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# **The Role of Cognitive Biases for Users’ Decision-Making in IS Usage Contexts**

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genehmigte

## **Dissertation**

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Miglena Amirpur, M.Sc.

geboren am 13.04.1988 in Gabrovo, Bulgarien

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Doctor rerum politicarum (Dr. rer. pol.)

Erstgutachter: Prof. Dr. Alexander Benlian

Zweitgutachter: Prof. Dr. Thomas Hess

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## Abstract

Human cognition and decision-making related to information systems (IS) is a major area of interest in IS research. However, despite being explored since the mid-seventies in psychology, the phenomenon of cognitive biases has only recently gained attention among IS researchers. This fact is reflected inter alia in the lack of a comprehensive literature review of research on cognitive biases in IS, on which authors could build their work upon. Against this backdrop, this thesis presents a scientometric analysis of 12 top IS outlets covering the time period between 1992 and 2012, providing a comprehensive picture of the current state of research on cognitive biases in IS. Building on its results and considering the current trends in IS usage practice, this thesis further presents three articles in the IS usage contexts ‘personal productivity software’ and ‘e-commerce’. These articles investigate the influence of cognitive biases on IS users’ decision-making and the potential reasons thereof on the example of software updates and purchase pressure cues. The first two studies draw on expectation-confirmation theory and the IS continuance literature. Within the first study, a laboratory experiment reveals that feature updates have a positive effect on users’ continuance intention (CI) – the update-effect. According to this effect, software vendors can increase their users’ CI by delivering updates incrementally rather than providing the entire feature set right with the first release. However the results show that the update-effect only occurs if the number of updates does not exceed a tipping point in a given timeframe, disclosing update frequency as crucial boundary condition. Additionally, the study indicates that this effect operates through positive disconfirmation of expectations, resulting in increased user satisfaction. The second study expands the focus of the first study by considering feature as well as non-feature updates and elaborating on the explanatory role of satisfaction (SAT), perceived ease of use (PEOU) and perceived usefulness (PU). Besides update frequency, the findings demonstrate update type as another boundary condition to the repeatedly identified update-effect, that is, it occurs only with functional feature updates and not with technical non-feature updates. Moreover, by analyzing the practice of employing purchase pressure cues (PPCs) on commercial websites, the third study provides another example of the effect of cognitive biases on users’ decision making in the IS usage context ‘e-commerce’. The results show that while limited time (LT) pressure cues significantly increase deal choice, limited product availability (LPA) pressure cues have no distinct influence on it. Furthermore, perceived stress and perceived product value serve as two serial mediators explaining the theoretical mechanism of why LT pressure cues affect deal choice.

Overall, the thesis highlights the role of human cognition and decision-making, and specifically of cognitive biases, for IS related users' decisions. It further emphasizes the importance of an alterable and malleable IS for the occurrence of biased decision-making. Moreover, the findings shed light on the underlying explanatory mechanisms of how and why biased decision-making takes place, thus answering several calls for research and elaborating on existing theories from psychology and IS. Software vendors and online retailers may use the findings described in the thesis to better understand how and why cognitive biases can be applied in a targeted way to achieve positive revenue effects. Specifically, software vendors are advised to distribute software functionality over time via updates, because feature updates can induce a positive state of surprise, which, in turn, increases users' CI. However, while the thesis' results disclose the update-effect as a useful measure for software vendors to achieve customers' satisfaction regarding a software product, it is also necessary to consider its boundary conditions in order to achieve the desired outcomes. Finally, online retailers are advised to carefully select the PPCs on their websites. While the thesis' results show that some of them are cost-effective solutions to stimulate positive value perceptions, which in turn impact online purchases, they also reveal that others have no effect on users' purchase decisions and can even be perceived as an attempt at deception.

## Zusammenfassung

Menschliches Denken und Entscheidungsfindung bezogen auf Informationssysteme (IS) ist ein bedeutendes Interessengebiet in der IS Forschung. Doch auch wenn es im Bereich der Psychologie seit Mitte der siebziger Jahre erforscht wurde, hat das Phänomen der kognitiven Verzerrungen (cognitive biases) erst vor kurzem die Aufmerksamkeit der IS-Forscher auf sich gezogen. Darauf deutet unter anderem das Fehlen einer umfassenden Literaturanalyse über den Stand der Bias-Forschung in IS hin, die als Grundlage künftiger Forschungsarbeiten auf dem Gebiet dienen könnte. Vor diesem Hintergrund präsentiert die vorliegende Dissertation eine wissenschaftliche Analyse der 12 Top-IS-Zeitschriften für den Zeitraum zwischen 1992 und 2012, deren Ergebnisse zu einem umfassenden Bild des aktuellen Forschungsstandes zu Cognitive Biases in IS zusammengefügt werden. Auf Grundlage dieser Ergebnisse und unter Berücksichtigung der aktuellen Trends in der IS-Nutzung (IS Usage), werden im Rahmen dieser Dissertation weiterhin drei Artikel präsentiert. Diese sind in den IS Usage-Bereichen ‚Personal Productivity Software‘ und ‚E-Commerce‘ angesiedelt und untersuchen den Einfluss von Cognitive Biases auf Nutzer-Entscheidungen und dessen potentiellen Gründen am Beispiel von Software-Updates und Purchase Pressure Cues (graphische Darstellungen auf einer Webseite, die Kaufdruck erzeugen sollen). Die ersten beiden Studien basieren auf der Expectation-Confirmation-Theorie und der IS- Post Adoption Literatur. Die Ergebnisse eines Laborexperiments in der ersten Studie zeigen, dass Feature-Updates einen positiven Effekt auf die Absicht der Anwender zur Weiternutzung der Software haben – den sogenannten Update-Effekt. Der Update-Effekt besagt, dass, im Vergleich zu einer Lieferung der gesamten Feature-Set direkt mit der ersten Software-Version, die inkrementelle Bereitstellung von Updates Softwareherstellern dazu verhelfen kann, die Weiternutzungsabsicht ihrer Kunden zu erhöhen. Die Ergebnisse jedoch zeigen auch, dass der Update-Effekt nur dann zustande kommt, wenn die Anzahl an Updates in einem bestimmten Zeitraum einen kritischen Punkt nicht übersteigt und stellen somit die Update-Häufigkeit als entscheidende Rahmenbedingung des Update-Effekts heraus. Darüber hinaus zeigen die Ergebnisse der ersten Studie, dass der Update-Effekt durch die positive Bestätigung der Erwartungen des Anwenders getrieben ist, die wiederum zu einer erhöhten Benutzerzufriedenheit führt. Die zweite Studie erweitert den Fokus der ersten Studie, indem sie auf der einen Seite sowohl Feature- als auch Non-Feature-Updates berücksichtigt, und auf der anderen Seite die Bedeutung von Zufriedenheit, wahrgenommene Nützlichkeit und wahrgenommene Benutzerfreundlichkeit für den Update-Effekt weiter erforscht. Die Ergebnisse deuten darauf hin, dass neben der Update-Häufigkeit

auch der Update-Typ eine entscheidende Rolle für das Auftreten des Update-Effekts spielt, so, dass dieser nur mit Funktionen bringenden Feature-Updates, nicht aber mit technischen Non-Feature-Updates, funktioniert. In der dritten in dieser Dissertation enthaltenen Studie wird weiterhin die Praxis der Verwendung von Purchase Pressure Cues (PPCs) auf kommerziellen Webseiten analysiert. Somit stellt die dritte Studie ein weiteres Beispiel für die Wirkung von Cognitive Biases auf die Entscheidungsfindung von Nutzern im IS Usage Kontext ‚E-Commerce‘ dar. Die Ergebnisse zeigen auf, dass, während Limited Time Pressure Cues (LT Pressure Cues)<sup>1</sup> eine positive Kaufentscheidung deutlich beeinflussen, Limited Product Availability Pressure Cues (LPA Pressure Cues)<sup>2</sup> keinen bedeutenden Effekt darauf nehmen können. Sie verdeutlichen weiterhin, *wie* LT Pressure Cues die Kaufentscheidung beeinflussen. Es konnte gezeigt werden, dass wahrgenommener Stress und wahrgenommener Produktwert zwei serielle Mediatoren darstellen, die den theoretischen Einflussmechanismus erklären.

Zusammenfassend lässt sich sagen, dass die vorliegende Dissertation die Rolle von menschlicher Kognition und Entscheidungsfindung, und insbesondere von Cognitive Biases, für Nutzerentscheidungen in IS hervorhebt. Dies geschieht am Beispiel der IS Usage Bereiche ‚Personal Productivity Software‘ und ‚E-Commerce‘, und insbesondere der Praxisphänomene Software-Updates und Purchase Pressure Cues. Die Dissertationsergebnisse unterstreichen ferner die Bedeutung eines veränderbaren und verformbaren IS für das Auftreten von Cognitive Bias-getriebener Entscheidungsfindung. Darüber hinaus beleuchten sie die zugrundeliegenden Erklärungsmechanismen, d.h. wie und warum Cognitive Bias-getriebene Entscheidungsfindung zustande kommt, indem sie auf etablierte Theorien aus Psychologie und IS zurückgreifen. Dadurch stellen sie zugleich eine Antwort auf wiederholten Forschungsaufforderungen dar. Softwareanbieter und Online-Händler können die in der Dissertation beschriebenen Ergebnisse nutzen, um besser zu verstehen, wie Cognitive Biases zum Erzielen positiver Einnahmeeffekte angewendet werden können. Insbesondere wird Softwareherstellern empfohlen, Software-Funktionalität im Laufe der Zeit über Updates zu verteilen, da Feature-Updates einen positiven Überraschungszustand induzieren können, was wiederum die Weiternutzungsabsicht der Nutzer erhöht. Obwohl die Ergebnisse der Dissertation den Update-Effekt als eine nützliche Maßnahme für Softwarehersteller

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<sup>1</sup> Graphische Darstellungen auf einer Webseite, die signalisieren, dass für den Kauf eines Produkts nur *eine begrenzte Zeit* zur Verfügung steht, und nach Ablauf dieser festgelegten Zeit das Produkt nicht mehr verfügbar ist (e.g. Suri and Monroe 2003).

<sup>2</sup> Graphische Darstellungen auf einer Webseite, die signalisieren, dass für den Kauf eines Produkts nur noch *eine bestimmte Menge* dieses Produkts verfügbar ist, d.h. dass das Produkt bald ausverkauft sein könnte (e.g. Jeong and Kwon 2012).



offenbaren, um die Kundenzufriedenheit bezüglich eines Softwareprodukts zu erhöhen, zeigen sie ebenfalls, dass Softwarehersteller darauf achten sollten, seine Rahmenbedingungen zu berücksichtigen, um die gewünschten Ergebnisse erzielen zu können. Schließlich wird Online-Händlern empfohlen, die PPCs auf ihren Webseiten sorgfältig auszuwählen. Während die Dissertationsergebnisse bestätigen, dass einige von ihnen kostengünstige Mittel zur Förderung positiver Produktwahrnehmung sind, die wiederum die Online-Einkäufe positiv beeinflusst, zeigen sie auch, dass andere PPCs keine Auswirkungen auf die Kaufentscheidung haben und sogar als Täuschungsversuch des Anbieters wahrgenommen werden können.

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## List of Abbreviations

AIS	Association for Information Systems
ANOVA	Analysis of Variance
AVE	Average Variance Extracted
CI	Continuance Intention
CFA	Confirmatory Factor Analysis
CRM	Customer Relationship Management
DISC	Positive Disconfirmation
DoD	Deal-of-the-Day
DSS	Decision Support Systems
ECIS	European Conference on Information Systems
ECT	Expectation-Confirmation Theory
EJIS	European Journal of Information Systems
ICIS	International Conference on Information Systems
ICT	Information and Communications Technology
IJEC	International Journal of Electronic Commerce
IS	Information System(s)
ISJ	Information Systems Journal
ISR	Information Systems Research
IT	Information Technology
JAIS	Journal of the Association for Information Systems
JIT	Journal of Information Technology
JMIS	Journal of Management Information Systems
JSIS	Journal of Strategic Information Systems
LLCI	Lower Limit of Confidence Interval
LPA	Limited Product Availability
LT	Limited Time
MISQ	Management Information Systems Quarterly

NAICS	North American Industry Classification System
PEoU	Perceived Ease of Use
PPC	Purchase Pressure Cues
PU	Perceived Usefulness
RQ	Research Question
SAT	Satisfaction
SIC	Standard Industry Classification
S-O-R	Stimulus-Organism-Response
ULCI	Upper Limit of Confidence Interval





# 1 Introduction

## 1.1 Motivation and Research Questions

In recent years, human cognition and decision-making related to information systems (IS) has become a ubiquitous phenomenon in IS practice as well as a growing area of interest in IS research. Crowdsourcing (e.g. Thies et al. 2016), electronic marketplaces (e.g. Benlian et al. 2012), web personalization (e.g. Benlian 2015b) or recommendation systems (e.g. Scholz et al. 2017), to name but a few, are examples from the IS practice, characterized by increasing information richness and interactive decision-making. Issues such as privacy, trust and security, which arise from these environments, are all closely connected to behavioral aspects (Goes 2013; Benlian and Hess 2011).

In times of fierce competition, predicting IS users' adoption, usage and particularly post-adoption decisions, for instance, is a task of crucial importance (Davis 1989; Venkatesh et al. 2003; Venkatesh et. al. 2012). Moreover, better understanding the effects of constantly changing software on users' beliefs, attitudes and behaviors regarding the software product, could be decisive as well in achieving higher user loyalty and sustained revenue streams (e.g., Jasperson 2005; Benbasat and Barki 2007; Benlian 2015a). Besides IS post-adoption behaviors, another prominent example from the IS practice regarding the role of human cognition and decision making provides the extensive use of core visual pressure cues on commercial websites. These visual cues are seeking to capture users' attention, to subliminally put customers under pressure and to become a nudge to a purchase decision. Considering the fact that more than 45% of Internet users in the United States and Europe already purchase goods online (Kollmann et al. 2012; Poncin et al. 2013) and that the competition among online shopping websites for regular and new customers is further intensifying, knowing about the influence of such graphical depictions on websites is becoming a clear advantage for online retailers (Benlian 2015b; Koch and Benlian 2015).

The above-mentioned economic relevance of human decision-making for IS practice has been also reflected in a growing stream of research in diverse IS fields like IS management, software development, application systems and IS usage (e.g. Gonzalez et al. 2006; Lacity et al. 2010; Arnott and Pervan 2005; Arnott and Pervan 2008; Venkatesh et al. 2003; Venkatesh et. al. 2012). In all this research, the body of psychological knowledge, used by advancing

different psychological theories in IS, was able to facilitate IS researchers in order to provide valuable recommendations for further IS research and practice.

