Understanding Customer Acceptance of Internet of Things Services in Retailing: An Empirical Study About the Moderating Effect of Degree of Technological Autonomy and Shopping Motivations

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Executive summary

The Internet of Things (IoT) represents a shift towards a digitally enriched environment connecting smart objects and users that promises to provide retailers with innovative ways to approach their customers. IoT technologies differ from previous innovations as they are ubiquitous, and encourage solutions to be intelligent and autonomous. In addition, in grocery shopping consumer interests change towards increasingly demanding shopping experience. Yet, research into the customer acceptance of IoT services in retailing is scarce and the relevance of technological autonomy and shopping motivations has been neglected. Hence, the aim of the present research was to assess factors influencing the acceptance of IoT retail services and to investigate whether technological characteristics affect the significance of certain predictors on intention. Based on the technology acceptance model (TAM) this research proposed an IoT retail service acceptance model that consists of seven perceptional factors (perceived usefulness, perceived ease of use, perceived enjoyment, perceived behavioural control, perceived credibility, perceived technology trust), one social factor (social influence) and two moderators (degree of autonomy and underlying shopping motivations). In a 2x2 experimental design, data from 339 international customers of the University of Twente campus supermarket were used to

analyse the research model by means of multiple regression analyses. The results presented statistically significant support for the effects of perceived usefulness, perceived compatibility, perceived enjoyment, social influence and perceived behavioural control. Perceived technology trust was of marginal significance in predicting intention. However, perceived ease of use and perceived credibility did not play a statistically significant role in determining intention. In addition, support was found that perceived usefulness, perceived enjoyment and perceived technology trust gained significance in situations in which technological autonomy was high. Furthermore, neither did shopping motivations influence the effects of perceived usefulness and perceived enjoyment on intention, nor did they correlate with autonomy. These findings highlight that perceptional factors presenting the relative advantage of using the service (usefulness and enjoyment) are distinctively important, especially when technologies are highly autonomous. Yet, the awareness of behavioural control and compatibility was found to be statistically significant. Coincidently, social influence appeared to influence acceptance behaviour and outweighed own trust perceptions. However, with technologies moving to the background and being experienced less consciously, the ease of actively using a technology becomes irrelevant. This challenges the robustness and applicability of TAM in future technologies. Finally, irrespective of the underlying shopping motivations, IoT services are able to create an enjoyable shopping experience. Yet, when technological autonomy is high, hedonic motivations were not able to minimize effects of perceived vulnerabilities as dissonant cognitions. The findings challenge future research to consider degree of autonomy and shopping motivations in other contexts of IoT technology acceptance. In addition, TAM itself appears obsolete which suggests that future research should consider other factors than ease of use. The results will have important implications for retail marketers to adjust their IoT service introductions. Practitioners should clearly communicate the relative advantage of usage and the controllability of the technology. In addition, marketers should encourage interactions between the customers and their social influencers to communicate the advantages and the trustworthiness of the service. Finally, IoT retail services need to be compatible with existing customer habits which suggests that marketers need to design services that do not challenge the user to vastly change current usage behaviour.

Keywords: Internet of Things; retail innovations; customer acceptance; technology acceptance model

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1.) Introduction

Advances in the Internet of Things (IoT) are a major strategic technology trend (High, 2015). The number of interconnected objects, consumers and activities will increase drastically across industries within the upcoming years (Gartner, 2014). The seamless integration of smart electronics into everyday physical objects will provide new opportunities for information and communication technologies. Establishing interconnections of physical and virtual realms will lead to new services and applications (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012). With the integration of latest technologies, the IoT will revolutionize the customer experience in retailing, allowing companies to introduce innovative consumer services. While IoT enabling technologies are readily available and retailers across the globe already augment the shopping experience with IoT services (Gregory, 2015), the expected vast adoption and diffusion has not taken place yet (Hwang, Kim, & Rho, 2015).

Even though advances in sensor and computing technology are expected to drastically change the retail shopping experience (Gregory, 2015), the individual acceptance of IoT services as pervasive applications in a holistic retail context has been neglected in current literature. Instead, existent research primarily focusses on technical and design issues concerning the implementation of IoT technologies (Atzori, Iera, & Morabito, 2010; Miorandi et al., 2012; Tan & Wang, 2010) and the IoT infrastructure (Agrawal & Das, 2011). While some articles were found that assess user perspectives towards the adoption of IoT enabling technologies such as RFID (Hossain & Prybutok, 2008; Juban & Wyld, 2004; Thiesse, 2007) and NFC (Dutot, 2015; Pham & Ho, 2015), only one paper was found which considers technology acceptance in a retail context (Müller-Seitz, Dautzenberg, Creusen, & Stromereder, 2009). Therefore, this paper aims at extending current literature in consumer technology acceptance by assessing the factors influencing intention to accept IoT services in a grocery shopping environment.

Consumer hesitation to adopt IoT services may be explained by two essential technology characteristics that distinguish IoT solutions from previous innovations. First, IoT services are ubiquitous and omnipresent in nature (Weiser, 1991). Technologies fade into the background, leading to an intelligent network of less visible and touchable applications (Weiser, 1993). Consequently, connecting devices such as smartphones are the only comprehensible components of the IoT (Gubbi, Buyya, Marusic, & Palaniswami, 2013). It is therefore important to understand if these changing characteristics affect the consumer's intention to accept new services. While previous research found user perceptions towards the innovation to predict technology adoption (Davis, 1989; Venkatesh, Thong, & Xu, 2012), research is needed to assess if consumers readily accept ubiquitous technologies or if it rather discourages adoption behaviour. Therefore, this paper integrates perceptional factors that have been found to be significant predictors in the adoption of related technologies and assesses the relevance of these on intention to accept ubiquitous IoT services in grocery retailing.

Second, IoT services build on autonomous and semi-intelligent technologies (Tan & Wang, 2010). As advances in these disciplines proceed, consumers may perceive increasing vulnerabilities

(Jalbert, 1987) and loss of control over the technology. Therefore, as services increasingly rely on technological autonomy, it is crucial to learn if the transfer of control to the technology influences consumers' willingness to adopt. This will strengthen the understanding of the relevance of technology autonomy as a factor influencing the acceptance of future services in grocery shopping. While prior research theoretically discusses the relevance of degree of autonomy (Beier, Spiekermann, & Rothensee, 2006; Röcker, 2010), no study was found that empirically assesses the impact of technological autonomy on acceptance behaviour. Thus, this paper recognizes the autonomous and semi-intelligent nature of IoT services by introducing degree of autonomy as a moderating factor influencing the significance of certain predictors on intention to accept IoT services in retailing.

Furthermore, the shopping experience itself becomes increasingly important, even in grocery shopping. Consumers progressively demand individualized attention and tailored shopping experiences (PricewaterhouseCoopers, 2014). That is why hedonic motivations, which are based on enjoyment seeking, gain importance (Babin & Attaway, 2000; Hirschman & Holbrook, 1982). Thus, considering the grocery shopping context, which is rather based on functional need satisfaction, it is important to understand if the acceptance of IoT services is influenced by the primary shopping motivations on which the service focusses. Previous research (Childers, Carr, Peck, & Carson, 2001) argues that different shopping motivations influence the impact of certain perceptions on the intention to accept. Hence, this study extends former research by recognizing the dichotomy of shopping motivations and evaluating the impact of underlying shopping motivations on the significance of key predictors on the intention to accept IoT retail services.

Coincidently, shopping motivations may be related to degree of autonomy. In order to use new IoT services, the consumer needs to accept its technological autonomy. Derived from the cognitive dissonance theory (Festinger, 1957), this may lead to an internal struggle of either accepting the vulnerabilities concerned, or denying the usage of the service. Hence, users may eliminate dissonance by placing greater emphasis on the shopping motivations rather than focussing on autonomy related vulnerabilities. It is therefore important to gain insight if shopping entertainment can outweigh the dissonance arising from technological autonomy. No research has been found that connects autonomy with shopping motivations and empirically tests the relevance in a shopping context. Hence, this study incorporates the interaction effect of degree of autonomy and motivations by empirically testing the impact of these constructs on the intention to accept IoT services in grocery retailing.

Taken together, this leads to the following research questions:

1. What are the factors influencing consumer acceptance of IoT services in grocery retail?
    1.1. What is the role of technology autonomy in the consumer acceptance of IoT services in grocery retail?
    1.2. What is the role of shopping motivations in the consumer acceptance of IoT services in grocery retail?

