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Thesis

Combining Mass Customization and Augmented Reality and its effect on customer purchase intention: an online experiment.

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Preface

This Master Thesis is written in order to complete my Master of Business Administration at the University of Twente.

The topic for this study is chosen because of the strong relation with my co-founded startup, named Cadchy. This is a webshop that sells customized metal wall art. I saw this research as an opportunity to gain relevant knowledge about Mass Customization, Augmented Reality and Purchase Behavior.

I hereby want to thank everyone that contributed to my research. I would like to express my gratitude to my supervisors. Starting with my 1st supervisor Ir. E.J. Sempel for providing valuable in-depth feedback multiple times during this study. Also my 2nd supervisor, Dr. Ir. D. Lutters, for the suggestion to do an experiment and providing me with expert knowledge about the topic. In addition, I would like to thank the company Expivi for providing me access to their software to build a product configurator. Menno Meijer, Ben Spaninks and Tom van der Wielen were a real help on several aspects during the study. Also I want to thank my companion Pim Borgerink and his company Vorm&Vorm for providing help regarding technical issues for setting up the experiment. Lastly, I would like to thank my family, friends and girlfriend for being supportive throughout the study.

Denekamp, 2021

Dennis Mensink

Abstract

Fundamental to further growth of the e-commerce market is the improvement of the online customer experience. Two trends that contribute to this are product customization to better fit customer needs at prices of mass-produced items (Mass Customization (MC)) and product visualization to support a customer during decision-making (Augmented Reality (AR)). This study investigates how combining the two will affect customers' purchase intention. An online experiment is organized in which participants go through a virtual buying process where they customize their piece of metal wall art in terms of size, material and color. About half of the 103 participants had access to Augmented Reality to evaluate their creation. Quantitative data is collected through surveying in which participants express themselves in terms of perceived value and purchase intention. The results indicate that the availability of AR results in more convenience, more pleasure and a higher purchase intention. It is concluded that the current state of WebAR provides value to its users during the customization process, although there is more to be gained by improving visual quality. Whereas the current quality of an AR model is good enough for determining product size, the evaluation of material and color are not sufficiently supported yet. However, customers' purchase intention is already positively affected with the presence of AR. The technology will absolutely improve the coming years which stresses the importance for (mass) customization companies to start with the development of an AR driven strategy or at least start experimenting with AR.

Contents

Introduction

Background

The motivation for this study is the result of a strong personal drive combined with current developments in e-commerce and supportive technologies. The personal drive is rooted in plans to start an online business named 'Cadchy' which sells metal wall art. These pieces of wall art are shaped by laser cutting them out of 3mm steel, stainless steel or Corten steel. Through a web shop configurator, customers are provided with tools to customize their wall art (e.g. material, color, size). These are high-involvement products, which means that they require consideration and deliberation before buying. Selling these products successfully through e-commerce, requires the webshop to be better than a bricks and mortar store.

Fundamental technologies like the personal computer, the Internet and an online payment infrastructure were crucial for e-commerce to exist and grow. E-commerce is settled in current society but keeps on growing. Hence, E-commerce is expected to grow globally at least till 2025 with an annual rate of 10% on average (Statista, 2020). This growth is accelerated by the COVID-19 pandemic, which especially boosted revenues for the segments food and personal care (Statista, 2020). High-involvement products, however, tend to lag behind in e-commerce adoption. According to Pantano, Rese and Baier (2017) this could be due to the absence of several aspects. They stated that *"The lack of direct experience in touching, feeling, smelling and trying on an item makes the evaluation difficult and may negatively affect enjoyment and the purchase decision (p. 81)".* Therefore, the development and implementation of technologies to improve the online customer experience are essential for further growth of the e-commerce market.

Augmented Reality (AR) is such a technology. AR is an interactive technology that simulates products in the real world and compensates for the lack of experiential information in online shopping (Baytar, Chung & Shin, 2016). AR differs from Virtual Reality due to grounding visual information in the physical world, whereas Virtual Reality does not. Mixed reality is a more recent technology that combines aspects from both Augmented and Virtual reality, which allows visual information to interact with the environment (Brigham, 2017). The customer experience created by AR improves customers' decision comfort and supports customers who find trouble in visualizing products (Hilken, Ruyter, Chylinski, Mahr & Keeling, 2017).

Another technology-based trend which improves online buying experiences is Mass Customization (MC). MC is a business strategy that enables customers to modify attributes of a product to better fit their needs at prices that reflect efficiencies of a mass produced item (Squire, Readman, Brown & Bessant, 2004). A study conducted by Franke, Schreier and Kaiser (2010) provides experimental evidence that this so called 'I designed it myself'-effect creates economic value for the customer. However, customers may find it challenging to design a product that fits personal needs. Therefore Randall, Terwiesch and Ulrich (2005) stretch the importance of companies developing user interfaces that *"are effective in supporting consumers in the user design process (p. 251)".* Customized products are unique in nature and therefore examples cannot be provided before the product is manufactured. According to Randall et al. (2005) this makes it difficult for consumers to anticipate post-purchase experience. Rich illustrations of the product and prototypes should be provided in order to improve the customers trust towards a product, and avoid surprises after delivery. AR has the potential to play a role in this current shortcoming, which stresses the importance of the research objective.

Research objective

The objective of this research is to investigate the *customers*' purchase intention if AR and MC are combined. MC itself already delivers a higher perceived value compared to a standard product catalogue (Aurélie, Chandon, Roux & Alizon, 2010). However, it is hypothesized that AR will strengthen the perceived value of MC even more, resulting in a higher purchase intention. During this study the term 'customer' is related to the end-user, thus business to consumer (B2C). New knowledge on this domain can stimulate further e-commerce growth, especially for high-involvement products. It appears that literature on AR and MC separately is extensive, but only little is known about the combination of both. This is confirmed by Turner and Welch (2019) who explored the potential influence of AR on customer's perception of value in the MC process. Therefore, this study will contribute to the literature by combining knowledge of AR and MC with regard to customers' purchase intention. The central research question is:

"What is the effect on customers' purchase intention if Mass Customization and Augmented Reality are combined when buying wall art online?"

For guidance during the research, extra sub-questions are defined. These are:

1. *Which factors determine customers' online purchase intention?*
2. *How is mass customization related to purchase intention?*
3. *How is Augmented Reality related to purchase intention?*
4. *How are mass customization and Augmented Reality related to each other?*

First the theoretical background is developed. A structured analysis of existing literature takes place in which variables that define purchase intention are investigated on how they relate to MC and AR. The goal is to find overlapping dimensions in which MC and AR could potentially strengthen or weaken each other. Based on this the hypotheses are defined, which will help answer the research question. This is followed by the research methodology which explains how data will be collected and analyzed. The research strategy as part of the methodology will be inspired by existing studies and literature on research methods in business. The complete methodology chapter gives the reader a full picture of how the study is conducted with enough details that the study could be replicated. Further, results are presented followed by the discussion and conclusion. The report is completed with limitations, recommendations for future research and managerial implications.

Literature review

Defining purchase intention

Online customer behavior is different compared to customer behavior in a bricks and mortar store. Where customers' in an offline store can directly feel, touch and smell a product, an online store needs to compensate for this. In order to understand how online customer behavior works, Pavlou and Fygenson (2006) extended the 'Theory of Planned Behavior (TPB)' model to explain and predict e-commerce adoption (Figure 1). Ajzen (1991) developed the TPB model in 1975 and describes the process as follows: *"Intentions to perform behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived behavioral control; and these intentions, together with perceptions of behavioral control, account for considerable variance in actual behavior (p. 179)"*. To put it simply, TPB implies that behavioral intention (purchase intention) is the most influential predictor of behavior (actually buying a product).

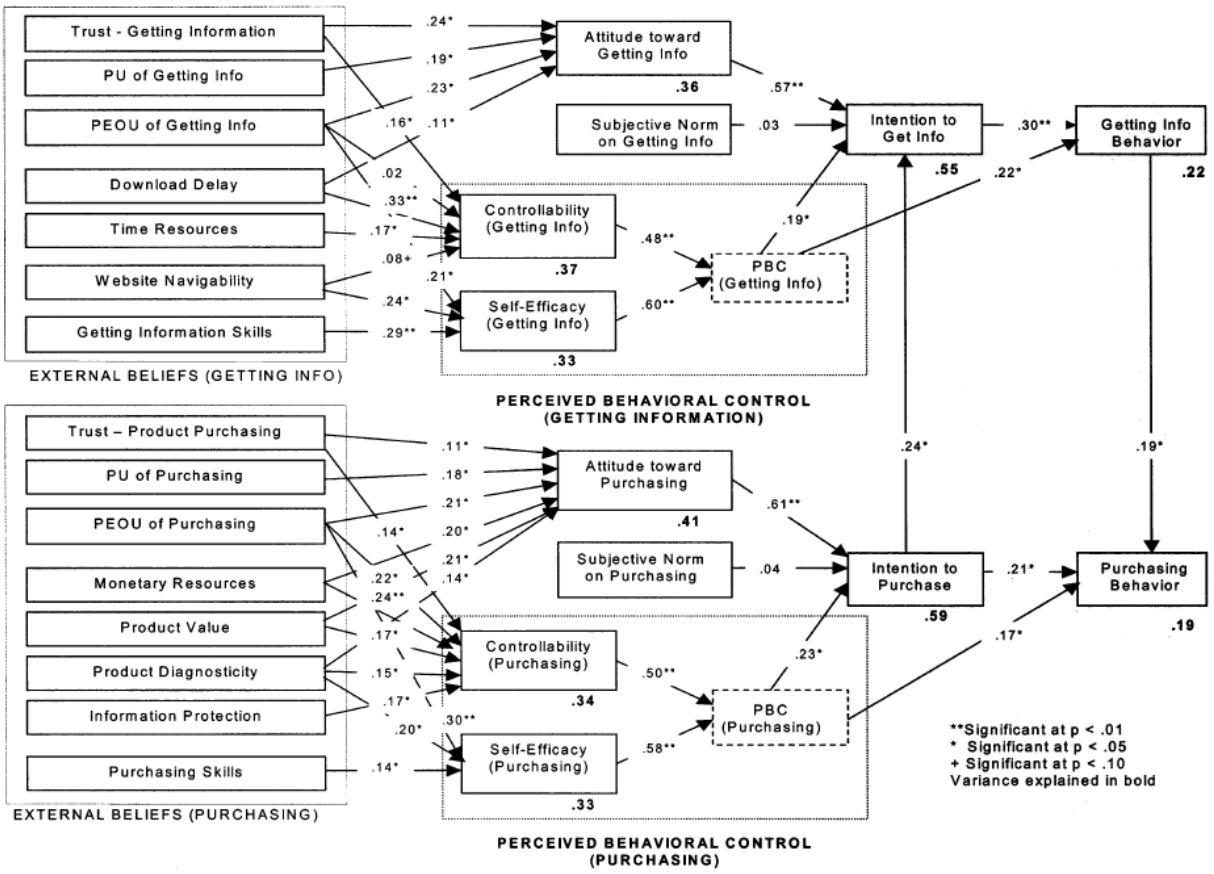


Figure 1 Extended TPB model (Pavlou and Fygenson, 2006)

Pavlou and Fygenson (2006) extended the model for the prediction of e-commerce adoption by capturing the process through two online customer behaviors; getting information and purchasing a product from a web vendor. They found that trust and technology adoption variables (e.g. perceived usefulness and ease of use defined by Davis (1989)) are core beliefs for the adoption of e-commerce. This justifies the integration of trust and technology adoption variables within the TPB framework. In addition a set of technological characteristics (website navigability, download delay and information protection) add to the predictive and explanatory power of the model. Although the extended TPB model is developed during the early days of e-commerce, the variables that play a role are as relevant today with further (technical) development of the online experience. While researching MC and AR in

relation to the extended TPB model, the variables trust, technology adoption and information protection are considered since they affect the purchase intention one way or another. Their effect on purchase intention is now further investigated.