One particular and thoroughly investigated phenomenon from psychology, however, that directly refers to human decision-making, has only recently gained attention in IS research – the so called *cognitive biases*. Cognitive biases are defined as systematic errors in human decision-making. Cognitive biases lead to objectively non-rational decisions that are suboptimal for the decision-maker or other individuals affected by the decision (Kahneman and Tversky 1973, Kahneman and Tversky 1979; Simon 1990; Thaler and Sunstein 2008; Wilkinson and Klaes 2012). Consequently, the application of these behavior-influencing cognitive biases, similar to other psychological theories and theoretical concepts, hold enormous potential to supplement and innovate IS research. Therefore, it is all the more surprising that research on cognitive biases in IS has still remained comparatively sparse. Moreover, the existing individual research studies are loosely connected and feature mostly inconsistent terminology and methodology (e.g. Mann et al. 2008). The identification of links between existing research studies however is important, for it would disclose possible avenues for future research and would contribute to cumulative knowledge building in IS. A primary goal of this thesis is hence to provide a comprehensive picture of the current state of research on cognitive biases in IS, guided by the overarching research question:

*RQ1: What is the current state of research on cognitive biases in the IS discipline?*

As already discussed, IS contexts are characterized by increasing information abundance. Furthermore, in the course of the omnipresent digitalization of everyday life, like the use of Internet and smartphones, the opportunities for a mass of users for interaction with IS are increasing drastically as well (e.g. Campbell and Park 2008; Wajcman et al. 2008). Whether buying products online or using one app or another, users come nearly every day to decision situations within their interaction with IS - an interaction between *users, changing their beliefs, attitudes and behaviors* over time and *constantly alterable and malleable IS* (e.g., Jasperson 2005; Benbasat and Barki 2007). However, the dynamic nature characterizing both – IS users and IS – impedes the predictability of the decision-making process and outcome. This, in turn, provides excellent ground for the closer investigation of cognitive biases, for the instability of a decision context increases the probability of the application of heuristics, and thus the occurrence of cognitive biases (e.g. Kahneman and Tversky 1979; Simon 1990). Figure 1-1 represents the described interplay.



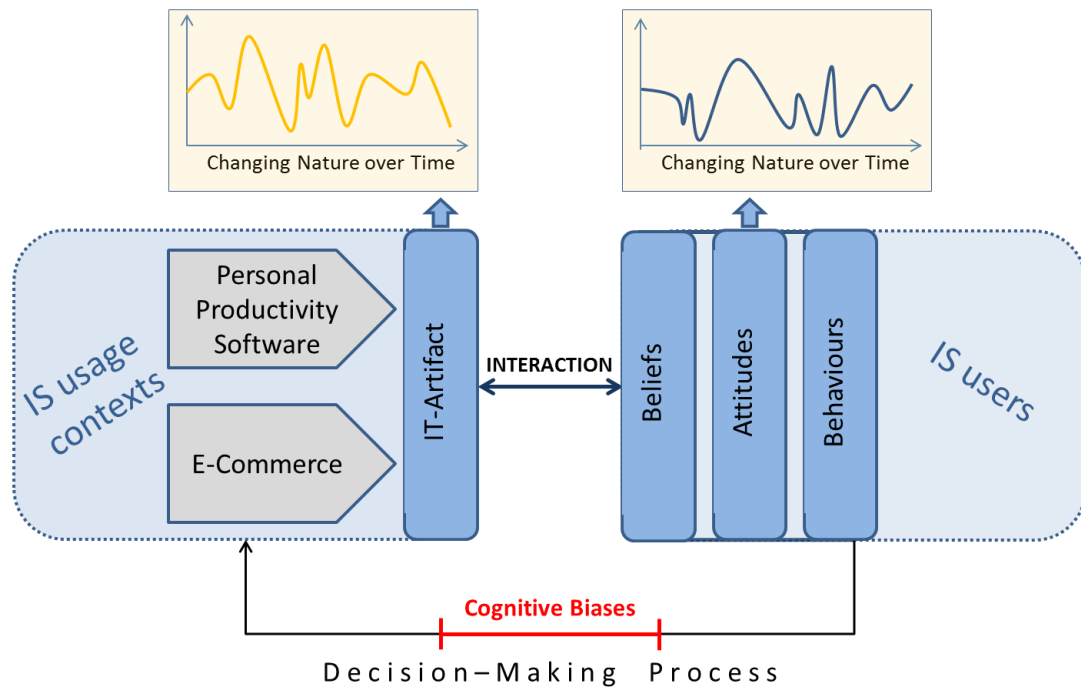


Figure 1-1: Conceptual Overview of the Thesis

Furthermore, the ever-growing competition on commercial market places (Benlian 2015b; Koch and Benlian 2015) and the less time available for customers to make an individual purchase decision makes the ‘*e-commerce*’ context particularly interesting for research on cognitive biases. How do customers form their product preferences when processing information heuristically? Which cognitive biases can occur and influence this process? Is it necessary to *avoid* cognitive biases? Or the other way around, is it expedient to *use* heuristic cognitive processing and cognitive biases to nudge customers to a purchase decision?

Besides ‘*e-commerce*’, similarly relevant to research on cognitive biases is the ‘*personal productivity software*’ context. Users are flooded with information and advertising for various smartphone apps or software programs (e.g. Venkatesh et. al. 2012). This abundance of products and vendors supports heuristic information processing when it comes to which app or software to select, or continue to use. How can software vendors stand out from the competition, being aware of the fact that their customers often do not choose rationally but rather heuristically? Can cognitive biases be a meaningful measure to impact customers’ decisions in the desired direction?

Taken all together, there is a need for more research on cognitive biases in IS (e.g. Browne and Parsons 2012), especially in contexts like ‘*personal productivity software*’ and ‘*e-commerce*’. Therefore, after providing a comprehensive picture of the current state of research on cognitive biases in IS, the focus of this thesis further lies in answering the overall

research question of whether, when and how cognitive biases influence IS related users' decisions in the IS usage contexts 'personal productivity software' and 'e-commerce':

*RQ2: Do cognitive biases influence users' decisions in the IS usage contexts 'personal productivity software' and 'e-commerce' and if so how and why?*

To investigate this second main research question, two cognitive biases, corresponding to current practices used in IS, are exemplarily chosen: the *update-effect* (related to post-adoption behavior and, respectively, to the IS usage context 'personal productivity software') and the pressure cues *limited time* and *limited product availability* (related to purchase behavior and, respectively, to the IS usage context 'e-commerce'). The update-effect describes a positive user reaction to software updates. Specifically, delivering software features incrementally through updates, during ongoing usage, can increase users' intentions to continue using the information system. The thesis' articles not only empirically demonstrate the occurrence of this bias-related effect. They also shed light on the *explanatory mechanism* behind the update-effect.

Furthermore, limited time (LT) or simply time pressure has been defined as the perceived constriction of the time available for an individual to perform a given task. Time pressure is a form of stress expressed in the perception of being hurried or rushed (Ackerman and Gross 2003; Iyer 1989). This perception triggers and directs subsequent heuristic cognitive processing (Simon 1959). In the 'e-commerce' context, heuristic cognitive processing may result in a *biased purchase decision*. In addition, LPA pressure cues refer to written statements or visual icons attached to products that inform consumers that only a limited number of products are available for purchase. LPA pressure cues are thus considered to be environmental signals that may also induce pressure and heuristic cognitive processing, resulting in a biased decision outcome.

In summary, investigating the role of cognitive biases on users' continuance and buying decisions is a topic of outstanding practical importance for vendors and online retailers. Specifically, being aware of heuristic cognitive processing and knowing about the potential influence of cognitive biases may help them better understand their clients' decision-making processes. This in turn may enable software vendors and online retailers to take influence on customers' decision outcome. Parallel to this *economic relevance*, understanding the role of cognitive biases on users' beliefs, attitudes and behaviors, emanating from the interaction with an alterable and malleable IT artifact, is a response to several *calls for research* from IS

scholars (Browne and Parsons 2012; Mann et al. 2008; Benbasat and Zmud 2003; Hevner et al. 2004). Therefore, this dissertation contributes to closing an existing research gap regarding the role of cognitive biases on users' continuance and buying decisions, both from a theoretical and an empirical perspective.

To contribute answering the thesis' overall research questions, four empirical studies were conducted published across four articles. The next section is devoted to the thesis research context and principal theories. Following afterwards, the structure of the thesis is presented and summarized.

## **1.2 Theoretical Foundation**

In this chapter, the theoretical foundations of the thesis are presented in order to clarify the fundamental concepts. To do so, the first section 1.2.1 describes the importance of heuristic cognitive processing for the occurrence of cognitive biases and elaborates on how cognitive biases are currently defined and categorized. In section 1.2.2 the concept of software updates and the theory of information systems continuance are introduced. Section 1.2.3 is devoted to the concept of purchase pressure cues (PPCs) and, specifically, to limited time (LT) and limited product availability (LPA). It further provides insights into the role of PPCs as environmental signals within the framework of the stimulus-organism-response (S-O-R) model. Based on these preceding sections, the positioning of the thesis in the research context is presented (section 1.2.4), concluding this chapter.

### **1.2.1 Heuristic Cognitive Processing and Cognitive Biases**

Heuristic cognitive processing was initially studied in cognitive science and psychology. Daniel Kahneman and Amos Tversky (e.g. 1973; 1979) demonstrated how human judgments and decisions may differ from "classical" concepts of rationality. Consequently, they developed prospect theory that more closely corresponds to actual choice behavior. As an alternative to rational choice theories, prospect theory claims that a change of one's reference point through current experience alters the preference order for prospects. That is, the reference point corresponds to an asset position that one had expected to attain (Kahneman and Tversky 1979). Simon (1990) furthermore emphasizes that a small collection of heuristics "*have been observed as central features of behavior in a wide range of problem-solving behaviors where recognition capabilities or systematic algorithms were not available for reaching solutions*" (p.10). According to Simon (1990), the prevalence of heuristic search is a basic law of qualitative structure for human problem solving. Problem solving by heuristic

search is an example of rational adaptation to complex task environments that take appropriate account of computational limitations. Thus, Simon (1990) defines heuristics not as optimizing techniques, but as “*methods for arriving at satisfactory solutions with modest amounts of computation*” (p.11). Moreover, while decision heuristics may or may not alter the qualities of decision outcomes, biases occur when cognitive abilities limit capacities and culminate in inferior decisions (Haley and Stumpf 1989). That is, cognitive biases are systematic deviations to rationality. “*The word ‘systematic’ is important because we often err in the same direction. For example, it is much more common that we surpass our knowledge than underestimate it. A mathematician would speak of a skewed distribution of our mental deficiencies*” (Dobelli 2016, p. 2).

Furthermore, over the last decades several cognitive biases like *framing, anchoring, the halo effect, social loafing* or *overconfidence* have been identified and described. These cognitive biases have comparatively precise definitions. They have been well investigated in psychology and increasingly in IS research (see Article 1). The fact that each individual has the potential to process information heuristically, however, suggests that there is a potential for new cognitive biases to be “discovered”. Moreover, particular phenomena, *already being used* in practice, can be “disclosed” as prerequisite for heuristic cognitive processing and, thus, for the occurrence of cognitive biases, yet not being documented or defined.

In addition, to date there are several categorizations of cognitive biases like the ones suggested by Burow (2010), Kahneman et al. (2011), Lovallo and Sibony (2010), Haley and Stumpf (1989) or Browne and Parsons (2012). All these categorizations aim to assign individual cognitive biases to root categories based on their influence on the decision-making process. However, the above mentioned categorizations are not completely consistent and uniform, and not exhaustive as well. Taking into account one of the main purposes of this thesis—presenting a comprehensive overview of research for cognitive biases in IS— an inclusive approach for bias categorization was selected, by integrating the proposed bias categories. A detailed description of each bias category is presented in Article 1.

On the following, in order to better understand the logic of categorizing cognitive biases, the phases of the decision-making process are presented, as suggested by Welford (1965; 1968). In addition, two cognitive biases are exemplarily introduced, considering their definitions, their assignment to individual phases of the decision-making process and their potential to influence IS users’ decision-making.

Welford's (1965, p. 6) model of the human sensory-motor system is known to provide a holistic view on human's decision-making process (see Figure 1). Due to its comprehensive lens ranging from humans' perceptions to their actual behaviors, this model allows for identifying the individual stages in this process where various cognitive biases might originate.

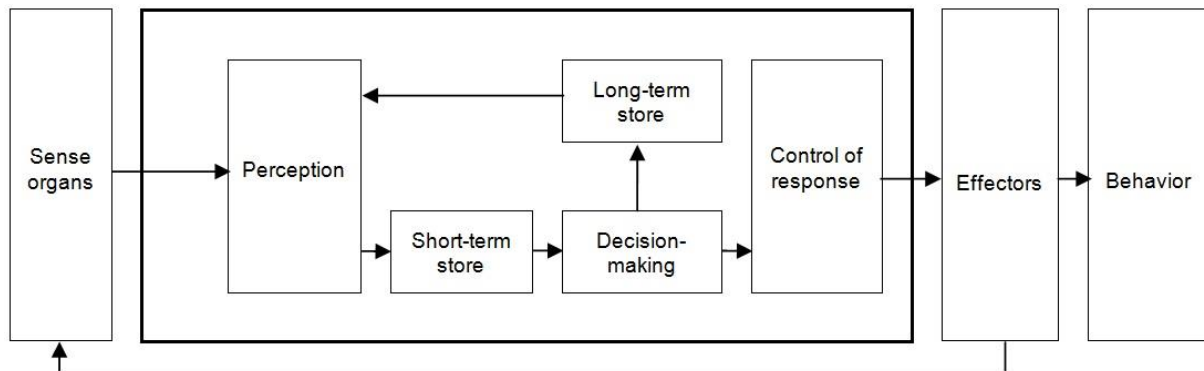


Figure 1-2: Decision-making according to Welford's (1965) Model of the Human Sensory-Motor System

According to Welford's (1965) model, *sense organs* receive and transport environmental stimuli, which are subsequently processed at the *perception stage*. This first processing of information takes place unconsciously. After its perception, information is then stored in the *short-term store* before it is utilized for actual *decision-making*. The information, utilized for the *decision-making* is on the one hand provided by the *short-term store* and on the other hand retrieved from the *long-term store*. Information, which is retrieved from the *long-term store*, flows through the *perception stage* into the *short-term store*, from where it is included into the *decision-making* process. After a particular decision has been made, it is stored in the *long-term store* and at the same time translated into action by the *effectors* (e.g. hands, organs of speech). However, before a decision is translated into action it has to pass a cognizant, controlling instance, which Welford (1968) labels *control of response*. Numerous feedback loops between these individual stages can occur. If a decision is translated into action by the *effectors*, we can observe *actual behavior*.

