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Adaptation Strategies to Increase Advertisement Effectiveness in Digital Media

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Abstract: Personalization can break through the information clutter in digital media and increase advertising effectiveness. However, the term personalization refers to many different adaptation strategies, each of which lead to distinct functional requirements for adaptive advertising systems: Additionally, these adaptation strategies can affect consumers in different ways. Therefore, it is necessary to differentiate between them. To do so, we suggest the PERSIT matrix, which distinguishes between PERson-centric and SITuation-centric adaptation strategies. Studies in the field of digital-out-of-home advertising are structured using the six identified adaptation strategies for advertising. Furthermore, the PERSIT matrix supports users in making educated decisions by encouraging them to select an adaptation strategy that fits the desired advertising goals. The matrix establishes a common base of understanding between advertisers and system designers, allowing effective cross-domain communication.

***Keywords**: Personalization, person-centred adaptation, situation-centred adaptation, digital-out-of-home-advertising, adaptation*

1 Introduction

Although advertising expenses have increased, advertising effectiveness has suffered dramatically in recent years. Consumers are overwhelmed by the quantity of advertising messages they receive, and it is getting more difficult to attract consumers' attention (Ha and McCann 2008). One of the best ways to break through the information clutter in digital media and to increase advertising effectiveness is to target advertisements dynamically – to "provide the right content in the right format to the right person at the right time" (Tam and Ho 2006).

In marketing, scholars use the term *personalization* to refer to the tailoring of products, services, or content to consumer needs, goals, knowledge, interests, or other characteristics (Zimmermann et al. 2005). Various terms (e.g. customization, profiling, segmentation) are used to refer to personalization, which itself is associated with many different strategies of adaptation (e.g. adapting the layout of a message to a display, tailoring content to consumer characteristics) (cf. Vesanen 2007).

Personalization has proven successful at increasing the effectiveness of advertisements (e.g. users show increased attention to an advertisement (Malheiros et al. 2012), perceive its usefulness (Tam and Ho 2006), or better remember an advertisement (Adolphs and Winkelmann 2010)). However, recent research has revealed some of personalization's drawbacks. For instance, consumers can react negatively towards advertisements once they become aware of the personalization (Malheiros et al. 2012).

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Furthermore, the availability of person-related data (required for personalization) is often limited (Tucker 2012) or restricted by privacy regulations (Goldfarb and Tucker 2011). Hence, personalization is not always possible, nor is it always the strategy of choice.

Another challenge relates to the design and implementation of adaptive advertising systems that rely on sophisticated information systems. These systems need to unite two very different domains (marketing and IT). Thus, it is important to create both a common base of understanding (to enable effective cross-domain communication) and well-defined business and functional requirements (to align business requirements with technical designs and implementations).

Therefore, advertisers (business) and system designers (IT) need guidance to communicate effectively and choose the right advertising adaptation strategy. From a strategic point of view, different forms of advertising adaptation lead to different advertising effects. From a technical point of view, different modalities of adaptation require adaptive advertising systems to perform distinct functions, meaning they will need specific technical infrastructures. It is thus necessary to differentiate between the adaptation strategies that are currently associated with the concept of personalization (Lasinger and Bauer 2013).

This paper proposes a novel concept, the PERSIT matrix, which provides a systematic overview of strategic options for advertising adaptation. The paper distinguishes between different strategies of advertising adaptation, relates them to their respective advertising effects, and outlines their distinct functional requirements. In line with Lewin (1935) and communication theory (Schulz von Thun et al. 2003), the PERSIT matrix differentiates between person-centric and situation-centric adaptation strategies and relates them to each other. Person-centric adaptation strategies use a consumer's person-related data, whereas situation-centric adaptation strategies leverage data about the situation where an advertisement is presented.

The proposed PERSIT matrix enables marketing experts to choose the adaptation strategy that best fits the desired advertising goals. Because the matrix also reflects a (technical) design viewpoint on adaptation, it facilitates communication between marketing experts and designers of adaptive advertising systems. In fact, the PERSIT matrix's utility was confirmed in expert discussions with marketing specialists.

The remainder of the article proceeds as follows: First, we briefly discuss the conceptual foundations of personalization. Next, we detail the PERSIT matrix, a classification scheme for studies in the field of adaptive advertising and a central contribution of this paper. Then we outline our methodology for performing a thorough literature review and evaluating the matrix's utility. After that, we discuss the benefits and challenges of the adaptation strategies that result from the PERSIT matrix, as well as the functional requirements and potential advertising effects of each strategy. Then, based on our literature review, we pinpoint research gaps that should be addressed with future research. After discussing the utility of the PERSIT matrix as considered by marketing experts, we conclude with a summary of the paper's contributions.

2 Conceptual Foundations

While personalization in advertising has a long history (Vesanen 2007), the dynamic adaptation of advertisements in real time, which is enabled by digital media, is rather new (Adams 2004).

2.1 Personalization of Advertisements

The concept of personalization arose as early as the 1870s, and by the 1970s, it was discussed mainly in connection with segmentation and targeting. Nowadays, several terms (e.g. profiling, segmentation, targeting, filtering, tailoring) are used to describe the concept of personalization; it is a broad concept that includes topics such as diagnosing location, fitting the visual layout of the message to data terminal equipment, and tailoring message content (Vesanen 2007).

A basic form of personalization is grounded in the idea of 'market segmentation'. A target population (i.e. the anonymous mass market) is divided into segments that are internally as homogenous as possible and externally as heterogeneous as possible; each segment is then provided with a specific tailored advertisement to increase advertising effectiveness for that segment. In the specific case where the size of a segment equals one, we speak of 'individualization' or 'one-to-one marketing': Consumers are addressed individually with customized messages or services ('mass customization') (Reutterer 2003). The basis for dividing a broad target market into subsets of consumers who have common needs is flexible; the market can, for instance, be segmented based on culture, lifestyle, or purchasing behaviour.

Besides consumer characteristics, the *current situation* influences thinking and behavior (Lewin 1935); this fact has long been acknowledged by research in psychology and marketing: Studies of television advertising (De Pelsmacker et al. 2002) and print advertisements (Dahlén 2005) have shown that 'editorial context' (the content surrounding an advertisement) highly impacts how advertising affects its audience.

This fundamental idea of accounting for situational context has been successfully applied to advertising in classical media: In all the approaches, advertisers anticipate a specific constellation of situational context and select an advertisement based on their assessment of that situation.

The situation-specific adaptation of advertisements has various effects. For example, a thematic fit between an advertisement and the respective magazine was also reported to increase positive feelings towards the advertised brand (Jun et al. 2003).

However, the marketing discipline frequently reduces situational context to 'editorial context' – the content that surrounds the advertisement in a magazine, on the radio, or on television. Although researchers acknowledge that this narrow view of situational context is limiting, to date little work has offered a broader perspective of situational context in advertising: "...virtually all studies have focused on the immediate editorial context, such as articles or television shows or segments, rather than on the total media context" (Dahlén 2005). The rare exceptions to this trend are studies on the impact of 'atmospherics' on purchase behavior at the point of sale (Newman et al. 2007).

2.2 Real-time Personalization of Advertisements

Digital media enable the adaptation of advertisements in real-time, supported or automated by information systems. Real-time personalization of advertisements can, hence, be described as the dynamic changing of advertising messages on digital media in real time based on information that is sourced from the targeted consumer or the situation shared by the advertising system and the consumer.

More than a decade ago, researchers described information systems that were aware of their context and could adapt to it. On the Web, personalization methods adapting in real time are already very advanced, making use of a wide range of techniques such as content-based filtering, collaborative filtering, and hybrid filtering, which combines the first two techniques (e.g. Adomavicius and

Tuzhilin 2005). These filtering techniques are based on modern statistical machine-learning methods. Real-time personalization has been proven to increase advertising effectiveness. For instance, it increases the user's level of attention (Malheiros et al. 2012) and perception of the usefulness of the information displayed (Tam and Ho 2006). Thus, personalized advertising seems to be particularly effective when addressing consumers whose preferences are (already) narrowly construed, since the advertisements focus on specific product details.

Typically, personalization is based on user information such as identity, demographics, lifestyle, specified preferences, past purchases, and historical visit patterns. Nowadays, situational aspects are rarely considered in real-time personalization settings. Situational adaptation strategies are merely understood as an addition to existing personalization approaches (e.g. Zimmermann et al. 2005).

3 The PERSIT Matrix and its Constructs

While existing literature typically considers personalization as one holistic construct, we differentiate between person-centric and situation-centric adaptation in respect to the design of an adaptive advertising system. As we will show, it is beneficial to explicitly distinguish between these two adaptation concepts, since, besides different functional requirements for designing such systems, these two concepts have different implications for advertising effectiveness.

To address these differences, this paper suggests the PERSIT matrix, which differentiates between PERson-centric and SITuation-centric adaptation strategies. In this section, we define the constructs that provide the foundation for this categorization matrix as represented in Table 1. In doing so, we draw on theory from the fields of advertising, communication psychology, and information systems.

