Acceptance of an AR-Based In-Store Shopping Advisor - the Impact of Psychological User Characteristics

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Abstract. We present a study on the acceptance of augmented reality-based product comparison and recommending in a physical store context. An online study was performed, in which a working prototype for head-mounted displays, developed in previous research, was used to showcase the concept. The survey included questionnaires to assess shopping behaviour, decision styles and propensity to adopt new technologies of the participants. A cluster analysis of these psychological traits reveals the existence of different types of customers, who also differ on their assessment of the system. While the technology adoption propensity index is the better predictor of the acceptance of an augmented reality shopping advisor, the results suggest that factors such as the user's previous experience, a high experiential chronic shopping orientation, or an intuitive decision style have a significant impact on it as well. Thus, predicting user acceptance solely based on one of the investigated psychological traits may be unreliable, and studying them in conjunction can provide a more accurate estimation.

Keywords: Technology acceptance · Augmented reality · Retailing · Shopping advisors.

1 Introduction

AR technology has made considerable advances in recent years [7], making it more readily available in a wider range of domains. Its usage has been successfully implemented in industry, specially concerning areas such as quality control, training and assistance in complex tasks [36]. AR is being well regarded in entertainment and marketing spheres too, due to the possibilities that it offers in terms of consumer engagement [14]. However, the use of AR in retailing is still scarce and most of the time e-commerce is the centre of attention, while physical retailing is left aside [34]. Bringing AR to physical stores requires finding more utilitarian uses for it [46], as well as suitable scenarios and proper visualization and interaction methods. Furthermore, it is essential that an AR-based solution

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brings clear added value in contrast to more traditional options in order to be acceptable.

With all of this in mind, a promising use of AR is that of supporting in-store product comparison. Physical retailing lacks the ease with which online stores provide their customers with plenty of useful data and shopping tools. AR could be used precisely for closing this gap by letting customers explore product attributes via augmentations, while also allowing their comparison by assisting clients in the process of finding and understanding their differences. A potential benefit of the approach is that users are free to inspect attributes directly on the physical object they belong to, which may be of help for obtaining a better understanding of its qualities and, thus, make a more satisfactory purchase decision. In combination with recommending functions, AR can build a bridge between physical stores and online shopping to create multi-channel options [27, 55], more so if the recommendations include products from the vendor's online catalogue. A system like this offers the rarely seen combination of digital and physical items of the same type, where the characteristics of all of them are accessible through a unified medium. This aspect may also have an impact on the decision making process of users by influencing how they explore the digital space and learn about physical and digital items.

However, it is unclear whether the use of AR technology in such context is acceptable to all users and which psychological characteristics may determine acceptance and attractiveness. Different general attitudes towards new technologies and user-specific shopping and decision-making behaviours may influence the acceptance of an AR system in a shop environment. Such factors may be particularly relevant when the system involves wearing an AR headset, which is conspicuous and may attract other customers' attention. Although research on the topic of AR acceptance already exists and even spans through different disciplines [37, 18], it approaches the investigation mostly from a technical angle (e.g. users proficiency, availability of learning tools or current reliability of AR) or contextual elements, but overlooks the involvement of other psychological factors and the interactions that may occur between them. Thus, the following research questions are raised:

RQ1 How useful do users consider the possibility to explore and compare products across physical and online spaces?

RQ2 What is the impact of individual and combined personal characteristics on the acceptance of AR-based support functions?

This paper makes a further contribution to existing literature by presenting a exploratory study where, unlike previous research, users are defined by a set of psychological traits. These traits are based on how clients make decisions in a shopping scenario with a heavy technological component; that is, by assessing their technology adoption propensity, decision-making styles and shopping orientation. Participants are then grouped into types of clients to study their acceptance of an AR shopping advisor running on a head mounted display, in an attempt to find out which characteristics are more significant and uncover possible interactions that may exist between them.

2 Related Work

2.1 Use and value of AR in retailing

Studies show that AR has a positive impact on the shopping experience, particularly regarding customer satisfaction, consumer engagement and purchase intention [43, 39]. Modern retailing can take advantage of AR at various consumer touch points, supported on the exponential growth of mobile technology [28] (e.g. IKEA's popular app [9]). Previous research shows that Mobile AR apps are perceived as valuable in retail contexts and provide benefits beyond the regular shopping experience [17]. Furthermore, due to its ability to merge digital and physical worlds together, AR acts as an enabler of omni-channel experiences by supporting the seamless integration of the different retailing channels [17, 10, 23]. Thus, it seems important for retailers to, at least, consider the adoption of AR-based experiences. However, the adoption of AR also presents its own challenges, such as taking the risk of its implementation, the initial investment in new technology or the need of training employees [17].

Previous approaches to AR in physical retailing include the PromoPad [59], an early application capable of providing context-aware information; Välkkynen et al. [54] explore the possibility of visualizing the content of a package before opening it; Rashid et al. [44] combined RFID with AR to browse product shelves; Cruz et al. [16] created an AR mobile application for retail stores that detects where the user is located and provides guidance to the item that the user is looking for. As of today and in terms of commercial success, virtual try-on [28] (or "magic-mirrors") are the most widely spread implementation of AR in physical contexts.

