of that natural person;" [17, p.33]. This definition explicitly acknowledges the possibility of indirect identification (e.g., through de-anonymization techniques), which makes this definition future-proof in a rapidly changing technology landscape. Thus, in general terms, we can speak of *personalization* whenever personal data in the described sense is used to adapt a system's input, functioning or output.

While, traditionally, personalization has been mainly employed on the Web [59], contemporary personalized services (e.g., social networks or shopping platforms) are often consumed on mobile devices such as smartphones or tablets. Thus, personalised content is already being consumed in various physical environments via these mobile devices. Yet, the physical setting (including, e.g., objects, or bystanders) is usually not included in or combined with the personalized content. Mixed Reality (MR) [40, 60, 61] technologies, however, further expand the scope of personalization systems to fully include physical reality: MR may (fully or partially) diminish or augment the perception of physical objects and the user's experience of their environment in a personalized way (e.g., through MR headsets or smartphones). While MR is often only associated with handheld or worn (visual) displays, such as HMDs or smartphones, it may stimulate all human senses [60] and thus extend the scope of personalization systems to include diverse modalities. Hence, when extending personalization to physical artifacts, personalization may be applied to any sensory modality that is compatible with the intended users of a system, e.g., through tactile [53, 76], gustatory [55], auditory [74], or olfactory interfaces [33], as well as vestibular [62] and electromuscular stimulation [7].

Often, personalization only considers *mediation* of reality, e.g., with hand-held or wearable MR devices; in addition, connected devices that are embedded in Ubiquitous Computing (UbiComp) environments as envisioned by Weiser [68] create opportunities for personalization as well. That is, if UbiComp devices have properties that can be dynamically changed based on (personal) user data, then they may personalize users' physical reality *directly*, without needing to rely on mediators such as MR devices. Recent examples of such *direct* personalization include robot bartenders that create personalized drinks [29], personalized interactions with a smart coffee machine [41], interactions with educational robots that act as personalized quizmasters [52], self-actuating furniture that improves its ergonomics for a specific user [71], and self-balancing bicycles that optimize their users' experience of gravity [69].

Thus, MR and UbiComp devices create the possibility to personalize people's full perceivable reality covering physical, hybrid, and virtual environments. This *ubiquitous personalization* leads to a considerable scope extension of personalized services, which could bring benefits of personalization such as more efficient and inclusive interactions, better preference matching, or the reduction of information overload to a wide range of application areas. However, also the possible harmful implications of (traditional) personalization, such as loss control for users [66], lack of transparency [10], or the nourishing of filter bubbles [48, 65] might then be transferred to ubiquitous personalization experiences. This becomes especially problematic when taking a look at research on pervasive Augmented or Mixed Reality ("a continuous, omnipresent, and universal augmented interface to information in the physical world" [25, p.1]) and related concepts [5, 22, 43, 46, 49, 70] which shows that ubiquitous interfaces may already have harmful implications if they are not explicitly personalized. The potential harms researchers predict for pervasive MR are similar to those of personalization. Both, pervasive MR and personalization, may lead to a loss of control and agency [30, 66], to the creation of perceptual filter bubbles [1, 57], or create other manipulation possibilities, such as dark patterns or deception [16, 21, 24, 39, 72, 75]. These harmful implications are likely to be amplified in ubiquitous personalization experiences, which integrate risks and benefits of both, pervasive MR and personalization. Existing visions of this integration give first, speculative glances at how these amplified implications may look like [35, 37, 38].

To ensure the creation of ubiquitous personalization experiences in which individuals using these systems benefit, but also their physical and social context is not negatively impacted, researchers need to study how ubiquitous personalization experiences can be designed and implemented in a *responsible* way. This starts with the design of the systems, continues to considerations on the intended users of the ubiquitous personalization, and eventually also concerns the social settings and regulatory landscape in which it is consumed.

2 Personalized Reality

To initiate a discussion about *responsible* personalization, we first define *Personalized Reality* (PR):

> *Personalized Reality* describes a physical, virtual, or mixed reality that has been modified in response to personal user data and may be perceived by one or multiple users through any sensory modality.

PR might be created by users themselves, a second party such the manufacturer of the medium delivering the PR, or a third party, such as a provider of a specific PR application. The creator of a PR is in a powerful position: They are able to personalize a space that potentially encompasses the full range of a user's perceptual experiences. Thus, if second- or third-parties create a PR for a user, the user has to place a considerable amount of trust in these entities because the user delegates some of their control and agency over their environment to these parties. Such second- or third-party PR creators could be, for instance, tourism agencies that may offer PR experiences for visiting a city through personalized MR content visually overlaid on sights and attractions (cf. [73]), manufacturers of industrial robots that want to increase user acceptance through personalized movement of the robots in human-robot collaboration scenarios (cf. [26]), museums that offer personalized audio tour guides [77], medical organizations that help patients' rehabilitation through personalized exergames in PR (cf. [36]), entertainment companies that may personalize users' reality corresponding to their favorite movie using MR headsets, or fitness studios that may provide PR systems to help users achieve their health goals

by nudging them to choose healthier food in supermarkets and restaurants (cf. [64]).