Table 1. The PERSIT Matrix with Adaptation Strategies

		Situation-centric adaptation	
		no	**yes**
Person-centric adaptation	**no**	(I) no adaptation	(IV) adaptation to a specific situation
	one-to-many	(II) adaptation to a group of individuals	(V) adaptation to a group of individuals and to a specific situation
	one-to-one	(III) adaptation to a specific individual	(VI) adaptation to a specific individual and to a specific situation

As outlined in the introduction, decades of advertising research has shown that personalization improves advertising effectiveness (Vesanen 2007). While advertisements are traditionally tailored to an individual consumer or consumer segment, other factors that impact advertising effectiveness

include the editorial context (Dahlén 2005) and the broader atmosphere (Newman et al. 2007). We used this (implicit) differentiation between person- and situation-related factors to build the PERSIT matrix.

Likewise, psychological research theorizes that consumer behavior is derived from personal and situational factors (Lewin 1935). Specifically, communication theory states that communication has two important anchors of reference, the person and the situation (Schulz von Thun et al. 2003). Effective communication addresses both. We transferred this concept from the field of interpersonal communication to the field of advertising adaptation.

Research on information systems has provided insight into the technical implementation and implications of personalization. On the one hand, some information systems use information about the user (e.g. personal characteristics, past transactions, the user's task) to adapt their services (Tam and Ho 2006); other information systems use awareness of their situational context (e.g. weather, location, time) to adapt their services. Both system types have specific functional requirements and face distinct challenges. The PERSIT matrix links these two system types to adaptation strategies, which emerge from advertising and psychological research.

Building on these theories, the PERSIT matrix presents person-centric adaptation on the vertical axis and situation-centric adaptation on the horizontal axis. As we have outlined in Section 2.1, there are basically three archetypes for person-centric adaptation (Reutterer 2003): no person-centric adaptation (addressing the anonymous mass market), adaptation to a group of individuals (segmentation, one-to-many person-centric adaptation), and addressing a particular individual (individualization, one-to-one person-centric adaptation). Considering this differentiation, the PERSIT matrix includes six possible adaptation strategies. All of these strategies inherit the advantages and challenges associated with person-centric adaptation or situation-centric adaptation, or both. Because every strategy implies the use of different information sources, different hardware and software will be required; in turn, these requirements lead to adaptive advertising systems of different technical complexity and expense.

3.1 Person-centric Adaptation

In the style of Vesanen (2007), person-centric adaptation can be defined as the use of personal information about a consumer or group of consumers to tailor information communication to an individual or group of consumers. Using information about the consumer – either previously obtained or provided in real time – the provision of information is altered to fit that consumer's needs, whether those needs have been stated directly by the consumer or perceived by an information provider (e.g., an advertiser).

The strategy of not performing any person-centric adaptation (i.e. addressing the mass market) can be thought of as a 'one-size-fits-all' strategy. Narrowing down the mass market to relatively homogenous subsegments and addressing those subsegments separately is a one-to-many person-centric adaptation; this personalization concept is also frequently referred to as 'segmentation' (e.g. Vesanen 2007). Further narrowing down the market to a single individual (i.e. concentrating on a specific person) is a one-to-one person-centric adaptation, a strategy that may also be referred to as 'individualization' (e.g. Reutterer 2003).

Particularly for the design of adaptive advertising systems, it is crucial to distinguish between advertisements that are tailored to an individual and those that address several people at once. When a system adapts for an individual, it must consider only the characteristics of that individual. When a system adapts for a group, it must categorize individuals according to characteristics that the

individuals share. Each option requires different kinds of identification and uses different approaches to analyze consumer characteristics.

Advertising systems for devices that are typically used by one person at a time (private screens such as desktop computers, smartphones, tablets, etc.) may only utilize the strategies of 'no person-centric adaptation' and 'one-to-one person-centric adaptation' since only in very rare cases will a second or third person join the main user. Public screens (e.g. digital-out-of-home advertising), in contrast, are placed in areas where several people can view the screen's contents and, accordingly, all three person-centric adaptation strategies are feasible: no adaptation (one-size-fits-all), adaptation to a group of individuals viewing the screen at the same time (segmentation), and one-to-one person-centric adaptation (individualization) for instances where only one person is within the service area of a public screen.

3.2 Situation-centric Adaptation

Instead of basing adaptation efforts on personal data, situation-centric adaptation draws on environmental information that is unrelated to an individual. We define situation-centric adaptation as delivering information that is relevant (to an individual or a group of individuals) in the present situation based on information about that situation. Information about the current situation is retrieved, transformed, or deduced from information sources.

An example application of situation-centric adaptation is advertising ear protection in a loud environment. The relevance of the advertisement is enhanced by the situation, regardless of the characteristics (e.g. age, gender, preferences) of the consumers. According to communication psychology, this situation-centric adapted advertisement fits the definition of a communication that is adequate in a particular situation (Schulz von Thun et al. 2003).

3.3 Distinguishing Person-centric from Situation-centric Adaptation

As outlined above, the constructs of person-centric and situation-centric adaptation are orthogonal. According to communication psychology, effective communication fits a particular person and situation (Schulz von Thun et al. 2003). In advertising, person-centric adaptation aims to fit an advertisement to a person, while situation-centric adaptation aims to fit an advertisement to a situation. Ideally, both dimensions are taken into account; however, depending on the purpose, or in the case that one option is unavailable, the other option can still be used to optimize communication efforts (see Section 5.1).

There are two major differences between person-centric and situation-centric adaptation: the targeted entity and the data used for the adaptation. Person-centric adaptation targets a defined person, group, or segment. In contrast, situation-centric adaptation does not target an individual, group, or segment, but instead tailors a message to everybody in a given situation. Person-centric adaptation relies on person-related data, data that has meaning only in relation to a particular person or group of people; situation-centric adaptation, however, relies on situation-related data, data that has meaning in relation to a situation but not to a person.

This also means that it is possible to optimize advertisements for a defined person as well as the general population, and to use data sources that relate to a situation and an individual. For instance, imagine advertisements on an online search engine. Traditionally, advertisements are selected based on the keywords entered. This adaptation is person-centric because the advertisements are only relevant to the person who is searching, since the search terms are meaningful only to this person. If

these advertisements were shown to any other person, they would very likely not be relevant. However, suppose that a search interface presents searchers with an advertisement based on the time of the search and the location of the searcher by using the most likely language and form of greeting that one would expect for these parameters. This advertisement would likely be meaningful to any other person in the same place and time. In this case, we speak of situation-centric adaptation. Person-centric and situation-centric adaptation can be combined. For example, the search term 'rock' could refer to a naturally occurring solid aggregate of minerals or a form of popular music. Advertisements could be selected based on personal information (e.g. previous searches, the user's job, user preferences), situational information (e.g. a person is more likely to look for rock music when in a bar or at home, while for an aggregate of minerals when taking an expedition), or both.

4 Methodology

In this section, we describe the methodologies employed for performing the literature review and evaluating the matrix's utility among marketing experts.

4.1 Literature Review for Digital-out-of-home Advertising (DOOHA)

In its essence, the PERSIT matrix was designed to categorize any kind of adaptive advertising. However, reviewing studies on every type of adaptive advertising would be tremendously difficult and is beyond the scope of this paper. Instead, we decided to examine studies on only one notable field of application: digital-out-of-home advertising (DOOHA).

A myriad of descriptors have been used for networks of displays in public spaces. When such displays are primarily used for advertising, we call them digital out-of-home advertising (DOOHA) (Telschow and Loose 2008). We define DOOHA as digital screens in public spaces that can be controlled independently via a centralized network and that are mainly used for advertising purposes.

DOOHA is a rapidly emerging marketing channel that promises to reach out to consumers at any time and any place in physical space. It can be used to display advertisements to consumers who are in transit, waiting, or at commercial locations such as a retail venue. In contrast to revenues from other forms of advertising, DOOHA revenues are growing at an accelerating pace. From 2007 to 2012, DOOHA revenues grew at a compound annual rate of 12.1 percent, and they contributed 7.88 billion USD to the global economy in 2012 (PQ Media 2013). DOOHA is said to be particularly influential in the realm of adaptive advertising because, equipped with various sensors, DOOHA allows adaptation of advertising messages in real time and for various purposes (Telschow and Loose 2008). As DOOHA is a public screen solution, all six adaptation strategies of the PERSIT matrix can potentially be leveraged with it. Person-centric information may, for instance, be gathered through Bluetooth connections to individuals' smartphones where profiles may be stored; cameras may be installed to detect a passerby's gender; and microphones may allow for emotion recognition in speech. Situation-centric information may, for instance, be sourced from installed sensors such as thermometers (e.g. weather), cameras (e.g. light conditions), or microphones (e.g. noise), or may be sourced via information providers (e.g. web services for weather forecasts) (Bauer et al. 2012).