2.2 Shopping Advisors

Shopping advisors are very common in online settings, including features such as comparison tools [29, 41], customer reviews and ratings [31] and product recommendations [50]. Per contra, it is difficult to find such elements in physical stores. An approach that brings such functionality into physical retailing can be found in Kourouthanassis et al. [30], where the authors present a system able to automatically create and keep track of a shopping list, and offer product information and personalized recommendations of promotions. APriori [47] is another example of a system that provides in-store product data, recommendations and user ratings.

Concerning AR, it has been stated that the technology offers improved search of information at the point of sale [52] and supports clients in making a purchase decision [15], characteristics that are desirable in a shopping advisor. Fully fledged AR shopping advisors are still rare, although some research exists on the topic: Ahn et al. [3] explore the benefits of using AR for product search in retail stores; Acquia Labs [13] developed a demo for a shopping assistant that provides, among other features, product information and in-store navigation support; Gutiérrez et al. [21] present a prototype for an AR shopping assistant that offers health-related information and discus different visualization layouts; Ludwig et al. [35] developed a working prototype to study the benefits of using AR to expose the underlying technical features of physical products. Commercial apps exist too: Aisle411 and Tango partnered to develop an app for Walgreens stores [1] that delivers product information, promotions and in-store navigation; or the Olai Skin Advisor [2], which offers recommendations of products after detecting the consumer's face skin conditions. Nonetheless, despite the existence of previous research on AR-based in-store shopping assistants, the combination of digital and physical products that can be seamlessly compared and recommended remains unexplored.

2.3 Acceptance of Augmented Reality Technology

Technology acceptance is defined by Dillon [19] as *"the demonstrable willingness within a user group to employ IT for the tasks it is designed to support"*. Despite what intuition might tell us based on that definition, the results provided by Roy et al. [49] suggest that technology readiness (i.e. an individual's propensity to embrace and use new technologies) may only influence customer acceptance towards smart retail technologies to some extent, that is, under certain conditions and for certain customers, while other factors such as perceived usefulness (PU), perceived ease of use (PEOU), and perceived adaptiveness play a larger role. Precisely, the review of existing literature [42] shows that one of the most widely used approaches to assess user acceptance of augmented reality in retail is the Technology Acceptance Model (TAM) [33], which considers that PU and PEOU are the main drivers of technology acceptance. The model has undergone several revisions through the years by both original and independent researchers [11], and it is often criticized because of its simplicity, which neglects the differences in decision-making and decision makers across technologies [8]. However, it is still a widely used model and considered valid for AR applications [18]. The extended versions of the TAM often discuss the addition of new factors such as perceived enjoyment (although the findings about its impact on user acceptance are conflicting) and perceived informativeness [42, 24]. As a contrasting note, several authors opt for using flow theory instead [57], which focuses on the four dimensions of immersion, curiosity, fun and control.

Security and privacy aspects have been flagged as other relevant factors that influence the acceptance of AR technology, where previous literature [56, 46] show that AR systems do not currently offer enough protection in that regard or, at the very least, do not sufficiently transmit the feeling of it.

When exploring the different factors involved in the acceptance of AR, existing studies mostly focus on the impact of aspects such as the characteristics of the technology (real or as perceived by users), psychological factors and environmental influences [42, 18]. However, the existence of different types of consumers (defined by the combination of several of these elements), and how they may differ in their perception of AR in retailing settings, are questions that have been generally overlooked.

3 Research Questions

3.1 RQ1: How useful do users consider the possibility to explore and compare products across physical and online spaces?

Supporting the comparison process is a key component of the prototype that is evaluated here. This is justified by the great relevance of comparing in how human beings learn about their environment [20] and, consequently, the significant role that it plays in consumer behaviour, where comparing products is the most natural way to reach a purchase decision [32]. A previous evaluation of the system [6] suggested that combining digital recommendations and physical items may be beneficial for understanding the qualities of the not physically present products, due to the possibility of learning about them through the examination of the real ones. Moreover, it also seems to exist some connection regarding how users navigate the digital space and what products are physically available, in a way that digital items are intuitively filtered out by exploring only the recommendations provided for already suitable, physical products. These points indicate some potential benefits of offering such in-store services, but there is still a need to confirm these results by surveying a larger population sample.

3.2 RQ2: What is the impact of individual and combined personal characteristics on the acceptance of AR-based support functions?

There is a research gap concerning how different decision-making-related psychological traits participate in a user's acceptance of in-store AR applications. To determine what these traits could be, we take the work by Alavi and Joachimsthaler [4] as reference, where the psychological variables involved in the acceptance of a decision support system are examined. *Cognitive style*, *personality traits*, *user situational variables* and *demographics* are identified as the most relevant factors. In the following, the measurement of each factor (as defined by Alavi and Joachimsthaler) is discussed.

Cognitive style refers to how information is processed and used. Different scales exist that allow its analysis, such as the Decision Styles Scale [22], which only requires 10 items to provide an outcome on two different scales (*rational* and *intuitive*); or the more complete and commonly used approach by Scott and Bruce [51], which distinguishes between *rational*, *avoidant*, *intuitive* and *dependent* decision-making styles, but at the expense of a greater number of items.

Personality traits are such as need for achievement, degree of defensiveness, locus of control or risk-taking propensity. Given that the matter at hand consists in the inclusion of a very intrusive technological component (a head mounted display) in a physical retailing context, we aim at the assessment of those traits involved in both technology adoption and shopping behaviour.