This research is highly relevant to both researchers and practitioners. Based on the gaps identified, this research extents current literature in consumer acceptance with latest technology trends in IoT services in a grocery retail environment. Building on the technology acceptance model (TAM) by Davis (1989), this paper assesses the applicability and robustness of TAM in a context of ubiquitous IoT technologies. For practitioners, the study is relevant, because it provides insights into perceptional factors, which facilitate or prevent the acceptance of IoT services. This will allow marketers to adapt their new services accordingly in order to encourage consumer acceptance. The paper starts with a literature study about the developments of IoT in retailing. Subsequently, it discusses the TAM and introduces the proposed research hypotheses. After describing the research methodology, the results are presented. Finally, the paper discusses the findings and provides practical implications and limitations

2.) Theoretical framework

2.1) Internet of things in retailing

The Internet of Things (IoT) is a progression of the conventional internet towards a system of intelligent things and devices connecting the physical and digital world. The IoT describes the pervasive presence of objects which are able to interact with each other through wireless telecommunication (Atzori et al., 2010). By augmenting physical things and devices with abilities to sense, compute and communicate, these objects form a collective network (Guo et al., 2013). Building on Tan and Wang (2010), this paper continues with the IoT in retailing as a smart and supportive environment which is based on connecting objects and assortment items via sensitive, responsive and adaptive technologies with devices enabling the consumer to experience an augmented shopping experience in- and outside the physical store.

2.2) From technologies to IoT retail services

Gubbi, Buyya, Marusic and Palaniswami (2013) define hardware, middleware and presentation as the three technological components which enable the IoT. Hardware describes the physical web of the IoT including sensors, actuators and embedded communication hardware (Gubbi et al., 2013). The middleware is concerned with the data storage and the computing tools for data analysis and enables IoT solutions to be smart and responsive to the user (Gubbi et al., 2013). Presentation refers to the visualization and interpretation tools accessible via different platforms, which are created for different applications (Gubbi et al., 2013). While hard- and middleware move to the background, the presentation component is the visible part which enables the user to interact with the smart environment (Gubbi et al., 2013). Thus, touch screen technologies, dedicated apps and websites installed on smart devices are the applications which enable the consumer to connect to the IoT. As a result, from a consumer's point of view this might be the only comprehensible part of the IoT. In this regard, presentation is the interface

between service provider and user which enable retailers to augment the consumer shopping experience with the help of IoT service introductions.

Retailers experiment with IoT technologies. Advances in the functions of IoT technologies allow retailers to offer services which enhance the in- and out-store shopping experience. Location-based services (LBS) encourage location-awareness of the user and enable the service to provide context-relevant information (Barnes, 2003). For instance, BLE beacons allow retailers to approach potential customers via notifications when being in short distance of the store (Gregory, 2015). Additionally, sensor technologies enable indoor mapping and navigation services (Newman, 2014). Other services augment the physical shopping experience by encouraging information, or upgrading the shopping convenience or enjoyment. For example, RFID tags enable contactless identification of the items and payment as the customer walks out of the store allowing to check out without queue times (Tellkamp & Haller, 2005). Application cases cover a wide array from product tracking and traceability, interactive consumer engagement, smart operations, shopper intelligence to mobile payments etc. (ComQi, 2015). With the introduction of such self-service technologies (Meuter, Ostrom, Roundtree, & Bitner, 2000), retailers place responsibilities on the customer to independently use these services and experience an extended retail environment.

2.3) Technology Acceptance Model

Over the last decades a large spectrum of research models about the adoption of information technologies has developed. A dedicated stream of research focusses on the individual acceptance of technology by considering intention or usage as the dependent variable (Ajzen, 1985; Davis, 1989; Fishbein & Ajzen, 1975; Venkatesh & Davis, 2000). The Technology Acceptance Model (TAM) by Davis (1989) has become the leading theory in information system literature (Li, 2008). TAM argues that the intention to use a technology predicts the actual usage. Davis (1989) introduces two determinants influencing usage intention: (1) perceived usefulness (PU) as the degree to which an individual thinks that using the new technology will improve his own performance and (2) perceived ease of use (PEOU) as the degree to which an individual believes the new technology will be free from effort. Research reveals that the individual intention to use information technology is primarily predicted by the PU, while PEOU is of minor importance (Davis, 1989).

TAM is a useful theoretical model to understand and explain consumer acceptance of information technologies (Legris, Ingham, & Collerette, 2003). The basic TAM is statistically reliable and readily generalizable to different information systems and user populations (Davis, Bagozzi, & Warshaw, 1989; Legris et al., 2003). Therefore, TAM provides a sound starting point for further analysis of the acceptance of IoT retail services. While TAM provides general information about the PU and PEOU across a range of users with different interests (Mathieson, 1991), Röcker (2010) argues, that TAM is inappropriate in assessing future information technology adoption and suggests that other factors might be relevant in determining adoption behaviour. Subsequently, TAM itself is not considered

to be sufficient in explaining the consumer adoption of IoT services for two reasons. First, the TAM has been designed and tested in a context of information technology acceptance at the workplace (Davis, 1989). This context is different to the environment of IoT retail services. Other than IT solutions at the workplace, IoT services build on advances in ubiquitous computing and intelligent behaviour. Therefore, users may experience IoT services less consciously compared to other technologies. Second, ubiquitous computing applications might be disruptive (Beier et al., 2006). Future retailing will be designed in an environment which is complemented with various technologies continuously supporting the consumer by providing personal and context-aware services (Gregory, 2015). Thus, perceptional aspects might play a significant role in adoption. In addition, acceptance of IoT services may be influenced by opinions of relevant others. Due to the realization that the basic TAM is not sufficiently adequate, this paper aims at developing and testing an extended research model (see Fig. 1).

2.4) Towards an IoT retail service acceptance model

While former research found intention to use to significantly predict actual usage behaviour (Davis, 1989; Venkatesh, Morris, Davis, & Davis, 2003), this paper argues that this construct is not suitable in assessing consumer acceptance of IoT services. This is because of the ubiquitous and semi-autonomous nature and the rather subconscious processes of how consumers experience and sense these services. Hence, considering these technology characteristics, instead of intention to use, this paper continues with *intention to accept* as the willingness to accept pervasive and autonomous IoT technology based services in the day-to-day shopping routine. Building on previous research, it is a reasonable approach to apply intention as the single dependent variable representing the willingness to accept IoT enabled services in retailing.

Additionally, various studies argue that user beliefs have a significant causal relation with user acceptance (Pavlou, 2003; Wang, Lin, & Luarn, 2006). Hence, this study suggests that the constructs of PU, PEOU, perceived enjoyment, perceived behavioural control, perceived credibility, perceived technology trust, perceived compatibility and social influence positively predict the acceptance of IoT services in retailing. Given the fact that advances in artificial intelligence and autonomous semi-intelligent behaviour proceed (Cook, Augusto, & Jakkula, 2009), the degree of technological autonomy is expected to moderate the effects of selected antecedents on the acceptance intention. Furthermore, considering the increasing relevance of having an enjoyable store experience while shopping efficiently, underlying shopping motivations are expected to moderate the effects of selected determinants on the intention to accept IoT services in retailing.

Perceived usefulness

Users will accept innovations only if it provides them with a unique advantage compared to the existing solutions (Rogers, 1995). Therefore, this paper suggests that PU, as the user's expectation that adopting a new service increases shopping performance, predicts acceptance intention. PU has been found to

predict adoption in related contexts such as electronic commerce (Gefen, Karahanna, & Straub, 2003; Pavlou, 2003), mobile commerce (Agrebi & Jallais, 2015; Wang et al., 2006) and IoT technology (Gao & Bai, 2014). Further, Müller-Seitz et al. (2009) have confirmed that PU determines technology acceptance of new services in electric appliance retail.

IoT enabling technologies lead to the introduction of new retail services (Gregory, 2015). Those services allow the user to save time and money, and increase the shopping convenience. Therefore, the consumer is expected to value PU as a major factor in accepting new services in grocery shopping. Referring to the underlying argumentation of TAM this research proposes the following hypothesis:

H1: The higher the PU, the higher the intention to accept IoT services in grocery shopping.

Perceived ease of use

PEOU is an important factor in the acceptance of new technologies (Thiesse, 2007). Rogers and Shoemaker (1971, p. 154) suggest that complexity as "the degree to which an innovation is perceived as relatively difficult to understand and use" plays a significant role in the adoption of innovative technologies. Previous literature in e-commerce (Gefen et al., 2003; Pavlou, 2003), m-commerce services (Fong & Wong, 2015; Wang et al., 2006) and RFID (Hossain & Prybutok, 2008) found PEOU to be a significant predictor of the intention to use. This is furthermore supported by recent research about the adoption of NFC technology (Dutot, 2015) and electronic toll collection as an IoT technology (Gao & Bai, 2014).