In the context of the decision-making process, Welford (1968) points out two modes of operation of the human mind. On the one hand, there are unfamiliar tasks requiring a lot of cognitive effort in decision-making. On the other hand, there are familiar tasks, which he describes as well-learned relationships, which enable fast, effortless decision-making. This decision-making is based on relationships that are built into the brain and enable it "to be bypassed for routine actions" (Welford, 1968, p. 18). Remarkably, Welford's (1968)

distinction between two modes of operation is in many ways similar to Kahneman's (e.g. 2011) concept of *System 1* and *System 2*, which he refers to as the explanation for bias formation. Similar to Welford's (1968) *well-learned relationships*, Kahneman's (e.g. 2011) *System 1* works with little cognitive effort, can provide quick solutions to (familiar) problems, and escapes voluntary control. This takes place by relying on *heuristics*. *System 2*, on the other hand, enables complex computations by allocating attention to these more intensive mental activities.

Based on Welford's (1965) and Kahneman's (2011) corresponding theoretical understanding of decision-making, the presented model of the human decision-making process (see Figure 1) provides a solid basis for categorizing cognitive biases. In particular, *the stages* of the core decision-making process from *perception* to *control of response* can be the foundation for categorizing biases. For example, inferring from its definition, the saliency bias (e.g. Schenk 2010) should occur at the perception stage in the decision-making model. In case of the *saliency bias*, individuals "*systematically focus on items or information that is prominent or salient and ignore items or information that is less visible*" (Schenk 2010, p. 253). Regarding IS, the saliency bias may be useful in some cases and impedimental in others. In the 'e-commerce' context, for instance, online retailers may consider the saliency bias in their advertising or marketing strategies. Salient items or information on commercial websites may be instrumental in attracting customers' attention and evoking interest in products and services. On the contrary, in the context of 'IS management', IT manager and CIO's are advised to be aware of the saliency bias when making decisions. In meetings and discussions for example they should not only consider the opinion of very actively participating employees, or information that is prominent at the point of decision-making. They should take into account less known facts and the arguments of more cautious employees as well. Otherwise they may fall into the saliency bias, impeding the quality of their decisions.

Another cognitive bias, relevant to the IS Management context, is the *overconfidence bias* (e.g. Van der Vyver 2004). The overconfidence bias is expected to occur at the *decision-making stage* of this model. In the case of the overconfidence bias, "*people are systematically overconfident about the outcomes of their decisions. This effect has been observed in experts and laypeople alike and can be a major impediment to sound decision making*" (Van der Vyver 2004, p. 1894). Overconfidence has been already offered as explanation for severe failures in decision making, like entrepreneurial failures or stock market bubbles (e.g. Glaser and Weber 2007). For the IS Management context this would mean, that it would be

important to sensitize CIO's for the existence of this bias. This is because "*Managers who fall prey to various heuristics and biases [like overconfidence] while making decisions [...] are a major source of risk [for good decisions]*" (Khan and Stylianou 2009, p. 64). In some cases, it even may be expedient to independently revise a CIO's decision regarding its potential outcomes, in order to avoid the overconfidence bias.

After presenting the importance of heuristic cognitive processing for the occurrence of cognitive biases and emphasizing the role of cognitive biases for IS users' decision-making, following next, the main theoretical concepts for the IS usage context '*personal productivity software*' are presented (1.2.2).

### **1.2.2 Software Updates and Information Systems Continuance**

Software updates have been described as self-contained modules of software. In generally, these are provided to the user for free in order to extend or modify software, while it is already in use (e.g. Dunn 2004). The software engineering literature has repeatedly addressed the concept of software updates (Sommerville 2010). Software release planning, software maintenance and evolution, and software product lines can be introduced here by way of example (Svahnberg et al. 2010; Shirabad et al. 2001; Weyns et al. 2011).

Moreover, software updates can be categorized in two basic types: feature updates and non-feature updates (e.g. Microsoft 2015). Via feature updates, core functionality can be added to or removed from the original software version. While feature updates directly affect users' interaction with the software by changing its core functionality, technical non-feature updates only correct system flaws. Because non-feature updates change software properties that are not directly related to its core functionality, they do not directly affect the users' interaction with the software (Popovic et. al. 2001).

Furthermore, to better understand users' reactions on software updates, it is necessary to take a closer look on the existing post-adoption literature. Regarding the importance of the software post adoption phase, Bhattacharjee (2001, p.351-352) emphasizes that "*while initial acceptance of IS is an important first step toward realizing IS success, long-term viability of an IS and its eventual success depend on its continued use rather than first-time use.*" Therein, Jasperson et al. (2005) criticize that researchers often define post-adoptive use of an IS as increasing, as individuals gain experience in using the IS. However, in reality, post-adoptive behaviors may also diminish or change over time. The various features of an IS may be treated with indifference or used in a limited fashion (Jasperson et al. 2005). These are

alterations, originating from changes in users' beliefs, attitudes and behaviors over the time (Benlian 2015a). The change in post-adoptive behaviors may also be a result of the dynamic nature of the IS itself that is constantly modified, for example, via software updates. Or it may originate from the interaction between changing users' attitudes and changing IS. Kim and Malhotra (2005), Kim (2009), Ortiz de Guinea and Markus (2009) and Ortiz de Guinea and Webster (2013), for instance, have provided research evidence in this direction.

In order to explore users' intentions to continue or discontinue using an IS, Bhattacharjee (2001) adopts expectation-confirmation theory (ECT). Later on, ECT has been successfully applied in several IS contexts like software-as-a-service (e.g. Benlian et al. 2011), mobile data services (e.g. Kim 2010), e-learning (e.g. Lee 2010) or knowledge creation in online communities (e.g. Chou et al. 2010), to name just a few. In ECT users' expectations are referred to as relative, subjective reference point or baseline (e.g. Helson 1964). Bhattacharjee's (2001) IS continuance model thus suggests that users compare their perception of the IS performance during actual usage with their pre-usage expectations. If perceived performance exceeds the users' expectations-baseline, they are positive disconfirmed, that in turn increases their PU and SAT regarding the IS. Building on Bhattacharjee's (2001) model that has a static perspective on the IS continuance setting, Bhattacharjee and Premkumar (2004) introduced a more dynamic perspective, showing that beliefs and attitudes change during the ongoing usage of an IS as well (Kim and Malhotra 2005). While this dynamic perspective already provides valuable insights into the drivers of post-adoption behavior, it still neglects the previously discussed changing and malleable IT artifact's nature. Therefore, one of the central research goals of this thesis is to address both - the dynamic nature of IS users and of IS itself, during ongoing IS usage.

After presenting the main theoretical concepts of the IS usage context 'personal productivity software', following next 1.2.3 introduces the theoretical foundations for the 'e-commerce' context. Specifically, the purchase pressure cues 'limited time' and 'limited product availability' are described. Furthermore, their importance as environmental stimuli is discussed against the background of the stimulus-organism-response (S-O-R) model.

### **1.2.3 Purchase Pressure Cues and the Stimulus-Organism-Response Model**

The retail and commerce sector has recognized the potential of pressure situations to stimulate positive purchase decisions for decades (e.g., Dawar and Parker 1994; Inman et al. 1990; Lynn 1991; Zhu et al. 2012). To create such pressure environments, marketers often use



pressure cues also called “persuasion claims” (Jeong and Kwon 2012). In the following, the role of constrictions in time (also Limited Time or Time Pressure) and product availability (Limited Product Availability) on users’ purchase decisions is presented, as discussed in the marketing literature. The S-O-R model is further introduced as a theoretical framework to explain the role of PPCs for online purchase decisions.

Decision making under time pressure is a ubiquitous phenomenon of many people’s daily lives. Time is considered one of the primary resources upon which decision making and choice draw. Taking into account that the quality of decision making depends heavily on time, requiring individuals to make decisions within a *limited* time frame may create pressure and stress for them. That is, time pressure may increase the level of arousal and psychological stress. Furthermore, when the level of stress is very high, an individual may make decisions without generating all the available alternatives. Consequently, a decrease in human judgment’s accuracy and an increase in the likelihood of heuristic processing can be observed, aiming to simplify the cognitive task (Ahituv et al. 1998). In addition, time pressure increases the weight placed on the more meaningful and salient features and in particular may increase the attention devoted to negative information (Dhar and Nowlis 1999). This suggests that LT pressure cues could have a positive effect on consumer choice behavior because they represent negative information, i.e. the product is soon no longer available. Moreover, investigating *LT pressure cues as environmental signals* in the marketing field, most attention have been paid to the *offline* in-store context (e.g., time-limited sales promotions, discounts, or coupons). However, LT pressure cues are a widespread phenomenon in the *online* retail context as well. Despite their prevalence in the online commercial environment, only few studies in IS research have investigated the effects of time pressure on users’ decision behavior. While those few studies have focused on user reactions in *non-commercial environments* (Eckhardt et al. 2013; Marsden et al. 2006), there is still a lack of research on the role of LT pressure cues for affecting consumers’ buying decisions on *commercial websites*.

Furthermore, consumers tend to place higher value on objects they own, compared to objects they do not own. They tend to evaluate a product they possess more positively even before actual ownership or consumption. Therefore, if consumers once possess an object, even temporarily as with in-store hoarding, the prospect of losing it is framed as a relatively large loss (e.g. Byun and Sternquist 2012; Kahneman and Tversky 1979). In addition, commodity theory (Brock 1968) suggests that the value of a commodity will increase to the extent that it

is perceived as being unavailable. Drawing on this theory, people may desire scarce commodities more strongly than comparable available products (Byun and Sternquist 2012). In online settings however the availability of a product cannot be guaranteed until an actual transaction occurs. The generalizability of the positive effects of LPA on users' purchase decisions (Byun and Sternquist 2012) for the 'e-commerce' context is, thus, restricted. Moreover, suspicion of firms' manipulative intent results in resistance to persuasion, leading to less favorable brand or vendor attitudes. Some message cues make manipulative intent more salient than others do (Kirmani and Zhu 2007). The assessment of *product availability* in online shopping environments, for instance, is more restricted than the assessment of the *time available* for a product purchase. Consumers may therefore consider LPA pressure cues rather as a marketer's manipulative tactic, and consequently waive the purchase. Considering the inconsistent findings in offline and online environments, Jeong and Kwon (2012) call for further research clarifying the role of LPA pressure cues in online commercial contexts.

Additionally, in order to explain how websites' features may affect consumers' internal preferential choice processes and the resulting choice behaviors, several IS studies drew on the Stimulus-Organism-Response (S-O-R) model from environmental psychology (Parboteeah et al. 2009; Xu et al. 2014). Belk (1975) defines *stimuli* as contextual cues external to the consumer that determine consumer's responses. In the 'e-commerce' setting, examples for stimuli are the product display, recommendation systems and online store's visual design (e.g. Jacoby 2002; Xu et al. 2014). Organism represents the cognitive and emotional reactions of the consumer to the stimuli on commercial websites. These intervening processes finally lead to behavioral or internal *response*. Behavioral response refers to actual acquisition of products or services. Internal response is expressed as formation or change in beliefs and attitudes regarding product brands and online providers (Mehrabian and Russell 1974). Consequently, considering PPCs as environmental signals, S-O-R seems to be an appropriate theoretical framework for investigating their effects on users' purchase behavior in the 'e-commerce' context.

### 1.2.4 Positioning of the Thesis

While the concept and resulting insights on cognitive biases have been around for more than 40 years now (Tversky and Kahneman 1974), research on cognitive biases in IS has remained comparatively sparse. Consequently, there are several calls for research in this direction (e.g. Browne and Parsons 2012). Specifically, there is to date no comprehensive literature review on cognitive biases in IS, on which authors could build their work upon. Furthermore, in well investigated areas of IS like IS usage, there is also still little understanding of the user's perspective on interacting with an IT artifact, as well as the role of cognitive biases within this interaction. In particular, the behavioral dimension, i.e. how an IT artifact is *perceived* by users, is still an area that has so far received only minimal research attention (Hong et al. 2011; Sandberg and Alvesson 2011; Benlian et al. 2012a). In the thesis' conceptual framework, the introduced research gaps (see Figure 1-1) are addressed and several calls for research from IS scholars who criticize the negligence of the IT artifact's role in IS research (Benbasat and Zmud 2003; Hevner et al. 2004; Orlikowski and Iacono 2001) are considered. In summary, on the one hand, this thesis yields insights regarding the influence of cognitive biases on IS related users' decisions, by focusing on the IS usage contexts 'personal productivity software' and 'e-commerce'. On the other hand, it elaborates on the *potential reasons* explaining their influence.

Furthermore, regarding both cognitive bias-phenomena investigated in this thesis – the *update-effect* and the purchase pressure cues *LT* and *LPA*, Table 1-1 provides an overview of their assignment to bias category and IS research context respectively. The particular IS context originates from their application in the IS practice and can be clearly defined. On the contrary, their assignment to a cognitive bias category is a quite ambiguous task, for these cognitive bias-phenomena may take influence on different phases of the decision-making process. Considering the bias category descriptions discussed in article 1, however, the categorization in Table 1-1 seems to be the most plausible one.

Table 1-1: Bias Category and IS Context of the Cognitive Bias Phenomena Included in the Thesis

<b>Bias</b>	<b>Cognitive Bias Category</b>	<b>IS Context</b>
<b>Update-Effect</b>	<ol style="list-style-type: none"> <li>1) <i>Pattern Recognition Biases</i>, particularly operating through cognitive disconfirmation</li> <li>2) <i>Perception Biases</i></li> </ol>	IS usage → <i>personal productivity software</i>
<b>LT/LPA</b>	<ol style="list-style-type: none"> <li>1) <i>Perception Biases</i></li> <li>2) <i>Decision Biases / Action-orientated Biases</i></li> </ol>	IS usage → <i>e-commerce</i>

### 1.3 Structure of the Thesis

In order to contribute to the principal research questions of the thesis, four studies were conducted, published across four scientific articles, which investigate the role of cognitive biases for IS-related users' decisions with different foci. The overall thesis is organized into six chapters. Following the introductory chapter, chapters 2 to 5 present the four published articles. These articles were slightly revised in order to achieve a consistent layout throughout the thesis. Chapter 6 concludes the thesis with a summary of key findings, contributions, limitations and opportunities for future research. Table 1-1 shows an overview of the chapters and articles.

Table 1-2: Thesis Structure and Overview of Articles

<b>Study 1</b>	<b>Chapter 2</b>	<b>Scientometric Analysis on Cognitive Biases in IS</b>
	Article 1	Fleischmann, M.; Amirpur, M.; Benlian, A.; Hess, T. (2014): <i>Cognitive Biases in Information Systems Research: A Scientometric Analysis</i> . In: European Conference on Information Systems (ECIS 2014), June 9-11, 2014, Tel Aviv, Israel.
<b>Study 2</b>	<b>Chapter 3</b>	<b>Role of Feature Updates on Users' Continuance Intention</b>
	Article 2	Amirpur, M.; Fleischmann, M.; Benlian, A.; Hess, T. (2015): <i>Keeping Software Users on Board – Increasing Continuance Intention through Incremental Feature Updates</i> . In: European Conference on Information Systems (ECIS 2015), May 26-29, 2015, Münster, Germany.
<b>Study 3</b>	<b>Chapter 4</b>	<b>Software Updates and Update-Effect in IS Continuance</b>
	Article 3	Fleischmann, M.; Amirpur, M.; Grupp, T.; Benlian, A.; Hess, T. (2016): <i>The Role of Software Updates in Information Systems Continuance – An Experimental Study from a User Perspective</i> . In: Decision Support Systems, 83 (C), 83-96.
<b>Study 4</b>	<b>Chapter 5</b>	<b>Purchase Pressure Cues and E-Commerce Decisions</b>
	Article 4	Amirpur, M.; Benlian, A. (2015): <i>Buying under Pressure: Purchase Pressure Cues and their Effects on Online Buying Decisions</i> . In: International Conference on Information Systems (ICIS 2015), December 13-16, 2015, Fort Worth, USA.
	<b>Chapter 6</b>	<b>Thesis Conclusion</b>

Additionally, Figure 1-3 presents an overview of the main content emphasis examined in the research articles and shows how they are positioned in the overall research context.