Variables

The first variable that is often found in literature related to purchase intention is trust. Luhmann (1979) composed the following definition: *"Trust is the belief that the trustee will act cooperatively to fulfill the trustor's expectations without exploiting its vulnerabilities".* It is viewed as a three-dimensional construct consisting of the elements competence, integrity and benevolence (Schurr and Ozanne, 1985; Rotter, 1971; Gefen, 2002). Competence is the belief in the ability of the trustee to perform as expected, integrity is the belief in honesty and promise-keeping, benevolence is the belief of not acting opportunistically although the trustee is given the chance. In the cited research above, trust was usually studied during an ongoing interpersonal interaction with an organization over time. It is indeed the case that trust is built through extensive ongoing interactions that enable customers to create reliable expectations (Gefen, 2004). This social aspect of trust is an important characteristic, since the lack of interpersonal interaction is typical for e-commerce. Gefen (2004) researched the effect of social presence on a website on e-trust and in turn purchase intention. He concluded that integrity and predictability are the most important antecedents of purchase intention and social presence significantly affects integrity, predictability and benevolence. Trust is acknowledged as a more robust predictor of purchase intention compared to technology adoption (Kim, 2012). However, the study conducted by Kim (2012) shows that also TAM constructs significantly affect the first purchase intention, which is explained next.

The second variable that might be more closely related to MC and AR is technology adoption. Customers of course need to be willing and able to make use of available technologies during their buying process. Kim (2012) implies that e-vendors should consider acceptance factors in online shopping systems next to initial trust building. These aspects of technology acceptance can be predicted through indicators like 'Perceived Usefulness (PU)' and 'Perceived Ease of Use (PEOU)' which are part of the Technology Acceptance Model (TAM) (Davis, 1989). PU of a system explains to what extend a person believes that it would enhance his or her job performance. A systems' PEOU refers to the degree to which a person beliefs that the use of a system would be free of effort. Cited from Davis (1989): *"all else being equal, we claim, an application perceived to be easier to use than another is more likely to be accepted by users (p. 320)".* Although PU and PEOU are reliable predictors of purchase intention, they are not useful if information protection is not guaranteed.

The third variable that plays a role in the extended TPB model and is related to MC and AR is information protection. It is defined as the customers' belief that the e-vendor is capable of safeguarding personal information from privacy and security breaches (Pavlou and Fygenson, 2006). Once customers are comfortable with and convinced of the e-vendors' abilities on this domain, psychological barriers to purchase are overcome. Information security and privacy have been termed obstacles for e-commerce. During the early days, but still relevant today, concerns about information protection have made customers skeptical about buying online (George, 2002). The three variables discussed here are relevant for both MC and AR separately. Although trust is more related to the overall appearance of the e-vendor, technology adoption variables and information protection are directly related to MC and AR. However, these constructs are not overlapping or hypothetically strengthening each other. During further literature research there appears to be another construct that covers the effect on purchase intention.

Antecedents of purchase intention are not only those proposed characteristics of the (extended) TPB model but also customers' perceived value (Overby, 2006; Chang & Wildt, 1994; Chiu, Wang, Fang & Huang, 2014). Customers' perceived value is an assessment of a products utility based on perceptions of what is received and what is given. The perceived value is higher once sacrifices made by the customer are estimated to be of lower value compared to what is expected to be received in return (Zeithaml, 1988). This is in line with the Means End Chain (MEC) theory which attempts to connect consumer value to behavior (Gutman, 1997). The basic aspect is that consumers act in a way that produces desired outcomes and reduces undesired outcomes. Once customers learn which acts lead to desired outcomes (benefits), their behavior acts accordingly (purchasing products). Researching customers' perceived value is complex, since perceived value is a personal assessment for every individual. However, perceived value in online shopping can be measured through two overall first order constructs, which are *utilitarian* and *hedonic* value (Overby, 2006).

Utilitarian value rises from the trade-off between benefits and sacrifices entailed with the buying decision (Squire et al., 2004). Childers, Carr, Peck and Carson (2001) explained it like this: *"In the utilitarian view, consumers are concerned with purchasing products in an efficient and timely manner to achieve their goals with a minimum of irritation (p. 513)".* Online shopping in itself already has several utilitarian (or functional) benefits. Chiu, Wang, Fang and Huan (2014) summarized these benefits. For example showing the total set of the items offered, providing detailed information, being easier aware of promotions and sales and saving time and effort by shopping online at any time of the day. *Hedonic value* can be defined as an overall judgment of experiential benefits and sacrifices such as entertainment and escapism (Overby, 2006). Not only task completion is a driver of customers' shopping behavior but also the appreciation of the experience (e.g. friends taking a day off to go shopping). The roots of this behavior are entangled in the current movement of society towards an 'experience economy' (Pine & Gilmore, 1999). Whereas in-store shopping literature recognized hedonic value already in the seventies, research stressed the importance of this dimension in online shopping during the late nineties (Darden and Reynolds, 1971; Burke, 1999). Based on the above, it appears that perceived value affects customers' purchase intention. Next to that perceived value can be measured through constructs like utilitarian value and hedonic value. Tue to the fact that perceived value and purchase intention can be measured, the first hypothesis suitable for this research is the following:

H1: *There is a positive correlation between Perceived Value and Purchase Intention.*

In the following sections the topics MC and AR are further investigated. For the purpose of this study it is relevant to understand how both topics provide value to customers and where these constructs of value overlap with each other.

Mass Customization

MC is defined as mitigating and ideally eliminating the trade-offs between customization and other operational performance dimensions (Pine, 1993). This means the concept not only considers the companies' interface towards the customer, which usually consists of a product configurator or MC toolkit, but also internal manufacturing capabilities and the ability to process varying orders. The definition of MC can only be applied if the customized product reflects price efficiencies of mass produced items. Manufacturers are required to apply standardized production processes for every produced item to reach these efficiencies (Haug, Ladeby & Edwards, 2009). If this is not the case, the

term Engineering to Order (ETO) is more suitable to use. The wall art products on which this study is build, are termed MC since laser cutting three types of material can be standardized. Next to that the customization architecture is closed, which allows for standardized CNC production files (for different designs and sizes). Hypothetically even an open architecture in which customers numerically add dimensions to their customized wall art could be standardized through software that generates production files automatically. In this research only the customer interface is considered, and to be more specific, customers' perceived value in the use of online MC toolkits.

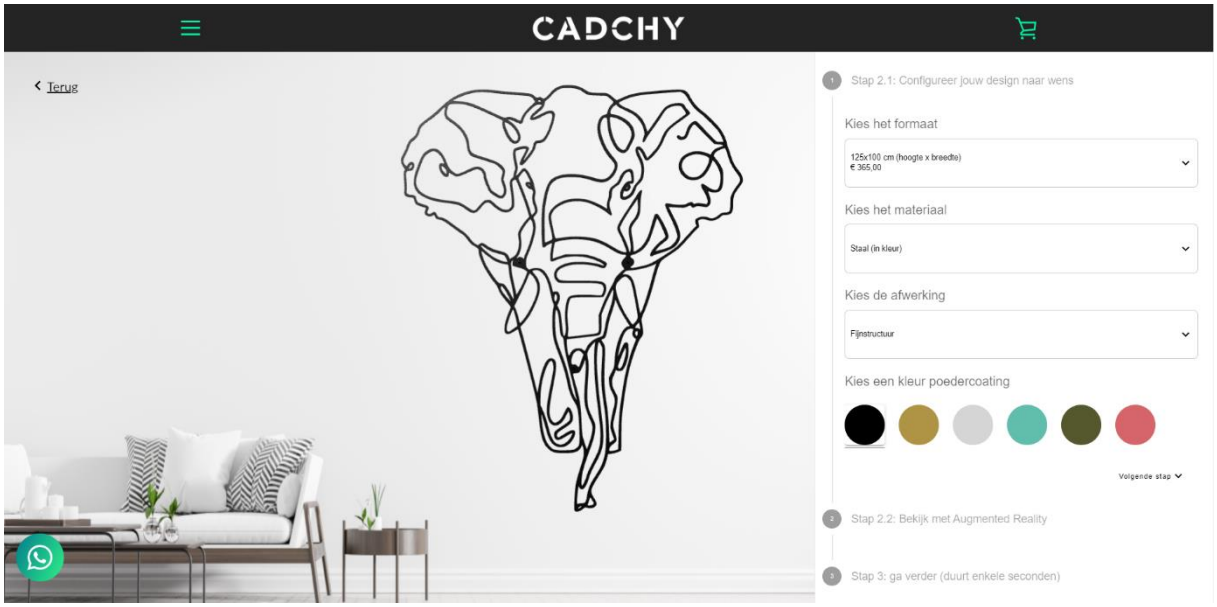


Figure 2 MC toolkit or 3D product configurator

Customers exhibit a higher preference fit once product features that can be manipulated are of significant relevance to the customer. According to Franke and Von Hippel (2003) such products generate for this reason a superior perceived value. Schreier (2006) elaborates on this by identifying four dimensions of the value composition. First the mentioned functional benefit, which considers the better fit between product characteristics and individual needs. Second dimension is the perceived uniqueness that comes with self-designed products. Third, the process benefit which is also described as the hedonic value of 'doing it oneself'. Fourth is the effect of taking pride in self-designing the product. These four dimensions positively affect customers' perceived value. In contrast however, Zipkin (2001) argues that customers often find trouble identifying their own needs which in turn results in customers being overwhelmed by too many options. A well designed toolkit or product configurator provides guidance during these elicitation processes (figure 2), although customers may experience complexity issues during the process. In contrast Dellaert and Stremersch (2005) argue that more product features to be manipulated not significantly increase perceived complexity but they do allow users to achieve higher product utility. These contradictions in defining customers' perceived value are explained with the study of Zeithaml (1988), he argues: *"Perceived value is the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given (p. 14)".* The received and given value differs among consumers and is personal in nature. For customers the given value could for example be money, time or effort whereas received value could be volume, high quality or convenience.