Consequently, this research argues that the intention to accept IoT retail services is significantly influenced by the perceived difficulty to understand and use the respective solution. Consumer might be more likely to accept services which do not require extensive preparation or familiarization. This leads to the following hypothesis:

H2: The higher the PEOU, the higher the intention to accept IoT services in grocery shopping.

Perceived enjoyment

Besides PU, perceived fun and pleasure may intrinsically motivate the user to accept new technologies (Davis, Bagozzi, & Warshaw, 1992). In this context, perceived enjoyment (PE) is defined as the degree to which the acceptance of IoT services in itself is perceived as enjoyable (Gao & Bai, 2014). Research found evidence that PE positively impacts the adoption of technologies in e-commerce (Doolin, Dillon, Thompson, & Corner, 2005; Ha & Stoel, 2009), m-commerce (Agrebi & Jallais, 2015; Lu & Su, 2009) and IoT (Gao & Bai, 2014). The UTAUT2 model revealed that PE is a crucial driver in consumer adoption of mobile internet services (Venkatesh et al., 2012).

The shopping experience is of increasing relevance for the consumer(PricewaterhouseCoopers, 2014). Smart devices allow retailers to offer new services and augment the shopping routine in order to establish a pleasurable shopping experience even in grocery shopping (Gregory, 2015). Hence, this paper argues that the higher the PE of the IoT service, the more likely it is that the consumer accepts it. This suggests the following hypothesis:

H3: The higher the PE, the higher the intention to accept IoT services in grocery shopping.

Perceived behavioural control

Advances in technologies encourage the shopping environment to become a smart space full of autonomous and semi-intelligent objects and self-service technologies (ComQi, 2015). The acceptance of such solutions may be determined by the consumer's perceived control. Based on social psychology research, control is a human driving force which manifests the individual's power over the environment (White, 1959). The need to control is motivated by the intention to understand the reasons and consequences of own and other behaviours (Baronas & Louis, 1988). Therefore, a loss of control may influence the willingness to adopt technology. By introducing the construct of perceived behavioural control (PBC), Ajzen (1985) considers situations in which people feel to have little power over their attitudes and behaviours. Former research reveals that the integration of this variable improves the prediction of usage intention (Madden, Ellen, & Ajzen, 1992; Mathieson, 1991). Studies in the consumer service experience (Hui & Bateson, 1991), self-service technologies (Lee & Allaway, 2002) and ubiquitous computing applications (Beier et al., 2006) indicate that PBC determines intention and usage behaviour.

Consumers avoid technologies in which PBC is lower than the existent personal need for control (Beier et al., 2006). Due to the ubiquitous and disappearing nature of new service introductions, users cannot comprehend technological behaviours and data processes. Thus, while the personal need for control is present, they may fear a loss in control. In this light, such a loss in PBC prevents the user from accepting new services. This suggests the following hypothesis:

H4: The higher the PBC, the higher the intention to accept IoT services in grocery shopping.

Perceived credibility

Privacy and security concerns play a significant role in the adoption of innovations. Perceived credibility (PC) is the consumer's perceived protection of privacy and security when accepting IoT retail services (Wang, Wang, Lin, & Tang, 2003). Perceived privacy is the the extent to which the consumer assumes that he possesses the right to control the collection and usage of his personal information, even after revealing it to others (Hossain & Prybutok, 2008). Concurrently, perceived security is the extent to

which the consumer experiences protection against security threats resulting from the use of IoT services. Previous research in e-commerce (Kim, Ferrin, & Rao, 2008), mobile services (Wang et al., 2006) and RFID (Hossain & Prybutok, 2008) indicate that privacy and security concerns influence the consumer adoption of the respective solutions. In a study among German customers about the acceptance of RFID solutions in an electronic retail store, the attitudes toward protection of data privacy were found to be the second most important factors influencing technology adoption (Müller-Seitz et al., 2009).

Consumers might expect IoT services to be a next step toward customer transparency. The integration of intelligent interconnected objects in consumer lives is potentially dangerous as this could enable surveillance mechanisms (Atzori et al., 2010). Thus, the consumer could fear increasing concerns of privacy and security loss. In addition, due to the ubiquitous and invisible nature of IoT devices, the internal working and data stream processing might be barely comprehensible for the user, leading to perceived privacy and security vulnerability (Rose, Eldridge, & Chapin, 2015). This paper argues that the higher the PCR of the underlying technology, the more likely it is that the consumers accept IoT retail services. Therefore, the following hypothesis is introduced:

H5: The higher the PCR, the higher the intention to accept IoT services in in grocery shopping.

Perceived technology trust

Innovations are related to benefits and risks (Cho, 2004). Trust is an important feature of both social and economic interactions in which uncertainty exists. It supports consumers to overcome perceived risks and insecurities (McKnight, Choudhury, & Kacmar, 2002). Thus, trust is effective in reducing uncertainty and risks by supporting safety perceptions (Lin, 2011). It is a complex construct composed of multiple dimensions (Lewis & Weigert, 1985). Therefore, this paper focuses on perceived technology trust (PTT) as the degree of subjective probability to which the consumer believes that the new technology usage is reliable and trustworthy (McKnight & Chervany, 2001). The trust-enhanced technology acceptance model recognized trust as a central construct in the adoption of mobile payment solutions (Dahlberg, Mallat, & Öörni, 2003). Literature in e-commerce (Grabner-Kräuter & Kaluscha, 2008), m-payment (Srivastava, Shalini, & Theng, 2010) and IoT technology (Gao & Bai, 2014) support the argumentation that trust in a system or technology influences adoption behaviour.

Closely related to the construct of PC, technology trust in the solution is argued to be a determining factor for the adoption of IoT retail services. With devices moving to the background and becoming less comprehensible for the consumer, technologies and data become increasingly invisible (Rose et al., 2015). This may lead to consumer perceptions of uncertainty and vulnerability. Since trust has been found to be a key feature to minimize perceived risks and insecurities (McKnight et al., 2002),

this paper argues that the higher the technology trust, the more likely it is that the consumer accepts the IoT services. Hence, this paper proposes the following hypothesis:

H6: The higher the PTT, the higher the intention to accept IoT services in grocery shopping.

Perceived compatibility

If innovative solutions are in conflict with existing patterns, consumers may show hesitation or even resistance to change their behaviour (Kleijnen, Lee, & Wetzels, 2009). Perceived compatibility (PCO) is the extent of perceived consistency of the innovation with existing values, experiences and needs (Rogers, 1995). Former research considers compatibility to be a key factor in technology acceptance (Rogers, 1995). Research in initial use of IT solutions (Agarwal & Prasad, 1998) and m-commerce (Mallat, Rossi, Tuunainen, & Oorni, 2009) indicates that PCO influences technology acceptance. More recently, Pham and Ho (2015) showed that the intention to adopt NFC mobile payments is significantly determined by the PCO with the existing lifestyle and habits of the individual.

IoT services are expected to become part of the shopping experience in retailing. While these services will disruptively change the retail shopping experience, they build on touch screen technologies (e.g. smartphones) the consumers are already familiar with (Gubbi et al., 2013). Nevertheless, it is important to determine if the technology is compatible with the consumer's needs and meets the existing value considerations. Hence, this paper argues that the higher the PCO between the proposed IoT service and current habits and applications, the more likely the consumer is to accept the service. This suggests the following hypotheses:

H7: The higher the PCO, the higher the intention to accept IoT services in grocery shopping.

Social influence

The social context of the user is an important factor influencing the decision process of technology adoption. Since, Davis (1989) focuses on the individual attitude of a person towards a technology, the TAM does not take subjective norm into consideration. This paper however, recognizes the relevance of the social context in acceptance intention. Based on Venkatesh et al. (2012) this paper introduces social influence (SI) as the importance observed by the consumer of the perception of relevant people to adopt IoT retail services. Both the Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Theory of Planned Behaviour (Ajzen, 1991) pay attention to social factors by integrating subjective norms as the normative beliefs influenced by the overall perception of relevant others about the behaviour (Fishbein & Ajzen, 1975). Related research in m-commerce (Fong & Wong, 2015), NFC technology (Dutot, 2015) and IoT technology (Gao & Bai, 2014) revealed that SI significantly

influences the adoption of the respective solution. In addition, Lu, Yao and Yu (2005) showed that SI is an important determinant in the adoption of wireless internet services in mobile technology.