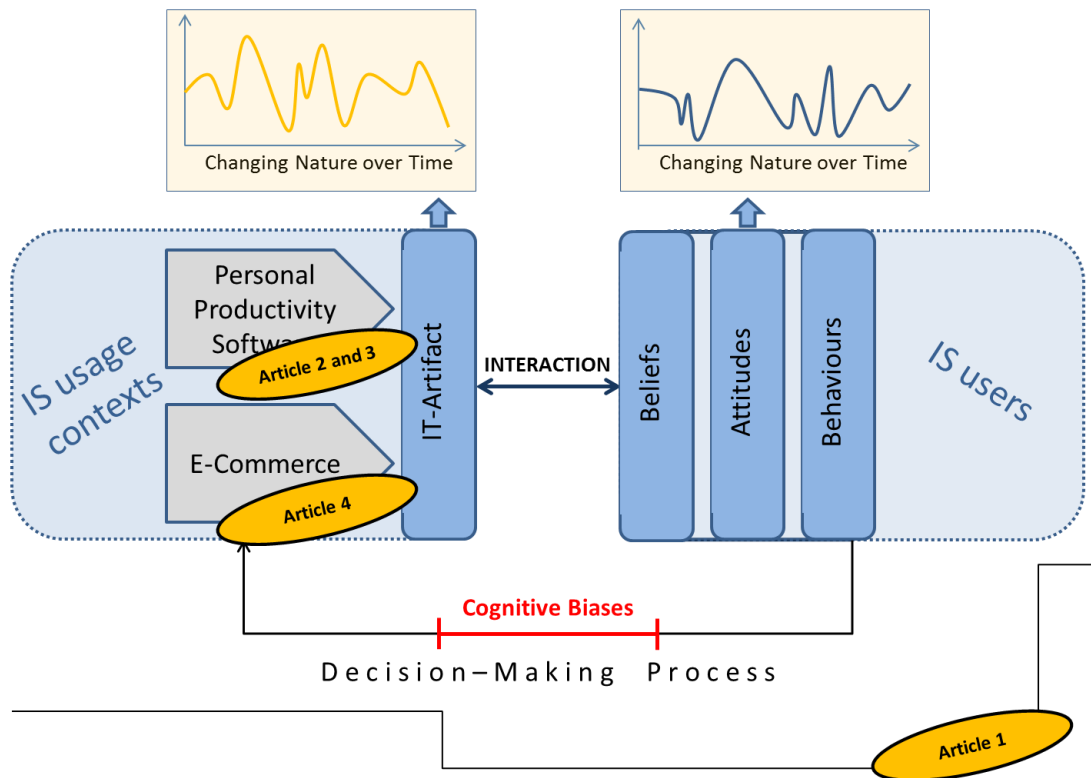


Figure 1-3: Overview of the Main Content Emphasis Examined in the Research Articles

Following the introductory chapter that presents motivation, research questions, theoretical foundations and positioning of the thesis, the main focus of chapter 2 (article 1) is to provide a first literature review of research on cognitive biases in IS, using a *scientometric analysis*. This study reveals research gaps and highlights common practices regarding the measurement of cognitive biases. It constitutes the foundation of this thesis and to great extent substantiates the subjects of investigation for the following research studies. Moreover, the first research area of the thesis – ‘personal productivity software’ – is represented by articles 2 and 3 (chapters 3 and 4). They disclose the role of software updates for IS continuance decisions, as well as crucial boundary conditions for the identified update-effect, like update type and update frequency. The second research area – ‘e-commerce’- is elicited by article 4 (chapter 5), which is focused on the role of purchase pressure cues in influencing consumers’ online buying decisions and the potential reasons thereof. Finally, chapter 6 concludes the thesis with a summary of key findings, contributions, limitations and opportunities for future research.

Following next, each chapter (i.e., article) is briefly summarized, including the main motivation and contributions to the research questions, as well as the linkages between the articles. Given that the articles and corresponding studies were written and conducted with co-authors, first person plural (i.e., “we”) is used throughout the thesis when applicable.

**Chapter 2 (Article 1):** The phenomenon of cognitive biases has been explored since the mid-seventies in psychology, but its potential to influence *IS users'* decision-making only recently gained attention among IS researchers. Consequently, there is still a comparatively sparse set of mostly disconnected publications, sometimes using inconsistent terminology and methodology. The purpose of the first article is to address this issue by providing a comprehensive picture of the current state of research on cognitive biases in IS. Therefore we conducted a systematic literature review – a scientometric analysis – of 12 top IS outlets, covering the time period between 1992 and 2012. We identified 84 publications related to cognitive biases. A subsequent content analysis shows a strong increase of interest in cognitive bias research in the IS discipline in the observed timeframe, yet uncovering a highly unequal distribution across IS fields and industry contexts. With regard to IS fields, the most widely examined category is *IS usage* with the clusters '*e-commerce*' and '*personal productivity software*'. Given this fact and considering its practical relevance, outlined in the introductory chapter, the field *IS usage* further determines the research domain of this thesis. In addition, we found that the most commonly examined cognitive bias categories are *perception* and *decision* biases. This was a reason to choose cognitive bias-phenomena for further investigation that can be classified in these two bias categories (see Table 1-1). To summarize, the first article is a constituting element of this thesis, for its results build the foundation and determine the direction of the whole thesis. This article mainly contributes to answering the first overall research question *RQ1*.

**Chapter 3 (Article 2):** The study presented in the second article of the thesis is concerned with the effects of feature updates on users' CI. Drawing on expectation-confirmation theory (ECT) and the IS continuance model (Bhattacharjee 2001), it is plausible to assume that perceived positive disconfirmation during software use will increase users' CI regarding the updated software. In the context of software features, ECT implies that positive disconfirmation from feature updates depends on a relative change in functionality, compared to a user's subjective reference point (the initial configuration of the software), rather than an absolute change (Helson 1964; Oliver 1980). Consequently, if some features of the initial software version are simply held back and subsequently delivered through updates, they are likely to elicit positive disconfirmation and thus a biased product perception and evaluation. The results of a controlled laboratory experiment could confirm a positive effect of feature updates on users' CI. They however also revealed a crucial boundary condition to this effect – update frequency, showing that CI diminishes when the number of updates exceeds a tipping point in a given timeframe. This study therefore contributes to answering the overall research

question *RQ2* by showing whether and how the common practice of delivering feature updates influence users' IS continuance intentions. Given that in article 2 we focus only on *feature* updates, disclosing update frequency as one crucial boundary condition, in article 3 we expand the examination field, including *feature* as well as *non-feature* updates, thus providing an additional moderator to the update-effect - *software type*.

**Chapter 4 (Article 3):** Article 3 analyzes how the granularity of software and its changes through software updates, i.e. feature and non-feature updates, influence the fluctuation of users' beliefs, attitudes, and behaviors over time. First, the results of a laboratory experiment show that while feature updates increase users' continuance intentions – the so-called *update-effect*, technical non-feature updates (e.g. bug fixes) have no effect on the intention to continue using the software. Second, the study provides evidence that users prefer the delivery of features in individual updates over a delivery in larger but less frequent update packages comprising several features. Third, article 3 contributes to opening up the theoretical black box of *how* software updates influence IS continuance intention by highlighting the complementary roles of cognition and affect for the occurrence of the update-effect. Consequently, this study contributes largely to research question *RQ2*, underlining and extending the results of article 2. It not only demonstrates the differential effects of feature and non-feature updates on users' continuance intention. Its results also emphasize the interplay of rational and emotional component in explaining the bias-driven update-effect.

**Chapter 5 (Article 4):** The research studies presented in articles 2 and 3 provide insights into the role of biased decision making in the IS usage context '*personal productivity software*', as well as the potential reasons thereof. The study described in article 4 further contributes to *RQ2* by demonstrating another example for the effect of cognitive biases on users' decision making in the IS usage context '*e-commerce*'. Although purchase pressure cues (PPC) that signal limited time (LT) or limited product availability (LPA) are widely used features on commercial websites to boost sales (Benlian 2015), research on whether and why PPCs affect consumers' purchase choice in online settings has remained largely unexplored (e.g. Jeong and Kwon 2012). The results of a controlled laboratory experiment with 121 subjects in the context of Deal-of-the-Day (DoD) platforms show that while LT pressure cues significantly increase deal choice, LPA pressure cues have no distinct influence on it. Furthermore, the study's results demonstrate that perceived stress and perceived product value serve as two serial mediators explaining why LT pressure cues affect deal choice. Complementary to these results, we could also show that higher perceived stress is accompanied by significant changes

in consumers' *physiological arousal*. As such, the article contributes to research question *RQ2*, showing how and why purchase pressure cues provoke biased purchase decisions in the 'e-commerce' context.

In addition to the articles included in the thesis, the following articles were also published during my time as a PhD candidate within the thesis' project, which are, however, not part of the thesis:

- Fleischmann, M.; Grupp, T.; Amirpur, M.; Benlian, A.; Hess, T. (2015): *When Updates Make a User Stick: Software Feature Updates and their Differential Effects on Users' Continuance Intentions*. In: International Conference on Information Systems (ICIS 2015), December 13-16, 2015, Fort Worth, USA.
- Fleischmann, M.; Grupp, T.; Amirpur, M.; Hess, T.; Benlian, A.: *Gains and Losses in Functionality – An Experimental Investigation of the Effect of Software Updates on Users' Continuance Intentions*. In: International Conference on Information Systems (ICIS 2015), December 13-16, 2015, Fort Worth, USA.

Based on the established basic theoretical background and considering Figure 1-2, the following chapters 2 to 5 present the aforementioned articles.



## 2 Article 1: Scientometric Analysis on Cognitive Biases in IS

**Titel:** Cognitive Biases in Information Systems Research: A Scientometric Analysis (2014)

**Authors:** Fleischmann, Marvin, Ludwig-Maximilians-Universität München, München, Germany  
Amirpur, Miglena, Technische Universität Darmstadt, Darmstadt, Germany  
Benlian, Alexander, Technische Universität Darmstadt, Darmstadt, Germany  
Hess, Thomas, Ludwig-Maximilians-Universität München, München, Germany

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### Abstract

Human cognition and decision-making related to information systems (IS) is a major area of interest in IS research. However, despite being explored since the mid-seventies in psychology, the phenomenon of cognitive bias has only recently gained attention among IS researchers. This fact is reflected in a comparatively sparse set of mostly disconnected publications, sometimes using inconsistent theory, methodology, and terminology. We address these issues in our scientometric analysis by providing the first review of cognitive bias-related research in IS. Our systematic literature review of 12 top IS outlets covering the past 20 years identifies 84 publications related to cognitive bias. A subsequent content analysis shows a strong increase of interest in cognitive bias research in the IS discipline in the observed timeframe, yet uncovers a highly unequal distribution across IS fields and industry contexts. While previous research on perception and decision biases has already led to valuable contributions in IS, there is still considerable potential for further research regarding social, memory and interest biases. Our study reveals research gaps in bias-related IS research and highlights common practices in how biases are identified and measured. We conclude with promising future research avenues with the intent to encourage cumulative knowledge-building.

**Key Words:** Decision-Making, Cognitive Biases in IS, Scientometric Analysis.

## 2.1 Introduction

Human decision-making is one of the main areas of interest in information systems (IS) research (Goes 2013). A prominent example is the extensive stream of technology acceptance research that aims to explain and predict the IS users' adoption and usage decisions (Davis 1989; Venkatesh et al. 2003, Venkatesh et al. 2012). Decision Support Systems (Shim et al. 2002; Arnott and Pervan 2005; Arnott and Pervan 2008) and IT Outsourcing (Dibbern et al. 2004; Gonzalez et al. 2006; Lacity et al. 2010) are other examples of areas that extensively explore decision-making. One commonality of these research streams is their collective reliance on theories which were originally adopted from psychology research. For example, technology acceptance research such as Davis' (1989) Technology Acceptance Model and its variations all draw on Fishbein and Ajzen's (1975) Theory of Reasoned Action. The successful history of each of the above mentioned research streams in IS shows the value of relying on psychological knowledge in order to gain insights into a wide variety of IS related phenomena (Goes 2013). In all these cases, the body of psychological knowledge has facilitated IS researchers to advance the discipline and to provide valuable recommendations for practitioners.

One particular phenomenon from psychology research that is related to human decision-making has recently gained attention in IS research—the so called cognitive biases. Being a side effect of the application of heuristics, cognitive biases are defined as systematic errors in human decision-making (Wilkinson and Klaes 2012). As described by Simon (1990, p.11), heuristics are “methods for arriving at satisfactory solutions with modest amounts of computation.” Heuristics are sometimes also referred to as rules of thumb. The results of cognitive biases are objectively nonrational decisions that often lead to suboptimal outcomes for the decision-maker or other individuals who are affected by the particular decision (Wilkinson and Klaes 2012). The application of these behavior-influencing cognitive biases, similar to other psychological theories and theoretical concepts, hold enormous potential to apprise and supplement IS research. IS contexts in particular are characterized by increasing information richness and interactive decision-making as can be seen in settings such as crowdsourcing and collective intelligence, electronic marketplaces, personalization and recommendation systems. Issues such as privacy, trust and security, for example, which arise from these environments, are closely connected to behavioral aspects and are thus potentially prone to cognitive biases (Goes 2013). First research results also show the direct value of applying insights on cognitive biases in IS (e.g. Arnott 2006; Kim and Kankanhalli 2009).

Finally, the seemingly increasing interest in cognitive biases among IS researchers can be also seen as evidence for this phenomenon being a welcomed innovation in the discipline (Browne and Parsons 2012).

However, while the concept and resulting insights on cognitive biases have been around for almost 40 years now (Tversky and Kahneman 1974), research on cognitive biases in IS has remained comparatively sparse. We thus agree with Browne and Parsons (2012) who advocate for more research in this direction. In addition to being sparse, research studies on biases in IS have also remained loosely connected to one another and have largely been inconsistent in their use of terminology and methodology (e.g. Mann et al. 2008). To the best of our knowledge, there is to date no comprehensive literature review of research on cognitive biases in IS, on which authors could build their work upon. As a result, it remains difficult to find links between existing research studies and to identify possible avenues for future research. This, in turn, makes it difficult to contribute to cumulative knowledge-building in IS.