CPVT

In order to specifically illustrate customers' perceived value in MC, Aurélie, Chandon, Roux and Alizon (2010) proposed a market-oriented instrument: the Customer Perceived Value Tool (CPVT). The tool identifies sources of value from a customers' point of view. Drawn from their theory foundation, Aurélie et al. (2010) labelled five perceived benefits of MC which are shown in Figure 3. These benefits are both related to the product as well as the co-design process. Based on Figure 3, *utilitarian value* and *hedonic value* will be further examined in the following paragraphs. It is hypothesized based on

Perceived benefit	Definition
Mass-customized product value	
Utilitarian value	Value acquired from the closeness of fit between product characteristics and individual preferences
Uniqueness value	Value acquired from the opportunity to assert personal uniqueness using the customized product
Self-expressiveness value	Value derived from the opportunity to possess a product that is a reflection of personality
Codesign process value*	
Hedonic value	Value acquired from the experience's capacity to meet needs related to enjoyment, fun, or pleasure
Creative achievement value	Value acquired from the feeling of accomplishment related to the creative task of codesigning

*For mass customization strategies that imply an elicitation process using a configuration tool.

Figure 3 The five perceived benefits of mass customization from a customer viewpoint (Aurelie et al., 2010)

literature exploration activities that these sources of value will also be found within the use of AR, whereas uniqueness, self-expressiveness and creative achievement are not. In addition it appears that *utilitarian* and *hedonic value* are the most universal dimensions of perceived value (Overby & Lee, 2006; Bauer, Falk & Hammerschmidt, 2006; Babin, Lee, Kim & Griffin, 2005).

The utilitarian value of MC is related to the product outcome, in which both the aesthetic fit and functional fit are integrated. The aesthetic and functional fit are the main arguments in favor of MC (Dellaert & Stremersch, 2005; Von Hippel, 2001; Schreier, 2006). The value is derived from the increase in utility a customer derives from the individualized product compared to the best standard product available. For example, consider being able to numerically define the size of a wall art design which is intended to be hanged on a small piece of empty wall between two windows. One could imagine that the functional fit is optimal by determining the dimensions yourself instead of choosing between a limited amount of standard sizes. The power of MC is related to the fact that the customer is the only one being able to define which product features will provide maximum value, in this case the size of a piece of wall decoration. Whereas this utilitarian value is related to the product outcome, the hedonic value dimension is process related.

Fiore, Lee and Kunz (2002) empirically investigated the relation between the willingness to use an MC toolkit and wanting to have an exciting experience in fashion retail, which is the hedonic value. Their conclusion supports this link, promoting the relevance of MC to generate hedonic value for customers. Therefore they argue: *"To effectively market co-design, one should stress both the resulting unique*

product and the experience of the co-design process (p. 845)". Shih (1998) concluded that advanced technology features like visualization software in the co-design process might not only enrich the experience but also ensure customer satisfaction with the resulting product. This is where AR comes into sight, which basically is a form of visualization software. To effectively market co-design and specifically enhance the co-design experience, AR is the technology with potential. To confirm this, AR will now be further researched.

Augmented Reality

AR applies several technologies for combining virtual information (e.g. text, images, 3D models, music or video) with the real world. Technologies like multimedia, 3D-modelling, real-time tracking, intelligent interaction and sensing are used for the real world enrichment (Chen, Wang, Chen, Song, Tang, & Tian, 2019). AR has received much attention by renowned research institutions and universities, which resulted in many papers and scientific results. As a consequence of improving computing power and computer software and hardware, AR has shifted (and continues shifting) from a theoretical research stage to the stage of mass and industry application.

Examples of AR implementation are therefore more and more available. Ikea's mobile app has integrated AR features which allows users to place furniture in their intended environment and Dutch E-commerce platform Coolblue lets customers hang a tv on their wall through AR in order to estimate the correct size. Tim Cook, CEO of Apple, states that AR will change the complete experience of how customers shop (Bloomberg, 2017). Apple refers to AR as a core technology and proceeds an AR driven acquisition strategy. Seamlessly merging the online and offline customer experiences is what the unique set of smart technologies that form AR promises (Marinova, de Ruyter, Huang, Meuter & Challagalla, 2015). However, Gartner (2017) and Dacko (2016) argue that AR will only deliver value if firms prioritize customer needs and reduce decision-making uncertainty. AR provides customer value through different dimensions, which are further investigated hereafter.

A synthesis of current research on AR in customer experiences is found in a study conducted by Hilken, Heller, Chylinski, Keeling, Mahr and Ruyter (2018). They explored the current and future roles of AR as an enabler of omnichannel experiences across the customer journey. Through extensive literature research they came up with a model that explains how AR variables are related to customer experience variables, shown in Figure 4 . It appears that the evaluation of an AR experience takes place through, among others, the same constructs as an MC experience. These are utilitarian and hedonic value, which are the most universal dimensions of perceived value (Overby & Lee, 2006; Bauer, Falk & Hammerschmidt, 2006; Babin, Lee, Kim & Griffin, 2005).

Therefore, this research focusses specifically on *utilitarian and hedonic value*. Research suggests that the use of AR in retail enhances customers' perceptions of both these values (Poushneh & Vasquesz-Parraga, 2017; Huang & Liao, 2015). The visually appealing experience provides excitement and joy of the online offering. In addition, the aesthetic and functional fit can be evaluated and relevant information is provided directly, embedded into the personal environment. Consider the previously used example of the intention to hang a piece of wall art on a wall between two windows. A customer can choose an appealing design and color (aesthetic fit) and immediately check for the correct size while visualizing the product through AR (functional fit). This excludes the step of using

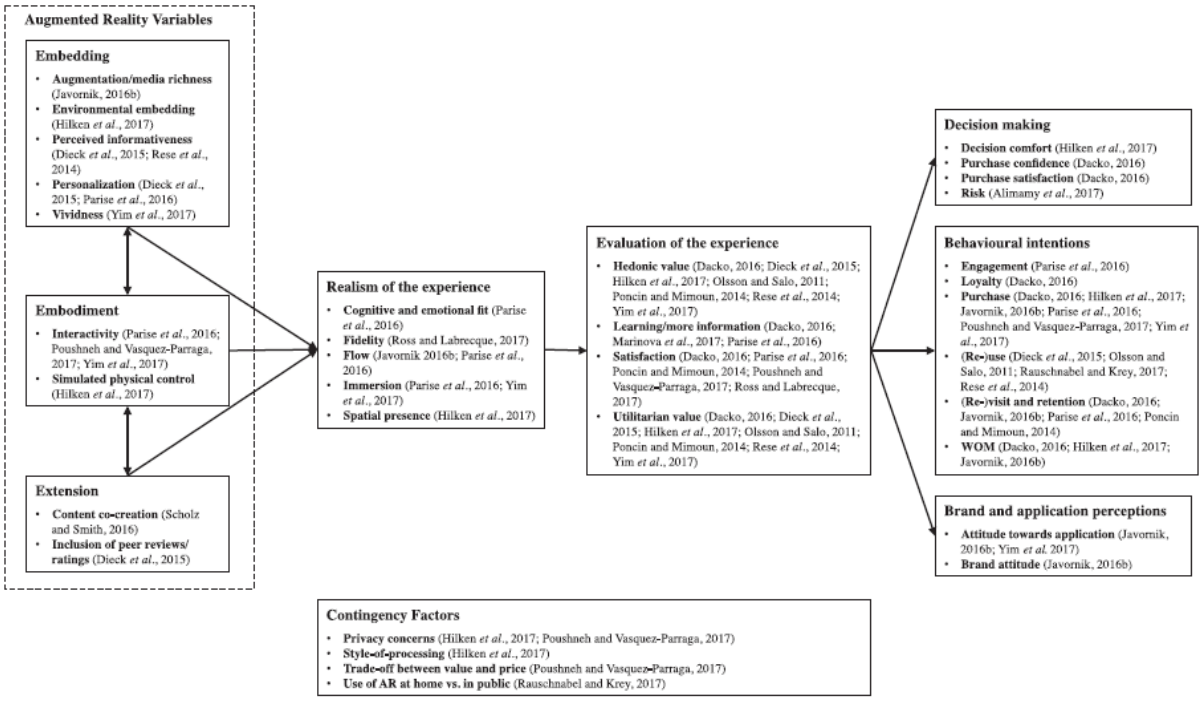


Figure 4 Synthesis of current AR research (Hilken et al., 2018)

measuring tape for determining the correct size. This specific example illustrates how AR can strengthen the effect of MC on perceived value. Furthermore the customer could take a snapshot and share it with friends which results in a boost in social value, which is another important variable that affects purchase intention (Gan & Wang, 2014). The process of social interaction and sharing increases perceived social value such as recognition from others, which in turn results in more satisfaction towards the website and a higher purchase intention. Hypothetically this could also explain the popularity of Snapchat filters, especially among younger generations.

The *utilitarian value* related to the use of AR is explained by its fit with the 'situated mode of cognition' which customers prefer in physical shopping experiences. Hilken et al. (2017) investigated this perspective and argue that it can be explained by the conjunction of environmental embedding and a sense of embodiment. The following is cited from their study: *"customers' information processing is embedded in their physical environment and embodied through physical simulations and actions. That is, situated cognition enables customers to learn more about the value of an offering when the associated service experience enables them to link abstract facts with real-time context and physical interaction"*. They conducted four studies in which they prove that customer value perceptions are enhanced by simultaneously providing simulated physical control (e.g. moving your head while fitting virtual sunglasses, the sunglasses move consequently) and environmental embedding. Their results show that 'verbalizers' derive a higher utilitarian value from AR compared to 'visualizers'. Thus, the effectiveness of providing AR service online is higher for customers who lack visualization skills. Interestingly it appears that 'visualizers' might even rely more on their own mental imagery which decreases the utilitarian value derived from AR. This is in line with earlier research from Childers, Houston and Heckler (1985) which argue that the effectiveness of visual representations of products depends on individual preferences regarding verbal or visual information processing. Hilken et al. (2018) argue in addition the relevance of allowing the customer experience to be 'extended'. This is related to customers' often relying on others during the evaluation of a product or service. The first

examples of AR facilitating omnichannel experiences are already commercially applied. Akzo Nobel's 'Visualizer' app allows users to artificially paint their wall after which they can share it on social media. Peers can modify colors and provide recommendations which stimulates customer co-creation experiences and results in deeper interaction with peers instead of being limited to liking or commenting on someone's post (Hilken et al., 2018).