IoT technology based services are in the early stages of market implementation in retailing. At this point, users may have insufficient information about usage (Gao & Bai, 2014). Therefore, social network opinions of relevant others may play an important role in adoption behaviour. In line with the diffusion of innovations theory, individuals may be influenced by perceptions of early adopters (Rogers, 1995). In addition, shopping is inherently social (Evans, Christiansen, & Gill, 1996) suggesting that opinions of influencers play a role in acceptance intention. Therefore, this paper argues that SI significantly impacts the intention to accept IoT retail services. This leads to the following hypothesis:

H8: The higher the SI, the higher the intention to accept IoT services in grocery shopping.

Degree of technological autonomy

Research in the 21st century information landscape needs to address the autonomy of technologies (McKenna, Arnone, Kaarst-Brown, McKnight, & Chauncey, 2013). Considering technological advancements in intelligent and semi-autonomous behaviour, technological autonomy is the degree to which IoT retail services are able to make and execute decisions independently on their own without being actively controlled by the user. Positions in the literature about the impact of technological autonomy are diverse. One research stream connecting philosophy and technology argues that technological autonomy makes human beings vulnerable to deleterious effects (Jalbert, 1987). Therefore, an increasing degree of autonomy may involve growing uncertainties and risks which in turn leads to a potential loss in control over the technology. On the other hand, recent research considers autonomous systems as close interaction partners which encourages the acceptance of such (Pfeifer, Lungarella, & Iida, 2012).

Röcker (2010) argues that future technologies will significantly differ regarding the degree of autonomy. Degree of autonomy may play a focal part in the acceptance intention of IoT retail services, because it may be intuitively linked to the users' technology perceptions. Therefore, this research introduces degree of autonomy as a moderating variable that influences the impact of the consumer perceptions on acceptance intention. The significance of certain perceptions may grow as technological autonomy increases. In situations, in which autonomy is high and uncertainties increase, perceptions of relative advantages generated through PU or PE may gain significance. In this regard, the relative advantage may compensate the higher risks concerned. Simultaneously, users may be more sensitive towards control, credibility and trust issues in uncertain environments. Therefore, PBC, PCR and PTT may become increasingly significant when facing highly autonomous services. This suggests the following hypotheses:

H9a: The impact of PU on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.

H9b: The impact of PE on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.

H9c: The impact of PBC on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.

H9d The impact of PCR on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.

H9e: The impact of PTT on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.

Shopping motivations

Next to the effective completion of doing grocery shopping, the shopping experience becomes more important (PricewaterhouseCoopers, 2014). The consumer's underlying shopping motivations are either focused on problem solving or enjoyment seeking (Hirschman & Holbrook, 1982). Past research in shopping behaviour distinguishes between utilitarian and hedonic motivations. Utilitarian motivations refer to the consumer evaluation of functional benefits (Overby & Lee, 2006). Cognitive attitudinal aspects, such as price considerations (Zeithaml, 1988), time savings and shopping convenience (Jarvenpaa & Todd, 1997) play a central role. In this regard, consumers are rather focussed on an efficient shopping process without irritation (Childers et al., 2001). Research recognizes the increasing relevance of hedonic motivations in the in-store shopping experience (Babin & Attaway, 2000). Hedonic motivations are related to the consumer evaluations of experiential advantages (Overby & Lee, 2006). Entertainment and enjoyment are hedonic motivations due to the self-fulfilling value to have a pleasurable shopping experience (Konus, Verhoef, & Neslin, 2008; van der Heijden, 2004).

As shopping entertainment gains importance in grocery shopping, it may be interesting to assess the impact of shopping motivations in consumer acceptance. While some new retail services rather focus on utilitarian motivations, others augment the shopping environment in order to create an enjoyable experience. Thus, this research recognizes the dichotomy of shopping motivations. Childers (2010) argues that the significances of PU and PE vary across different shopping contexts (hedonic vs. utilitarian). Therefore, this research suggests that the primary shopping motivation of the respective service moderates the effects between consumer perceptions on acceptance intention. While PU is related to performance, convenience and efficiency, PE is related to hedonic motivations. Thus, PU may have a stronger effect on intention to accept among utilitarian IoT services and PE may have a stronger effect on intention to accept among hedonic IoT services. This is supported by research of van der Heijden (2004) who found that PE is a strong determinant of usage intention in hedonic information systems. This suggests the following hypotheses:

H10a: The impact of PU on the intention to accept IoT services in grocery shopping positively increases when the service is based on utilitarian shopping motivations.

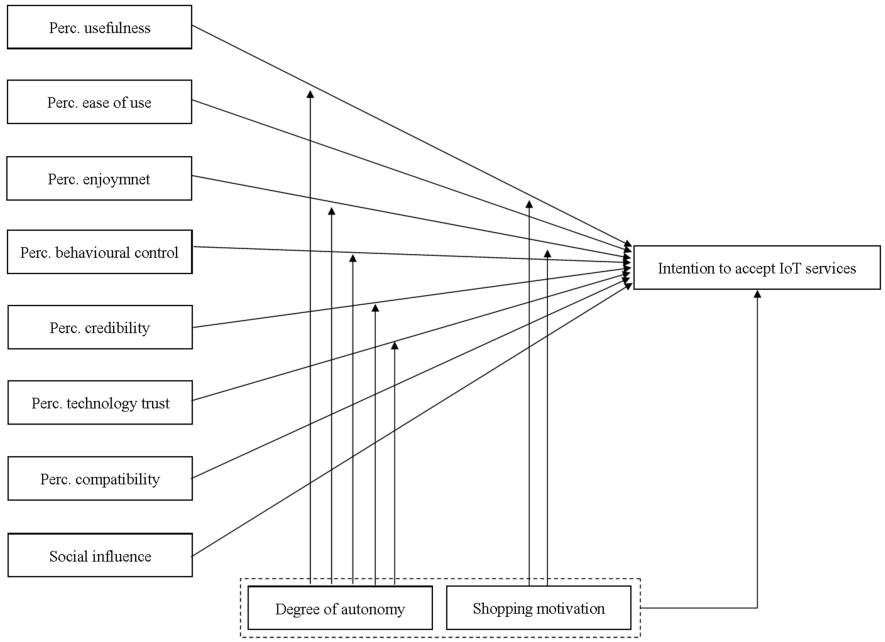
H10b: The impact of PE on the intention to accept IoT services in grocery shopping positively increases when the service is based on hedonic shopping motivations.

Combining degree of autonomy with shopping motivations

Furthermore, following the cognitive dissonance theory that argues that people have an inner drive to hold attitudes and beliefs in harmony while avoiding dissonance (Festinger, 1957), this paper suggests to examine degree of autonomy and shopping motivations coincidentally. Accepting highly autonomous services may imply an increase in vulnerability as dissonant cognition. As one strategy to reduce dissonance, Festinger (1957) suggests to lower the importance of the cognition. Recognizing the increasing relevance of hedonic motivations in grocery shopping, the consumer may convince himself that having an enjoyable shopping experience is of larger importance than being discouraged by the vulnerability resulting from accepting high technological autonomy. Therefore, the intention to accept highly autonomous IoT services based on hedonic shopping motivations is expected to be higher compared to highly autonomous services based on utilitarian motivations. This suggests the following hypothesis:

H10c: The mean score of intention to accept IoT services in grocery shopping is significantly higher in highly autonomous services that focus on hedonic shopping motivations compared with highly autonomous services that focus on utilitarian shopping motivations.

Research model 1: IoT retail service acceptance model



3.) Research methodology

To answer the central research question "What are the determining factors influencing consumer acceptance of IoT technology based services in retailing?" this paper builds on an experimental research design. While intention to accept was measured as the single dependent variable, PU, PEOU, PE, PC, PTT, PCO and SI were the independent variables. In addition, degree of autonomy and shopping motivations were integrated as potential interaction terms. To assess the impact of the moderators, a 2 (degree of autonomy: high vs. low) x 2 (shopping motivations: utilitarian vs. hedonic) between-subject design was chosen, which leads to a set of four conditions (see table 1).

Table 1: 2x2 experimental design

	High Degree of autonomy	Low Degree of autonomy
Hedonic shopping motivation	Group 1	Group 2
Utilitarian shopping motivation	Group 3	Group 4

3.1) Data collection: Setting and participants

For the study, customers of the grocery store at the University of Twente campus were selected via convenience sampling. Customers have been approached right after making their purchases and were asked to participate in the survey. Thus, respondents were approached in a grocery shopping situation which is argued to increase the reliability of the results, because the data capture the shopping mood. Respondents were shortly briefed and were told that this survey is part of a master thesis in the acceptance of future retail services. The survey was provided via digital means using a laptop-pc and a tablet-pc. Respondents were randomly assigned to one of the four conditions and were introduced to the respective case with the help of a short 'Imagine…' description (see appendix A and appendix B). At the end, a few socio-demographic questions were asked, such as age, gender and professional background. Afterwards respondents were thanked for their participation and debriefed. The data collection took place during three weeks in May 2016.