In the present study, we aim to address these issues and thus close a gap in the research on cognitive biases in IS. In order to achieve this goal, we examine the following two research questions:

RQ1: What is the current state of research on cognitive biases in the IS discipline?

RQ2: What are promising avenues for future research on cognitive biases in the IS discipline?

In the course of answering these research questions, we make several contributions. First, we provide a systematic literature review—a scientometric analysis—of research dealing with cognitive biases in IS. By combining our findings on cognitive biases with information about research fields, applied research methods, and industry contexts, our review provides a comprehensive picture of the current state of research on biases in IS. On the one hand, this allows us to identify areas in which biases have already received substantial acknowledgement by researchers. On the other hand, we are able to disclose existing areas with no or only few publications on biases. Based on these research gaps, we are able to provide well-grounded and theory-guided avenues for future research that have the potential to further advance the explanatory and predictive capabilities of the IS research discipline.

The remainder of this study is organized as follows. In section 2, we report on the procedures of our scientometric analysis. Its results are presented in section 3. In section 4, we give a summary of our overall findings, discuss the results from our analysis, and provide avenues for further research.

## **2.2 Scientometric Analysis**

Leydesdorff (2001) defines scientometrics as “the quantitative study of scientific communication” (Leydesdorff 2001, p.1), while Lowry et al. (2004) consider it “the scientific study of the process of science”. Lewis et al. (2007) recommend scientometric studies to advance the ongoing evaluation and improvement of an academic discipline. Scientometric studies have been conducted on a broad range of topics in IS research such as on IS as a reference discipline or the epistemological structure of the IS field in general (Grovel et al. 2006; Kroenung and Eckhardt 2011). In this study, we selected the scientometric approach for its structured, systematic procedure, compared to, a narrative literature review (Leydesdorff 2001), for example.

Following Pateli and Giaglis (2004), in the first step, we defined the scope of our search. It can be characterized along three dimensions: (1) the outlets, which are covered by our search, (2) the relevant time span, and (3) the search terms used. In our search procedure, we then performed two separate rounds: initial search and subsequent (forward and backward) search (Webster and Watson 2002; Yang and Tate 2012). In a third step, we conducted a content analysis (Krippendorff 2004) to examine all relevant identified papers. In the remainder of this section, we elaborate on the aforementioned steps of the scientometric approach: scope of literature search, search procedure, and procedure of analysis.

### **2.2.1 Scope of Literature Search**

To achieve our goal of characterizing the current state of research on cognitive biases in the IS discipline, we focused on the top-rated publications in IS research. Therefore, we primarily relied on the AIS Senior Scholar’s Basket of Journals (AIS 2013). Based on Mylonopoulos and Theoharakis’ (2001) ranking of IS journals, we also included the International Journal of Electronic Commerce and Decision Support Systems. To extend our scope and capture more contemporary research, we included the International Conference on Information Systems Proceedings and the European Conference on Information Systems Proceedings. This resulted in the following set of outlets: Decision Support Systems (DSS), European Conference on Information Systems (ECIS) (Proceedings), European Journal of Information Systems (EJIS),

Information Systems Journal (ISJ), Information Systems Research (ISR), International Conference on Information Systems (ICIS) (Proceedings), International Journal of Electronic Commerce (IJEC), Journal of AIS (JAIS), Journal of Information Technology (JIT), Journal of Management Information Systems (JMIS), Journal of Strategic Information Systems (JSIS) and MIS Quarterly (MISQ).

From these publications, we included in our search completed research papers and research-in-progress papers. Within this scope, we considered any research published from January 1992 to October 2013, as well as forthcoming papers, if available. We considered the past 20 years of IS research to be a sufficient time frame in order to enable us to draw a comprehensive picture of the development of research on cognitive biases in IS.

To develop the set of relevant search terms for our review, we started with the terms *bias* and *non-rational behavior*. From basic literature on cognitive biases, we extracted further, more specific terms, such as *framing* or *anchoring* until theoretical saturation was achieved (Auerbach and Silverstein 2003). After an expert validation of the collected search terms, we ended up with an exhaustive set of 120 search terms<sup>3</sup>.

### 2.2.2 Search Procedure

In the first round, we scanned the abovementioned 12 journals and conference proceedings. Depending on the type of publication, we relied on the databases of EBSCOhost, Palgrave Macmillan, Science Direct and SpringerLink. To identify relevant forthcoming papers, we also checked the forthcoming sections of each journal website, if available. The inclusion criteria for a paper to be considered relevant was one or more of our search terms being in its title, abstract or among its self-reported keywords. This first search-round resulted in 160 hits. The full texts of these 160 papers were then manually scanned for irrelevant articles. Articles that did not address the bias phenomenon in the sense of cognitive biases (e.g. discussions of the selection bias in statistical analysis of quantitative empirical research) were excluded (Yang and Tate 2012). After this step, 84 relevant articles remained.

To ensure integrity of our search, we then conducted a second round: a forward and backward search (Webster and Watson 2002). Backward search refers to reviewing older literature cited in the articles from the initial search. A forward search means reviewing additional sources

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<sup>3</sup> The complete list of employed search terms, including references for each search term, can be obtained from the authors upon request.

that have cited the relevant articles and determining which of the newfound articles should be included in the review. For our forward search, we used Reuters' (2013) *Web of Science*.

Both our forward and our backward search were confirmatory and thus had the same scope as round one. No additional relevant articles were found during this second round. This is a confirmation of the comprehensiveness of our first search round. The final number of relevant articles used for the following analysis thus remained 84 (the 84 articles included in our scientometric analysis are marked with \* in the References section). Based on the scope of our search, the total number of searched articles was 12.990. The number of publications dealing with biases (n=84) was thus less than 1% of all articles in our search scope.

### 2.2.3 Procedure of Analysis

The 84 identified papers were examined based on 12 factors. These are (1) year of publication, (2) outlet, (3) biases studied, (4) bias category (5) examined research field, (6) industry context, (7) applied research method, (8) approach of measuring the cognitive bias of interest, (9) theoretical foundations, (10) bias position in the paper, (11) prior research goal, and (12) level of analysis (Kroenung and Eckhardt 2011; Yang and Tate 2012). These factors are of three different types.

The factors of the first type (*year, journal, bias(es), theoretical foundations*) were directly collected from the papers' full text. The second type contains deductively derived factors. These factors are *research method, bias category* and *research field*. For the factor *research method*, we adopted the taxonomy developed by Palvia et al. (2007) that comprises 14 individual research methods. Its application in other contexts has shown that this taxonomy is complete and can also be applied in other IS research areas outside the scope of the journal *Information & Management*, for which it was originally developed (Avison et al. 2008). For the factor *industry context*, we relied on the North American Industry Classification System (NAICS 2012) of the United States Census Bureau. NAICS is the successor of the Standard Industry Classification (SIC) System, which has been widely used in research. Specifically, we adopted the top level classification from NAICS that distinguishes 20 industry sectors.

For the factor *bias category*, we aggregated the categorizations suggested by Burow (2010), Kahneman et al. (2011) and Lovullo and Sibony (2010), as well as Haley and Stumpf (1989) and Browne and Parsons (2012). The common rationale behind these categorizations is to assign individual biases to root categories based on their influence on the decision-making process, as it is proposed by, for example, Wellford's (1968) model. However, despite the

development of a broad stream of literature around heuristics and cognitive biases, to the best of our knowledge, to date, there is no standardized, generally accepted and scientifically grounded framework for cognitive biases. Besides being not completely consistent and uniform the above mentioned categorizations are also not exhaustive: while in one categorization a bias category is contained, in another one, it is not (e.g. Lovallo and Sibony's (2010) categorization does not contain the category "decision biases"). Taking into account the purpose of this study—presenting a comprehensive overview of research for cognitive biases in IS—we preferred to be rather inclusive than exclusive by integrating the proposed bias categories. For the factor bias category we thus employed eight categories: 1=perception biases; 2=pattern recognition biases; 3=memory biases; 4=decision biases; 5=action-orientated biases; 6=stability biases; 7=social biases and 8=interest biases.

*Perception biases* particularly affect the processing of new information that is received by an individual. A potential subsequent decision and the resulting behavior are flawed, when based on this biased information (e.g. framing; Tversky and Kahneman, 1981). *Pattern recognition biases* occur when, in the evaluation of alternative patterns of thinking, barely known information or unknown information is discarded in favour of familiar patterns of thinking or information that currently happen to be present in the mind (e.g. availability bias/availability cascade; Tversky and Kahneman, 1973). *Memory biases* affect the process of recalling information that refers to the past and thereby substantially diminish the quality of this information, which is later used for decision-making. (e.g. consistency bias/reference point dependency; McFarland and Ross, 1987). *Decision biases* occur directly during the actual process of decision-making and diminish the quality of actual as well as future decision outcomes (e.g. illusion of control; Langer, 1975). *Action-orientated biases* and *stability biases* are two distinct subgroups within the category of *decision biases*. *Stability biases* make individuals stick with established or familiar decisions, even though alternative information, arguments, or conditions exist that are objectively superior (e.g. status quo bias; Kahneman et al., 1991). *Action-oriented biases* lead to premature decisions made without considering actually relevant information or alternative courses of action (e.g. overconfidence bias; Keren, 1997). *Social biases* affect the perception or evaluation of alternatives and decisions and thus might occur at different stages of the decision-making process. Biases from this category arise from attitudes shaped by the individual's relationship to other people (e.g. herd behavior; Scharfstein and Stein, 1990). *Interest biases* lead to suboptimal evaluations and/or decisions owing to an individual's preferences, ideas, or sympathy for other people or arguments. These are also biases that might occur at different stages of the decision-making process. Resulting

decisions can potentially have negative consequences for third parties (e.g. self-serving bias; Babcock et al., 1996).

The individual biases, which had been explored in the 84 identified IS papers were each assigned to a category based on the respective bias' and the categories' definitions<sup>4</sup>. In this process, two researchers examined and discussed each definition until they agreed on in which category the respective cognitive bias is to be located (Barki et al., 1988). Subsequently, these results were discussed and validated by two experts from cognitive psychology.

The factor *research field* was examined based on seven categories: 1=research for business models of information systems; 2=software development; 3=application systems; 4=IS management; 5=IS usage; 6=economic impact of IS; 7=meta-research. These categories were theoretically derived from a consolidated review of existing categorizations of the IS research field. Thereby, we relied on Barki et al. (1988; 1993), Alavi and Carlson (1992), Claver et al. (2000), Vessey et al. (2002), Avison et al. (2008) and Dwivedi and Kuljis (2008).

Finally, factors of the third type have been developed inductively during the analysis of the articles, as recommended and described by Yang and Tate (2012, p.41). This approach resulted in the following five categories: *measurement* (1=interpretative measurement, e.g. qualitative/case study; 2=semi-objective measurement e.g. survey without objective baseline; 3=objective measurement, e.g. laboratory experiment, survey with objective base line), *prior research goal* (1=explanation of biases; 2=avoidance or targeted use of biases), *bias position in paper* (1=weak; 2=medium; 3=strong), *bias impact* (1=positive; 2=negative) and *level of analysis* (1 =individual; 2=group/collective).

To ensure objectivity and reliability in the coding process, we set up a codebook, including proof-texts for each value in the categories of types two and three. The content analysis was performed by two researchers (Krippendorff 2004). To evaluate the content analysis' interrater reliability, a random 20% sample of articles was double-coded. The resulting interrater reliability, measured by Krippendorff's alpha, was 96 %, which is considered a high interrater reliability (Holsti 1969). All 84 articles were categorized according to the described categorization scheme. The evaluation results are presented in the following section.

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<sup>4</sup> A complete list of the bias definitions' sources and the categories' definitions can be obtained from the authors upon request.



## 2.3 Results of the Scientometric Analysis

### 2.3.1 Cognitive Biases in IS Research Over the Past 20 Years

Figure 2-1 shows a clear increase of interest in cognitive bias research in the IS discipline over the past 20 years, especially after 2008. It depicts the share of the identified articles, compared to the overall number of publications in the examined outlets for a given year.

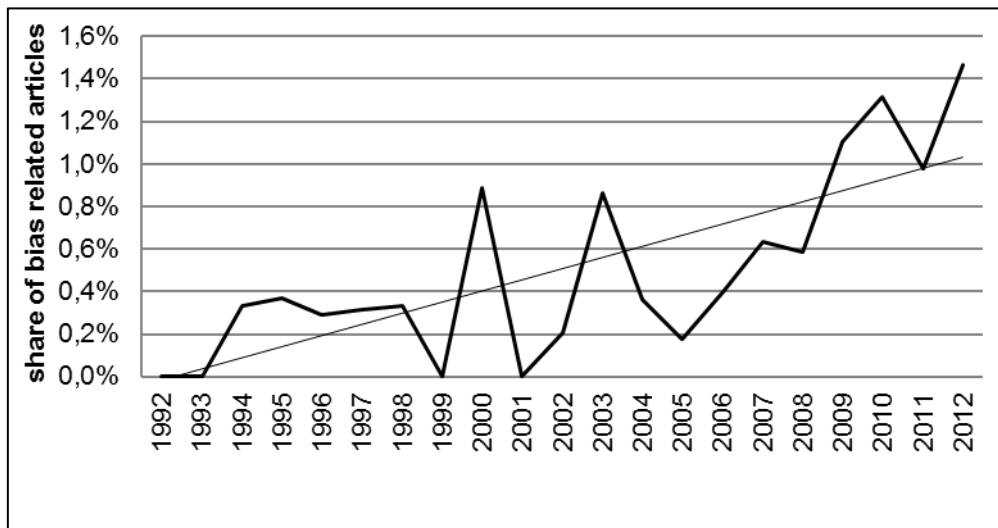


Figure 2-1: Publications on Cognitive Biases in IS between 1992 and 2012.

Most of the 84 identified articles we extracted were published in the ICIS proceedings (18). 16 were published in DSS, 13 in ISR, 10 in MISQ, 9 in JMIS, 8 in IJEC, 4 in ECIS, 3 in ISJ, 2 in JAIS, and 1 in EJIS. We did not identify any publications on cognitive biases in JIT or JSIS.

### 2.3.2 Different Types of Cognitive Biases in the IS Discipline

Concerning the distribution of the individual cognitive biases, we found that the most commonly examined cognitive biases are *framing* ( $n=14$ ) and *anchoring* ( $n=10$ ). In addition, there are some moderately well-studied cognitive biases such as *negativity bias* ( $n=7$ ), *sunk cost bias* ( $n=7$ ), *confirmation bias* ( $n=5$ ), and the *halo effect* ( $n=4$ ). We also observed a considerable amount of cognitive biases investigated in only one article, such as the *exponential forecast bias* or the *cultural bias*. Finally, there are also some cognitive biases that have not yet been investigated in the IS discipline but have been studied in other disciplines. Examples include the *sunflower management bias* (Boot et al. 2005), *groupthink* (Janis 1972; Aldag and Fuller 1993), or the *planning fallacy* (Buehler et al. 1994).