Where *utilitarian* motivated shoppers are mission or task oriented, *hedonically* oriented shoppers are concerned with the entertainment and sensory stimulation aspects of shopping. Therefore hedonic customers are more likely to engage in interactive shopping features like AR (Arnold & Reynolds, 2003; Chang, Eckman & Yan, 2011). An experimental study conducted by Watson, Alexander and Salavati (2018) demonstrates that an AR retail application positively impacts the purchase intention. This effect is mediated by a positive affective response (sensation, emotions, sentiments). Furthermore, they showed that the hedonic shopping motivation moderates the relationship between the presence of AR and the positive affective response. Hence, providing AR solutions to customers will especially lead to higher purchase intentions once these customers are hedonically motivated. However, Watson et al. (2018) found that customers with low hedonic motivation also experienced a higher positive affective response resulting in a higher purchase intention. This is in line with Javornik (2016b), she argues that the customer experience with AR might be more hedonic than utilitarian assuming that the affective (emotional) component plays a stronger role than the cognitive (intellectual) component.

Relation MC and AR

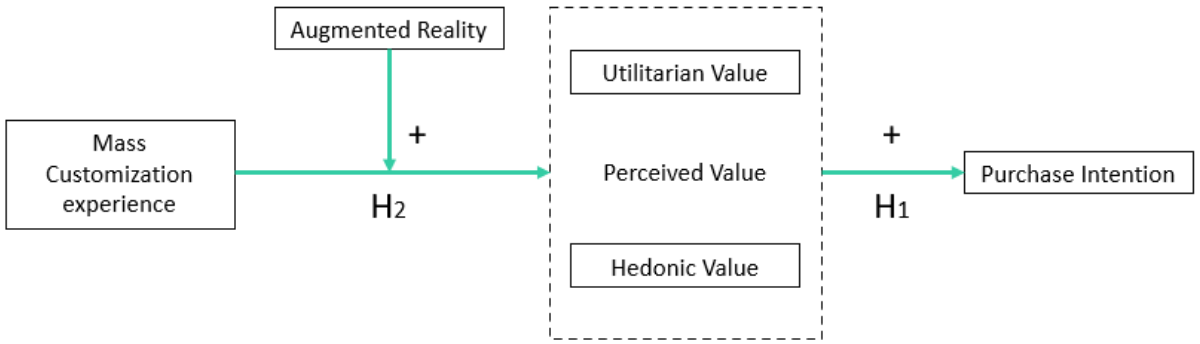
Literature that covers both MC and AR is limited, especially in relation to the customer experience. Turner and Welch (2019) are the first ones exploring the potential influence of a Mixed Reality toolkit on customers' perceived value of a MC co-design experience. A Mixed Reality toolkit covers both VR and AR, although they consider AR as the best option due to its grounding in the personal environment. In their study they mention the likeliness of AR enhancing the MC co-design experience by enabling creativity. The interactive aspect and giving users the power to manipulate offerings or environments stimulates creativity. Furthermore Turner and Welch (2019) stress the importance of experiential values of complexity, control and enjoyment while designing a Mixed Reality co-design toolkit. Complexity and control are important features from the TAM model that, if not taken into account, could slow down user acceptance of a new technology in which MC and AR are combined. Both are technology-based features in which the customer needs to adapt or learn new skills. Therefore the user interface should be carefully designed and for e-vendors the right customer segment should be targeted.

Another aspect on which AR might strongly affect the perceived value of MC is the extension of the experience by allowing users to share their customized product with the personal environment included (Hilken et al., 2018). A standard product configurator often only visualizes the product with a standard background. By sharing a screenshot of a customized product combined with the real personal environment, others can provide support and suggestions during the decision-making process with regard to product features that can be manipulated. This might result in a higher buying confidence.

In this research the literature-based assumption is established in which MC leads to a higher perceived value compared to standard products. This can be measured through constructs like utilitarian and hedonic value as part of the CPVT. With this relationship as a basis and the relationship between perceived value and purchase intention (H1), the presence of AR will now be added which

results in the conceptual framework shown in Figure 5. It is hypothesized that the presence of AR will lead to a stronger relationship between the MC experience and perceived value. This is covered in the second hypothesis:

H2: *The presence of Augmented Reality has a moderating effect on the relationship between the Mass Customization experience and Perceived Value.*



H_1: There is a positive correlation between Perceived Value and Purchase Intention

H_2: The presence of Augmented Reality has a moderating effect on the relationship between the Mass Customization experience and Perceived Value

Figure 5 Conceptual framework

Methodology

In this chapter the research strategy is outlined. First existing literature and comparable studies are analyzed to make solid choices.

Orientation

Different types of research designs can be applied in business research. Bryman and Bell (2007) divided research designs in the following categories: experimental, cross-sectional, longitudinal, case study and comparative study. All these research designs are typically applied through either quantitative or qualitative strategies except for the experimental design. Bryman and Bell (2007) state that experimental studies usually consist of quantitative comparisons between experimental and control groups with regard to the dependent variable. Choosing an appropriate research design is paramount to come up with useful results for academical as well as practical purposes. Since it is intended to generalize results for a larger population, namely online customers buying high-involvement products, already two research designs can be excluded. The case and comparative study are ideal for a better understanding of the nature of the phenomenon, like value dimensions and purchase intention. However, such results are unlikely to represent the whole population. Also the longitudinal study is excluded, since there is no interest in the time related aspect between variables. In business research, often the independent variables cannot be manipulated (e.g. age, gender, habits) which makes the cross-sectional research design applicable in most cases (Bryman and Bell, 2007). This is not the case for this study, as shown in Figure 5. AR can either be present or not during the buying process, this is easily organized. Therefore an experimental design is best suitable, in which a control group and experimental group are compared.

True experiments tend to be very strong in terms of internal validity (Bryman and Bell, 2007). Babbie (2007) states in addition that experiments are especially well suited to research involving limited and well-defined concepts and next to that the experimental model is appropriate for hypothesis testing. Especially online businesses can benefit from experimental designs to implement new features of a website. Fabijan, Dmitriev, Olsson and Bosch (2018) argue that Online Controlled Experiments (OCEs) are the most powerful tools for evaluating how much value new software or website features bring to the customer. Microsoft, Amazon and Booking.com for example report the ability to conduct thousands of OCEs every year. In addition, the explanatory nature of this research is positively related to experimental designs due to its focus on determining causation (Babbie, 2007). A number of experimental research designs exist, which are clarified and evaluated first.

Bryman and Bell (2007) consider in their book ‘Business research methods’ three types of experiments; classical experiments, laboratory experiments and quasi-experiments. Laboratory experiments are organized in a completely controlled environment, without real-world interaction. This gives the researcher greater influence over the experimental arrangements, although these experiments suffer limitations in terms of external validity and random assignment. This study could for example be organized in a laboratory setting, where participants would customize wall art on a desktop and afterwards fill out a survey. The following limitations are likely to appear. First, the sample will be drawn from the University of Twente campus for feasibility purposes. However, having mostly students participating will not be a true reflection of the population and thus limiting generalizability. Second, it takes enormous effort to reach an acceptable sample size. Time and resources are not sufficient in this case. Third, participants might affect each other which is hard to avoid. These limitations all impair robustness of the test results. Quasi experiments are much like classic experiments, although the researcher actively assigns participants to a group (Bryman and Bell, 2007).

Also control groups are not required. These characteristics of quasi experiments raise doubt on the internal validity, since groups may not be equivalent. The classical experiment is considered the best option for testing the hypotheses from Figure 5. The classical experiment consists of a control group and treatment group. Both groups are equivalent in characteristics. The treatment group receives the treatment, which is the presence of AR during the MC process. Comparable studies are analyzed on their methodology, to find and validate a suitable approach for this study.

Franke et al. (2010) found a third factor of MC that increases customers' economic value. Next to the achieved preference fit (should be maximized) and design effort (should be minimized) they suggest that the awareness of being the creator of the product results in a higher willingness to pay. Through five different studies they provided evidence for this so called "I designed it myself effect". They explored the existence of this effect, if it generates customer value and how this could be understood. All five experiments took place in a laboratory setting, after four of these experiments quantitative data was gathered through surveys with 5-point Likert scales. Sample sizes of studies 2/3/4/5 were respectively: n2= 114, n3= 116, n4=129, n5= 66. Through a set of questions Franke et al. (2010) checked for differences between groups regarding control variables (product interest, purchase intention and income). It is not known how they came to their sample size, for which the following study is analyzed.

Another study, conducted by Watson et al. (2018), examined the effects of AR on customers' affective and behavioral response (purchase intention) and whether hedonic motivation moderates this relationship. They conducted an online experiment through a retail cosmetics app of a leading cosmetics brand in which n=162 people participated. Two conditions were created. The control group experienced the application without AR and the treatment group with AR. Participants were recruited through social media, make-up forums and YouTube. The experiment lasted for 15 minutes and took place in the following order: (1) participants answering demographic questions, (2) questions concerning the hedonic motivation, (3) participants were asked to interact with either the AR app or the standard webshop, (4) completing the remaining questions. This experimental design is without pre-testing, which normally is the case with experiments. Much can be learned from this experiment, especially regarding the sample size. Watson et al. (2018) based their sample size criteria on two sources, namely Stevens (1996) and Tabachnick and Fidell (2001). Stevens (1996) suggests that 15 respondents per independent variable are needed. Tabachnick and Fidell (2001) advices a minimum of n=50 with an additional eight respondents per independent variable. Furthermore Watson et al. (2018) claims that their sample size of n=162 is in line with or exceeds similar studies (e.g. Javornik, 2016a with n=60 and Moon, Chadee and Tikoo (2008) with n=116). Above information is fundamental for the research design of this study, which will be outlined hereafter.