In total 347 respondents agreed to participate in the experiment. After a first review of the results, 8 responses were discarded either because the respondents did not complete the survey or did not meet the requirement of owning a smartphone. Ownership of a smartphone is essential because it is a gateway technology that enables the IoT. Thus, familiarity with such a technology is considered as a pre-requirement. This allowed further analysis of 339 usable samples. Table 2 displays the descriptives statistics per condition. The first group included 87 respondents of which 44 male and 42 female respondents. The mean age in this group was 22.71. The majority of this group came from the Netherlands (47.1%) and was doing a bachelor study (54%). The second group comprised of 85 respondents (44 males and 41 females). The mean age was 22.27. More than half of the group two

respondents were Dutch and 65.9% followed bachelor courses. Group 3 incorporated 83 respondents of which 54 males and 28 females. The mean age was 21.53. 60.2 % of the respondents of this group came from the Netherlands and 61.4% were in bachelor studies. The fourth group included 84 respondents (45 males and 39 females) with a mean age of 22.44. 51.2% came from the Netherlands and 58.3% followed bachelor course.

Table 2: Attributes of respondents per experimental group

	Experimental group				**Total**
	Group1: High autonomy/ hedonic	Group 2: Low autonomy/ hedonic	Group 3: High autonomy/ utilitarian	Group 4: Low autonomy/ utilitarian	
Mean age (sd)	22.71 (3.02)	22.27(3.08)	21.52 (2.65)	22.44 (2.41)	22.24 (2.83)
Gender					
Male	44 (51.2%)	44 (51.8%)	54 (65.9%)	45 (53.6%)	187 (55.5%)
Female	42 (48.8%)	41 (48.2%)	28 (34.1%)	39 (46.4%)	150 (44.5%)
Country of origin					
The Netherlands	41 (47.1%)	43 (50.6%)	50 (60.2%)	43 (51.2%)	177 (52.2%)
Germany	20 (23%)	14 (16.5%)	15 (18.1%)	19 (22.6%)	68 (20.1%)
Other	26 (29.9%)	28 (32.9%)	18 (21.7%)	22 (26.2%)	94 (27.7%)
Current profession					
Bachelor student	47 (54%)	56 (65.9%)	51 (61.4%)	49 (58.3%)	203 (59.9%)
Master student	33 (37.9%)	20 (23.5%)	25 (30.1%)	29 (34.5%)	107 (31.6%)
Employee	5 (5.7%)	6 (7.1%)	5 (6%)	4 (4.8%)	20 (5.9%
Self-employed	2 (2.3%)	0	0	1 (1.2%)	3 (0.9%)
Other	0	3 (3.5%)	2 (2.4%)	1 (1.2%)	6 (1.8%)
Innovativeness score [1 low – 7 high] (sd)	4.94 (1.08)	4.84 (1.24)	4.96 (1.16)	4.97 (1.15)	4.93 (1.16)
Total	87 (25.7%)	85 (25.1%)	83 (24.5%)	84 (24.8%)	339

3.2) Measures

The survey was comprised of 39 questions, mainly worded as statements. Items measuring the focal constructs were adopted from previous literature because they show high reliabilities in the respective contexts. Dutot's (2015) items were adopted to capture the intention to accept. Davis' (1989) scales were modified in order measure the constructs PU and PEOU. Gao and Bai (2013) provide the basic items to measure PE, SI and PBC. PCR was measured by adopting Wang et al.'s (2003) scales. Pavlou (2003) provided the basis for the PTT construct. PCO scores were adapted from Mallat et al. (2009). In order to test if the respondents recognize the autonomy of the respective condition, this paper introduces

the construct of degree of autonomy as a control variable and establishes new scales measuring this construct. In addition, Agarwal and Prasad's (1998) scales were modified to measure personal innovativeness. The constructs were measured using a 7-point-Likert-type scale varying from 1 (strongly disagree) to 7 (strongly agree). Reliability of the constructs was confirmed by Cronbach's alpha (Table 3). All constructs were found to have a solid reliability of 0.73 or higher.

Table 3: Overview of items per construct and respective reliabilities

Construct	Items		α
Intention to accept	(1)	"I intend to use the service for shopping in grocery stores."	.926
	(2)	"I intend to use the service when available in store."	
Perceived usefulness	(1)	"I consider the service to be useful in retail."	.730
	(2)	"I see the usefulness of the service."	
Perceived ease of use	(1)	"Learning to use the service in retail would be easy for me."	.735
	(2)	"I would find the service easy to use."	
Perceived enjoyment	(1)	"I would have fun with the service."	.878
	(2)	"The service is pleasurable."	
	(3)	"The service brings enjoyment."	
Perceived behavioural control	(1)	"When accepting the service, I am still able to decide if I want to use the service."	.850
	(2)	"I am able to actively control the service provision."	
	(3)	"The service provision is under my control."	
	(4)	"When using the service, I am still in control of what happens."	
	(5)	"Using the service is entirely within my control."	
Perceived credibility	(1)	[Reverse] "I am concerned that the service is collecting too much personal information from me."	.890
	(2)	[Reverse] "I am concerned that the service will use my personal information for other purposes without my a...	
	(3)	[Reverse] "I am concerned about the privacy of my personal information when accepting the service."	
	(4)	[Reverse] "I am concerned that I do not have the right to control the collection and usage of my personal information."	
	(5)	"I would find the service secure when shopping groceries."	

	(6)	"I feel secure about the service."	
Perceived technology trust	(1)	"The service is trustworthy."	.835
	(2)	"I believe that the service keeps my best interests in mind."	
	(3)	"I trust the service."	
Personal innovativeness	(1)	"If I heard about a new information technology, I would look for ways to experiment with it."	.833
	(2)	"Among my peers, I am usually the first to explore new information technology."	
	(3)	"I like to experiment with new information technologies."	
Compatibility	(1)	"The service is a compatible method for me to support shopping in grocery stores."	.831
	(2)	"The service is compatible with my style and habits."	
	(3)	"The service is compatible with my way to do shopping."	
Social influence	(1)	"People who are important to me would probably recommend this service."	.878
	(2)	"People who are important to me would find the service beneficial."	
	(3)	"People who are important to me would find the service to be a good idea to use."	
Degree of autonomy [control variable]	(1)	"The smartphone autonomously starts the service."	.843
	(2)	"The service is initiated without my active control."	
	(3)	"Once accepted, the service itself works independently without my active control"	
	(4)	"Once accepted, I do not have to do anything in order to use the service."	
	(5)	"Once accepted, the service acts autonomously"	
	(6)	"Once accepted, I pass the control over the service provision to the technology."	
	(7)	"There is no need for me to intervene because the service acts independently."	

4.) Results

4.1) Main effects

A hierarchical multiple regression was run to predict intention to accept from PU, PEOU, PE, PBC, PC, PTT, PCO and SI. Hierarchical multiple regression was chosen because it allowed taking into account causal effects of predicting variables. Visual inspection of a plot of studentized residuals versus unstandardized predicted values indicated that the assumption of homoscedasticity was violated. This was supported by Breusch-Pagan test ($p < 0.05$) and Koenker test for Heteroscedasticity ($p < 0.05$). Consequently, a hierarchical weighted least-squares (WLS) regression was run. The partial regression plots and a plot of studentized residuals against the predicted values express linearity between predictors and dependent variable. As assessed by a Durbin-Watson statistic of 2.082, independence of residuals was supported. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were three studentized deleted residuals greater than ±3 standard deviations. However, these were not excluded from further analysis. Visual inspection of the Q-Q Plot shows that the assumption of normality was met.

The full model of PU, PEOU, PE, PBC, PC, PTT, PCO and SI (model 4) statistically significantly predicted intention to accept, $R2 = 0.553$, $F(8, 330) = 51.058$, $p < .001$, adj. $R2 = .542$. The simple TAM consisting of PU and PEOU (model 1) was statistically significant in determining acceptance intention, $R1 = 0.360$, $F(2, 336) = 94.352$, $p < .001$, adj. $R2 = .356$. The addition of PE, PBC, PCR and PTT to the prediction of intention to accept (model 2) led to a statistically significant increase in R2 of 0.128 $F(4, 332) = 20.650$, $p < .001$. The addition of PCO to the prediction of intention to accept (model 3) led to a statistically significant growth in R2 of 0.057, $F(1, 331) = 41.389$, $p < .001$. Finally, the inclusion of SI led to a statistically significant increase in R2 of 0.009, $F(1, 330) = 6.586$, $p = 0.011$. In the full model, five of the eight variables added statistical significance to the prediction, $p < .05$.