Concerning technology adoption, it has already been stated that the Technology Acceptance Model [33] is the most popular theory. The Technology Readiness

Index [40] is another well-known tool for measuring an individual's propensity to adopt and embrace new technology, and it focuses on four different dimensions that act as motivators (*optimism*, *innovation*) or inhibitors (*discomfort*, *insecurity*). Consistent with this idea, the Technology Adoption Propensity index [45] also considers the existence of positive (*optimism*, *proficiency*) and negative (*dependence*, *vulnerability*) attitudes in the assessment of technology acceptance, but uses a more contained set of items.

Among the alternatives for measuring consumer-related traits, the most prominently used is the Consumer Styles Inventory [53], which profiles individuals by analysing eight basic characteristics. Westbrook and Black [58] propose another widely used approach based on *hedonic* and *utilitarian* shopping motivations. A more recent study by Büttner et al. [12] discusses the creation of a 7-items long Chronic Shopping Orientation Scale, which aims at the prediction of the consumer's stable shopping disposition (*experiential* or *task-focused*).

Demographic data on gender, age and education can be easily collected. As for user-situational variables, the work by Alavi and Joachimsthaler [4] refers to user training and experience, which in our case could be associated with the user's previous knowledge about augmented reality.

Gathering information on each one of these personal characteristics would allow the investigation of their role in the judgement of a system like the one described in the following section. Furthermore, by uncovering possible relationships between these characteristics, it would be possible to determine the existence of distinguishable customer types and any variations in their acceptance of the system.

4 Description of the Prototype

A prototype for an AR-shopping advisor designed for Microsoft HoloLens was developed [5, 6]. As of today, using a smartphone could have been a more practical approach. However, this research chose to use a head mounted display as AR enabler because of its growing relevance and availability, and its facility to provide a more engaging experience (which is specially relevant in shopping contexts) and allow for more interesting interaction possibilities (e.g. hands-free direct inspection of products).

Vacuum cleaners were chosen as the product domain, since they are common, technical commodity products. The approach, however, could have been applied to a wide range of products, so long as they are rich in attributes and their physical qualities are relevant for consumers. It is also necessary to keep in mind that this approach may not be best suited for standard shopping environments, but in stores whose activities include working as show-rooms: spaces where a carefully selected range of products are presented (usually specialized in a specific type of items), and where clients have enough space to wander around and freedom to examine them.

Fig. 1. Main view of the system. Attribute categories and recommendations are placed on the left and right sides of the product.

4.1 Access to Product Information

When a user looks to a product that is physically present in the store, relevant information is displayed surrounding it (Figure 1). Clients can then move from one product to another to inspect them individually. Product information is organized in categories that group attributes based on their impact over a certain aspect. Within a category, the system shows the values of the attributes that belong to it. They can be selected, which shows extra information (Figure 2).

Against the argument that similar results could be achieved by more standard means (e.g. a smartphone app with object recognition capabilities), an AR approach enables the inclusion of relevant spatial information for each attribute (i.e. where they are located), bringing into play a new layer of interaction between digital and physical worlds where their connexion is made more apparent. Such union should call for direct exploration and testing of physical items, while improving the understanding of their digitally displayed properties.

4.2 Product Comparison

Taking online comparison tools as a reference, the prototype lets users select up to three different products to be compared. When the user looks to one of the selected items, the attributes of the other one(s) (not directly in the client's line of sight) are shown next to the attributes of the former, in a side-by-side manner (but maintaining the same attribute organization and exploration methods that have been previously explained). Each product is assigned a specific colour that helps to distinguish their properties. The system highlights in green or red the attributes of the current product to easily identify in which ones it performs better or worse than the other selected items (Figure 3).

Fig. 2. Selecting an attribute shows its location on the product, a brief description and critiquing buttons (+/–).

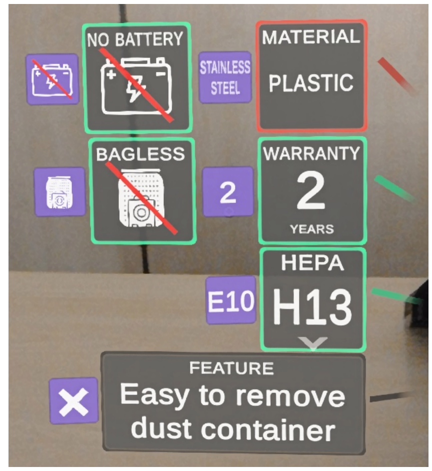

Fig. 3. Comparison view. Colour-coded attribute values (e.g. purple) belong to products not in the client's line of sight.

4.3 Product Recommendation

Product recommendations are obtained likewise attribute information is retrieved: just by looking at a certain product. Items similar to the product directly in the line of sight of the client are shown next to it (Figure 1). These recommendations can be directly compared without requiring users to find the real objects they represent. This allows the inclusion of recommendation of products that are not physically present at the store, effectively expanding the store's catalogue.

Recommendations can be modified, either by directly removing those that are not wanted (which brings new ones in their place) or by critiquing the attributes of the item for which they have been recommended (users can choose whether they seek for products with higher or lower values in a particular property).