Table 2-1 shows the cognitive biases we identified in our scientometric analysis, including the frequency of occurrence and sample articles. The total number of identified biases is 120. This number is larger than the total number of relevant articles (n=84) because in some articles more than one cognitive bias were investigated.

Table 2-1: Categorization of Biases, n=120.

Category	Biases
<b>Perception biases</b> (n=40)	<i>framing</i> (n=14, e.g. Allport and Kerler, 2003; Cheng and Wu, 2010); <i>negativity bias</i> (n=7, e.g. Yin et al., 2010; Wu et al., 2011); <i>halo effect</i> (n=4, e.g. Chong, 2004; Djamasbi et al., 2010); <i>selection bias</i> (n=3, e.g. Aral et al., 2011; Ma and Kim, 2011); <i>representativeness bias</i> (n=2, Lim and Benbasat, 1997; Calikli et al., 2012); <i>sequential bias</i> (n=2, Piramuthu et al., 2012; Purnawirawan et al., 2013); <i>priming effect</i> (n=2, Stewart and Malaga, 2009; Dennis et al., 2013); <i>recency effect</i> (n=2, Pathak et al., 2010; Ghose et al., 2013); <i>biased perception of partitioned prices</i> (n=1, Frischmann et al., 2012); <i>emotional bias</i> (n=1, e.g. Turel et al., 2011); <i>primacy effect</i> (n=1, Lim et al., 2000); <i>selective perception</i> (n=1; e.g. Dennis et al., 2012).
<b>Pattern recognition biases</b> (n=11)	<i>confirmation bias</i> (n=5, e.g. Huang et al., 2012; Turel et al., 2011); <i>availability bias</i> (n=4, e.g. Lim and Benbasat, 1997); <i>reasoning by analogy</i> (n=1, Chen and Lee, 2003); <i>disconfirmation bias</i> (n=1, Rouse and Corbitt, 2007).
<b>Memory biases</b> (n=1)	<i>reference point dependency</i> (n=1, Vetter et. al., 2011a)
<b>Decision biases</b> (n=24)	<i>irrational escalation</i> (n=4, e.g. Keil et al., 2000; Boonthanom, 2003); <i>reactance</i> (n=4, e.g. Murray and Häubl, 2011; Aljukhadar et al., 2012); <i>illusion of control</i> (n=3, e.g. Duedezeit and Leidner, 2011; Vetter et al., 2011b); <i>cognitive dissonance</i> (n=3, e.g. Vetter et al., 2011a; Turel et al., 2011); <i>mental accounting</i> (n=2, Gupta and Kim, 2007; Kim and Gupta, 2009); <i>mere exposure effect</i> (n=2, Yang and Teo, 2008; Lowry et al., 2008); <i>exponential forecast bias</i> (n=1, Arnott and O'Donnell, 2008); <i>ambiguity effect</i> (n=1, Bhandari et al., 2008); <i>zero-risk bias</i> (n=1, Frischmann et al., 2012); <i>input bias</i> (n=1, Ramachandran and Gopal, 2010); <i>base-rate fallacy</i> (n=1, Roy and Lerch, 1996); <i>omission bias</i> (n=1, Hong et al., 2011).
<b>Action-orientated biases</b> (n=9)	<i>overconfidence</i> (n=6, e.g. Van der Vyver, 2004; Tan et al., 2012); <i>optimism bias</i> (n=3, e.g. Rhee et al., 2005; Nandedkar and Midha, 2009).
<b>Stability Biases</b> (n=24)	<i>anchoring</i> (n=10, e.g. Allen and Parsons, 2010; George et al., 2000); <i>sunk cost bias</i> (n=7, e.g. Vetter et al., 2010; Lee et al., 2012a); <i>status-quo bias</i> (n=4, e.g. Gupta et al., 2007; Kim and Kankanhalli, 2009); <i>loss aversion</i> (n=2, Davis and Ganeshan, 2009; Yin et al., 2012); <i>endowment effect</i> (n=1, Rafaeli and Raban, 2003).
<b>Social biases</b> (n=9)	<i>herding</i> (n=4, e.g. Duan et al., 2009; Wang and Greiner, 2010); <i>stereotype</i> (n=2, Clayton et al., 2012; Quesenberry and Trauth, 2012); <i>value bias</i> (n=1, Hosack, 2007); <i>attribution error</i> (n=1, Rouse and Corbitt, 2007); <i>cultural bias</i> (n=1, Burtch et al., 2012).
<b>Interest biases</b> (n=2)	<i>after-purchase rationalization</i> (n=1, Turel et al., 2011 ); <i>self-justification</i> (n=1, Keil et al., 1994).

### 2.3.3 Cognitive Biases and Their Context

As noted above, to create a more comprehensive picture of the state of research on cognitive biases in the IS discipline, it is important to determine not only which types of cognitive biases have already been studied, but also in which research fields and in which industry contexts they have been investigated. Figure 2 therefore depicts a matrix comprised of bias categories and IS research fields. Each cell in this matrix holds the number of biases examined in a certain category and in a particular IS research field. Figure 2 shows that research on cognitive bases is not equally distributed over the research fields. There are certain combinations, such as *IS usage* and *perception biases* (n=27), *IS usage* and *decision biases* (n=16), or *IS usage* and *stability biases* (n=14) that have been investigated repeatedly so far. On the other hand, there are closely related combinations such as *IS usage* and *memory biases* that have not been examined in IS research at all (see footnote 3, p.9). These research gaps will be addressed in more detail in section 4.2 in which we provide concrete avenues for future research as well.

	Business Models of ICT-Firms	Software Development	Application Systems	IS Management	IS Usage	Economic impact of IS	Meta-research	$\Sigma$ (biases)↓
Perception Biases	0	2	2	7	27	0	2	40
Pattern Recognition Biases	0	2	3	2	4	0	0	11
Memory Biases	0	0	0	1	0	0	0	1
Decision Biases	0	2	1	5	16	0	0	24
Action-Orientated Biases	0	0	2	5	2	0	0	9
Stability Biases	0	5	2	3	14	0	0	24
Social Biases	0	0	0	3	6	0	0	9
Interest Biases	0	0	0	1	1	0	0	2
$\Sigma$ (research field) →	0	11	10	27	70	0	2	$\Sigma = 120$

Figure 2-2: Bias Category – IS Research Field Results Matrix.

Furthermore, we observed that the largest share of biases in our sample was explored outside any specific industry context (n=41). In those cases in which cognitive biases were examined in a particular context, *retail trade* (n=37) and *information* (e.g. software, publishing, broadcasting, telecommunications) (n=15) were the most researched industries. In contrast, the sectors *arts and entertainment* (n=2), *real estate* (n=1), *manufacturing* (n=1) and *health care and social assistance* (n=1) have to date received little attention. However, there is also a set of industry sectors in which we found no research at all on cognitive biases. Concerning

combinations between certain bias categories and industry contexts, we found the same phenomenon as with the combinations between bias categories and industry fields, i.e. areas with extensive research (*retail trade* and *perception biases*, n=20) and others with none (*retail trade* and *memory biases*, n = 0).

### **2.3.4 Theoretical Foundations and Methodology in Cognitive Bias Research**

Most of the 84 articles we examined stated that they used *prospect theory* (n=13), *cognitive bias theory* (n=9) and *theory of planned behavior* (n=7) to develop a research model or to explain their empirical results. Other theories that were reported were *behavioral decision theory* (n=7), *status quo bias theory* (n=4), *cognitive dissonance theory* (n=4) and *bounded rationality* (n=3). Three articles claimed to be based on *behavioral economics theories* without specifying which theory in particular they considered. 13 articles did not refer to any theory to explain cognitive biases.

Concerning the research method of the studies on cognitive biases in IS, most utilized a *laboratory experiment* (26) or a *field experiment* (9). 18 studies were based on *survey data*, 15 on *secondary data analysis*. Ten articles reportedly used a *multi-method* approach for conducting their study. Only a few authors made use of a *mathematical model*, *case study* or *interviews* as a research method.

Closely related to the research method is the approach used for measuring the cognitive bias of interest. To analyse this, we inductively developed three measurement categories based on the analysis of the research method of each paper: qualitative, quantitative argumentative, and quantitative objective. Most of the publications (n=41) apply what we label an objective measurement (e.g. Lowry et al., 2008). We consider a bias measurement to be objective, when elicited or observed decision making is quantified and then benchmarked against an objective, rational baseline or a control group in the case of experiments (e.g. Kahneman and Tversky, 1979). The authors of 29 papers employed a quantitative argumentative approach to research the bias(es) of interest. In these cases, survey or observational data are analysed with e.g. regression or structural equation modelling. The effects found, are attributed to certain biases argumentatively (e.g. Gupta and Kim, 2007). Only 6 of the papers rely on a qualitative approach to explore the existence and the effects of cognitive biases. In these cases, observed correlations are attributed to certain biases argumentatively (e.g. Ramachandran and Gopal,

2010). Examples for applied research methods here are interviews and case studies. Eight articles did not refer to any bias measurement at all.

### **2.3.5 Bias Position in Paper, Prior Research Goal and Level of Analysis**

Moreover, we found that in the vast majority of cases, cognitive biases took a strong (n=58) or medium (n=17) position in the article. This means that cognitive biases were at the center of the research study and not just examined as an ancillary phenomenon. Furthermore, most papers' primary research goal was the explanation of the cognitive bias phenomenon (n=64). Only 20 articles attempted to develop a specific way to avoid the occurrence of the respective cognitive bias ("de-biasing strategies") or its targeted application. Finally, we investigated whether the research on cognitive biases was conducted at the individual or the group level of analysis. The results show that almost all research was conducted at the individual level (n=72). Only 12 articles examined cognitive biases at the group level.<sup>5</sup>

## **2.4 Discussion and Research Opportunities**

### **2.4.1 Key Findings**

With our scientometric analysis, we have provided a comprehensive overview of research on cognitive biases in IS (see RQ1). Based on this analysis, we will subsequently summarize our findings, provide a more in-depth discussion of the state-of-the-art in cognitive bias research in IS and derive possible avenues for future research.

The findings from our scientometric analysis raise several key points. First, we found a distinct upward tendency in IS research on cognitive biases in the past 20 years. Additionally, we observed that in the vast majority of the examined articles, cognitive biases took center stage rather than being pushed to the sidelines. This rapid growth of publications and the focus on cognitive biases as a central research object can be interpreted as increasing acceptance of cognitive biases as a salient and legitimate research area in the IS discipline. Nonetheless, it was most articles' research goal to provide an explanation of the cognitive bias phenomenon rather than to develop ways and strategies for its avoidance or targeted use. This might indicate that the research on cognitive biases in the IS field is still in its infancy, as we suggest that explaining a phenomenon in a defined research field is often the initial step, and advancing it—the subsequent one.

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<sup>5</sup> A complete table including matched *research fields*, *bias categories*, *bias position in paper*, *prior research goal and level of analysis* for each individual article can be obtained from the authors upon request.

In addition, and as expected, we found that the vast majority of papers focused on the individual level of analysis. This, again, supports our suggestion that bias research in IS is still in its infancy, since biases at the individual decision-making level were also the ones that were first explored in early cognitive bias research (e.g. Tversky and Kahneman, 1973) before more sophisticated, group-related phenomena (e.g. herd behavior, Scharfstein and Stein, 1990) were explored. Moreover, our finding of research conducted predominantly at the individual level was reflected in the fact that e-commerce was one of the most prominent research settings in the papers we identified in our scientometric analysis. In e-commerce, it is common to investigate decision-making at the individual level (Smith and Brynjolfsson 2001; Corbitt et al. 2003; Cowart and Goldsmith 2007). However, since the influence of social networks is increasing (Wilcox and Stephen 2013) and their use often leads to decision-making at the group level (Kempe et al. 2003; Kim and Srivastava 2007), future research should pay more attention to the influence of cognitive biases on group decisions. It might be particularly interesting to explore the influence of social biases such as *value bias* or *cultural bias* (see Table 1) in group-decision-making processes (e.g. in online communities). In addition, it would be reasonable to conduct studies investigating whether results on cognitive biases gained in a particular individual decision-making context could readily be transferred to a group decision context.

Regarding the theoretical foundations to which the examined studies referred, we observed that most authors provided a reasonable basis for their investigation of the respective cognitive bias (e.g. *prospect theory*). However, we also identified a considerable amount of articles, where this was not the case and no or an insufficient theoretical basis was provided. We therefore advocate the use of a solid theoretical basis and its explicit argumentation and discussion in future IS studies on cognitive biases.

Concerning the employed research methods and bias measurement, our scientometric analysis identified that there are 41 articles using quantitative and objective bias measurement methods. Since cognitive biases are latent phenomena and cannot be observed directly, for a definite proof, it would be required to benchmark assumed biased decisions against an objective baseline (Kahneman and Tversky 1979). However, this does not mean that using qualitative or quantitative, argumentative methods such as interviews or secondary data analysis (e.g. regression) are inappropriate at all. The method of choice should always depend on the research questions of interest. Nonetheless, we recommend being aware of the

methodological peculiarities required by bias-related research when selecting research methods for future studies.

## 2.4.2 Avenues for Future Research

For the remainder of our paper, we return to the individual IS research fields and discuss existing and potential bias-related research in order to exemplarily present opportunities for future research (see RQ2).

In the research field *IS usage*, we could identify three large clusters: (1) e-commerce (B2C), (2) technology adoption and post adoption research, and (3) decision support system and recommender system use. Combined, these three clusters alone make up half of the 84 bias-related articles we identified in our analysis. Therefore, we dedicate a more extensive discussion to this research field.

The dominant themes in the e-commerce cluster (23 articles) are online reviews (e.g. Yin et al., 2012), product choice (e.g. Davis and Ganeshan, 2009), pricing (e.g. Goh and Bockstedt, 2013), trust in online shopping (e.g. Lowry et al., 2008) and customer retention (e.g. Park et al., 2010). With regard to biases, the most widely examined category in *IS usage* is *perception biases*, and here, the most prominent single bias is *framing*. As an extension of the existing investigation of *framing*, we recommend examining the effect of different framing operationalization options. It could not be just the wording, that is framed, but also other web-design characteristics such as size, color, presentation mode (e.g. dynamic vs. static), saliency of website objects etc. While there is already a considerable amount of research on these characteristics, such articles are most often not grounded in theoretical foundations that are related to cognitive biases or non-rational decision-making at all (Li et al. 2012; Lee et al. 2012b). Recognizing cognitive biases in such studies may, however, provide substantial new insights for IS research in general and human-computer interaction research in particular.