Besides DOOHA, mobile advertising revenue is growing rapidly, having contributed 9.6 billion USD to the global economy in 2012 (Gartner 2012). Mobile advertising, however, uses individuals' private screens and is therefore restricted to four adaptation strategies only, because one-to-many person-centric adaptation cannot be realized.

As a result, we decided to focus on DOOHA in our analysis. The procedure for analyzing and categorizing published studies in the field of DOOHA is outlined below.

4.1.1 Sample

We sampled articles that we found in the most common scientific online databases in the field: ACM, EBSCO, IEEE, SpringerLink, and Wiley Online Library. First, we searched these online databases in full text for articles containing the term 'digital out of home' or any of the different (and often synonymously used) definitions for DOOHA that were reported by Telschow and Loose (2008) and Kaupp (2010) (Table 2).

Using these search terms, 838 articles published before 30 June 2011 were retrieved from the five online databases. The number of articles retrieved from each online database is as follows: ACM (220), EBSCO (117), IEEE (194), SpringerLink (209), and Wiley Online Library (98). A detailed breakdown of the 838 articles regarding search terms and sources is depicted in Table 2. After reviewing the titles and abstracts of these articles, 742 were excluded because they were either retrieved from multiple online databases or unrelated to the topic at hand. The remaining 96 articles made up our final sample.

Table 2. Retrieved Articles per Source and Search Term

	ACM	EBSCO	IEEE	Springer	Wiley	Total
captive audience network	-	-	-	-	-	-
digital media advertising	1	8	-	3	1	**13**
digital media network	4	11	19	7	9	**50**
digital out of home	-	7	1	9	-	**17**
digital signage	45	-	42	55	14	**156**
dynamic signage	4	45	-	5	-	**54**
electronic signage	3	6	-	7	8	**24**
in-store TV network	-	-	-	-	-	-
peripheral display	106	10	61	74	24	**275**
video wall	57	30	71	49	42	**249**
Total	**220**	**117**	**194**	**209**	**98**	**838**

4.1.2 Coding

The 96 articles were independently reviewed and coded by two reviewers. In the few instances (9 articles) where disagreement emerged, the reviewers discussed the issue until consensus was established. We included the following coding dimensions: (1) type of adaptation (individual, group, situation, none); (2) variables that were used for the adaptation, such as identity or weather; (3) purpose of the application, such as advertising, information presentation, or entertainment; and (4) meta-information (citation information).

Based on coding dimension (3) 'purpose of the application', we split the sample into 16 advertising-related articles and 80 articles falling into the broader category of 'digital signage' (excluding advertising-related articles). For both sample parts, each of the articles was assigned to one of the six

fields of the PERSIT matrix based on the following coding dimensions: (1) 'type of adaptation' and (2)'variables used for adaptation'. The results of this review and analysis are discussed in Section 5.

4.2 Expert Discussions

We employed expert discussions to ensure the applicability and utility of the PERSIT matrix. The matrix was discussed with five experts (three marketing managers and two operating advertisement design officers) from a global advertising agency. Each of the meetings started with a presentation teaser about the matrix and outcomes concerning advertising effects; a semi-structured discussion followed. After each meeting, insights from the expert discussions were discussed in analytical group reflection sessions by the research team.

5 Results and Discussion

5.1 The Benefits and Challenges of the Advertising Adaptation Strategies

The main advantages of person-centric adaptation are as follows: increased advertising effectiveness (e.g. improved memory or improved attitude towards the brand) (Adolphs and Winkelmann 2010), increased perceived usefulness of information (Tam and Ho 2006), and increased attention towards the advertisement (Malheiros et al. 2012). Person-centric adaptation is also well suited for any situation where just one consumer views an advertisement (one-to-one). Furthermore, person-centric adaptation techniques are based on established technologies and have been studied and optimized for years (Adams 2004).

However, recent research pinpoints the limitations of person-centric adaptation: First, person-centric adaptation is not possible in all situations, and second, its benefits are limited by a phenomenon referred to as 'personalization reactance'. The first implication is based on the concept of a trade-off between personalization and privacy (Lee et al. 2011). An increase in required privacy or decrease in available personal data reduces the options for person-centric adaptation. The second implication – personalization reactance – describes a phenomenon where consumers feel that advertising using person-centric adaptation intrudes on their privacy; as a result, consumers develop negative emotions towards the advertised product or company, or both (Malheiros et al. 2012; Tucker 2012). We expect that personalization reactance will be particularly high when person-centric adapted advertisements are shown on public displays, since sensitive information is potentially disclosed to nearby people.

The most significant benefit of situation-centric adaptation is that it resolves the main challenges of personalization. Because the adaptation process is based on situational information (shared and available to the general public) and is not based on person-related data, no person-related data can be revealed. Consumers will not feel observed and personalization reactance is avoided. Also, no personal data is required, avoiding a privacy trade-off (Lee et al. 2011). In addition to avoiding the challenges of person-centric adaptation, situation-centric adaptation has other benefits. As stated previously, research has revealed that perceived thematic closeness between television advertisements and the programs during which they air enhances recall (De Pelsmacker et al. 2002). Furthermore, consumers have more positive attitudes when they perceive that an advertisement is relevant and related to its medium (Dahlén 2005).

However, conceptual and technical challenges arise when situation-centric concepts are applied to advertising. For instance, it is not yet clear how situations (context) can best be conceptualized and which parameters should be chosen for adapting advertisements. Existing research mainly focuses on rather 'simplistic' variables such as time, place, or weather. Consequently, the empirical implications

of situation-centric adaptive advertising are not clear. Technical challenges include the deployment of required sensor infrastructures and the lack of algorithms to match advertisement content to situations.

5.2 Research Concerning Adaptive Advertising in the DOOHA Domain

As outlined in the methods section, we reviewed published studies in the field of DOOHA. All 16 articles from the sample that were attributed to the DOOHA domain could be directly assigned to the matrix. As can be seen from Table 3, while eight articles deal with person-centric adaptation, only three articles consider situation-centric adaptation. Yu et al. (2010) and Stalder (2011) describe situation-centric adaptation without person-centric adaptation, basing the adaptation on Global Positioning System (GPS) localization and atmospherics (e.g. weather, light), respectively. In contrast, Eriksson and Åkesson (2008) describe a combination of situation-centric and person-centric adaptation for an individual (based on consumer schedule, time of day, and location).

Table 3. Populated PERSIT Matrix with DOOHA-related Articles

		Situation-centric adaptation	
		no	**yes**
Person-centric adaptation	**no**	• Touch-based multi-projector display for advertising and road shows (Dietz et al. 2004) • Analysis when people look at displays; recommendations for positioning of displays (Huang et al. 2008) • Measuring advertising effectiveness of DOOHA (Burke 2010) • Overview of the effects of Digital Signage in retail applications (Silberer 2010) • Study on public opinion towards digital billboards in the US (Taylor and Franke 2011) • Guidelines for display integration at point of sale (Dräger 2011)	• Mobile screens mounted on buses; advertisements based on GPS location (Yu et al. 2010) • Screens reflecting atmospheric and other environmental conditions like light, noise, or crowding (Stalder 2011)
	one-to-many	• Personalized advertisements based on group demographics captured via digital camera (Harrison and Andrusiewicz 2003)	
	one-to-one	• RFID tracking supporting grocery shopping (Kalyanam et al. 2006) • Location/position of user (Allen 2009) • Shopping list on consumer's mobile device (Krüger et al. 2011) • Shopping list and profile information (Strohbach 2011) • Digital notice boards based on user identification (Alt et al. 2011) • Suggestion of privacy controls for Digital Signage (Geiger 2011)	• Situation-based advertising based on consumer schedule, time of day, and location (Eriksson and Åkesson 2008)

As can be seen from Table 3, more than one third of the articles in the sample (6) follow no adaptation strategy at all; neither person-centric nor situation-centric adaptation options are considered. Most of this research provides general recommendations for DOOHA (Dräger 2011; Huang et al. 2008) or analyzes its effects (Silberer 2010; Taylor and Franke 2011; Burke 2010) without addressing adaptation options.

Another six articles describe one-to-one person-centric adaptation strategies (individualization). The articles all note the need to identify the consumer (e.g. via RFID as described in Kalyanam et al. (2006)) and address privacy considerations (Geiger 2011). Two of the articles refer to using personal information on a user device (a shopping list on a mobile device) to adapt the screen (Krüger et al. 2011; Strohbach 2011).

Surprisingly, only one DOOHA article describes a strategy of person-centric adaptation for a group (one-to-many; segmentation): Harrison and Andrusiewicz (2003) deployed video cameras to capture demographic data that was used to adapt the screen.

No article addresses situation-centric adaptation and person-centric adaptation for a group. Also, none of the retrieved research explicitly considers situation-centric adaptation as an alternative to person-centric adaptation. Instead, deciding how to perform an adequate adaptation is solely based on functional requirements and technical possibilities.