5 Online Study

An online study has been conducted to assess the acceptance of an AR-based in-store shopping advisor designed for head-mounted displays and the specific functions described in the previous section. An online study design was chosen to get a broader feedback following an initial lab study[1] [6]. The goals of the study include defining different consumer profiles based on their propensity to adopt technology, shopping orientation and decision styles, and to analyse whether differences exist in their judgement of the system. Finding possible relationships between the psychological traits that characterize those profiles and their impact on the acceptance of the concept is also within the scope of this investigation.

[1] Conducting another, larger lab experiment was also considered, but that option had to be discarded due to restrictions related to the COVID-19 pandemic.

5.1 Settings of the study

Participants were asked to complete an online questionnaire with three distinct parts. The first one focused on determining the psychological profile of the participants and included questionnaires to that effect. Then, since participants could not experience the system by themselves, a video was included that had an initial part where the concept was introduced, followed by a thorough description of the prototype's functionality, showcased with real images of the system as seen from the user's point of view. The last part of the survey was comprised by a set of questions in relation to the aforementioned video with the purpose of collecting information about the acceptance of the prototype.

5.2 Method

A total of 63 participants (40 females, average age of 34.1, σ 12.29) took part in the study. They were recruited through the online platform *Prolific*[2] and received a monetary award of £1.50 after successfully completing a survey (as per the site's policy). As it can be seen in Table 1, the majority were residents of the United Kingdom, while most of them had achieved a master's degree level of education and worked either as employees or were self-employed. Furthermore, many of them reported to have limited knowledge about augmented reality and its possible applications.

Table 1. Demographic information of the sample

Country	#
United Kingdom	43
United States	8
Ireland	4
Netherlands	2
Canada	2
Other	4

Education level	#
Secondary school	2
High school	9
Apprenticeship	1
Bachelor's degree	19
Master's degree	32

Working status	#
Pupil/in school	3
Training/apprenticeship	1
University student	8
Employee	28
Civil servant	4
Self-employed	10
Unemployed	9

Table 2. Knowledge about augmented reality technology

I know nothing about it	8
I know the name, but not much more	21
I know a bit about it and its possible applications	30
I have followed its development and know it well	4
I know a lot and could be considered an expert in the field	0

The survey itself was hosted by *SosciSurvey*[3]. The first part of the survey comprised questionnaires that were to be used in the creation of the participant's psychological profile. Since different traits had to be measured, and to prevent response fatigue and collect more truthful answers [38], the length of the questionnaires included in the survey was an important factor when selecting them.

[2] www.prolific.co
[3] www.soscisurvey.de

Even though the chosen questionnaires might not offer as much information as others available, their combination should suffice to create a reliable user profile:

- *Technology Adoption Propensity* (TAP) index [45], a 14-items-long questionnaire that provides a score that represents how likely a person is to adopt new technology by considering four sub-scales: *optimism*, *proficiency*, *dependence* and *vulnerability*. A TAP score is equal to the sum of the average scores on each of the four factors, with inhibiting factors reverse coded. Each individual item is rated using a 5-point Likert scale.
- *Chronic Shopping Orientation* (CSO) scale [12], which assesses whether a person has a stable consumer disposition to shop under an experiential or a task-focused shopping orientation. It uses a 7-points Likert scale, ranging from *task-oriented* (lower values) to *experience-based* (higher values) shopping orientations.
- *Rational and Intuitive Decision Styles* (RDS and IDS) scale [22], which reflects the prevailing manner by which individuals make decisions. Each decision style is measured independently, hence two scores (in a 5-point Likert scale) are provided.

Following these questionnaires, a video that explains the concept and showcases the implemented prototype for Microsoft HoloLens was presented to participants[4]. After watching it, a final set of system-related questions were presented to assess the acceptance of the concept. These questions were designed to measure the constructs *perceived usefulness* and *perceive ease of use* (the two main constructs in TAM), extended with *decision-making support*, *hedonic motivation* and *intention to use*. Items regarding *social acceptance* and *privacy* were also part of it, which have been highlighted as inhibitors in the adoption of AR headsets [46].

In the following, to examine the overall acceptance of the concept and the usefulness of the AR functions provided (RQ1), the results obtained for the sample are examined as a whole. Afterwards, psychological data is used to find how different psychological traits influence the adoption of an in-store AR advisor, either individually or combined to define consumer types (RQ2).

5.3 General Results

Table 3 reports descriptive data obtained for each one of the investigated constructs and the items within them, which are relevant for determining the overall acceptance of the system and the usefulness of the combination of digital and physical elements (RQ1). *Perceived usefulness* and *decision support* received the highest scores among all the constructs, while *privacy* and *social acceptance* obtained the lowest ones. However, it has to be noted that all constructs fall into the positive side of the scale (their scores are higher than 3). Furthermore, although the construct *importance of physical items* appears in fourth position, the score for the single item *"Inspecting products will help me to make a more informed buying decision"* is among the most highly rated.