The second cluster (10 articles) in the research field *IS usage* contains articles that discuss biases in the context of technology adoption (e.g. *sunk cost bias*, Polites and Karahanna, 2012) and post-adoption theory (e.g. *status quo bias*, Hong et al., 2011). Although adoption is one of the more mature areas in IS, and there are widely acknowledged models such as UTAUT and UTAUT2 (Venkatesh et al. 2003; Venkatesh et al. 2012), it could be helpful to consider the role of cognitive biases more explicitly, given that in existing models, bias-related concepts such as “habit” (e.g. as reflected in biases such as the status quo bias) are already included (Venkatesh et al. 2012). This might not only contribute to better understand

and explain IS users' adoption behavior and thus advance existing adoption and post-adoption theories. It might also lead to a better prediction of possible nonrational adoption-decisions, resulting from the influence of cognitive biases. Research for software selection is another area where biases have so far received little attention (e.g. Benlian, 2011; Benlian and Hess, 2011).

The third cluster within *IS usage* (9 articles) includes issues of decision support system use (e.g. Kahai et al., 1998) and recommender system use (e.g. Pathak et al., 2010). Pathak et al. (2010) for example explore the *recency effect* and propose that future research could adopt different types of recommendation approaches, such as content-based or hybrids of content-based and collaborative filtering mechanisms. We additionally recommend exploring this *perception bias* (see Table 1) in combination with the *framing effect*. This might allow the uncovering of the conditions of recommendation-framing under which the *recency effect* is most influential or, in turn, which might deflate it. Such additions could advance the research for recommender system use where biases have often not been considered explicitly (e.g. Benlian et al., 2012a). In summary, we could observe that in the field of *IS usage* there already exist important contributions focusing on the phenomenon of nonrational decision-making. Nonetheless, we could also identify a research gap (see Figure 2). The bias category *memory biases* is yet not examined at all in *IS usage*. However, it could be particularly interesting to see how "old" decisions can bias "new" ones, or, in other words, how the *reference point dependency bias* (McFarland and Ross 1987) influences user behavior.

Furthermore, a closer look at the research field *IS management* shows that, similar to *IS usage*, there are three areas that have so far been addressed more intensely with regard to cognitive biases: these are IT outsourcing (Ramachandran and Gopal 2010; Vetter et al. 2010; Vetter et al. 2011a), IS project escalation (Keil et al. 1994; Boonthanom 2003), and IS security (Kannan et al. 2007; Anderson and Agarwal 2010). In this context, IS security might be an area that is particularly worthwhile further exploring, since companies are increasingly shifting their business processes to IS and might thus put their entire business at stake through insufficient or flawed IS security (Campbell et al. 2003; Cavusoglu et al. 2004). Future research concerning the development of ways for avoiding biases in decisions regarding corporate IS security might thus be beneficial. In addition, we could not find any bias-related research in the areas of software evaluation, knowledge management, and selection decisions. These research gaps in *IS management* also hold potential for future research studies. In the area of selection decisions for example, biases from the category *decision biases*, e.g. *illusion*



*of control* (Langer 1975), the *choice supportive bias* (Brehm 1956) or *neglect of probability* (Sunstein 2002) could be specifically interesting to explore.

In the research field *software development*, the identified articles deal with different aspects of the software development cycle (Laudon and Laudon 2013). One article deals with requirements elicitation (Jayanth et al. 2011), two articles deal with the design of software (Rafaeli and Raban 2003; Arnott 2006) and one article addresses quality management (Calikli et al. 2012). In addition to that, two articles deal with the general management of software development projects (Keil et al. 2000; Lee et al. 2012a). However, among the identified articles, there is no research that deals with cognitive biases at the actual implementation stage. We argue, however, that this is a worthwhile area to explore cognitive biases, because even in a structured software development process, a considerable amount of decision-making remains in the responsibility of the individual developer.

With regard to cognitive bias research, we found the field of *application systems* to be dominated by articles that discuss the functionality and system architecture of decision support systems (e.g. George et al., 2000). While decision support system functionality is an obvious object of investigation in this research field, a closer investigation of other corporate application systems as well as consumer application systems may offer ample potential for further bias related research. For example, the functionality and performance of customer relationship management (CRM) systems might benefit from an explicit consideration of *herding* effects among customers. At the consumer side of application systems, operators of social networks might be able to increase their members' satisfaction by considering *social biases* (see Table 1) in the architecture and functionality of their services.

Because research on *business models of ICT firms* is a rather new field in IS (Veit et al. 2014), a lack of findings in our literature search is consistent with the overall few publications on this topic. Nonetheless, we suggest that it is also worthwhile to explore cognitive biases in this particular research field. For example, the process of creating a business model for an ICT venture itself might be prone to biases. The identification of market potential, the development of a revenue model, or the actual implementation of an ICT business model is often performed by an individual or few decision- makers, i.e. entrepreneurs. Examining the appropriateness of transferring Kahneman et al.'s (2011) checklist for identifying potential biases in impending decisions to the ICT entrepreneurship context might be an interesting question that could be examined in future research studies.

Additionally, in the field *economic impact of IS*, we did not discover any publications concerning research on cognitive biases (see Figure 2). One explanation of this finding might be that a large portion of research in this field does not rely on cognitive approaches and individual decision-making (e.g. Kraemer and Dedrick, 1998). Nonetheless, we argue that it might be worthwhile to also consider biases in this field. In particular, the group of social biases, such as herd behavior, might affect the economic impact of IS through the virulence observed in online social communities (Chen et al. 2010).

Finally, the lack of sufficient *meta research* related to cognitive biases in IS is the primary motivation for our scientometric analysis. The results of our study confirm the existence of this research gap and provide additional evidence for the relevance and necessity of conducting a literature review on cognitive biases in IS in order to derive implications for IS specific research topics.

In summary, we can conclude that in cognitive bias related IS research, there are some leading fields such as *IS usage* and *IS management* and also some leading contexts, such as *retail trade* and *information*, but also others that are less or not examined at all (e.g., *business models of ICT-firms* or *economic impact of IS*). Future research can delve deeper into the individual IS research fields, discuss its goals and the types of cognitive biases examined in this field, reveal their implications for the field, and dispute the possible implications of non-investigated biases or elaborate on how examining other types of biases can contribute to this field. The abovementioned opportunities for future research studies, as well as our results matrix (see Figure 2) could serve here as a meaningful point of departure.

## 2.5 Limitations and Conclusion

As with any study, there are some limitations that we discuss below. First, in our scientometric analysis, we focused on the top-rated publications in IS research and thus neglected other IS journals or conferences that may include articles on cognitive biases (e.g. Benlian et al., 2012b). Although we consider this focus an acceptable limitation, we nonetheless suggest that future literature reviews may include a more extensive set of IS journals and conference proceedings to validate our findings.

Second, for the factor bias category in our scientometric analysis we could not find any uniform and complete existing typology. We therefore integrated existing typologies, in order to achieve a preferably exhaustive bias categorization. We, however, are aware of the shortcomings of the applied approach and therefore recommend future studies on cognitive

biases to further address the categorization of biases, focusing on and working toward the development and verification of a unified typology of cognitive biases.

Third, some categories of the categorization scheme used for the data analysis (e.g. *bias position in paper* and *bias impact*) are to some extent interpretative. Given the high interrater reliability of our coding process (96%) and the ongoing validations through experts, however, we are confident that our results are as objective as possible. Nevertheless, future literature reviews on cognitive biases may additionally validate the categories employed in our analysis.

Finally, for reasons of space, we could only briefly and exemplarily discuss potential topics for bias-related future research studies. The results of our scientometric analysis nevertheless provide an objective basis for a prompt identification of which cognitive biases have already been covered in previous IS research and which ones have not (possible research gaps). We are therefore confident that this scientometric analysis can be a useful starting point for IS researchers interested in cognitive biases. However, while figure 2 seems a promising tool for identifying research gaps in cognitive bias research, we also advise that the results from this matrix are to be interpreted with caution. Considering the identified research gaps in the individual IS fields, we don't claim, that cognitive bias research should be equivalently distributed across all these fields. We thus also don't recommend investigating all cognitive biases in all industries, for it is for example possible that the types of biases more likely to occur in "application systems" or "economic impacts of IS" categories are different from those in "IS usage" research. In other words, not every research gap in this matrix is per se a research area which should be explored. On the other hand, intensely researched bias categories and research fields must not be mistaken for over-researched areas where no further investigations are required. Hence, if the investigation of a certain combination of *bias category*, *research field* and *industry context* is desirable and should be pursued in future research, should still be evaluated case by case, also because the need for research in certain areas and the aforementioned meaningfulness of economic and societal contributions may shift over time.

In conclusion, this study's main research contribution is to be seen in providing a comprehensive picture of the state of research on cognitive biases in the IS discipline. Such an overview enables finding links between existing research studies, identifying research gaps, providing directions and implications for future research and, in this way, contributing to cumulative knowledge-building. In summary, our literature review supports our initial claim, that insights from psychology, and in particular cognitive biases, can further enrich existing

theories and models in IS, increasing their explanatory power. Ultimately, it is our hope that the findings of this scientometric analysis will encourage many IS researchers to further explore the exciting phenomenon of cognitive biases and thus will serve as a springboard for future research studies.

### 3 Article 2: Role of Feature Updates on Users' Continuance Intention

**Titel:** Keeping Software Users on Board – Increasing Continuance Intention through Incremental Feature Updates (2015)

**Authors:** Amirpur, Miglena, Technische Universität Darmstadt, Darmstadt, Germany

Fleischmann, Marvin, Ludwig-Maximilians-Universität München, München, Germany

Benlian, Alexander, Technische Universität Darmstadt, Darmstadt, Germany

Hess, Thomas, Ludwig-Maximilians-Universität München, München, Germany

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#### Abstract

Although feature updates are a ubiquitous phenomenon in both professional and private IT usage, they have to date received little attention in the IS post-adoption literature. Drawing on expectation-confirmation theory and the IS continuance literature, we investigate whether, when and how incremental feature updates affect users' continuance intentions (CI). Based on a controlled laboratory experiment, we find a positive effect of feature updates on users' CI. According to this effect, software vendors can increase their users' CI by delivering updates incrementally rather than providing the entire feature set right with the first release. However, we also find that CI diminishes when the number of updates exceeds a tipping point in a given timeframe, disclosing update frequency as crucial boundary condition. Furthermore, we unveil that the beneficial effect of feature updates on CI operates through positive disconfirmation of expectations, resulting in increased user satisfaction. Implications for research and practice as well as directions for future research are discussed.

**Keywords:** Feature Updates, IT Features, Expectation-Confirmation Theory, IS Continuance, IS Post-Adoption.

### 3.1 Introduction

In recent years, software vendors have increasingly leveraged feature updates as a measure to enhance their software products. Feature updates are self-contained modules of software, that are provided to the user for free in order to extend and enhance the functionality of software after it has been rolled out and is already in use. Functionality thereby refers to distinct, discernible features which are deliberately employed by the user in accomplishing the task or goal for which he or she uses the software (Benlian 2015). Feature updates are thus no discrete and stand-alone programs themselves but rather integrated into the base software once they are applied to it (e.g., Dunn 2004). Such feature updates that are the focus of the present study, are to be distinguished from other, non-feature update types, such as bug-fixes. These technical non-feature updates do not change the core feature set of software but only correct flaws or change software properties. In contrast to feature updates, they often do not directly affect the user's interaction with the software and are typically not even visible to the user (e.g., improvements in stability, compatibility, security or performance) (Popović et al. 2001).

Feature updates are a particularly prevalent phenomenon in the area of mobile applications and operating systems, but have also been used long before in the desktop space. In a 2013 update, the popular Facebook app for smartphones and tablet computers received a comprehensive instant messaging chat feature (Etherington 2013). On the desktop, web browsers such as Google Chrome and Mozilla Firefox continuously receive feature updates, which extend their functionalities. Here, an example is the 'tab sync' functionality, which was added to the browser Google Chrome in 2012 via a feature update. This particular feature enabled users to synchronize opened websites (tabs) across different computers and mobile devices in order to seamlessly continue browsing when switching devices (Mathias 2012).

This ubiquitous use of feature updates by software vendors in practice is reflected in a large body of research on the technical design of software, its maintenance and management. Research on software engineering (Sommerville 2010), including software product lines (Clements and Northrop 2002), software release planning (Svahnberg et al. 2010) and software evolution and maintenance (Mens and Demeyer 2008) explores how and when software functionality should be developed and delivered in order to maintain the technical integrity of the software and optimize the vendor's production process. While this stream of research does account for customer needs, its focus nonetheless lies on the supply side, primarily exploring technical design aspects of software. There is as yet, however, little

understanding of the user's perspective on updates—the demand side. In particular, the behavioral dimension, i.e. how updates are perceived by users is still an area that has so far received only minimal research attention (Hong et al. 2011; Sandberg and Alvesson 2011).

Investigating the effect of feature updates on users' beliefs, attitudes and behaviors regarding an information system (IS), however, might be beneficial for software vendors and of particular interest in the post-adoption context, because users' continuance decisions (i.e., customer loyalty) are strongly influenced by their experiences made during actual IS use (Bhattacharjee and Barfar 2011). For software vendors, shedding light on the role of feature updates for the IS continuance decision can result in a better understanding of how to strategically utilize updates in order to achieve desirable performance outcomes such as higher user loyalty and sustained revenue streams. From a research perspective, a better understanding of feature updates from a user's perspective has the potential to increase the explanatory and predictive power of existing post-adoption theory. In particular, researchers studying IS post-adoption phenomena often tend to conceptualize information systems as a monolithic and coarse-grained black box, rather than as collection of specific and finer-grained features that are dynamic and alterable over time. However, understanding the granularity of software and its changes through feature updates would help explain how users' beliefs, attitudes, and behaviors fluctuate over time as a result of the dynamic nature of information systems. In addition, the focus on changes in beliefs, attitudes and behaviors, emanating from the IT artifact itself rather than from other IT-unrelated environmental stimuli, is a response to several calls for research from IS scholars who criticize the negligence of the IT artifact's role in IS research (Benbasat and Zmud 2003; Hevner et al. 2004; Orlikowski and Iacono 2001).

We therefore seek to address the discussed research gaps by examining the questions of *whether, when and how feature updates influence users' IS continuance intentions*.

We contribute to prior research in three important ways. First, we identify a positive and somewhat counterintuitive effect of feature updates on users' CI. According to this effect, software vendors can increase their users' CI by delivering functionality via incremental updates rather than providing the entire feature set right with the first release of the software. A key boundary condition of this effect, however, is update frequency. We found that CI diminishes when the number of updates exceeds a tipping point in a given timeframe. Second, we not only investigate the direct effect of feature updates on CI; we also open up the theoretical black box of how feature updates influence IS continuance intention by highlighting the role of affect. Third, our overarching contribution is to advance the

predominant view of information systems in post-adoption literature from a mostly monolithic and static to a finer-grained and more dynamic perspective by showing how a functionally malleable information system might influence users' beliefs, attitudes and behaviors over time. As such, we also accentuate the changing nature of the IT artifact for users' CI and thus explicitly consider the software product lifecycle in our theorizing. From a practitioner's perspective, our study offers implications for software vendors on how to increase their customers' loyalty (i.e., CI) through the delivery of feature updates. We not only provide guidelines on which actions to take, but also on which measures to avoid in order to benefit from the positive effect of feature updates on users' CI.