Research strategy

The purpose of this study is to find out what the effect is on customers' purchase intention if MC and AR are combined. This causal relationship is revealed through an experimental design approach comparable to that of Watson et al. (2018). The classical experiment usually consists of three major components: (1) independent and dependent variables, (2) pretesting and post-testing and (3) experimental and control groups (Babbie, 2014). In this study however, only post-testing takes place due to practical reasons. The independent variable is the presence of MC and AR and the dependent variables are Perceived Value and in turn Purchase Intention. The experimental group receives a treatment which is the presence of AR in addition to MC, whereas the control group does not. Perceived value is measured through the indicators Utilitarian Value and Hedonic Value, which are both related to MC and AR experiences. Figure 5 clarifies the conceptual framework. It should be noted that the relationship between MC and Perceived Value is established by existing literature (Dellaert & Stremersch, 2005; Von Hippel, 2001; Schreier, 2006). However, constant awareness concerning this literature based assumption is guaranteed.

Cadchy already has a web shop online were customers can customize their wall art in terms of material, size and color. Seven wall art designs, for example the ones shown in Figure 6, are made available for the purpose of this study. Schwartz (2011) suggested using several products to minimize personal bias and taste. A 'split-test' is developed with the use of Google Optimize, which randomly assigns website visitors to one of the two wall-art collection pages (two different URL's). These pages are identical, except for the stimulus to use AR and the availability of AR for the experimental group. Both groups fill out a survey right after their experience and shortly before check-out in which they express their attitude towards the constructs hedonic and utilitarian value. The process is shown in Figure 7. The user friendliness and quality of the MC and AR process receives high priority. Therefore, an existing configuration module from the company Expivi will be integrated into Cadchy's webshop through an API key.

Software provider Expivi is specialized in providing customization toolkits and their product is a subscription based module integration. Using this module allows the user to set up a 3D product configurator also known as a MC toolkit. In here the customizable attributes are defined like in this case material, size and color. For every product variant a 3D model should be made, which is linked to the product attributes. So, if a customer wants wall art out of brushed stainless steel, a detailed and realistic 3D model will appear in the 3D configurator from which anyone would recognize the type of material. This 3D model is also the basis for AR purposes, which is integrated into the module from Expivi.

Figure 6 Examples of available designs for the experiment

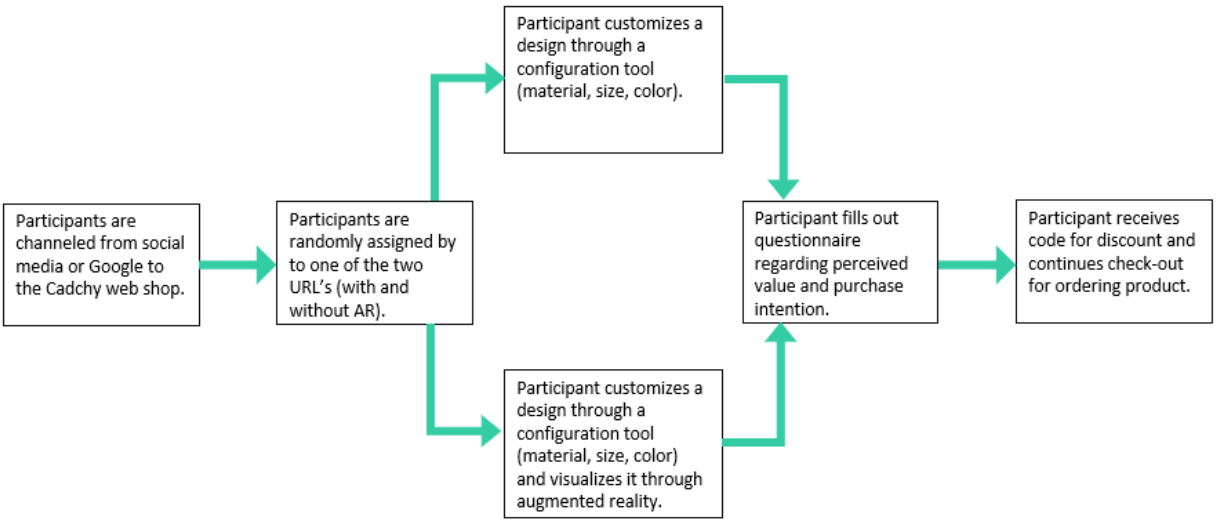


Figure 7 Process of surveying explained

Sampling

The characteristics (e.g. gender and age) of the target population under research for this experiment are not known. However, it is known that any Dutch speaking person willing to buy wall art online falls under the population of interest. Therefore a self-selection sampling procedure is organized in which participants find out about the experiment while searching for wall art. Awareness about the experiment is increased through social media and Google advertisements. Advantage of this non-probability sampling procedure is the relatively low importance of the sample size, although sampling bias could occur as an disadvantage (e.g. snowball effect resulting in influencing results between participants) (Babbie, 2014). Due to the lack of information on the population under research, an estimation of the required sample size is complex. However, Tabachnick and Fidell (2001) formulated general guidelines for sample sizes. A minimum of n=50 plus eight respondents per independent variable would require this study to have a sample size of n=66 in total. In reality it is likely to find trouble in achieving big sample sizes for this experiment and there will also be a number of responses that are not usable. Thus it might help to set sample size goals that pass the minimum required sample size. Therefore, the goal is set on a sample size of n=100 respondents to be in the safe area. If it appears during data collection that the average variance of sample characteristics are not changing significantly anymore, it can be decided to stop the procedure and continue with the data analysis. The samples are considered representative for the population since the channels through which participants are made aware of the experiment are the same as the marketing channels through which customers of Cadchy are approached usually. These channels are Facebook, Instagram, Pinterest and Google advertising. Sample bias originating in for example web accessibility is therefore excluded. To stimulate the amount of respondents that attend the experiment and fill out the survey, a discount code is provided afterwards. This form of incentive is expected to be crucial in stimulating the amount of participants, although too much discount will result in sampling bias since it is likely to attract participants with an extraordinary set of characteristics, not representing the population (Babbie, 2014).

Survey

The survey is composed of general questions to determine the sample profile and construct-specific questions regarding perceived value and purchase intention. Answers are based on a 7 point Likert scale (1=strongly disagree, 2=disagree, 3=more or less disagree, 4=neither agree or disagree, 5=more or less agree, 6=agree, 7=strongly agree). Construct-specific questions are mostly adapted from literature (Figure 8). Three to four items represent one construct, with the purpose of securing internal consistency (Gliem & Gliem, 2004). The general questions are based on a study conducted by Overby (2006) and include gender, age and education.

Several ethical considerations are included into the survey complying with general guidelines and making participants comfortable with the experiment. These are retrieved from Bryman and Bell (2007) and cover the following aspects: participation takes place on voluntary basis and participants can withdraw from the study at any stage, participants are informed about the purpose of the experiment and privacy and anonymity is guaranteed.

Label	Question	Adapted from
UV1	Shopping wall art on this website would allow me to quickly find out the appropriate size.	Gan & Wang (2017)
UV2	Shopping wall art on this website would allow me to quickly find out the appropriate material.	Gan & Wang (2017)
UV3	Shopping wall art on this website would allow me to quickly find out the appropriate color.	Gan & Wang (2017)
UV4	I was able to imagine/visualize how the customized piece of wall art will look like in my personal environment.	-
UV5	Using this website would be a convenient way to shop wall art.	Chiu et al. (2014)
HV1	I found it fun to customize and evaluate my wall art.	Aurelie et al. (2010)
HV2	This web shop not only sells products – it entertains me.	-
HV3	Shopping wall art on this website feels like an adventure.	Chiu et al. (2014)
HV4	The possibility to share my customized wall art with friends is important to me.	-
PI1	I predict that I would shop wall art on this website in the future.	Gan & Wang (2017)
PI2	I will recommend friends to purchase wall art on this website.	Gan & Wang (2017)
PI3	I intend to shop on this website in the future.	Gan & Wang (2017)

Figure 8 Survey items

Data analysis

Goal is to compare the means of both samples regarding utilitarian and hedonic value items and attitude towards purchase intention. If it appears that the mean values are significantly higher for the experimental group, the null hypotheses are rejected. Either a two-sample t-test or a Mann-Whitney test will be used for data analysis (De Veaux, Velleman & Bock, 2013). The two-sample t-test tends to be more robust (De Winter & Dodou, 2010). The data will first be uploaded into the statistical software program SPSS, after which the file will be cleared of incomplete data followed by the analysis.

Reliability and validity

Reliability and validity are in the first place ensured by using survey questions that are validated from earlier research. Afterwards, reliability is checked by calculating Cronbach's Alpha once all data is collected. Measuring the reliability of one single item will result in an insufficient internal consistency as argued by Gliem and Gliem (2004). Therefore they advise to combine the means of all items that represent a single construct and calculate the Cronbach's Alpha based on the averages. Constructs are often too complex to be measured based on a single-item. Lance, Butts and Michels (2006) recommend a minimum Cronbach's Alpha of 0.7 for exploratory research and 0.8 for basic research. Statistical software program SPSS will be used for the calculation. It is assumed that the difference between the available wall art designs does not cause sample profile characteristics to be different, although this can be easily checked once data is collected. If this is not guaranteed, chances are that results are internally invalid. Internal invalidity is referred to as the possibility that conclusions drawn from experiments may not accurately reflect what truly happened during the experiment (Campbell & Stanley, 1963; Cook & Campbell, 1979). Therefore, the designs available to the control group and experimental group are the same and attract the same type of customer. External invalidity is related to the generalizability of the findings to the real world (Babbie, 2014,). Often the artificial aspect of an experiment, like testing in a laboratory setting, creates distance between the same setting in the real world. Therefore the conclusions drawn from the experimental setting cannot always be applied in reality. By logical reasoning it is assumed that this online experiment is externally valid due to its reflection of reality. Participants are real customers and they are surveyed immediately after their experience. Thus, conclusions are generalizable at least for settings in which wall art can be customized, but likely also for settings in which other high-involvement products are customizable through comparable processes.

Results

This chapter explains how the data is processed and which results are retrieved. This part is written completely neutral without drawing conclusions. Before any analysis is done, the SPSS file is being cleared of incomplete data and unnecessary information. A clean data file is used in every analysis. In addition constructs are created inside SPSS by combining the mean values of items that belong to one of the constructs Utilitarian Value, Hedonic Value and Purchase Intention. These constructs are used for the independent sample t-test later in this chapter.

Sample characteristics

People that participated in the experiment were asked 12 questions regarding the customization and visualization process and 3 demographic questions. 103 participants took part in the experiment. It appears that the control group and experimental group are equal in demographic characteristics. The sample characteristics are shown below in figure 9. Most participants of this experiment were male with 54%, against 47% female. 60% of the participants used AR during the experiment. There are some differences between demographic groups and whether participants used AR or not. During analysis these groups are combined, forming the categories sex, age and educational level. The actual population composition is not known. The sample characteristics are considered to be equal to the population characteristics. Participants were gathered through online channels like Instagram, Facebook, LinkedIn and Google Ads. These channels are also used for marketing, thus reaching the same type of customers.