Interestingly, little research about DOOHA describes information systems that dynamically adapt advertisements to the situation (e.g. Eriksson and Åkesson 2008; Stalder 2011; Yu et al. 2010). This finding is surprising since several researchers emphasize the importance of situational context in this setting. For instance, Silberer (2010) indicates that the effects of advertising largely depend on the display's environment. Also, Telschow and Loose (2008) state that advertisements that are directly related to the current purchasing situation are remembered better. Where researchers do consider adaptation to the situation, they generally perceive it not as an independent form of adaptation, but rather as a complement of person-centric adaptation (Zimmermann et al. 2005).

5.3 Research Concerning Adaptive Advertising in Digital Signage

We also reviewed the remaining 80 articles of our sample, expanding the scope to the entirety of digital signage (Table 4). Again, all 80 articles could be matched to the PERSIT matrix. 26 articles described person-centric adaptation for an individual, and only five considered person-centric adaptation for a group. In total, 16 papers dealt with situation-centric adaptation, with 11 papers focusing on situation-centric adaptation only (without personalization), and five papers describing situation-centric adaptation in combination with person-centric adaptation for the individual.

Table 4. Populated PERSIT Matrix with Articles not Related to DOOHA

		Situation-centric adaptation	
		no	**yes**
Person-centric adaptation	**no**	• Uploading content from laptops to a conference screen (Nobuyuki et al. 2010) • Information display for museum visitors (Min et al. 2010) • Screens in a museum (Hsieh et al. 2011) • Messages posted to a certain screen (Fitton et al.	• Location-aware content selection (Ribeiro and José 2009) • Recommender system using place (using keywords) (Ribeiro and José 2010) • Video selection based on bypassing traffic (Storz et al. 2006)

		2005) • Multi-touch information and game display (Lin et al. 2009) • Screen used for triggering user behavior ("follow the light") (Rogers et al. 2010) • Touch screen for art images (Cappellini et al. 2010) • Positioning of displays to maximize visibility and information pickup (Dalton et al. 2010) • Toolkit for managing user attention in development of peripheral displays (Matthews et al. 2004) • Designing "glanceable" displays using symbolic representations (Matthews 2006) • Proposal for evaluation of ambient displays (Hazlewood and Stolterman 2011) • Large screen enhancing collaboration of children in learning situations (Lamberty et al. 2010) • Multi-touch wall for presentations (Lai et al. 2010) • Description of display blindness (Müller et al. 2009b) • Visualizing web activity on screen (Gellersen et al. 1999) • Attention capturing through luminance changes (Lambert et al. 2003) • Turning aesthetical object into information display (Ferscha 2007) • Fostering social exchange as well as disseminating local information on large screens (Bullivant 2007) • Collaborative storytelling on a large screen (Numa et al. 2009) • Architecture of a water display system (Tao et al. 2010) • Review of 3D displays (Redert et al. 2006) • Gesture and mouse interaction on a large screen (Li et al. 2000) • Large screen interaction with a touch mouse and keyboard (Robertson et al. 2005) • Research outlook: organic displays to turn everyday objects into displays (Foote 2006) • Multiprojector displays (Brown et al. 2005) • Gesture sensor for 3D interaction (Ito et al. 2010) • Dual-sided wall display (Taher et al. 2009) • Tactile sensation for screen objects created by ultrasound (Hoshi et al. 2009) • Smoke alarm display (Tokuda et al. 2010) • Large display based on networked LEDs (Chandler et al. 2009) • Touch and hand gesture controlled display (Pinhanez et al. 2003) • Screen pointing via touch mobile phone (McCallum and Irani 2009) • Continuously scrolling screens (Maglio and Campbell 2000)	• Display adaptation based on data traffic, email arrival (Abowd et al. 2002) • Displays providing awareness concerning environmental audio for deaf people (Ho-Ching et al. 2003) • Tracking movement of a large number of people for displaying information (Massink et al. 2010) • Constructing topological maps of displays with 3D positioning information; location-awareness (Patterson 2009) • View time triggering prioritization of displayed content (Müller et al. 2009a) • Visualizing weather and stock markets (Shami et al. 2005) • Monitoring and accessing information from multiple channels (Angelucci et al. 2011) • Video walls for crisis situation management (Popp 2005)
	one-to-many	• Demographics capture via digital camera (Harrison and Andrusiewicz 2003) • Tracking user head to adapt display (3D effect on fog screen) (Rakkolainen and Lugmayr 2007) • Tracking user head to adapt display (Rakkolainen 2008) • Display sharing between residents and visitors (of a building) (Kray et al. 2006) • Collaboration: awareness of other groups while being absorbed by a demanding primary task (Reynolds et al. 2010)	

	one-to-one	• User identification via face detection and RFID (Ojala et al. 2010) • Human motion (presence) detection via TV broadcasting waves (Maeda et al. 2010) • Positioning of user and mobile phone using ultrasonics (Horiuchi et al. 2011) • Approach to split display of information: public info on a large screen, private information on a mobile device (Olivier et al. 2006) • Collaboration on a large screen using RFID badges (identification) and keyboard, mouse (Huang et al. 2006) • Gaze recognition and user location (Darrell et al. 1996) • Person locator in buildings (Taher et al. 2009) • Face-recognition, Facebook integration (Hosio et al. 2010b) • Capturing a public display for personal use with RFID (Hosio et al. 2010a) • Content adaption based on presence, body movement, and gestures (Beyer et al. 2011) • Face detection from video feed from two overhead cameras; RFID tags (Linden et al. 2010) • Interaction modalities (presence, body position, body posture, facial expression, gaze, speech, gesture, remote control, keys, and touch); mental models (Müller et al. 2010) • Attention capturing (Peters and Mennecke 2011) • Implicit and explicit profile creation; ID using Bluetooth (Kern et al. 2008) • Interaction framework for large screens (Vogel and Balakrishnan 2004) • Feedback on social dynamics of meetings (speak time, eye gaze) (Sturm et al. 2007) • Feedback on social dynamics of meetings (Terken and Sturm 2010) • Face detection (Shen et al. 2005; Barrington et al. 2006) • Recognition of users via speech (DiMicco et al. 2004) • Multiple channels accessed via badge reader (Huang et al. 2002) • Augmented mirror, displaying additional user information, increasing awareness and connectedness (Dey and De Guzman 2006) • Awareness information regarding instant messenger status (De Guzman et al. 2004) • RFID or Bluetooth for visitor detection (Harrison and Massink 2009) • Using cameras, microphones, and RFID for interface design (Valli 2008) • Personalization of content on screen (Stasko et al. 2004)	• Research outlook: User ID (face, Bluetooth, RFID, optical markers) and environment (weather, time, traffic, news, web activity) (Kuikkaniemi et al. 2011) • Displaying augmented objects based on user location and object location (Madeira and Correia 2007) • Presentation media selection (screen, mobile) based on user preferences, time, and location (Ranganathan and Campbell 2004) • Reminder display (location, time) (Müller and Krüger 2007) • Notification display (Di Paolo and Tarantiono 2010)

5.4 Functional Requirements of Each Adaptation Strategy

When analyzing the DOOHA literature, we identified technical challenges associated with the different adaptation strategies of the PERSIT matrix. These challenges lead to specific functional requirements for each adaptation strategy. The results are presented in Table 5.

When reading Table 5, note that the advertising situation for DOOHA differs from the one on the Web. On the Web, a single user typically browses a website on his or her computer or mobile device. In contrast, DOOHA is encountered in a public space, where several people can see the advertisement

concurrently. Therefore, person-centric adaptation must consider several people at once, for example by adapting for the closest consumer (individualization) or by using characteristics that are shared between people (segmentation).

Table 5. Functional Requirements Associated with the Advertising Adaptation Strategies of the PERSIT Matrix

		Situation-centric adaptation	
		no	**yes**
Person-centric adaptation	**no**	• Selection of content and advertising type (e.g. image, video, text, sound) • Capturing of attention (e.g. movement, contrasts, colors, sound) • Scheduling of advertisements (e.g. timing, length of ads) • Defining user interaction (e.g. interaction modalities (Müller et al. 2010)) • Positioning of advertisements (e.g. advertising format and ad location) • Positioning of the viewing medium (e.g. positioning of the screen)	In addition to requirements for no adaptation: • Selection of context variables (e.g. location, time, weather) • Operationalization of variables • Deployment of physical sensors • Integration of physical and virtual sensors • Abstraction from sensor data (semantic representation of situations) • Fallback strategy in case situational information is missing • Matching of advertisements to situations (algorithm)
	one-to-many	In addition to requirements for no adaptation: • Selection of personalization strategy (e.g. personalize for average, personalize for majority, personalize for outlier) • Selection of group variables (e.g. demographics shared in the group) • Operationalization of variables • Detection of group variables (e.g. video camera, microphone) Matching of advertisements to groups (algorithms)	*No literature* In addition to situation-centric only and group-centric only requirements: • Prioritizing group-related and situation-related input for the adaptation (e.g. group-centric adaptation and then situation-centric, situation-centric and then group-centric, or concurrent adaptation) Fallback strategy in case group and/or situational information is missing
	one-to-one	In addition to requirements for no adaptation: • Selection of personalization strategy (e.g. preference-driven, transaction-driven, or goal/task-driven) • Selection of personalization variables (e.g. past behavior, demographics) • Operationalization of variables • User identification or detection of user variables (e.g. via login, RFID, cookies) • Profiling and building profile databases • Fallback strategy in case personal information is missing • Privacy control (e.g. opt-in or opt-out options) • Matching of advertisements to profiles (algorithm)	In addition to situation-centric only and person-centric only requirements: • Prioritizing person-related and situation-related input for the adaptation (e.g. person-centric adaptation and then situation-centric, situation-centric and then person-centric, or concurrent adaptation) • Fallback strategy in case personal and/or situational information is missing

5.5 The PERSIT Matrix's Utility as Considered by Marketing Experts

The PERSIT matrix is more than a classification of literature. In this section, we outline the utility of the matrix for marketing practitioners.