Table 4: Hierarchical multiple WLS regression predicting intention to accept from PU, PEOU, PE, PBC, PC, PTT, PCO and SI

	Intention to accept							
	Model 1		Model 2		Model 3		Model 4	
Variable	B	Beta	B	Beta	B	Beta	B	Beta
Constant	5.347		5.194		5.061**		5.047**	
Perceived usefulness	.775**	.421	.541**	.411	.372**	2.83	.357**	.271
Perceived ease of use	.064	.012	-.020	-.018	-.027	-.024	-.045	-.040
Perceived enjoyment			.285**	.287	.177**	.179	.176**	.178
Perceived behavioural control			.106*	.110	.078*	.081	.091*	.094
Perceived credibility			.047	.053	.057	.065	.053	.061
Perceived technology trust			.115*	.133	.088*	.102	.044	.051
Perceived compatibility					.314**	.329	.294**	.309
Social influence							.114*	.117
R Square	.360		.487		.544		.553	
F	94.352**		52.574**		56.458**		51.058**	
R Square Change	.360		.128		.057		.009	
F Change	94.352**		20.650**		41.389**		6.586*	

Note: N = 339; * p < , 05; ** p < .001; B = unstandardized regression coefficient; Beta = standardized coefficient

4.2) Interaction effects

Degree of autonomy

Prior to the actual moderator analyses, a one-way ANOVA was conducted to assess if the respondents recognize significant differences in the autonomy between the cases of the conditions high vs. low autonomy. The mean score in the variable perceived autonomy increased from low autonomy cases ($M = 3.9$, $SD = 1.08$) to high autonomy cases ($M = 4.8$, $SD = 1.09$). Differences were statistically significant, $F(1, 337) = 49.251$, $p < 0.001$, indicating that the cases are significantly distinctive and allow for further moderation analysis.

In order to assess the moderating effects of degree of autonomy between the predicting variables (PU, PE, PBC, PCR, PTT, PCO) and the dependent variable (intention to accept), six moderated WLS regressions were run separately. Weighted least-squares approach is an accurate method for comparing groups via moderated regression, especially when heteroscedasticity is at hand(Overton, 2001). Ex ante analyses via Breusch-Pagan test ($p < 0.05$) and a Koenker test for Heteroscedasticity reveal that the assumption of homoscedasticity was violated in the regressions. Therefore, moderated WLS regressions were run. Among the individual regressions studentized deleted residuals greater than ±3 standard deviations were detected. However, outliers were kept for further analyses because neither the leverage values nor Cook's Distance values exceeded the critical points.

Moderated WLS regression supports the interaction effect of degree of autonomy between PU and intention to accept. The inclusion of the moderator leads to a statistically significant 1.2% increase in total variation explained, $F(1, 335) = 5.483$, $p = 0.02$. Simple slopes of both conditions show statistically significant positive linear relationships between acceptance intention and PU. PU was more strongly associated with the intention to accept for high degree of autonomy ($b = 1.054$, $SE = 0.123$, $\beta = 0.667$, $p < 0.001$) than low degree of autonomy ($b = 0.696$, $SE = 0.09$, $\beta = 0.441$, $p < 0.001$).

A separate moderated WLS regression analysis indicates that degree of autonomy moderated the effect of PE on intention to accept, as suggested by a statistically significant 1.9% growth in total variation explained, $F(1, 335) = 8.439$, $p = 0.004$. Simple slopes tests for both conditions indicate statistically significant positive linear relationship between intention to accept and PE. PE was more strongly related to intention to accept for high degree of autonomy ($b = 0.758$, $SE = 0.084$, $\beta = 0.650$, $p < 0.001$) compared to low degree of autonomy ($b = 0.437$, $SE = 0.072$, $\beta = 0.375$, $p < 0.001$).

Another individual moderated WLS regression shows that degree of autonomy moderated the effect of PTT on intention to accept, as suggested by a statistically significant increase of 2% in total variation explained, $F(1, 335) = 7.639$, $p = 0.006$. Simple slopes were tested for the two conditions. Both simple slopes tests indicate statistically significant positive linear relationship between intention to accept and PTT. However, PTT was more strongly related to intention to accept for high degree of autonomy ($b = 0.579$, $SE = 0.092$, $\beta = 0.509$, $p < 0.001$) compared to low degree of autonomy ($b = 0.244$, $SE = 0.079$, $\beta = 0.215$, $p = 0.002$).

No support was found that degree of autonomy moderates the effects of PBC and PCR on intention to accept as evidenced by two individual moderated WLS regressions. Degree of autonomy was not found to significantly moderate the association between PBC and intention. The 0.1% increase in total variation explained through the inclusion of the interaction term was not statistically significant ($F(1, 335) = 0.47$, $p = 0.494$. Furthermore, degree of autonomy did not moderate the association between PCR and intention to accept, as shown by a statistically non-significant 1% increase in total variation explained ($F(1, 335) = 3.512$, $p = 0.062$).

Shopping motivations

Two moderated WLS regression analyses were conducted separately in order to evaluate the interaction effect of shopping motivations on the effects between PU, PE and intention to accept. No support was found that the interaction term statistically significantly increased the variations explained by the main effects. Shopping motivations did not moderate the effect of PU on intention to accept, as evidenced by a 0.001% change in total variation explained, which was not statistically significant ($F(1, 335) = 0.313$, $p = 0.576$). Also, shopping motivations did not moderate the effect of enjoyment on intention to accept, as evidenced by a 0.3% change in total variation explained, which was not statistically significant ($F(1, 335) = 1.186$, $p = 0.2711$).

Combining degree of autonomy with shopping motivations

Due to the insignificance of shopping motivations, no further interaction analyses that combines technological autonomy and shopping motivations were conducted. Thus, no support was found that the construct connecting degree of autonomy and shopping significantly influences intention to accept.

Table 5: Hypotheses results

Hypothesis		Support
H1:	The higher the PU, the higher the intention to accept IoT services in grocery shopping.	Yes
H2:	The higher the PEOU, the higher the intention to accept IoT services in grocery shopping.	No
H3:	The higher the PE, the higher the intention to accept IoT services in grocery shopping.	Yes
H4:	The higher the PBC, the higher the intention to accept IoT services in grocery shopping.	Yes
H5:	The higher the PCR, the higher the intention to accept IoT services in in grocery shopping.	No
H6:	The higher the PTT, the higher the intention to accept IoT services in grocery shopping.	Partial

H7:	The higher the PCO, the higher the intention to accept IoT services in grocery shopping.	Yes
H8:	The higher the SI, the higher the intention to accept IoT services in grocery shopping.	Yes
H9a:	The impact of PU on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.	Yes
H9b:	The impact of PE on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.	Yes
H9c:	The impact of PBC on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.	No
H9d	The impact of PCR on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.	No
H9e:	The impact of PTT on the intention to accept IoT services in grocery shopping positively increases when technological autonomy is high.	Yes
H10a:	The impact of PU on the intention to accept IoT services in grocery shopping positively increases when the service is based on utilitarian shopping motivations.	No
H10b:	The impact of PE on the intention to accept IoT services in grocery shopping positively increases when the service is based on hedonic shopping motivations.	No
H10c:	The mean score of intention to accept IoT services in grocery shopping is significantly higher in highly autonomous services that focus on hedonic shopping motivations compared with highly autonomous services that focus on utilitarian shopping motivations.	No

Personal characteristics and the intention to accept

Separate one-way ANOVAs reveal that personal characteristics may play a significant role in the acceptance intention, as well. The mean score of the intention was found to be statistically significant when comparing female (M = 5.2, SD = 1.31) with male respondents (M = 4.9, SD = 1.51), $F(1, 335) = 5.071$, $p = 0.025$. Also, country of origin was statistically significant ($F(2, 336) = 5.93$, $p = 0.003$), showing that respondents from other countries had a significantly higher mean intention to accept (M = 5.4, SD = 1.31) than Dutch customers (M = 4.8, SD = 1.49). In addition, respondents with a higher innovativeness tended to show higher scores in the mean intention to accept ($F (18, 320) = 2.723$, $p < 0.001$). No statistically significant variance was found in the mean intention between the professional backgrounds ($F (4, 334) = 0.615$, $p = 0.652$) and the respondents age ($F (14, 324) = 1.455$, $p = 0.127$).