While similar personalized applications using MR and Ubicomp devices exist today (see e.g., [20, 26, 36, 64, 71, 73]), these are usually regarded in isolation from each other and target only a specific task and environment. However, PR provides a perspective to view them as part of the full perceived reality. This perspective enables studying the implications of the individual applications as well as the full perceived PR on users, bystanders and their environment.

Researchers are only beginning to highlight this need to study the implications of personalization that may be ubiquitously available to users through MR and Ubicomp devices (cf. [12, 14, 28, 42, 46, 63]). Thus, we argue that research on ubiquitous personalization will need to be extended and that the phenomenon will need to be studied from a broad range of perspectives to ensure the creation of responsible PR experiences that are beneficial for individuals and society alike. *Responsible Computing* describes the perspective to take ethical, social, and societal aspects of computing into account during the full life cycle of a technological artifact. This includes considering the implications of a technology on individuals and society [32], creating inclusive and accessible systems [11], and respecting users' rights (e.g., towards data privacy cf.[13, 31]) beyond applicable regulation. A *responsible* approach to PR and ubiquitous personalization should therefore include (at least) the consideration of the following aspects:

Hardware and Software System. Already during the design and development of personalization systems that create PR, it should be considered how the system itself has to be constructed to yield responsible PR experiences. This includes the involved entities' level of control over the system components, access to (personal) data sources, or the interfaces between different system components such as the data sources, personalization algorithm, and the devices delivering the PR. Especially the latter need to receive more attention than in traditional personalization systems, since MR and UbiComp technologies enable a plethora of possible PR delivery devices (e.g., MR headsets, industrial robots, smartwatches, public displays, or smart coffee machines).

Based on the aforementioned notion of personalization, PR necessarily needs personal data as input, thus data privacy and security of PR experiences is another important issue to consider (cf. [4, 13]). The handling of personal user data, such as eye tracking data, could, e.g., be facilitated in a privacy-respecting manner through the use of personal data stores that enable users to control who gets access to their gaze data [6, 23].

Individuals. To create beneficial and transparent PR experiences for individual users, methods to inform users about the information shared with a PR system (cf. [1]) and on which parts of users' reality are personalized (cf. [30, 56]) will need to be considered. Also, it needs to be investigated how users can be given agency over controlling PR (cf. [44, 46]) and over which parts of their PR are shared with others (cf. [54, 63]). Additionally, the physiological and psychological well-being of PR users and bystanders should be considered (cf. [28]), so that the use of PR does not lead to, e.g., information overload, isolated perceptions of reality, or overdependence on PR technologies. Future research needs to take all of these different aspects into account in the context of PR, so that responsible PR experiences ensue for individual users.

Society. Since in PR the content is adapted based on personal data, it is likely that multiple users will be presented with content that is adapted in different ways, i.e., different versions of reality—even if they use the same PR application in the same environment. Thus, the resulting output may create perceptual filter bubbles or isolated perceptions of reality (cf.[1, 57]). The expansion of personalization technology from the virtual to our physical world hence does not only extend the material scope of personalization but might also further deplete the common experiences and references that bind society together (*shared worlds* [10]). The considered proliferation of personalization then may significantly impact individuals and society since physical reality with its shared worlds and (physically-grounded) experiences constitutes the foundation of how we understand and communicate about these experiences. Thus, methods need to be studied to mitigate this development. Research about multi-user scenarios in MR [54, 58], the sharing of personalized content [30, 63], the sharing of awareness and communication cues [27, 50], or avatars emulating users' eye and body movements [51] may serve as starting points for future research.

Regulation. Laws that regulate personalized services such as the EU's Digital Services Act (DSA) [18] or GDPR [17], or China's Personal Information Security Specification [45] have predominantly been created in the light of social media and other Web-based services. However, whether and to what extent these regulations are applicable to the context of PR is questionable, since PR considerably widens the scope of personalization to the physical world. Thus, regulators will need to analyze this in an interdisciplinary context, to create legal boundaries for responsible ubiquitous personalization.

3 Conclusion

Although the concept of PR overlaps with pervasive MR concepts regarding possible (harmful) implications (see, e.g., [16, 24, 30, 39, 46, 47, 72]), PR is challenged stronger by a possible erosion of a common view on reality, since it potentially provides each user a uniquely adapted perception of reality. While currently only visions of PRs exist (e.g., [35, 37, 38]), more research in this domain is necessary, since known harms of personalization (cf. [10, 48, 66, 67, 75]) and pervasive AR/MR (cf. [1, 21, 30, 57, 72]) are prone to be amplified if combined in PR.

In their paper on manipulative advertising techniques [39], Mhaidli et al. investigate potential future incarnations of XR (eXtended Reality) advertising and issue a call to action to "address and mitigate manipulative XR advertising risks." In the same way, we urge researchers and practitioners to study ubiquitous personalization and its possible implications, including possible harms and practical strategies for ensuring the responsible and ethical implementation of PR. As technologies for creating elaborate PR experiences through MR and UbiComp systems are increasingly available and capable, this topic should receive considerable attention over the next decade.

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