Variable	Label	Frequency	Percentage	Used AR
Sex	*Male*	56	54,4%	60,7%
	Female	47	46,6%	57,4%
	Total	103	100%	60,2%
Age	*15 – 24 years*	30	29,1%	80%
	25 – 34 years	48	46,6%	50%
	35 – 44 years	8	7,8%	62,5%
	45 – 54 years	11	10,7%	45,4%
	55 – 64 years	6	5,8%	66,7%
	Total	103	100%	60,2%
Level of education	*Secondary education (voortgezet onderwijs)*	9	8,7%	77,8%
	Post-secondary vocational education (mbo)	15	14,6%	73,3%
	University of Applied Sciences (hbo)	42	40,8%	52,4%
	University (wo)	37	35,9%	59,4%
	Total	103	100%	60,2%

Figure 9 Sample characteristics

Reliability

The results of this experiment are reliable once the same results are achieved when another researcher repeats the process following the methodology of this study (Babbie, 2014). The scale is valid if it actually measures the construct it is supposed to measure. The first method to ensure reliability and validity was applied when preparing the questionnaire. The questions were based on existing and validated literature. The second method to test the reliability of the collected data is by applying Cronbach's Alpha. This is a measure to test the internal consistency of a construct, meaning that every item measures the same construct (Lance et al., 2006).

	Cronbach's Alpha	*Cronbach's Alpha if item deleted*
Utilitarian Value (UV)	0,81	0,84 if UV2 removed
Hedonic Value (HV)	0,78	0,84 if HV9 removed
Purchase Intention (PI)	0,9	-

Figure 10 Testing internal consistency of the constructs

As shown in figure 10 the Cronbach's Alpha is for every construct above the lower limit of 0,7 as defined by Lance et al. (2006). This proves that the data used in this study is internally consistent for every construct. This enhances the reliability of the data. Both UV and HV consist of an item that lowers the construct's Cronbach's Alpha. For UV this is the question "Shopping wall art like I just did, allows me to quickly choose the material". If the data from this question is removed during the analysis the Cronbach's Alpha will increase with 0,03 to 0,084 and thus making it more reliable. For HV the Cronbach's Alpha will increase with 0,06 to 0,84 when removing the question: "The possibility to share my customized wall art with friends and family is important to me". It is decided to leave all items in the test during analysis.

Analysis

The data analysis is guided by the hypotheses that were established earlier. First hypothesis 1: *There is a positive correlation between Perceived Value and Purchase Intention.* Meaning, that a higher PV results in a higher PI. This hypothesis is defined to establish and validate what was found during the literature study to be applied in this study.

To test for a correlation between two variables (PV and PI) a bivariate analysis is applied. This is a statistical analysis between two variables through which a correlation could be determined. Conducting a bivariate analysis is sufficient for this study since only one independent variable and one dependent variable is investigated. This is the result of searching for variables during the literature study that apply to both MC and AR.

The relation can be tested by conducting a linear regression analysis. This is done by following these five steps: (1) Examining the relationship by making a scatterplot, (2) calculate the regression coefficients, (3) check if the linear model fits the data using R^2, (4) check if the regression coefficient is significant from zero, (5) check if the relationship is positive or negative (coefficient bigger or smaller than zero).

In SPSS a scatterplot is made with the independent variable (PV) on the X-axis and the dependent variable (PI) on the Y-axis. The graph in Appendix 1.1/1.2 visualizes a positive relationship between PV and PI. When comparing the two graphs for both (control and experimental) groups it can

be noticed that the experimental group has relatively more dots in the upright corner compared to the control group. Next to that, the control group has more dots in the overall plot due to the difference in sample sizes (N=62 versus N=41). Another difference can be seen by comparing the slope of the regression lines of both graphs. The average line of the control group is steeper as opposed to the experimental group. This visual appearance is related to the regression coefficient. For the control group the coefficient is β=1,112 and for the experimental group this coefficient is β=0,871. This regression coefficient describes the slope of the regression line as part of a formula. The formulas are defined as:

Control group (no AR)	*Y=1,16+1,11*X*
Experimental group (AR)	*Y=0,2+0,87*X*

By translating these formulas into words, one could get a better picture of what the data is clarifying. If in the control group a participant experiences one more unit of Perceived Value (e.g. on the Likert Scale), this would result in an increase of 1,11 units of Purchase Intention on average. For the experimental group an increase of one unit of Perceived Value, would result in an increase of 0,87 of Purchase Intention on average. Both these relationships are significant with an α=0,001 (shown in Appendix 1.1/1.2). Important note here is that this increase is on average and it depends on the model fit of the regression line to what extend the increase can be explained by the independent variable Perceived Value. For this reason the R^2 exists. The R^2 is a calculation automatically executed by SPSS when doing a linear regression and it tells the user to what extend the variance of the dependent variable is explained by the independent variable. In this case, the control group has R^2=0,648 and the experimental group R^2=0,419 (Appendix 1.1/1.2). So, the variance in Purchase Intention of the control group is for 65% explained by the independent variable Perceived Value. The variance in Purchase Intention for the experimental group is for 42% explained by the variable Perceived Value.

In order to confirm hypothesis 1 it should be checked whether the regression coefficient is significant from zero. For both the control and experimental group the regression coefficient is P<0,001 which is below the significance level of α=0,05. Therefore hypothesis 1 is confirmed. There is statistical evidence that Perceived Value is a good predictor for Purchase Intention.

The second hypothesis will be tested by conducting an independent sample t-test. Hypothesis 2 is described as: *The presence of Augmented Reality has a moderating effect on the relationship between the Mass Customization experience and Perceived Value.* To confirm this hypothesis the mean values of perceived value should be significantly higher for the experimental group (experiencing AR) compared to the control group (not experiencing AR). In figure 11 below, the group statistics are shown

Group Statistics

	Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken?	N	Mean	Std. Deviation	Std. Error Mean
PerceivedValue	Ja	62	5,4444	,86652	,11005
	Nee	41	4,8780	1,16556	,18203

Figure 11 Mean values of Perceived Value (control and experimental group)

for the construct PV, which is the combined average of the constructs UV and HV. By simply looking at the mean values it can be noted that participants that experienced AR perceived more value in the experience compared to participants that did not experience AR. From the 1 to 7 Likert Scale on which the participants were able to express their opinion, the experimental group answered with an average of 5.44 were the control group had an average of 4.87.

The next test should reveal if the difference in mean values are significant or not. From SPSS this is the second part of conducting the independent sample t-test.

The independent sample t-test is based on the assumption that both groups are equal in variances. This assumption can be made if both groups are equal in size. However, in this study the control group consists of N=41 participants were the experimental group consists of N=62 participants. To check for the homogeneity assumption the Levene's test is conducted. This test consists of the null hypothesis "the groups we are comparing all have equal population variances" and is confirmed if the test result is significant with α=0.05. This test is reliable and only correctly applied if the following assumptions are met: (1) Independent observations took place and (2) the test variable is quantitative instead of qualitative. Both assumptions are met since the online experiment disables participants to communicate with each other and the test variable PV is a scale variable since it is the combined average of UV and HV items. The table below shows that equal variances are assumed after which the result of the independent sample t-test is immediately shown. It can be noted that the mean average value of PV is significantly higher (with P=0,006) for the experimental group compared to the control group. This confirms hypothesis 2, meaning that AR strengthens the relationship between the MC experience and Perceived Value.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
PerceivedValue	Equal variances assumed	5,680	,019	2,826	101	,006	,56640	,20044
	Equal variances not assumed			2,663	68,576	,010	,56640	,21271

Figure 12 Levene's test and Independent Sample T-test

Perceived Value is subdivided into the first order constructs Utilitarian Value and Hedonic Value. Drawn from literature these constructs are again divided into several items on which they can be measured. Every item corresponds with a specific question in the survey. The items´ combined average, which form a construct, is significantly higher for the experimental group compared to the control group. However, this does not imply that this difference is significant. This would mean that for these specific items, AR is not resulting in a higher Utilitarian Value or Hedonic value. This is visualized in figure 13. The figure shows that, as part of the construct Utilitarian Value, users of AR were not in a better position to determine the material and color of their customized wall art. However, they did perceive a higher utility in determining the size of the wall art. In more than 95% of the cases people that used AR were better in determining the size. This is also the case for the ability to visualize their customized wall art in their personal environment. As an overall item of Utilitarian Value, users of AR found convenience in using this website for shopping wall art.

When analyzing the items of the construct Hedonic Value, it appears that users of AR not necessarily think that customizing their wall art is more fun compared to going through the customization process without AR. Immediately seeing the customized wall art is more fun when experiencing AR at a significance level of α=0,1. In 90% of the cases people that used AR found it fun

to immediately see their customized wall art. Also in 90% of the cases (α=0,1), people that used AR find it more important to have the possibility to share their customized wall art with friends. The most significant item (α=0,05) of Hedonic Value is related to the statement that the web shop not only sells products but it entertains the user.

The construct Purchase Intention, divided into three items, is significant on two of them. Apparently, the AR users do not immediately have a higher intention to purchase from the webshop. However, they do predict that they will shop wall art on this webshop in the future (more compared to the control group). Also people that used AR are prone to recommending friends to purchase wall art from this webshop.

Construct	Label	Question	Significant P < α = 0,05	Significant α = 0,05 < P < α = 0,10	Not significant P > α = 0,10
Utilitarian Value	UV1	Shopping wall art on this website would allow me to quickly find out the appropriate **size**.	0,007		
	UV2	Shopping wall art on this website would allow me to quickly find out the appropriate **material**.			0,749
	UV3	Shopping wall art on this website would allow me to quickly find out the appropriate **color**.			0,195
	UV4	I was able to imagine/visualize how the customized piece of wall art will look like in my personal environment.	0,004		
	UV5	Using this website would be a convenient way to shop wall art.	0,008		
Hedonic Value	HV1	I found it fun to customize my wall art.			0,249
	HV2	I found if fun to immediately see my customized wall art		0,061	
	HV3	This webshop not only sells products, but it pleasures me	0,012		
	HV4	The possibility to share my customized wall art with friends is important to me.		0,064	
Purchase Intention	PI1	I predict that I would shop wall art on this website in the future.	0,005		
	PI2	I will recommend friends to purchase wall art on this website.	0,047		

Figure 13 Independent Sample T-test per item

Discussion

In this chapter results are interpreted in relation to the literature. The aim is to give meaning to what is found during the experiment. Results are compared with expectations and explanations are given.