As outlined in the methods section, we presented the PERSIT matrix to experts in the field so that they could evaluate the utility of the matrix. They were strongly convinced of the benefits of person-centric adaptation but were surprised to hear about possible drawbacks, such as personalization reactance. Interestingly, they did not worry about the privacy–personalization trade-off; in their opinion, lobbying will ensure continuous and sufficient access to personal data. The interviewees valued the structuring of the different adaptation options in the PERSIT matrix. In fact, they had already experimented with situation-centric adaptation without being aware of it. For instance, they had advertised painkillers after each foul in a soccer match on television. However, the marketing experts had not been aware of the actual benefits of this adaptation strategy. They stated they would consider the matrix in their future client sessions to discuss different adaptation options, particularly with respect to automating advertising adaptations in digital media. The benefits, disadvantages, and open questions for each adaptation strategy from a marketing perspective are outlined in Table 6.

Table 6. Marketing Perspective on the Advertising Strategies of the PERSIT Matrix

		Situation-centric adaptation	
		no	**yes**
Person-centric adaptation	**no**	+ The technically least challenging approach + Privacy-friendly because no person-related data is used − No improved advertising effectiveness; random effects concerning situations and personal variables − May induce disturbance caused by unsuitable or disruptive ad placements (e.g. Acquisti and Spiekermann 2011) − Advertisements might be ignored (e.g. display blindness (Müller et al. 2009b))	+ Privacy-friendly, as only freely available data about the situation is used for the adaptation; no need for person-related data + Expected to induce increased advertising effectiveness (improved recall, attitude towards the brand, and willingness to pay) as shown in research on editorial context (e.g., De Pelsmacker et al. 2002; Dahlén 2005) − Lacking technical implementations (e.g. lacking operationalizations of variables, data/sensor infrastructures, and algorithms to match advertisements to situations)
	one-to-many	+ Benefits of customer segmentation (to a group) (Vesanen 2007) + Ideally suited for shared devices (e.g. public screens, shared tablets) ? May induce personalization reactance (negative emotions caused by perceived personalization) (Malheiros et al. 2012; Tucker 2012) ? Privacy–personalization trade-off (Lee et al. 2011)	+ Combining the strengths of one-to-many person-centric adaptation and situation-centric adaptation ? May induce personalization reactance (negative emotions caused by perceived personalization) (Malheiros et al. 2012; Tucker 2012) ? Privacy–personalization trade-off (Lee et al. 2011)

	one-to-one	+ Benefits of customer segmentation (to an individual) (Vesanen 2007) + Increased advertising effectiveness (e.g. improved memory, improved attitude towards the brand, and improved willingness to pay for the advertised product) (Adolphs and Winkelmann 2010) + Increased attention towards the advertisement (Malheiros et al. 2012) + Use of established technology (Adams 2004) + Ideally suited for personal (1 user only) devices (e.g. mobile phones, personal computers) − May induce personalization reactance (negative emotions caused by perceived personalization) (Malheiros et al. 2012; Tucker 2012) − Privacy–personalization trade-off (Lee et al. 2011) − Increased data requirements (need to collect, store, and use person-related data) − Identification technologies required (e.g. cameras, cookies) (Malheiros et al. 2012) − Potential regulations and consumer reluctance to provide data might limit the availability of personal data	+ Combining the benefits of situation-centric only and person-centric only adaptation, possibly leading to further increased advertising effectiveness + Possibility to fall back on situation-centric only or person-centric only adaptation strategies (e.g. in case of missing data) − The drawbacks of situation-centric only and person-centric only adaptation remain ? Unclear if personalization reactance would also occur in this setting

From the experts' point of view, the PERSIT matrix supports them in (1) considering all possible adaptation strategies, (2) generating new ideas to increase advertisement relevance, and (3) structuring the decision process by evaluating the feasibility and balancing the benefits and challenges of the considered adaptation options (for instance, as part of technical, legal, and business due diligence).

6 Conclusions

The personalization of advertising messages promises to break through the information clutter that confronts consumers. While personalization is considered a rather broad concept, from a strategic (advertising effect) and technical (system design) point of view, it is necessary to break it down to its basic adaptation strategies. For this purpose, this paper proposes the PERSIT matrix, a systematic overview of available adaptation strategies for personalized advertising organized according to the dimensions of person-centric and situation-centric adaptation. This overview allows advertisers to consider various adaptation opportunities systematically, and to select a feasible adaptation strategy that accounts for regulatory, time, and cost constraints. In other words, *it supports systematic, strategic decision making for advertising adaptation that reflects the business requirements of marketing experts as well as the functional requirements of system designers.*

This work contributes to the interactive marketing research field in three ways. First, the proposed PERSIT matrix enables marketing experts to choose the best adaptation strategy from among ones with different advertising effects, because the matrix (1) reflects the benefits and drawbacks (regarding business requirements) of the respective adaptation strategies and (2) outlines the different strategic options for adapting advertisements. Second, as the PERSIT matrix provides a level of

abstraction that both business people and system designers can understand, it facilitates communication between these groups, since the matrix reflects (1) the different functional requirements for different advertising adaptation strategies and (2) the strategies' advertising effects. Advertisers can use the strategic options that the matrix offers to create coherent advertising messages. Its utility for marketing experts was evaluated and the experts perceived the matrix to be useful.

Third, the work provides a literature review of adaptive advertising in the field of DOOHA and structures it along the six identified adaptation strategies. A main finding is that research that combines person-centric and situation-centric adaptation is still underrepresented, particularly with respect to one-to-many person-centric adaptation. Further research in this field is encouraged.

A limitation of our work is that the advertising effects of different adaptation strategies have only been analyzed in terms of the DOOHA field. Accordingly, future research should evaluate the PERSIT matrix in a broader advertising context. Furthermore, as the PERSIT matrix deals with adaptation strategies generally, its findings could be transferred to contexts other than advertising. For instance, applying the matrix to product recommendation systems is also possible. A respective evaluation is missing, and research in this direction is strongly encouraged.

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References

Abowd GD, Mynatt ED, Rodden T (2002) The human experience [of ubiquitous computing]. IEEE Pervas Comput 1 (1):48-57. doi:10.1109/MPRV.2002.993144

Acquisti A, Spiekermann S (2011) Do Interruptions Pay off? Effects of Interruptive Ads on Consumers' Willingness to Pay. J Interactive Marketing 25 (4):226-240. doi:10.1016/j.intmar.2011.04.003

Adams R (2004) Intelligent advertising. AI & Society 18 (1):68-81. doi:10.1007/s00146-003-0259-9

Adolphs C, Winkelmann A (2010) Personalization Research in E-Commerce: A State of the Art Review (2000-2008). J Elect Com Res 11 (4):326-341

Adomavicius G, Tuzhilin A (2005) Toward the Next Generation of Recommender Systems: A Survey of the State-of-the-Art and Possible Extensions. IEEE T Knowl Data En 17 (6):734-749. doi:10.1109/Tkde.2005.99

Allen P Place and Locality in Augmented Public Space: A Case Study in the Site Specific Nature of Urban Screens. In: 2009 International Conference on CyberWorlds (CW 2009), Bradford, UK, 7-11 September 2009. IEEE, pp 371-376. doi:10.1109/CW.2009.54

Alt F, Memarovic N, Elhart I, Bial D, Schmidt A, Langheinrich M, Harboe G, Huang E, Scipioni MP (2011) Designing Shared Public Display Networks: Implications from Today's Paper-Based Notice Areas. In: Pervasive Computing. Springer, pp 258-275

Angelucci D, Cardinali A, Tarantino L (2011) A Customizable Glanceable Peripheral Display for Monitoring and Accessing Information from Multiple Channels. In: D'Atri A, Ferrara M, George JF, Spagnoletti P (eds) Information Technology and Innovation Trends in Organizations: ItAIS: the

Italian Association for Information Systems. Physica-Verlag, Heidelberg, pp 199-207. doi:10.1007/978-3-7908-2632-6