5.) Discussion

This study aimed at assessing the factors that influence the intention to accept IoT technology based services in retailing. Based on literature, TAM was extended by adding perceived enjoyment, perceived behavioural control, perceived credibility, perceived technology trust, perceived compatibility and social influence to the basic model of perceived usefulness and perceived ease of use as predictors of acceptance intention. In addition, the study evaluates the moderating effects of the degree of autonomy and shopping motivations between a set of selected predictors and the intention to accept. The hierarchical regression indicates that the extension of TAM describes significantly more variance in the dependent variable compared to the basic TAM. Perceived usefulness, perceived compatibility, perceived enjoyment, social influence, perceived behavioural control were found to be the factors influencing the intention to accept IoT retail services.

The results reveal that perceived usefulness positively predicts the intention to accept IoT retail services (H1 confirmed). The comparison of the unstandardized regression coefficients reveals that usefulness is the most powerful predictor of acceptance intention. This supports previous research that PU is the principal determinant of intention (Davis, 1989; Gao & Bai, 2014). This is reasoned by the relative advantage the consumer experiences. If the consumer perceives a service to be relatively beneficial (compared to other services or to not adopting) they will probably accept it. IoT retail services are built to support the customers shopping routine and increase convenience.

Furthermore, the results show that perceived compatibility significantly predicts acceptance intention (H7 confirmed). Compatibility was found to be the second most powerful determinant of intention. This is in line with Rogers (1995), who suggested that compatibility is a major factor in technology acceptance, as well as recent research regarding the adoption of NFC mobile payments (Pham & Ho, 2015). The grocery retail industry may be considered as rather traditional instead of being remarkably innovative. Simultaneously, consumers may have their inert shopping patterns. For the time being, consumers are hesitant to accept innovative services that highly disrupt their existing shopping and smartphone usage behaviour. Hence, if a new service requires vast conversions of existing habits, it is likely that the intention to accept is low.

In addition, the results support the hypothesis that perceived enjoyment positively predicts intention to accept (H3 confirmed). Enjoyment is the third most important predictor of acceptance intention. Thus, the results support former studies, which found enjoyment to be a crucial factor in consumer adoption (Gao & Bai, 2014; Venkatesh et al., 2012). Even though grocery shopping may be primarily connected to satisfy functional needs, the results indicate that the consumer expects to have a pleasurable shopping experience through the interaction with IoT services. Thus, enjoyment is of growing importance in a rather utilitarian area. Concurrently, the results highlight that IoT services potentially augment the shopping experience with a dimension of pleasure.

Besides, the results reveal that social influence significantly determines the intention to accept IoT retail services (H8 confirmed). This supports previous studies in congeneric areas (Dutot, 2015;

Fong & Wong, 2015). Shopping is a social process (Evans et al., 1996). Therefore, the consumer may be inherently influenced by relevant others when facing new service introductions. Additionally, IoT services may be perceived as disruptive. Trustworthy opinions of relevant others play a central role in initial acceptance.

Moreover, the results show support that perceived behavioural control positively predicts the intention to accept IoT retail services (H4 confirmed). Therewith, the findings underpin prior research, which showed that a relative loss in perceived control negatively influences the willingness to technology acceptance (Beier et al., 2006). Consumers, who believe they have the ability to control a service – or in turn have lower concerns to lose control – may interact with the new service with more confidence in controllability, which may lead to an increase of intention to accept.

Aside from that, the results show that perceived technology trust is an insignificant determinant in the full model, while being significant in stage two and three of the hierarchical model (H6 partially confirmed). Therefore, trust is considered to be a marginal predictor of acceptance intention. This supports findings of previous studies, which found trust to be a relevant construct in the acceptance of technology (Dahlberg et al., 2003). This is explained by the characteristics that IoT services are ubiquitous and barely comprehensible. Therefore, uncertainty exists about the underlying processes. Trust is key to reduce uncertainties and risks (Lin, 2011) and influences acceptance behaviour. Remarkably, trust turns insignificant when social influence is added to the model. This indicates correlation between the two constructs. As argued above, social influence implies confidence in trustworthy opinions. Thus, social influence may contain a large proportion of perceived trust indicating that those trustworthy opinions may be of higher relevance than own customer perceptions about trust.

Contrary to the proposed hypothesis, no support was found that perceived ease of use predicts acceptance intention (H2 rejected). This is inconsistent with previous research, which found ease of use to be of leading importance for the adoption of RFID (Müller-Seitz et al., 2009) and NFC technologies (Dutot, 2015). Two major developments may explain this result. First, the sophistication in gateway technologies, such as smartphones, proceeds. Consumers are familiar with the enabling technologies and may consider such innovations in retailing not as highly disruptive, but rather as an advancement of the current fields of application. Second, hardware increasingly disappears and the consumer experiences technologies less consciously (Weiser, 1991). Consequently, the interaction with the technology moves to the background (Beier et al., 2006). Therefore, the perceived ease or difficulty of actively accepting and using a technology becomes irrelevant.

Perceived credibility, as the perceived protection against privacy and security threats, was found to not significantly predict the intention to accept IoT retail services (H5 rejected). Thus, this study counters prior research that found credibility to determine acceptance behaviour (Wang et al., 2006). A plausible explanation may be that, due to the incomprehensible and ubiquitous nature of IoT services, the consumer is not able to estimate the extent to which such services intervene in his personal life

through data collection. The consumer may only comprehend the visible part of the IoT, but does not recognize the invisible data processes in the background.

This paper introduced degree of autonomy as a new construct to the literature of technology acceptance. Technological autonomy was found to be a significant factor moderating the direct effect of certain perceptions on intention. The results support the hypotheses that perceived usefulness, perceived enjoyment and perceived technology trust have a positively stronger impact on intention to accept among services that are highly autonomous compared to services connected to lower levels of autonomy (H9a, H9b and H9e confirmed). Increasing technological autonomy goes hand in hand with growing vulnerabilities and uncertainties (Jalbert, 1987), because the user can barely recognize technological processes running in the background of applications. The results indicate that usefulness and enjoyment are able to compensate an increase in underlying uncertainties and risks. In this light, the consumer needs to experience a relative advantage that exceeds the drawback of accepting uncertainties when using a highly independent service. In addition, trust effectively minimizes uncertainties connected to high autonomy. In contrary, the consumer who is faced with low autonomy applications may not apprehend uncertainties, which make trust issues rather irrelevant.

In contrast to the hypothesis, no evidence was found that degree of autonomy has an impact on the interaction between perceived behavioural control or perceived credibility and acceptance intention (H9c and H9d rejected). Thus, control is a significant predictor of intention – irrespective of the degree of autonomy. This suggests that control perceptions and actual state diverge. The user may think to have strong control over a service, while the high autonomy indicates a loss in actual controllability. This is explained by humans' innate need to be able to control their environment (White, 1959). Thus, the significance of perceived control outweighs the actual controllability. In addition, credibility does not gain significance when autonomy is high. High technological autonomy involves internal data mining and processing that may cause privacy and security concerns. Possibly, the consumer does not realize that autonomous applications require high amounts of data to be processed, which in turn would increases privacy and security concerns.

Furthermore, this paper introduced shopping motivations to the model. Shopping motivations were not found to be a significant factor moderating the direct effect of certain perceptions on intention. Contrary to the hypotheses, no support was found that shopping motivations moderate the direct effects between perceived usefulness, perceived enjoyment and intention to accept (H10a and H10b rejected). Thus, neither utilitarian shopping motivations significantly increased the impact of usefulness on acceptance intention, nor did hedonic shopping motivations positively affect the association between enjoyment and intention. This challenges research by Childers et al. (2010), who suggest that different shopping contexts (hedonic vs. utilitarian) lead to diverging significances of usefulness and enjoyment. Yet, the findings support the rationale that IoT retail services have the capability to extend the shopping experience with a dimension of pleasure (Gregory, 2015) irrespective of the underlying shopping motivation.

Finally, the paper evaluated the significance of the combination of degree of autonomy and shopping motivations on intention to accept. The results reveal that the interaction term combining degree of autonomy and shopping motivations is not significant in influencing the intention to accept (H10c rejected). Thus, while recognizing the increasing relevance of shopping entertainment, hedonic motivations are not able to lower the importance of dissonant factors preventing intention when autonomy is high. Therefore, the perceived vulnerabilities underlying technological autonomy may outweigh the need to have a services that satisfies the need of hedonic motivations in grocery retailing.

6.) Future research, implications and limitations

The major theoretical contribution of this study is the extension of the technology acceptance literature in the context of IoT services in retailing. This paper theorizes the determinants of consumer acceptance by extending the basic TAM (Davis, 1989), composed of perceived usefulness and perceived ease of use, with additional perceptional factors (perceived enjoyment, perceived behavioural control, perceived credibility, perceived technology trust, perceived compatibility) and a social component (social influence). In doing so, the integrated model creates a better understanding of the factors influencing the acceptance of IoT services in grocery shopping.