The results as shown in figure 11 are in line with the hypotheses on the level of 2nd order constructs, meaning that based on literature it is expected for Perceived Value and Purchase Intention to be significantly higher when AR is used. On single item level some extraordinary results were found which were not expected. During the development of the experiment it is found that the quality of AR is not consistent and highly dependent on environmental aspects (lighting, wall-texture, wall-color). Therefore it is remarkable that users were significantly better in determining the size of wall art and not the color/material. This is probably related to the level of detail required to evaluate material and color. The product configurator with its scene and lighting allows for a detailed evaluation of material properties and color whereas the product size cannot be evaluated. It could be the case that AR users were not particularly good in determining size, but the non-AR users were particularly bad with just the product configurator. The real value of this significance could only be tested by actually delivering the piece of wall art and ask users if the size is following expectations. Users of AR are not better in determining material and color which could also be explained by the limitation in the software to finetune colors and textures of the AR model. Colors in the product configurator were not always equal to the AR model. Therefore the difference in aesthetic aspects between the product configurator and the AR model might have resulted in confusion among users which raises questions about the effects of quality aspects on the experience.

A study conducted by Wells, Valacich and Hess (2011) stresses the importance of website quality in relation to customers' purchase intention. They argue that customers use website quality as a predictor for product quality which in turn affects the purchase intention. Cited from their study, they mention that "*With experience products, the aesthetic or emotional elements of a website (e.g., visual appeal), have been shown to be the most important component of website quality. Online sellers should strive for very high levels of aesthetics with experience products and/or hedonic shopping contexts (p.391)".* Although they did not include AR during the experiment, it is expected that the conclusions are especially applicable to AR due to its hedonic character. This is in contrast with Alimamy and Al-Imamy (2021). In their study they found that there is no direct relationship between the quality of AR during online shopping and customers' perceived value. However, they found evidence that there is a relationship between users' attitude towards AR and perceived value. People that have a positive (previous) experience with AR perceived a higher value in every next AR experience due to their attitude towards the technology. This is a mediating effect, meaning that the quality of the AR service might indirectly increase perceived value through the construct 'attitude'. Therefore, the results of this study should not be generalized among age categories. It is likely that the lower age categories had many experiences with AR before (e.g. Snapchat and Instagram) and therefore a positive attitude towards AR followed by a higher perceived value during this experiment. Since 76% of participants were below the age of 35 this could have been the case during this experiment. In addition, it is expected that some participants were not actually looking to buy wall art which caused them to be less critical of the AR experience resulting in higher values.

During the literature study it was found that Perceived Value, with the constructs UV and HV, is the main predictor of Purchase Intention. Therefore, while optimizing the MC/AR experience, the focus should be on UV and HV. Hilken et al. (2017) stressed the importance, based on evidence, that a higher environmental embedding of AR results in a higher UV and HV. If the user is actually looking for the product, in this case wall art, it is necessary to use AR in the personal environment for which the

wall art is intended for. Therefore, the results of this experiment should be interpreted with care. It is expected that some participants were not actually looking for wall art, meaning that they might have used the application somewhere else (e.g. at the office or in public transport) resulting in a different perceived value. A positive note here is that the results would be even more in favor of UV and HV once buyers actually use the application during purchasing and thus being in the intended environment. However, using AR in the personal environment might also raise questions regarding privacy concerns. Previous research by Hilken et al. (2017) already investigated the role of privacy concerns in relation to AR. It detracts from customers' perceived value but this can be compensated by providing a disclosure regarding a companies' data treatment. It is expected that there is no effect the addition of MC has no effect on privacy concerns.

An alternative or extra explanation of the significantly higher purchase intention for AR users is the customer engagement caused by the AR experience. Customer engagement is found in both MC and AR experiences, although it did not receive much attention during this study. Previous research conducted by Algharabat (2018) stressed the importance of telepresence as part of online customer engagement. Telepresence is mainly caused by interactivity which is fostered by the use of an MC toolkit and AR. Much literature exists which posits that behavioral intentions are key outcomes of customer engagement. A related term is the "playground effect" of AR, which indicates the creative customer engagement enabled by AR. According to Jessen, Hilken, Chylinski, Mahr, Heller, Kelling and de Ruyter (2020) customer creativity emerges as an intrinsically satisfying activity in the early stages of the customer purchase journey. Especially those customers that value unique and personalized products value the supportive role AR can play during the process of creating products.

On single item level it stands out that users of AR did not necessarily experience the MC process as being more fun compared to non-AR users. This is likely the effect of MC and AR being separate experiences with hopping between web pages. If a user wants to experience different colors and sizes through AR, he or she needs to go back and forth on different web pages with substantial buffering times. Inspired by the result of this study it is hypothesized that a lot can be gained by integrating MC and AR into one experience. This could be seen as customizing a product while projecting it with AR in the intended environment. Hilken et al. (2017) proved that customer value perceptions are enhanced by simultaneously providing simulated physical control and environmental embedding. If the software allows users to change attributes of a product (e.g. size, material, color) while projecting it through AR, the user can evaluate more options in less time resulting in a higher UV and HV.

Conclusion

The research problem, which is fundamental to this study, is the disability of providing examples or prototypes of products which can be customized or personalized. In addition, the absence of physical contact between buyer and seller due to being online makes it difficult for consumers to anticipate whether a product will satisfy or not. Randall et al. (2005) argued the importance of providing rich illustrations of the product to improve customers' trust towards a product and avoid surprises after delivery. This research aimed at exploring the effect on customers' purchase intention when AR is made available during an online product customization processes. The central research question during this research is: *"What is the effect on customers' purchase intention if Mass Customization and Augmented Reality are combined when buying wall art online?".* For guidance it was first investigated which factors determine customers' online purchase intention, how MC and AR are related to purchase

intention and how MC and AR are related to each other. Information is gathered through an online experiment which closely matches a real buying process.

From literature it is derived that one of the main predictors of Purchase Intention is the second order construct Perceived Value (Overby et al., 1994; Chiu et al., 2014). Perceived value in online shopping can be measured through two overall first order constructs, which are utilitarian and hedonic value (Overby, 2006). This study revealed that there is a positive correlation between perceived value and purchase intention, which is in line with literature (Overby, 2006; Chang & Wildt, 1994; Chiu, Wang, Fang & Huang, 2014). Aurelie et al. (2010) proposed five sources of value in MC of which utilitarian and hedonic value are examined in this study. It is hypothesized that these variables are strengthened by the use of AR. The visually appealing experience provides excitement and joy of the online offering (hedonic value). The aesthetic and functional fit can be evaluated and relevant information is provided directly, embedded into the personal environment (utilitarian value) (Poushneh & Vasquesz-Parraga, 2017; Huang & Liao, 2015). MC in itself provides customers with a higher perceived value compared to a standard product catalogue. The results from the experiment indeed confirm that those 'customers' that used AR perceived a higher utilitarian value and hedonic value during their customization experience. Meaning, that customers are more capable in determining product features and they find pleasure in the experience. In addition, these customers confirmed to have a higher intention to purchase the product compared to those who did not use AR.

Limitations

This study is confronted with limitations that should be taken into consideration. First, the choice for retrieving data through surveying. The choice for this method is related to feasibility aspects. Measuring actual buying behavior through clicks and sales is not realistic due to the recent start of the webshop and thus a limited amount of webshop visitors and buyers. However, drawing conclusions based on survey data comes with limitations. First, participants were not forced to buy their customized wall art. Thus, no money related sacrifice is made which normally would trigger a customer to evaluate a product or service critically and consider alternatives (Zeithaml, 1988). Being less critically oriented towards the AR experience might cause participants to express their feelings more positive on the 1 to 7 Likert scale as part of the survey. Second, there is an incentive to quickly fill out the survey to receive the reward at the end of it (€25,- discount code). Since randomly filling out the survey has no consequences for the participants, chances are that some participants did not think thoroughly about the questions asked. This is not taken into account during the analysis although the shortest survey completion time was a questionable 51 seconds for 12 (+5 demographic) questions.

The second set of limitations are related to the research design of which the scope is narrow. Existing literature confirmed causality between perceived value and purchase intention, which is not claimed in this study (Overby, 2006; Chang & Wildt, 1994; Chiu, Wang, Fang & Huang, 2014). Other related variables (e.g. trust, information protection, monetary resources) should be included into the research design to test for causality. Next to that, the experiment was built upon one product category which is wall-art. Wall art is a high involvement product during purchasing, but serves as an aesthetical object without physical interaction. It cannot be claimed that the effects of combining MC and AR will also be applicable to everyday use products (e.g. chairs, sofa's, tables). In addition, the study took place in the Netherlands and culture and ethnicity were not included. Therefore, the results of this study cannot be simply applied to every country globally.

The third set of limitations are related to practical issues surrounding the experiment. During the experiment the software caused users to have access to AR in any case. Also the control group had

access to AR, simply because the functionality could not be shut off. Therefore, the AR button was made less visible by tweaking the background picture, which caused most participants in the control group to overlook the option. In addition, group discrimination was based on the question whether participants made use of AR to see their customized wall art. This item (yes=1, no=2) allowed for splitting the data in SPSS. Also a limitation was found while promoting the experiment on Social Media. Specifically LinkedIn, which caused the dysfunctionality of AR when sharing the link to the experiment directly in a LinkedIn post. This was detected immediately after which the post was adapted. Instead of directly linking to the experiment, participants had to copy/paste the URL into their browser. Another issue with AR is the projection of wall art on solid colored walls. At least with IOS devices, solid colored walls are not detected unless contrast is created by hanging a piece of paper on the wall with a different color. In addition, the colors of the AR model are not corresponding with the model shown in the configurator, which is lighter colored. These limitations are mostly related to the AR functionality. Therefore, it is likely that once AR functionality could be improved, collected data would show different results. Currently, users of AR found utility in determining the size of wall art. However, AR has the potential to support customers in their decision making process once aesthetic quality, interactivity, response time and quality of information are optimized and thus product features like material and color can be evaluated (Pantano et al., 2017). It should be kept in mind that the product configurator with AR is build on a software platform and without any developing and coding skills. The prototype used in the experiment could have been higher in quality once the prototype was custom build by experts. This would have delivered different results and conclusions. This lowers the threshold for companies to start experimenting with the technology which will be elaborated in the managerial implications.

Recommendations for future research

The experiment in this study has provided new insight into the relationship between MC plus AR and customers' purchase intention. In addition, this study has contributed to the academical field by providing new knowledge about applying AR in the wall art business as part of the interior design market.