Barrington L, Lyons MJ, Diegmann D, Abe S Ambient Display using Musical Effects. In: 11th International Conference on Intelligent User Interfaces (IUI '06), Sydney, Australia, 29 January - 1 February 2006. ACM Press, pp 372-374. doi:10.1145/1111449.1111541

Bauer C, Dohmen P, Strauss C (2012) A conceptual framework for backend services of contextual digital signage. J Serv Sci Res 4 (2):271-297. doi:10.1007/s12927-012-0011-4

Beyer G, Alt F, Müller J, Schmidt A, Isakovic K, Klose S, Schiewe M, Haulsen I Audience behavior around large interactive cylindrical screens. In: 2011 annual conference on Human factors in computing systems (CHI 2011), Vancouver, BC, 7-12 May 2011. ACM, pp 1021-1030

Brown M, Majumder A, Yang R (2005) Camera-based calibration techniques for seamless multiprojector displays. IEEE T Vis Compout Gr 11 (2):193-206. doi:10.1109/TVCG.2005.27

Bullivant L (2007) Beyond the Kiosk and the Billboard: Manhattan limits the possibility for interactive art sites. Archit Design 77 (188):14-23

Burke RR (2010) The third wave of marketing intelligence. Retailing in the 21st Century: Current and Future Trends, Second Edition:159-171. doi:10.1007/978-3-540-72003-4_10

Cappellini M, De Rocco P, Serni L Uffizi touch®: a new experience with art. In: 18th International Conference on Multimedia (MM 2010), Firenze, Italy, 25-29 October 2010. ACM, pp 1511-1512

Chandler A, Finney J, Lewis C, Dix A Toward emergent technology for blended public displays. In: 11th International Conference on Ubiquitous Computing (Ubicomp 2009), Orlando, FL, 30 September - 3 October 2009. ACM Press, p 101. doi:10.1145/1620545.1620562

Dahlén M (2005) The Medium as a Contextual Cue: Effects of Creative Media Choice. J Advertising 34 (3):89-98

Dalton SN, Marshall P, Dalton RC Measuring Environments for Public Displays: A Space Syntax Approach. In: 28th of the international conference extended abstracts on Human factors in computing systems (CHI 2010), Atlanta, GA, 10-15 April 2010. ACM, pp 3841-3846

Darrell T, Moghaddam B, Pentland AP Active face tracking and pose estimation in an interactive room. In: IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 1996), San Francisco, CA, 18-20 June 1996. IEEE Comput. Soc. Press, pp 67-72. doi:10.1109/CVPR.1996.517055

De Guzman ES, Yau M, Gagliano A, Park A, Dey AK Exploring the design and use of peripheral displays of awareness information. In: Extended abstracts of the 2004 conference on Human factors and computing systems (CHI 2004), Vienna, Austria, 24-29 April 2004. ACM Press, p 1247. doi:10.1145/985921.986035

De Pelsmacker P, Geuens M, Anckaert P (2002) Media Context and Advertising Effectiveness : The Role of Context Appreciation and Context / Ad Similarity. J Advertising 31 (2):49-61

Dey AK, De Guzman ES From awareness to connectedness: the design and deployment of presence displays. In: SIGCHI conference on Human Factors in computing systems (CHI 2006), Montréal, Canada, 22-27 April 2006. ACM, pp 899-908

Di Paolo S, Tarantiono L (2010) A Peripheral Notification Display for Multiple Alerts: Design Rationale. In: D'Atri A, Saccà D (eds) Information Systems: People, Organizations, Institutions, and Technologies. Physica-Verlag HD, Heidelberg, pp 521-528. doi:10.1007/978-3-7908-2148-2

Dietz P, Raskar R, Booth S, van Baar J, Wittenburg K, Knep B Multi-projectors and implicit interaction in persuasive public displays. In: Working conference on Advanced visual interfaces (AVI 2004), Gallipoli, Italy, 25-28 May 2004. ACM Press, p 209. doi:10.1145/989863.989898

DiMicco JM, Pandolfo A, Bender W Influencing group participation with a shared display. In: 2004 ACM conference on Computer supported cooperative work - CSCW '04, Chicago, IL, 6–10 November 2004. ACM Press, p 614. doi:10.1145/1031607.1031713

Dräger P (2011) Einsatz digitaler POS-Medien im Shopper-Marketing. Shopper-Marketing:209-245

Eriksson CI, Åkesson M Ubiquitous Advertising Challenges. In: 7th International Conference on Mobile Business (ICMB 2008), Barcelona, Spain, 7-8 July 2008. IEEE Computer Society, pp 9-18. doi:10.1109/ICMB.2008.19

Ferscha A (2007) Informative art display metaphors. Lect Notes Comput Sc 4555:82-92

Fitton D, Cheverst K, Kray C, Dix A, Rouncefield M, Saslis-Lagoudakis G (2005) Rapid prototyping and user-centered design of interactive display-based systems. IEEE Pervas Comput 4 (4):58-66. doi:10.1109/MPRV.2005.85

Foote J (2006) Where's My Holodeck? The New Frontier of Media Display. IEEE Multimedia 13 (3):104-104. doi:10.1109/MMUL.2006.73

Gartner (2012) Forecast: Mobile Advertising, Worldwide, 2009-2016. Gartner,

Geiger HL (2011) A Standard for Digital Signage Privacy. In: Müller J, Alt F, Michelis D (eds) Pervasive Advertising. Human–Comp edn. Springer, London, pp 103-117

Gellersen H-W, Schmidt A, Beigl M (1999) Ambient media for peripheral information display. Pers Ubiquitous Comput 3:199-208

Goldfarb A, Tucker CE (2011) Privacy Regulation and Online Advertising. Manage Sci 57 (1):57-71. doi:10.1287/mnsc.1100.1246

Ha L, McCann K (2008) An integrated model of advertising clutter in offline and online media. Int J Advertising 27 (4):569-592. doi:10.2501/S0265048708080153

Harrison JV, Andrusiewicz A An emerging marketplace for digital advertising based on amalgamated digital signage networks. In: IEEE International Conference on E-Commerce (CEC 2003), Newport Beach, CA, 24-27 June 2003 2003. IEEE, pp 149-156

Harrison MD, Massink M Engineering crowd interaction within smart environments. In: 1st ACM SIGCHI symposium on Engineering interactive computing systems (EICS 2009), Pittsburgh, PA, 14-17 July 2009. ACM, pp 117-122. doi:10.1145/1570433.1570456

Hazlewood WR, Stolterman E Issues in evaluating ambient displays in the wild: two case studies. In: CHI 2011, Vancouver, BC, 7-12 May 2011. pp 877-886

Ho-Ching FW-l, Mankoff J, Landay JA Can you see what I hear? The design and evaluation of a peripheral sound display for the deaf. In: CHI 2003, Fort Lauderdale, FL, 5-10 April 2003. pp 161-168

Horiuchi T, Takayama S, Kato T A pointing system based on acoustic position estimation and gravity sensing. In: 2011 IEEE Symposium on 3D User Interfaces (3DUI 2011), Singapore, 19-20 March 2011. pp 105-106

Hoshi T, Takahashi M, Nakatsuma K, Shinoda H Touchable holography. In: ACM SIGGRAPH 2009 Emerging Technologies on (SIGGRAPH 2009), New Orleans, LA, 3-7 August 2009. ACM Press. doi:10.1145/1597956.1597979

Hosio S, Jurmu M, Kukka H, Riekki J, Ojala T Supporting distributed private and public user interfaces in urban environments. In: 11th Workshop on Mobile Computing Systems & Applications (HotMobile 2010), Annapolis, MD, 22-23 February 2010a. ACM Press, p 25. doi:10.1145/1734583.1734590

Hosio S, Kukka H, Jurmu M, Ojala T Enhancing interactive public displays with social networking services. In: MUM 2010, Limassol, Cyprus, 1-3 December 2010b.