[4] The video is available on www.youtube.com/watch?v=k4nyTDQ-n7U

Table 3: Overall results for the system-related items

Constructs and items from higher to lower mean	Mean	σ	95% CI Lower	95% CI Upper
Perceived Usefulness	**4.18**	**0.84**	**3.97**	**4.39**
I find the system will be useful.	4.21	0.85	3.99	4.42
I believe that the use of Augmented Reality is beneficial in the given scenario (physical retailing).	4.16	0.90	3.93	4.39
Decision Support	**3.94**	**0.81**	**3.74**	**4.15**
I can have a better view of all the available choices with the help of the system.	4.16	0.94	3.92	4.39
The system will help me to discover new products.	4.13	0.92	3.89	4.36
By using the system, I think it will be easier to find an item that I like.	4.00	0.90	3.77	4.23
This recommender system will increase my confidence in my selection/decision.	3.98	1.04	3.72	4.25
By using the system, I think it will be easier to find an item to buy.	3.86	1.00	3.61	4.11
Using the system will help me to make a decision more quickly.	3.52	1.06	3.26	3.79
Interface Adequacy	**3.94**	**0.95**	**3.70**	**4.18**
The information provided for the recommended items will be sufficient for me to make a purchase decision.	3.94	0.95	3.70	4.18
Importance of Physical Products	**3.78**	**0.70**	**3.60**	**3.95**
Inspecting products will help me to make a more informed buying decision	4.11	0.85	3.90	4.32
Interacting with physical products will help me to understand the features of similar, digital ones.	3.89	0.81	3.69	4.09
I would use the system even if a digital catalogue were not available (the system would only recommend physically available products)	3.69	1.06	3.42	3.95
If the same catalogue is available at an online store and a physical one, I generally prefer to do the extra effort of travelling to the physical one to inspect the products by myself.	3.43	1.10	3.15	3.71
Intention to Use	**3.67**	**0.95**	**3.43**	**3.91**
Assuming I had access to the system, I would likely use it.	3.89	0.99	3.64	4.14
Being able to use the system will be a reason for choosing one store over another.	3.57	1.20	3.27	3.87
When in a physical store, I would rather use this system than a more traditional web-based recommender.	3.54	1.11	3.26	3.82
Perceived Ease of Use	**3.64**	**0.92**	**3.40**	**3.87**
Learning how to use the system will be easy for me.	3.94	1.08	3.67	4.21
I think that the interaction with the system will be clear and understandable.	3.70	1.01	3.44	3.95
I find the system will be easy to use.	3.52	1.03	3.26	3.78
Interacting with the system will be an effortless task.	3.38	1.07	3.11	3.65

Continued on next page

Constructs and items from higher to lower mean (cont.)	Mean	σ	95% CI Lower	Upper
Hedonic Motivation	**3.61**	**1.16**	**3.32**	**3.90**
Using the system will be fun.	3.71	1.18	3.42	4.01
Using the system will be entertaining.	3.51	1.19	3.21	3.81
Privacy (reversed)	**3.25**	**1.14**	**2.97**	**3.54**
I would be concerned that my data is stored and used for other purposes.	3.05	1.25	2.73	3.36
I would have privacy concerns if someone uses the glasses around me (e.g. when that person looks at me).	2.44	1.20	2.14	2.75
Social Acceptance (reversed)	**3.22**	**0.88**	**3.00**	**3.44**
Being able to share the experience with my shopping partner (e.g., we both see and interact with the same AR elements in real time) is relevant for deciding whether to use the system or not.	3.35	1.17	3.06	3.64
I would not feel comfortable using the system while other people are around.	2.64	1.24	2.32	2.95
I would find it annoying/irritating when other person uses the system nearby.	2.35	1.21	2.05	2.65

The data in Table 4 shows that that providing *comparison support* is perceived as the most important feature of the system. *Product recommendations* and *access to a digital catalogue* are close to each other, while *interaction with physical items* falls a bit behind, in the last position. These results are in line with the scores given to the constructs, where *decision support* (comparing and recommending) obtained higher ratings than *importance of physical products*.

Finally, when having to choose between using the system or being assisted by sales personnel, 21 participants stated that they would use the system only; other 29 said that they would use the system first, and ask for support if required; 10 would first ask for support, and likely use the system afterwards; and the remaining 3 would not use the system at all.

Table 4. Importance assigned by participants to each feature of the system (1-5 scale).

Feature	Mean	σ	95% CI Lower	Upper
Product comparison support	4.60	0.61	4.45	4.76
Access to product recommendations	4.33	0.78	4.14	4.53
Access to a digital catalogue	4.27	0.77	4.08	4.46
Interaction with physical products	3.94	1.03	3.68	4.20

An analysis of the Pearson's product-moment correlation between psychological traits and the questionnaire's constructs was performed to study the impact of individual personal traits on the acceptance of the system (RQ2). After the adjustment of the p-values by using the Benjamini-Hochberg procedure, only a moderately negative correlation between intuitive decision style and *social acceptance* ($r(89) = -.37, p < .05$) was found. Although the results hint at other possible correlations, they are not strong enough to be reported here.

5.4 Cluster Analysis

In order to find combinations of user characteristics that may have an effect on system acceptance (RQ2), it is first necessary to classify users into customer types, which allows the comparative analysis of their responses. In our case, this classification considers the scores that subjects obtained in TAP, CSO, RDS and IDS scales, that is: how likely they are to adopt a new technology, the way they approach shopping and how they make decisions. To this end, a two-step process was performed: first, data was classified through a hierarchical cluster analysis based on average linkage between groups, which provided information on outliers and an initial distribution of participants; second, a K-means clustering analysis was conducted to confirm the results obtained in the first step. Since the variables involved have different scales, their z-scores were used for clustering purposes.