Albeit, the results indicate that TAM may not be the most appropriate model to assess acceptance of ubiquitous IoT technologies and services. While ease of use is a central construct in TAM (Davis, 1989), the study found that it does not significantly predict intention to accept IoT retail services. Thus, the results suggest to disconfirm the robustness of TAM in explicating the acceptance of IoT services in a retail environment. This may be primarily explained by the technology characteristics of IoT services. In line with Röcker (2010), ease of use appears to be an obsolete construct because human-technology interactions increasingly fade into the background. Future IoT services are positioned in a digital environment full of ubiquitous and intelligent technologies that steadily support the user. This recommends that there are other factors rather than ease of use that should be considered in future research (e.g. social influence).

Furthermore, the study found support for the integration of the degree of autonomy as a moderator. Derived from technological advancements in semi-intelligent and independent technologies, degree of autonomy is expected to play a decisive role in the acceptance of future technologies. This suggests that additional research is needed that considers degree of autonomy as a moderator in acceptance behaviour in the literature about the acceptance of future technologies.

Coincidently, no evidence was found for the relevance of the integration of shopping motivations as a moderator. Additional research is required to assess if shopping motivations could moderate the effects in rather hedonic environments such as luxury shopping in which utilitarian motivations such as time or money savings are expected to be rather irrelevant.

From a practical point of view, this study provides starting points for retail marketers to adjust their IoT services. Usefulness and enjoyment are found to be major predictors of acceptance intention,

especially when the service is highly autonomous. Thus, grocery shoppers expect new IoT services not only to provide a relative advantage in usefulness, but the services also need to extend the shopping experience with a dimension of pleasure. Therefore, marketers should clearly communicate the advantages connected to the use of a new service. Concurrently, practitioners should assess existing shopping patterns and future developments in order to create services that do not exceed the adaptability of the consumer. Compatibility is a strong determinant of intention to accept. Thus, services need to be adjusted in a way that they are not too challenging and disruptive, but rather meet present usage characteristics. Besides, marketers need to notice the relevance of social influence on the intention to accept, especially when considering the innovative character of IoT retail solutions. This suggests that marketers should target opinion leaders in order to create a positive sentiment about the new service Relevant others appear to be trustworthy influencers who have the power to influence own trust perceptions. Therefore, marketing communication should encourage information exchanges between the users and their trustworthy social influencers. Aside from that, perceptions of control are important factors determining the intention to accept. When introducing new services, retailers should maintain the pretence of behavioural control – also if technological autonomy is high. This could be done by keeping control mechanisms in the application such as user confirmations or system log-ins.

By nature, there are some limitations connected to this research. First, this research was built on a survey with customers of a grocery store. Therefore, consumption is rather based on the satisfaction of functional needs by purchasing fast-moving consumer goods. Research in a more hedonic context such as fashion shopping may reveal different results. Follow-up studies should therefore focus on other environments and different product categories. In addition, previous research in TAM literature is dominantly based on studies involving student populations (Legris et al., 2003). This study also relies on a sample conducted at the University of Twente campus supermarket. The results may not represent the average population with regards to personal characteristics. For instance, the University of Twente is a technology-focused institution. Therefore, the respondents are expected to be more open towards new technologies and rather willing to experiment with it. Future research should concentrate on a broader population that does not only consist of a campus community. Finally, the results were based on a short "Imagine…" description. Thus, the future technologies were not experienceable, but respondents needed to envision the service based on a case description. Therefore, it was challenging for the respondents to rate the construct ease of use. Results may be more convincing if they were connected to a try-out of the new service. However, prior literature, which used the same approach of showing a case, found similar results concerning ease of use (Beier et al., 2006), indicating that the results indeed capture the underlying realities. Subsequent studies could use real-life simulations of IoT retail services. As supplementary analysis suggests, additional factors such as gender, country of origin and innovativeness significantly differ regarding the intention to accept. This suggests, that personal characteristics may play a role in the acceptance of new IoT service introductions. Future research should consider these factors and assess their power as predicting variables.

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8.) Appendices

Appendix A: Descriptions of the use cases

Group 1 (hedonic + high degree of autonomy): Imagine the grocery store introduces a service that enables your smartphone to automatically recognize the groceries which are added to your shopping trolley in order to show you additional information such as ingredients, nutrition values, production conditions, customer reviews, social media commentaries and recipes.
Group 2 (hedonic + low degree of autonomy): Imagine the grocery store introduces a service that allows you, by using your smartphone and the retailer's app, to scan and connect with groceries when standing in front of them in the supermarket in order to access additional information such as ingredients, nutrition values, production conditions, customer reviews, social media commentaries and recipes.
Group 3: (utilitarian + high degree of autonomy): Imagine the grocery store introduces a service that automatically recognizes when you are in the supermarket and informs you via instant notification on your smartphone about a price discount for a product that you have frequently bought in the past. When standing at the checkout counter the discount will be automatically subtracted from your receipt.
Group 4: (utilitarian + low degree of autonomy): Imagine the grocery store introduces a service that allows you, by using your smartphone and the retailer's app, to access and save coupons for price discounts for products that are relevant to you in the supermarket. When standing at the checkout counter you need to show the coupon on your phone in order to receive the discount.

Appendix B: Questionnaire

Acceptance of new services in grocery retailing

Welcome to my survey about new service introductions in grocery shopping. This survey is part of my master thesis in Business Administration at the University of Twente.

Please support me by taking five minutes of your time to complete the questionnaire! The results are anonymous.

Many thanks in advance,
Marius Kahlert

PS: In case of questions do not hesitate to contact me via m.kahlert@student.utwente.nl

Now, after you have read the description, I would like to ask you to rate the following statements regarding your perception on the service. Please do not rate how you would prefer the service to be but rather how you perceive it.

“The smartphone autonomously starts the service.”						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"The service is initiated without my active control."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"Once accepted, the service itself works independently without my active control"						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"Once accepted, I do not have to do anything in order to use the service."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"Once accepted, the service acts autonomously"						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"Once accepted, I pass the control over the service provision to the technology."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"There is no need for me to intervene because the service acts independently."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"When accepting the service, I am still able to decide if I want to use the service."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I am able to actively control the service provision."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"The service provision is under my control."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"When using the service, I am still in control of what happens."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"Using the service is entirely within my control."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐

Now, please consider your personal opinion towards the service and rate the statements.

"I intend to use the service for shopping in grocery stores."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"I intend to use the service when available in store."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"I intend to use the service in the near future."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"I consider the service to be useful in retail."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"I see the usefulness of the service."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"Learning to use the service in retail would be easy for me."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"I would have fun with the service."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"The service is pleasurable."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"The service brings enjoyment."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐

Please also rate the following statements with regard to the service.

"The service is compatible with my smartphone use."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"The service is a compatible method for me to support shopping in grocery stores."						
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
☐	☐	☐	☐	☐	☐	☐
"The service is compatible with my style and habits."						

Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"The service is compatible with my way to do shopping."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I believe that the service keeps my best interests in mind."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I trust the service."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"People who are important to me would probably recommend this service."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"People who are important to me would find the service beneficial."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"People who are important to me would find the service to be a good idea to use."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I am concerned that the service is collecting too much personal information from me."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I am concerned that the service will use my personal information for other purposes without my authorization."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I am concerned about the privacy of my personal information when accepting the service."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I am concerned that I do not have the right to control the collection and usage of my personal information."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I would find the service secure when shopping groceries."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐

"The service implements security measures to protect the user."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I feel secure about the service."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐

Finally, please provide some basic information about yourself.

"If I heard about a new information technology, I would look for ways to experiment with it."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"Among my peers, I am usually the first to explore new information technology."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
"I like to experiment with new information technologies."						
Strongly disagree ☐	Disagree ☐	Somewhat disagree ☐	Neither agree nor disagree ☐	Somewhat agree ☐	Agree ☐	Strongly agree ☐
How old are you? _____						
What is your gender?						
☐ Male ☐ Female						
What country do you come from?						
☐ The Netherlands ☐ Germany ☐ Other, Namely _____						
Do you own a smart phone?						
☐ Yes ☐ No						
Have you done grocery shopping on your own?						
☐ Yes ☐ No						
What is your current profession?						
☐ High school student ☐ Bachelor student ☐ Master student ☐ Employee ☐ Self-employed ☐ Other						

Thank you very much for supporting my master thesis.

In case of questions, please contact me via m.kahlert@student.utwente.nl