Hsieh C-K, Lin Q-P, Huang C-Y, Chang C-Y, Lin Y-J, Hung Y-P Easy and Deep Media in Cultural Heritage Field. In: 3rd International Workshop on Education Technology and Computer Science (ETCS 2011), Wuhan, China, 12-13 March 2011. pp 55-59. doi:10.1109/ETCS.2011.22

Huang EM, Koster A, Borchers J (2008) Overcoming assumptions and uncovering practices: When does the public really look at public displays? IEEE Pervas Comput:228-243

Huang EM, Mynatt ED, Russell DM, Sue AE (2006) Secrets to success and fatal flaws: the design of large-display groupware. IEEE Comput Graph 26 (1):37-45

Huang EM, Tullio J, Costa TJ, McCarthy JF Promoting awareness of work activities through peripheral displays. In: CHI 2002 extended abstracts on Human factors in computer systems (CHI 2002), Minneapolis, MN, 20-25 April 2002. ACM Press, p 648. doi:10.1145/506486.506527

Ito K, Kikuchi H, Sakurai H, Kobayashi I, Yasunaga H, Mori H, Tokuyama K, Ishikawa H, Hayasaka K, Yanagisawa H 360-degree autostereoscopic display. In: 37th International Conference and Exhibition on Computer Graphics and interactive Techniques (SIGGRAPH 2010), Los Angeles, CA, 25-29 July 2010. pp 4503-4503. doi:10.1145/1836821.1836822

Jun S, Putrevu S, Hyun YJ, Gentry JW (2003) The Influence of Editorial Context on Consumer Response to Advertisements in a Specialty Magazine. J Curr Issues Res Advertising 25 (2):1-11. doi:10.1080/10641734.2003.10505144

Kalyanam K, Lal R, Wolfram G (2006) Future Store Technologies and Their Impact on Grocery Retailing. Retailing in the 21st Century:95-112

Kaupp M (2010) Digital Signage: Technologie, Anwendung, Chancen & Risiken. Diplomica Verlag GmbH, Hamburg, Germany

Kern D, Harding M, Storz O, Davis N, Schmidt A Shaping how advertisers see me: user views on implicit and explicit profile capture. In: CHI 2008 extended abstracts, Florence, Italy, 5-10 April 2008. pp 3363-3368

Kray C, Cheverst K, Fitton D, Sas C, Patterson J, Rouncefield M, Stahl C Sharing control of dispersed situated displays between nand residential users. In: 8th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI 2006), Espoo, Finland, 12-15 September 2006. ACM Press, p 61. doi:10.1145/1152215.1152229

Krüger A, Schöning J, Olivier P (2011) How Computing Will Change the Face of Retail. Computer 44 (4):84-87

Kuikkaniemi K, Jacucci G, Turpeinen M, Hoggan E, Müller J (2011) From Space to Stage: How Interactive Screens Will Change Urban Life. Computer 44 (6):40-47

Lai A, Soro A, Scateni R Interactive calibration of a multi-projector system in a video-wall multi-touch environment. In: Adjunct proceedings of the 23nd annual ACM symposium on User interface software and technology (UIST 2010), New York, NY, 3-6 October 2010. ACM, pp 437-438

Lambert A, Wells I, Kean M (2003) Do isoluminant color changes capture attention? Percept Psychophys 65 (4):495-507

Lamberty KK, Froiland K, Biatek J, Adams S Encouraging awareness of peers' learning activities using large displays in the periphery. In: 28th of the international conference extended abstracts on Human factors in computing systems (CHI EA 2010), Atlanta, GA, 10-15 April 2010. ACM Press, p 3655. doi:10.1145/1753846.1754034

Lasinger P, Bauer C Situationalization: the new road to adaptive digital-out-of-home advertising. In: IADIS e-Society 2013 (ES 2013), Lisbon, Portugal, 13-16 March 2013. IADIS,

Lee D-J, Ahn J-H, Bang Y (2011) Managing Consumer Privacy Concerns in Personalization: A Strategic Analysis of Privacy Protection. Mis Quart 35 (2):423-444

Lewin K (1935) Survey of the Experimental Investigations. In: A dynamic theory of personality. McGraw-Hill, New York, NY, pp 239-249

Li K, Chen H, Chen Y, Clark DW, Cook P, Damianakis S, Essl G, Finkelstein A, Funkhouser T, Housel T, Klein A, Liu Z, Praun E, Samanta R, Shedd B, Singh JP, Tzanetakis G, Zheng J (2000) Building and using a scalable display wall system. IEEE Comput Graph 20 (4):29-37. doi:10.1109/38.851747

Lin J-Y, Chen Y-Y, Ko J-C, Kao H, Chen W-H, Tsai T-H, Hsu S-C, Hung Y-P im-Tube: an interactive multi-resolution tubular display. In: 17th ACM international conference on Multimedia (MM 2009), Bejing, China, 19-24 October 2009. ACM, pp 253-260

Linden T, Heikkinen T, Ojala T, Kukka H, Jurmu M Web-based framework for spatiotemporal screen real estate management of interactive public displays. In: 19th International Conference on World wide web (WWW 2010), Raleigh, NC, 26-30 April 2010. ACM Press, p 1277. doi:10.1145/1772690.1772901

Madeira RN, Correia N Interaction between Shared Displays and Mobile Devices in an Augmented Objects Framework. In: International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (UBICOMM 2007), Papeete, Tahiti, 4-9 November 2007. IEEE, pp 189-194. doi:10.1109/UBICOMM.2007.41

Maeda K, Nishi M, Yoshida T, Suzuki K, Inoue H Digital Signage with Audience Detection Using TV Broadcasting Waves. In: 10th IEEE/IPSJ International Symposium on Applications and the Internet (SAINT 2010), Seoul, Korea, 19-23 July 2010. IEEE, pp 225-228. doi:10.1109/SAINT.2010.99

Maglio PP, Campbell CS Tradeoffs in displaying peripheral information. In: SIGCHI conference on Human factors in computing systems (CHI 2000), The Hague, The Netherlands, 1-6 April 2000. ACM Press, pp 241-248. doi:10.1145/332040.332438

Malheiros M, Jennett C, Patel S, Brostoff S, Sasse MA Too Close for Comfort: A Study of the Effectiveness and Acceptability of Rich-Media Personalized Advertising. In: CHI 2012, Austin, Texas, USA, 5-10 May 2012. pp 579-588

Massink M, Harrison M, Latella D Scalable analysis of collective behaviour in smart service systems. In: 25th ACM Symposium On Applied Computing (SAC 2010), Sierre, Switzerland, 22-26 March 2010. ACM Press, p 1173. doi:10.1145/1774088.1774337

Matthews T Designing and evaluating glanceable peripheral displays. In: 6th ACM conference on Designing Interactive systems (DIS 2006), University Park, PA, 26-28 June 2006. ACM Press, p 343. doi:10.1145/1142405.1142457

Matthews T, Dey AK, Mankoff J, Carter S, Rattenbury T A toolkit for managing user attention in peripheral displays. In: 17th annual ACM symposium on User interface software and technology (UIST 2004), Santa Fe, NM, 24 - 27 October 2004. ACM Press, p 247. doi:10.1145/1029632.1029676

McCallum DC, Irani P Arc-pad: absolute+ relative cursor positioning for large displays with a mobile touchscreen. In: 22nd annual ACM symposium on User interface software and technology (UIST 2009), Victoria, BC, 4-7 October 2009. pp 153-156

Min W, Ketai H, Hua H Research on Using of Digital Signage in Museum Visiting Navigation. In: International Conference on Optoelectronics and Image Processing (ICOIP 2010), Haiko, Hainan, China, 11-12 November 2010. IEEE, pp 327-330. doi:10.1109/ICOIP.2010.172

Müller J, Alt F, Michelis D, Schmidt A Requirements and design space for interactive public displays. In: International Conference on Multimedia (MM 2010), Firenze, Italy, 25-29 October 2010. ACM, pp 1285-1294

Müller J, Exeler J, Buzeck M, Krüger A (2009a) ReflectiveSigns: Digital signs that adapt to audience attention. IEEE Pervas Comput:17-24

Müller J, Krüger A Competing for your attention: negative externalities in digital signage advertising. In: Pervasive 2007, Workshop: W9 - Ambient Information Systems, Toronto, Canada, 13 May 2007.

Müller J, Wilmsmann D, Exeler J, Buzeck M, Schmidt A, Jay T, Krüger A (2009b) Display Blindness: The Effect of Expectations on Attention towards Digital Signage. IEEE Pervas Comput:1-8

Newman A, Dennis C, Zaman S (2007) Marketing Images and Consumers' Experiences in Selling Environments. Marketing Manage J 17 (1):136-150

Nobuyuki K, Fleury G, Leigh J Tiled Display System for Improved Communication Efficiency. In: 5th International Conference on P2P, Parallel, Grid, Cloud and Internet Computing (3PGCIC 2010), Fukuoka, Japan, 4-6 November 2010. IEEE, pp 446-449. doi:10.1109/3PGCIC.2010.75

Numa K, Tomobe H, Sugimoto T, Miyata M, Toriumi K, Abe J, Hori K Public Large Screen Enabled Content Collection and Connection. In: 13th International Conference on Knowledge-Based and Intelligent Information and Engineering Systems (KES 2009), Santiago, Chile, 28-30 September 2009.