The outcome shows that four well-distinguishable groups can be identified, although 9 out of the total of 63 participants are considered as outliers and can thus not be classified. The silhouette scores [48] for each cluster are reported in Figure 4, and the average results that each group obtained in the psychological tests are shown in Table 5. It is possible to identify what traits characterize each cluster by considering the relation between their means and the average of the sample (in the following, “group” and “cluster” are used interchangeably):

Group 1 is composed of average technology users (relative to this sample). This group is the most experiential one when it comes to shopping and has an over the average intuitive decision-making style. It is also the largest group, gathers the youngest participants and is mostly composed of females.

Group 2 includes people with higher probabilities of adopting new technology, who also see shopping as a task-oriented experience. The group presents a notable polarization between rational and intuitive decision scales: their RDS is the highest among groups, while their IDS shows the lowest value.

Group 3 has the lowest probabilities of adopting new technology: its members do not perceive it as useful, are not proficient at it and believe themselves to be very dependant and vulnerable. Consequently, they know the least about AR. They also show the lowest rational decision style score.

Group 4 has a TAP value similar to that of group 2, but its CSO, RDS and IDS scores are more moderate, and has more knowledge of AR technology than any other cluster. The average age is higher than that of the other groups and it is the only one composed predominantly of male participants.

Table 6 shows the scores obtained by cluster in each construct, which already suggests a difference in their assessment of the system. Although the ranking of the constructs is mostly maintained between groups (with perceived usefulness and decision support in the first places and privacy and social acceptance in the last), the range of scores differs: group 2 has the most positive view of the system and group 3 the most negative; group 1, on the other hand, is the most polarized (it provides some of the highest and some of the lowest scores of the sample), while, in contrast, group 4 shows a more uniform and moderate rating distribution.

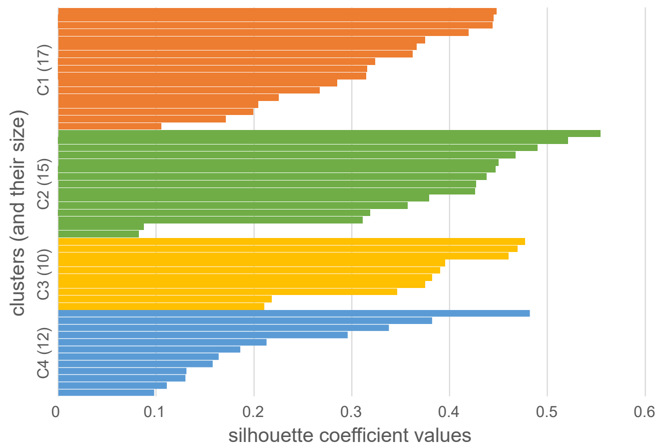

Fig. 4. Silhouette scores by clusters. Average silhouette width = 0.32.

Table 5. Psychological traits per group. From left to right: group size; percentage of females; average age; AR knowledge (on a 1-5 scale); TAP sub-scales (1-5): Optimism, Proficiency, Dependence, Vulnerability; total TAP score; Chronic Shopping Orientation (1-7); Rational and Intuitive Decision Styles (1-5); and the difference between them. Values of the psychological traits are relative to the average of the sample without outliers (last row of the table). Coloured cells identify those values where a group's mean noticeably differs from the total.

	#	Fem.	Age	AR Kno.	TAP Sub-scales Opt.	Pro.	Dep.	Vul.	TAP Score	CSO Score	RDS Score	IDS Score	RDS - IDS
G1	17	88%	28.53	-0.09	0.10	0.01	0.30	0.20	-0.39	1.23	0.05	0.58	0.72
G2	15	47%	34.53	0.09	0.06	0.35	-0.36	-0.52	1.28	-0.84	0.46	-0.91	2.63
G3	10	70%	33.70	-0.44	-0.30	-0.96	0.78	0.76	-2.80	-0.37	-0.50	0.22	0.54
G4	12	33%	37.75	0.39	0.03	0.36	-0.62	-0.27	1.29	-0.37	-0.24	0.13	0.88
		Avg.	2.44	4.27	3.68	2.95	3.60	13.40	3.58	4.25	3.00	1.25	

Table 6. Differences in the assessment of the system among user groups.

	Group 1 Mean	σ	Group 2 Mean	σ	Group 3 Mean	σ	Group 4 Mean	σ	Total Mean	σ
Perceived Usefulness*	4.44	0.58	4.43	0.65	3.75	0.79	3.83	1.03	4.18	0.80
Decision Support	4.20	0.62	4.19	0.47	3.52	0.81	3.89	0.72	4.00	0.68
Interface Adequacy	4.06	0.90	4.27	0.88	3.40	0.84	3.92	0.79	3.96	0.89
Imp. of Physical Products	4.04	0.54	3.93	0.70	3.78	0.77	3.40	0.58	3.82	0.67
Hedonic Motivation*	4.06	1.00	4.00	1.02	3.00	1.00	3.54	0.81	3.73	1.02
Intention to Use*	3.98	0.69	4.11	0.87	3.27	0.94	3.28	0.84	3.73	0.89
Perceived Ease of Use	3.72	0.96	3.88	0.60	3.23	1.10	3.71	0.80	3.67	0.87
Privacy	3.09	1.08	3.77	1.05	2.90	1.02	3.38	0.12	3.31	1.06
Social Acceptance*	2.86	0.53	3.87	0.75	2.93	0.93	3.19	0.93	3.23	0.86