This study was organized to serve multiple purposes. The number one priority was to combine and provide insight into combining two technology based trends about which the academical field has been writing a lot. However, the second purpose was to gain direct practical knowledge about the application of MC and AR and how it is perceived by customers. Cadchy, the recently launched webshop on which the experiment took place, is due to this study strongly considering an MC + AR driven strategy to serve its customers. Future research could build upon the fundamentals of this study, by measuring the effect on actual sales figures (and/or product returns). This was not feasible during this study due to the relatively low number of sales. In the ideal situation a follow-up study would be a firm that already sells high numbers of MC products to which AR is added as a service during the buying process. Through A/B testing the effect can be measured, similar to this study. In addition, future research could reveal if the effects are the same for other product categories. Furniture for example, is different compared to wall art in the sense that material properties might be even more important. Evaluating different fabrics for a chair on which the consumer will sit on frequently is more complex.

Combining AR with MC results in a higher perceived value during the information search. This should be put in perspective with regard to the complete customer buying process. Problem recognition, information search, evaluation of alternatives, purchase and post purchase behavior are

part of this process (Engel & Blackwell, 1982). Current developments like customer co-creation and omnichannel retailing mostly focus on one or more of these elements. AR combined with MC could strengthen these aspects, especially when moving towards product personalization instead of just customization (e.g. adding names or pictures). The 'I designed it myself' effect which is grounded in the customers' awareness of being the creator, is stimulated when having the possibility to share a preliminary design with peer customers or friends. Franke et al. (2010) already proved positive effects on the design evaluation and in turn the perceived preference fit, purchase intention and willingness to pay when others are involved during the customization process. Future research is required to explore and explain the role of AR in this customization and co-creation atmosphere.

It was discussed that a closer integration of MC and AR might result in a higher perceived value. Outlined during the literature review, the perceived value is higher once sacrifices made by the customer are estimated to be lower compared to what is expected to be received in return (Zeithaml, 1988). One of the sacrifices is the amount of time spend by the customer. Therefore, making it easier for customers to evaluate product features by combining MC and AR in one interface might add value but it might also add complexity and lower the ease of use. This should be explored during future research.

Managerial implications

The value of MC is derived from the idea that the customer knows best what he or she needs. However, if many features of a product can be manipulated, the customer needs to be supported in their decision-making by providing rich illustrations of the product (Randall et al., 2005). AR is a solution to this. This study proves that mass customizers' perceived value increases if they used AR for product evaluation. In addition, customers' purchase intention increases with the availability of AR during the customization process. Although the current state and quality of AR is sufficient for product evaluation, it should be kept in mind that if the AR model is not a full representation of the actual product that customers are made aware of this. In this study for example, the size of wall art was a correct representation although the visual appearance of material and color needs improvement. However, it is suggested for firms that sell MC products online to develop an AR strategy or at least start experimenting with it.

It is relatively easy to set up a product configurator with AR included to test whether such customer interface is effective or not. Developer and coding skills are not required. Several software suppliers are available to the e-commerce market, which can be connected to a webshop through an API key. For setting up the product configurator, time is mostly spend on creating the architecture and getting to know the program. Keep in mind that 3D models with correct UV-mapping are required in the correct file type to implement them. It is advised to have support from a 3D artist to set up the models and create the materials with textures and colors. Once a 3D configurator is implemented, the addition of new products with corresponding materials is easily done which makes the use of the software scalable. Although there are limitations to the use of a software platform for setting up a product configurator, like interface design and optimizing the AR model, the overall quality in relation to costs is reason enough for exploring the possibilities.

Another aspect that should be kept in mind is the target population for companies. During this study the focus was on the end-user. These customers have no expertise on the products they are customizing, which requires the configurator to provide information and guidance during the process. Next to that, too many product features to be manipulated might overwhelm the customer and result in choice stress. Therefore, developing a product configurator in the business to business atmosphere

might allow for a more extensive and complicated configurator design with more options and extra features. Users (e.g. interior designers in the case of this study) will learn to work with the software and use it as a tool to provide value to their customers.

Although the current perspective on AR might completely change the coming years, the fundamental aspects like embedding, embodiment and extension are here to stay. The physical gap between e-commerce products and the customers' personal space will become smaller through AR or comparable technologies. This adds to the argument of starting to experiment with available technologies and finding out what exactly provides value to customers. This study can be used for inspiration and guidance.

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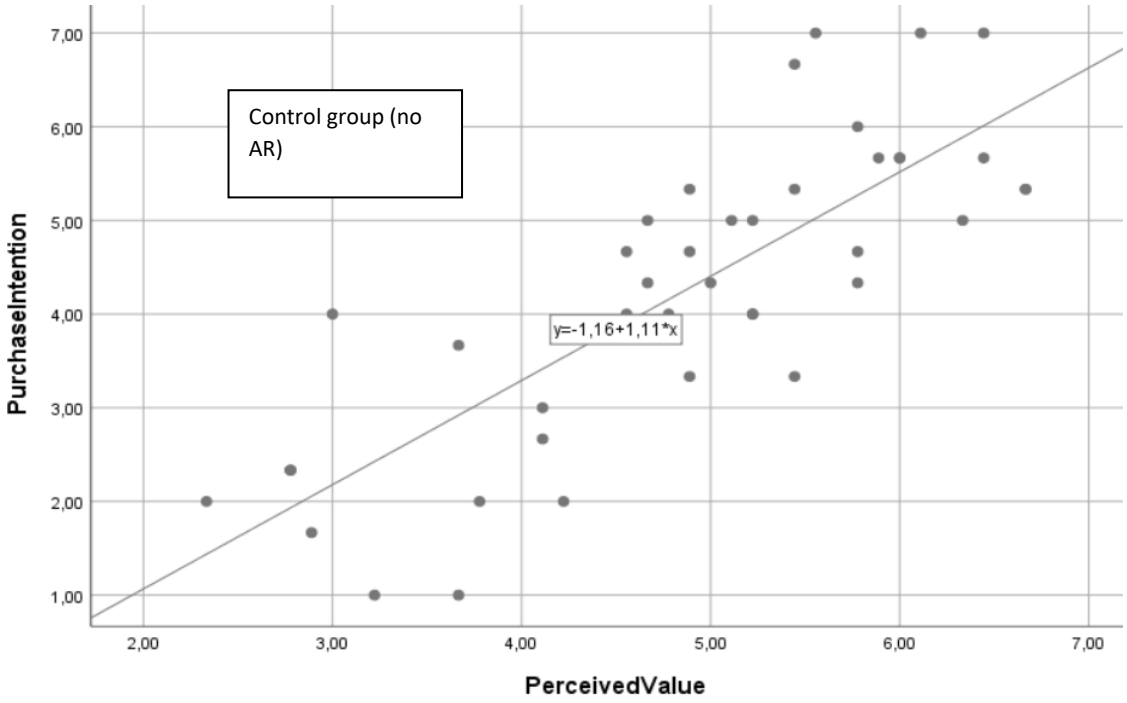
Appendix 1.1 – Linear Regression Analysis – Control Group



Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1,158	,658		-1,759	,086
	PerceivedValue	1,112	,131	,805	8,468	,000

a. Dependent Variable: PurchaseIntention

b. Selecting only cases for which Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? = Nee

Model Summary[b,c]

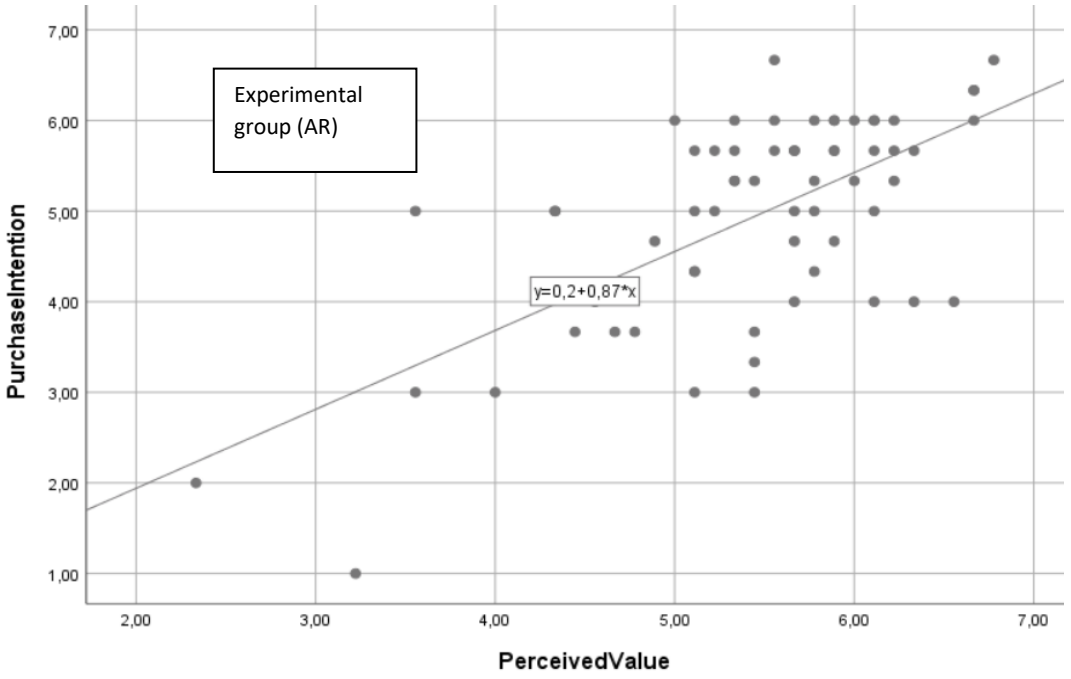
Model	R Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? = Nee (Selected)	R Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? ~= Nee (Unselected)	R Square	Adjusted R Square	Std. Error of the Estimate
1	,805[a]	,647	,648	,639	,96841

a. Predictors: (Constant), PerceivedValue

b. Unless noted otherwise, statistics are based only on cases for which Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? = Nee.

c. Dependent Variable: PurchaseIntention

Appendix 1.2 – Linear Regression Analysis – Experimental Group



Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	,199	,730		,273	,786
	PerceivedValue	,871	,133	,647	6,571	,000

a. Dependent Variable: PurchaseIntention

b. Selecting only cases for which Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? = Ja

Model Summary[b,c]

Model	R Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? = Ja (Selected)	R Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? ~= Ja (Unselected)	R Square	Adjusted R Square	Std. Error of the Estimate
1	,647[a]	,805	,419	,409	,89691

a. Predictors: (Constant), PerceivedValue

b. Unless noted otherwise, statistics are based only on cases for which Heeft u zojuist Augmented Reality (AR) gebruikt om jouw wanddecoratie te bekijken? = Ja.

c. Dependent Variable: PurchaseIntention