Ojala T, Kukka H, Lindén T, Heikkinen T, Jurmu M, Hosio S, Kruger F UBI-Hotspot 1.0: Large-Scale Long-Term Deployment of Interactive Public Displays in a City Center. In: 5th International Conference on Internet and Web Applications and Services (ICIW 2010), Barcelona, Spain, 9-15 May 2010. IEEE, pp 285-294. doi:10.1109/ICIW.2010.49

Olivier P, Gilroy SW, Jackson DG, Kray C Crossmodal Attention in Public-Private Displays. In: 2006 ACS/IEEE International Conference on Pervasive Services (ICPS 206), Lyon, France, 26-29 June 2006. IEEE, pp 13-18. doi:10.1109/PERSER.2006.1652201

Patterson DJ Constructing Topological Maps of Displays with 3-D Positioning Information. In: 3rd European Conference on Ambient Intelligence (AmI 2009), Salzburg, Austria, 18-21 November 2009. pp 49-54

Peters A, Mennecke B The role of dynamic digital menu boards in consumer decision making. In: CHI 2011, Vancouver, BC, 7-12 May 2011. ACM, pp 1693-1698

Pinhanez C, Kjeldsen R, Tang L, Levas A, Podlaseck M, Sukaviriya N, Pingali G Creating touch-screens anywhere with interactive projected displays. In: 11th ACM international conference on Multimedia (MM 2003), Berkeley, CA, 2-8 November 2003. ACM Press, p 460. doi:10.1145/957102.957112

Popp HF (2005) Videowände als Informationsschiene im Krisen- und Katastrophenfall. Notfall Rettungsmedizin 8 (3):234-237. doi:10.1007/s10049-005-0731-9

PQ Media (2013) Global Digital Out-of-Home Media Forecast 2013-2017. Global DOOH Report Series, vol 6. PQ Media, Stamford, CT

Rakkolainen IK Mid-air displays enabling novel user interfaces. In: 1st ACM international workshop on Semantic ambient media experiences (SAME 2008) (MM 2008), Vancouver, BC, 26-31 October 2008. ACM Press, p 25. doi:10.1145/1461912.1461919

Rakkolainen IK, Lugmayr AK Immaterial display for interactive advertisements. In: 9th International Conference on Advances in Computer Entertainment (ACE 2007), Salzburg, Austria, 13-15 June 2007. ACM Press, pp 95-98. doi:10.1145/1255047.1255066

Ranganathan A, Campbell RH Autonomic pervasive computing based on planning. In: 1st International Conference on Autonomic Computing (ICAC 2004), New York, NY, 17-19 May 2004. IEEE, pp 80-88. doi:10.1109/ICAC.2004.1301350

Redert A, Berretty R-P, Varekamp C, Willemsen O, Swillens J, Driessen H Philips 3D Solutions: From Content Creation to Visualization. In: 3rd International Symposium on 3D Data Processing, Visualization, and Transmission (3DPVT 2006), Chapel Hill, USA, 14-16 June 2006. IEEE, pp 429-431. doi:10.1109/3DPVT.2006.107

Reutterer T (2003) Bestandsaufnahme und aktuelle Entwicklungen bei der Segmentierungsanalyse von Produktmärkten. J Betrieb 53 (2):52-74

Reynolds L, Birnholtz J, Luxenberg E, Gutwin C, Mustafa M Comparing awareness and distraction between desktop and peripheral-vision displays. In: 28th of the international conference extended abstracts on Human factors in computing systems (CHI EA 2010), Atlanta, GA, 10-15 April 2010. ACM Press, p 3571. doi:10.1145/1753846.1754020

Ribeiro FR, José R Place-Aware Content Selection from Dynamic Web Sources for Public Displays. In: 5th International Conference on Signal Image Technology and Internet Based Systems (SITIS 2009), Marrakesh, Morocco, 29 November - 4 December 2009. IEEE, pp 302-309. doi:10.1109/SITIS.2009.56

Ribeiro FR, José R Timely and Keyword-Based Dynamic Content Selection for Public Displays. In: International Conference on Complex, Intelligent and Software Intensive Systems (CISIS 2010), Krakow, Poland, 15-18 February 2010. IEEE, pp 655-660. doi:10.1109/CISIS.2010.114

Robertson G, Czerwinski M, Baudisch P, Meyers B, Robbins D, Smith G, Tan D (2005) The large-display user experience. IEEE Comput Graph 25 (4):44-51

Rogers Y, Hazlewood WR, Marshall P, Dalton N, Hertrich S Ambient influence: can twinkly lights lure and abstract representations trigger behavioral change? In: UbiComp 2010, Copenhagen, Denmark, 26-29 September 2010. pp 261-270

Schulz von Thun F, Ruppel J, Stratmann R (2003) Miteinander reden. Kommunikationspsychologie für Führungskräfte. , vol 12. rororo,

Shami NS, Leshed G, Klein D Context of use evaluation of peripheral displays (CUEPD). In: Human-Computer Interaction (INTERACT 2005), Rome, Italy, 12-16 September 2005. Springer, pp 579-587

Shen X, Moere AV, Eades P An intrusive evaluation of peripheral display. In: 3rd International Conference on Computer Graphics and Interactive Techniques in Australasia and Southeast Asia (GRAPHITE 2005), Dunedin, New Zealand, 29 November - 2 December 2005. ACM Press. doi:10.1145/1101389.1101447

Silberer GA (2010) Digital Signage im stationären Handel: Das Anwendungs- und Wirkungspotenzial eines neuen POS-Mediums. Der Markt 49 (1):3-16. doi:10.1007/s12642-010-0025-8

Stalder U (2011) Digital Out-of-Home Media: Towards a Better Understanding of Means and Effects of Digital Media in Public Space. In: Müller J, Alt F, Michelis D (eds) Pervasive Advertising. Human–Comp edn. Springer, London, pp 31-56

Stasko J, Miller T, Pousman Z, Plaue C, Ullah O Personalized peripheral information awareness through information art. In: 6th International Conference on Ubiquitous Computing (Ubicomp 2004), Nottingham, UK, 7-10 September 2004. Springer, pp 18-35

Storz O, Friday A, Davies N, Finney J, Sas C, Sheridan JG (2006) Public ubiquitous computing systems: Lessons from the e-Campus display deployments. IEEE Pervas Comput 5 (3):40-47. doi:10.1109/Mprv.2006.56

Strohbach M (2011) Toward a Platform for Pervasive Display Applications in Retail Environments. IEEE Pervas Comput 10 (2):19-27. doi:10.1109/Mprv.2011.16

Sturm J, Herwijnen OH-v, Eyck A, Terken J Influencing social dynamics in meetings through a peripheral display. In: 9th International Conference on Multimodal Interfaces (ICMI 2007), Nagoya, Japan, 12-15 November 2007. ACM Press, p 263. doi:10.1145/1322192.1322238

Taher F, Cheverst K, Harding M, Fitton D Formative studies for dynamic wayfinding support with in-building situated displays and mobile devices. In: 8th International Conference on Mobile and Ubiquitous Multimedia (MUM 2009), Cambridge, UK, 22-25 November 2009. ACM Press, pp 1-10. doi:10.1145/1658550.1658555

Tam KY, Ho SY (2006) Understanding the impact of web personalization on user information processing and decision outcomes. Mis Quart 30 (4):865-890

Tao J, Geng Z, Fan Q A Digitized Water Display System Based on RS-422 Bus. In: International Conference on Electrical and Control Engineering (ICECE 2010), Wuhan, China, 25-27 June 2010. IEEE, pp 39-43. doi:10.1109/iCECE.2010.18

Taylor CR, Franke GR (2011) Public Opinion towards Digital Billboards in the United States: An Analysis of Recent Polls. Adv Advertising Res 2

Telschow S, Loose N (2008) Digital Signage: Die globale Studie: Chancen und Risiken. Elsevier, Heidelberg, Germany

Terken J, Sturm J (2010) Multimodal support for social dynamics in co-located meetings. Pers Ubiquitous Comput 14 (8):703-714. doi:10.1007/s00779-010-0284-x

Tokuda Y, Suzuki Y, Nishimura K, Tanikawa T, Hirose M Cloud Display. In: 7th International Conference on Advances in Computer Entertainment Technology (ACE 2010), Taipei, Taiwan, 17-19 November 2010. pp 32-35. doi:10.1145/1971630.1971640

Tucker CE (2012) The economics of advertising and privacy. Int J Ind Organ 30 (3):326-329. doi:10.1016/j.ijindorg.2011.11.004

Valli A (2008) The design of natural interaction. Multimedia Tool Ap 38 (3):295-305. doi:10.1007/s11042-007-0190-z

Vesanen J (2007) What is personalization? A conceptual framework. Eur J Marketing 41 (5/6):409-418. doi:10.1108/03090560710737534

Vogel D, Balakrishnan R Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. In: 17th Annual ACM Symposium on User Interface Software and Technology (UIST 2004), Santa Fe, NM, 24-27 October 2004. ACM, pp 137-146

Yu K-m, Yu C-y, Yeh B-h, Hsu C-h, Hsieh H-n The Design and Implementation of a Mobile Location-Aware Digital Signage System. In: 6th International Conference on Mobile Ad-hoc and Sensor Networks (MSN 2010), Hangzhou, China, 20-22 December 2010. IEEE, pp 235-238. doi:10.1109/MSN.2010.44

Zimmermann A, Specht M, Lorenz A (2005) Personalization and context management. User Model User-Adap 15 (3-4):275-302. doi:10.1007/S11257-005-1092-2