**There is statistically significant difference between groups ($p < .05$)*

The analysis of the means by performing a Kruskal-Wallis test revealed statistically significant differences between clusters for *perceived usefulness*, *hedonic motivation*, *intention to use* and *social acceptance*. Subsequent Dunn-Bonferroni pairwise comparison tests reported a significant difference between groups 1-3 in terms of *hedonic motivation*, and groups 1-2, and 2-3 regarding *social acceptance* ($p < .05$ in all cases). In that regard, group 1 shows the highest *hedonic motivation* but, at the same time, it seems to be the most worried about *social acceptance*, in contrast to groups 3 (the least attracted by the system) and 2 (the least concerned about *social acceptance*). These results agree with the previously established negative correlation between intuitive decision style and *social acceptance* because, as a matter of fact, group 1 comprises the most intuitive participants. As for the remaining statistically significant constructs, post-hoc tests were not able to specify the groups for which the differences were significant, which suggests the existence of more complex relationships. Further testing of different group combinations showed that there is a statistically significant difference between the union of groups 1 and 2 and the union of groups 3 and 4 for *perceived usefulness* and *intention to use* ($p < .01$ in a Mann-Whitney U test).

Performing the same procedure over individual items of the questionnaire shows more significant differences, but most of them are in line with the test involving constructs and, therefore, are not reported here. However, some new disparities were found in relation to *decision support*, more specifically for *"This RS will increase my confidence in my selection/decision"* (between groups 1-3, $p < .05$) and *"I can have a better view of all the available choices"* (between groups 2-3, and 2-4, both $p < .05$).

Regarding what features are more important (Table 7), groups with higher TAP (2 and 4) seem to prioritize exploration-related functions (comparison and digital catalogue). On the other hand, group 3, the least technologically proficient and rational, finds product recommendations to be the most valuable feature. It also seems that the lower the TAP value is, the more importance is given to physical interaction with products.

Lastly, Table 8 shows the distribution of answers concerning users intention to use the system when sales personnel is also available. The responses are consistent with each group's assessment of the system. Interestingly, it is in group 4 (the one with the highest knowledge about AR) where, given the chance to use the system, one of its members would choose not to do so.

Table 7. Importance assigned by groups to each feature of the system (1-5 scale, 'R' is for rank).

	Group 1			Group 2			Group 3			Group 4		
Feature	m	σ	R	m	σ	R	m	σ	R	m	σ	R
Product comparison	4.59	0.51	1	4.73	0.46	1	4.40	0.70	2	4.67	0.65	1
Product recommendations	4.53	0.51	2	4.07	0.88	3	4.60	0.96	1	4.25	0.75	3
Digital catalogue	4.18	0.64	3	4.20	0.77	2	4.20	0.92	3	4.33	0.78	2
Int. with physical products	4.12	0.86	4	4.00	1.25	4	4.20	0.79	3	3.42	0.90	4

Table 8. Intention to use the system by group.

If I need support and the system is available...	G1	G2	G3	G4
... I would use it to find what I need.	6	7	1	4
... I would use the system and ask for assistance only in case of doubt.	9	8	4	5
... I would first ask for assistance and likely use the system afterwards.	2	0	5	2
... I would prefer to receive assistance from sales personnel only.	0	0	0	1

5.5 Discussion

In relation to the usefulness of the hybrid physical-digital approach (RQ1), the feedback received on the AR-based shopping advisor can generally be considered positive. While it was not possible to assess the prototype against a baseline due to the lack of a system with comparable functionality, the scores received for the different functions and interaction methods are all in the positive range. The constructs *perceived usefulness* (considered one of the main drivers of user acceptance in conjunction with *perceived ease of use*) and *decision support* received particularly high ratings. Although interacting with physical products is overshadowed by the other features, it is still regarded as helpful to make a more informed buying decision.

As for the impact of the traits investigated here (RQ2), none of them appear to fully determine the acceptance of in-store AR-based advisors. In some cases, participants with apparently opposing psychological profiles seem to coincide in their assessment of the system. For instance, both persons with a heavily task-oriented CSO and a rational DS and those with an experiential CSO and an intuitive DS are more likely to perceive the system as useful and to use it. In contrast, those with a low TAP score who also have little knowledge about AR and those with a high TAP score and knowledgeable in AR technology are less inclined to its usage. However, their reasons for accepting or rejecting the system may as well be very different: perhaps they see a practical value in it, or think that it may offer an enjoyable experience; maybe they simply do not like technology in general or, if they do, they have had a higher exposure to AR already, in a way that they are less impressed by its novelty and more aware of its current limitations. In general terms, a lower TAP score appears to be the better predictor of the rejection of the system, but average to high TAP scores seem to be moderated by previous experience with AR technology. This may be a reflection of how quickly the novelty of AR fades away [25] and the difficulty of finding reasons to use it on a regular basis instead of a more traditional method [26]. Finally, a prominent experiential CSO and an intuitive DS seem to lead to a good acceptance of the concept too, although overexposure to AR could have the same moderating effect as with high TAP values.

The outcome of the study also indicates that rejection of the system due to privacy or social acceptance concerns is more likely to happen on subjects with higher intuitive decision styles and lower TAP scores. In spite of that, it must be noted that these worries were present in all groups to a certain degree. This finding agrees with previous research on the topic where privacy and social acceptance are identified as challenges in the adoption of AR [56, 46]. Some participants left comments where they defined the glasses as *"too creepy"* or would express their fear to *"be pick-pocketed or robbed when not on guard"*. These worries are mostly related to 1) the insecurity of not knowing what operations are being performed when other person is wearing the glasses and 2) the vulnerability derived from having a reduced view of the surroundings and few control over the collected data when the client is the one wearing them. It seems that there is a need for finding less obtrusive solutions for AR glasses as well as to make sure that users know and understand their capabilities and how their personal data is going to be treated. Additionally, some time is still required until wearing such devices in public is more socially acceptable, factor that seems to affect to a greater extent to people with an intuitive decision style. In the meantime, other ways for alleviating this issue could be explored, like more natural interaction methods that do not involve unusual gestures (as "air tapping" could be considered) or that help to better discern the wearer's intentions, so that other people around are more aware of them and less worried.

Some participants were also troubled about the trustworthiness of the recommendations and whether they could be biased towards the store's particular interests. Making clear the source of the provided information and its neutrality may be another relevant factor to increase the acceptance of applications like the one presented here.

What do these results mean for physical stores? Current AR technology is still young and well under development. Challenges in terms of social acceptance and privacy concerns can be expected to be overcome the more mature and available the technology becomes. As of today, however, it may be difficult to find a selling point to convince those users preoccupied for such matters, which stresses the importance of increasing customer awareness of privacy regulations and device capabilities. Nonetheless, AR is able already, at its current state, to provide a number of useful in-store functions, and there seems to be a great portion of consumers who are willing to try them. Stores may contribute in developing the potential of AR in physical retailing, while also making profit from it, by focusing on attracting these types of clients: those who enjoy shopping and those who find AR technology to be useful. That means developing applications and designing settings that contribute to an improved shopping experience and offer utilitarian benefits. Precisely this last part, focusing on the practical side of AR, may be a crucial factor in drawing the interest of those who have used AR in the past and no longer feel the so-called "wow" effect. Due to the current limitations of AR, it would be necessary to create specialized areas with different set-ups, more appropriate for experimenting and learning about products. In that regard, systems like the one here described may be more suitable for event-like shopping scenarios (such as trade fairs) where customer experience in a special setting is of the highest importance.

Limitations Participants only watched a video of the system and were not able to test the prototype by themselves nor had access to the physical products; thus, they were not able to experience the "physical side" of the approach, perhaps the hardest part to imagine in conjunction with the other features of the system. Besides, participants were recruited through an online platform, which increases the probabilities for them to be more proficient in the use of technology and to have more trust on it than the average of the population. These factors may have had an impact on the assessment of the acceptance of the approach. There is also a probability of finding new types of customers if a bigger sample is used. In the same manner, the measurement of different psychological traits than the ones proposed here could uncover other still unknown relationships between them and the acceptance of the concept. Finally, few differences found between groups were actually statistically significant. However, considering the exploratory nature of this study, the observed results strongly suggest that such differences may indeed exist and offer a starting point for further research on the topic.

6 Conclusions

Related work on the topic of in-store AR acceptance has mainly focused on the independent assessment of technological, psychological and environmental factors. However, it is generally overlooked that connections between these aspects may exist that could be used to obtain a better understanding of how different types of clients accept the technology and what the obstacles are. To that end, this paper presents an exploratory study that investigates the interactions between a set of decision-making-related traits and their effects on the acceptance of an in-store AR advisor that runs on a head-mounted display.

Personal characteristics were defined by the Technology Adoption Propensity (TAP) [45], Chronic Shopping Orientation (CSO) [12] and Decision Styles (irrational, IDS, and rational, RDS) [22]. Using them to group participants uncovers the existence of four types of users within the sample, and a further analysis suggest differences between them in the acceptance of the system. There is an indication that technology-related aspects are not entirely responsible for defining AR acceptance, but that other factors are involved as well (and even negate the effects of high TAP scores). Overall results show that the approach is generally well-received, but users with low TAP scores are less convinced about its benefits and, thus, are less likely to make use of it. Both persons who know and trust technology (high TAP) and those who are experiential shoppers (high CSO) seem to be related to higher acceptance values. However, AR knowledge above the average seems to have a moderating effect on high TAP values. The most relevant issues to overcome involve concerns about privacy and social acceptance, opinion that is shared by all groups. Nevertheless, an intuitive decision style seems to be correlated with greater worries about the social acceptance of the approach.

The results indicate the existence of some psychological traits that have an impact on the acceptance of an AR-based in-store advisor and that relationships between them exist. Some of these relationships are revealed here, which may provide a deeper insight into how the concept could be introduced as a new in-store service by focusing on specific types of clients and making sure to cover privacy-related concerns. Nonetheless, further technology-dependant advances are still required in terms of intrusiveness for the approach to be more socially acceptable.

Future research should focus on discovering other underlying factors and on how to use them in both the improvement of the system to adapt to the specific needs of targeted consumer-types, and its successful introduction in real shopping environments.

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