## **3.2 Theoretical Foundations**

### **3.2.1 Feature Updates**

In the software engineering literature (e.g., Sommerville 2010), a feature update is the delivery of functionality after the first release of a software and falls within the strategic considerations regarding when to deliver what type of functionality to the user (Svahnberg et al. 2010). A first release is the version of a software that is released to the market for the very first time, as well as the initial release of a new generation of an already established software. As pointed out in the introduction, functionality refers to distinct, discernible features which are deliberately employed by the user in accomplishing the task or goal for which he uses the software (Benlian and Hess 2011; Benlian 2015). From the user's perspective, feature updates occur during the continued use of software and are usually recognized through notifications, required actions during installation or through the display of new or changed functionality. As we will outline later on, we argue that this has the potential to influence users' beliefs, attitudes, and behaviors regarding the focal software in the post-adoption stage of IS usage, including their decisions on continued use or discontinuance in those settings where use is not mandated, such as consumer software.

### **3.2.2 Information Systems Continuance**

In post adoption research (Karahanna et al. 1999; Bhattacharjee 2001), the term information systems continuance refers to "sustained use of an IT by individual users over the long-term after their initial acceptance" (Bhattacharjee and Barfar 2011, p. 2). To explore IS users' intentions to continue or discontinue using an IS, Bhattacharjee (2001) adopts expectation-confirmation theory (ECT) (Locke 1976; Oliver 1980, 1993; Anderson and Sullivan 1993). ECT proposes satisfaction (SAT) with a product or service as the essential driver of



repurchase intention. In Bhattacharjee's (2001) model, repurchase intention is replaced by a user's intention to continue using an IS (CI)—the core dependent variable in his model. According to Bhattacharjee (2001), it is influenced by satisfaction (SAT) and perceived usefulness (PU). SAT is an affective state and the result of a positive disconfirmation of prior expectations (Oliver 1980; Bhattacharjee 2001). Following ECT, the IS continuance model suggests that users compare their pre-usage expectations of an IS with their perception of the performance of this IS during actual usage (Bhattacharjee 2001). If perceived performance exceeds their initial expectations, users experience positive disconfirmation which has a positive impact on their satisfaction with the IS. If perceived performance falls short of the initial expectations, negative disconfirmation occurs and users are dissatisfied with the IS (Bhattacharjee and Barfar 2011). Positive (negative) disconfirmation thus consists of two elements—unexpectedness and a positive (negative) experience. Satisfied users intend to continue using the IS, while dissatisfied users discontinue its subsequent use. PU, on the other hand, captures the expectations about future benefits from using the IS (Bhattacharjee and Barfar 2011).

In its original form, the IS continuance model (Bhattacharjee 2001) has a static perspective on the IS continuance setting, failing to account for changing user beliefs and attitudes over time. In response to this limitation, Bhattacharjee and Premkumar (2004) introduce a more dynamic perspective by showing that beliefs and attitudes do not only change from pre usage to actual usage but also during the ongoing usage of an IS (Kim and Malhotra 2005). While this dynamic perspective already provides valuable insights into the drivers of post-adoption behavior, it still neglects the IT artifact's changing and malleable nature. Evidence from practice shows that information systems are constantly modified over time, for example, when vendors update and change their software or introduce new software generations. Following Bhattacharjee and Premkumar (2004), it is reasonable to assume that a change in the IT artifact may also induce a change in users' beliefs and attitudes toward it. Kim and Malhotra (2005), Kim (2009), Ortiz de Guinea and Markus (2009) and Ortiz de Guinea and Webster (2013), for instance, have provided evidence that the IS itself can shape users' beliefs, attitudes and even their affect regarding the IT in later usage stages. In order to investigate the changing nature of the IT artifact and its effect on users' beliefs, attitudes and behaviors during post-adoption use, we explore feature updates through the lens of the disconfirmation mechanism in ECT.

### **3.3 Hypotheses Development**

#### **3.3.1 The Effect of Unexpected Feature Updates on Users' Continuance Intentions**

We argue that if a free feature update provides additional functionality that directly serves users in accomplishing their IS-based tasks, it will be perceived as a positive experience with the software. Furthermore, it is reasonable to assume that feature updates are usually not anticipated by users and can thus be perceived as unexpected experiences with the software. Even if a software vendor does provide release plans about future feature updates, we suggest that in practice, most users—and especially consumers—are unlikely to follow such update plans in detail for each and every individual software product they have in use. If feature updates are perceived as unexpected and positive experiences during usage, according to ECT, they should consequently induce perceived positive disconfirmation (Oliver 1980). As a result, drawing on ECT and the IS continuance model (Bhattacharjee 2001), it is plausible that perceived positive disconfirmation during software use will increase users' CI regarding the updated software.

In the context of software features, ECT moreover implies that positive disconfirmation from feature updates depends on a relative change in functionality compared to a user's subjective reference point (the initial configuration of the software) rather than an absolute change (Helson 1964; Oliver 1980). According to this logic, a software vendor should thus be able to create positive disconfirmation and therefore increase the user's CI by applying the strategy of simply holding back features (functionality) in the first release of a software package and delivering this functionality only later on, through incremental, free feature updates. Under this incremental feature delivery strategy, a feature-complete software package might be designed and developed by the software vendor, but certain features might not be included in the initially shipped software version. The user is assumed to be unaware of the existence of these remaining features. Once these remaining features are subsequently delivered through updates, they are likely to elicit positive disconfirmation. Consistent with the IS continuance model, this could then lead to an increase in CI. This incremental feature delivery strategy is thus to be distinguished from an all-at-once feature delivery strategy under which all developed features are delivered in the first release.

Nonetheless, both feature delivery strategies are assumed to overall comprise the same type and number of features. We additionally assume that under both strategies, the user's evaluation of the software regarding CI takes place at the same point in time, which is after

the incremental feature delivery strategy has been executed (i.e. when users are endowed with the same set of features as if they had received them right with the first release). To summarize, because of the nature of the disconfirmation mechanism in ECT, which operates through an evaluation of relative instead of absolute change, the users of software that receive functionality via incremental feature updates will likely have a higher intention to continue using this software than users who received all these features right with the first release. We accordingly derive our first hypothesis:

***H1:** Software that receives functionality via incremental feature updates induces a higher continuance intention compared to software that includes the complete and equivalent set of functionality right with the first release.*

### **3.3.2 The Effect of Expected Feature Updates on Users' Continuance Intentions**

As outlined before, users must perceive updates as unexpected 'small gifts' from the vendor akin to a surprise that surpasses users' expectations (Oliver 1980). However, if these feature updates are delivered too frequently, they will probably no longer be perceived as unexpected by users because the feature updates become a predictable routine. Therefore, it is likely that the anticipated benefits from these expected feature updates will be included in the expectation about the future performance of the software (Kim and Malhotra 2005). The experience with the software would then no longer exceed the expectation, leading to a lack of positive disconfirmation. As a result an increase in CI from feature updates, as suggested in hypothesis 1, would fail to occur. In addition to this lack of positive disconfirmation, a high frequency of updates also increases the likelihood of being perceived as unsolicited interruptions of the workflow (Gluck et al. 2007; Hodgetts and Jones 2007). While additional functionality through updates may be welcomed by the user, with increasing frequency of updates, the accompanied interruptions might reach a point, where they are perceived as disproportionately high compared to the benefits (i.e. functionality) that accompany them. In terms of ECT, such a negative experience with the software from a too high frequency of updates may also diminish or even annihilate the previously discussed positive effect of the added functionality received through the feature update. Based on this logic, we argue that when the number of updates goes beyond a specific tipping point, the positive effect of feature updates on users' CI will decrease again or even completely disappear. Taken together, we thus hypothesize:

*H2: Beyond a threshold level of update frequency, incremental feature updates will no longer increase users' continuance intentions.*

### **3.3.3 The mediating Effect of Satisfaction for Feature Updates**

According to ECT (Oliver 1980) and the IS continuance model (Bhattacharjee 2001), disconfirmation will not have a direct effect on CI but will instead work through a mediation mechanism. Specifically, a positive disconfirmation leads—in a first step—to an affective response: an increase in the user's SAT with the IS. Only in a subsequent, second step will this increased SAT with the IS lead to a higher intention to continue using the IS. In the case of an unexpected feature update (hypothesis 1), the pleasant surprise of this helpful, 'free gift' from the software vendor that exceeds the expectation about this software would induce positive disconfirmation. ECT suggests that the positive disconfirmation from such a feature update then would trigger a positive affect which is reflected in increased SAT. Accordingly, we argue that SAT is the factor that drives and explains this increase in CI regarding the software that receives functionality through incremental feature updates compared to software that includes all features right with the first release.

Even though PU is another core driver of CI in the IS continuance model, we argue that the positive effect from an incremental feature delivery strategy—compared to an all-at-once feature delivery strategy—on CI is not driven by PU. This is because in the continuance model PU represents the user's evaluation of future benefits from using the software, regarding its functionality, i.e. features (Bhattacharjee 2001). According to our initial assumption (hypothesis 1), under both feature delivery strategies, the user's evaluation of PU occurs when the incremental feature delivery strategy is executed, i.e. the feature updates have already been delivered and users are thus endowed with the same set of features as if they had received them right with the first release. In both cases, the prospective benefits from using the software should thus be identical, implying the same level of PU (Bhattacharjee 2001). Moreover, it should be noted, that this assumption likely resembles the real-world use scenario. When users have to make a decision about continuing an IS, they will probably base their decision on the configuration of the software that they have recently worked with rather than the configuration, which they originally started to work with. To sum up, the specific comparative increase in CI from an incremental feature delivery strategy as proposed in hypothesis 1 is solely mediated by SAT. We thus hypothesize:

*H3: The positive effect of incremental feature updates on users' continuance intentions is mediated by satisfaction with the software.*

## 3.4 Method

### 3.4.1 Experimental Design

With the goal to examine the effects of feature updates on users' CI as suggested by our hypotheses, we opted for a laboratory experiment that allowed us to investigate and isolate the causal mechanisms that operate between feature updates and attitudinal user reactions. Even though this laboratory setting comes with the downsides of a simplified experimental task and a limited time span of observable usage, it also allows for an accurate identification of the hypothesized effects which we consider as crucial given that this study is the first to explore the effect of feature updates on users' continuance intentions. A second reason for choosing an experiment was the indication from theory that, working through affect, the core mechanism behind our proposed effect of feature updates might be outside of users' awareness, which made a cross-sectional survey with self-reported measures less suitable. Third, the experimental setting enabled us to account for the claims of numerous continuance researchers to put the IT artifact more at the center of investigation in post-adoption research by using an IS as basis for manipulations. We thus conducted a 1 x 3 between-subjects laboratory experiment (see Figure 1) with 90 participants recruited at a large public university in Germany to evaluate the impact of feature updates on the user's SAT, PU and CI. The participants used a word-processing program ('eWrite') with a simplified user interface that was developed and tailored to the purposes of this experiment to complete a text formatting task. The use of a student sample is appropriate for this study, because college students are likely to be familiar with both feature updates and word processing programs and show similar attitudes and beliefs toward the feature updates offered in our experiment compared to non-student samples (Jeong and Kwon 2012).

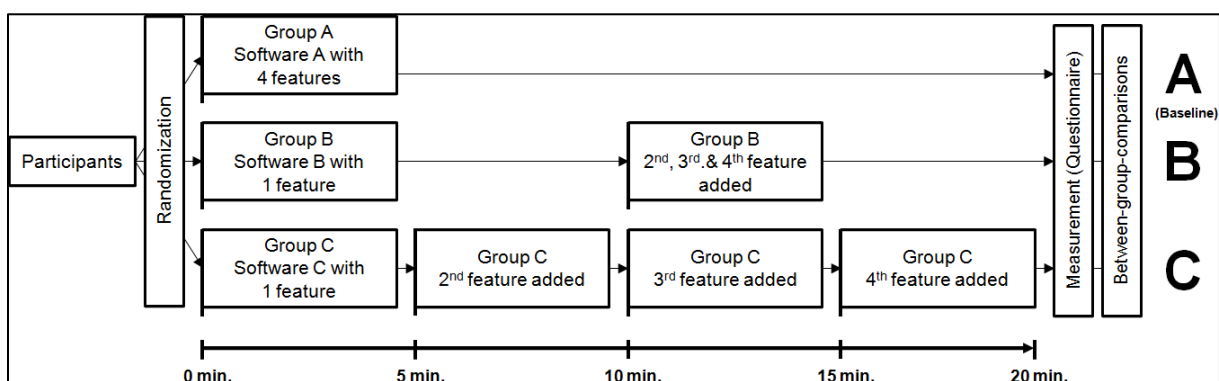


Figure 3-1: Experimental Setup, Groups, and Treatments.

### 3.4.2 Manipulation of Independent Variables

In our experiment, we used a word-processing program for two reasons: Our first criterion was ensuring a basic familiarity with the program of choice for all participants. Because nowadays almost any young person, especially students, needs to work with word-processing programs, we considered this criterion to be met<sup>6</sup>. Second, to minimize unwanted variance in our response data, we were looking for software features that are preferably value-free, equivalent<sup>7</sup>, and independent (i.e., modular). We used a total of four text formatting features in our word-processing system context: 1) font size, 2) font style, 3) font, and 4) text alignment. The feature updates were directly related to the experimental task by adding new text-formatting functionalities. The available time for task completion was 20 minutes. In the one-feature-update condition (B), participants simultaneously received features 2, 3, and 4 ten minutes after having started to work on the task (see Figure 1). In the three-feature-update condition (C), participants received the first update (with feature 2) after five minutes, the second update (with feature 3) after ten minutes and the third update (with feature 4) after fifteen minutes. Participants in each group were informed about updates via a pop-up notification window at the center of the screen, which contained a brief explanation of the update's content and required them to confirm the update by clicking on an 'Ok' button before they could proceed with their experimental task. After confirming the notification, participants could immediately use the new feature. This notification had been included in order to ensure awareness with the feature update. Figure 3-2 provides examples of the user interface.

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<sup>6</sup> Section 4.4 shows, that this assumption is clearly met in our sample, as the vast majority of our participants indicated a regular use of word-processing programs and reported high levels competence in the use of word-processing programs.

<sup>7</sup> The scope and importance of the four text formatting functionalities in groups A, B and C were held constant in order to avoid potential confounding effects from the nature of the updates' contents. The functional equivalence of the individual feature updates for the text formatting task were validated in a pre-study with 52 subjects that were recruited using WorkHub, a crowdsourcing platform similar to Amazon Mechanical Turk (Paolacci et al. 2010). The subjects participated online for a small payment. No significant differences emerged among the four text-formatting features (all  $t < 1$ ).

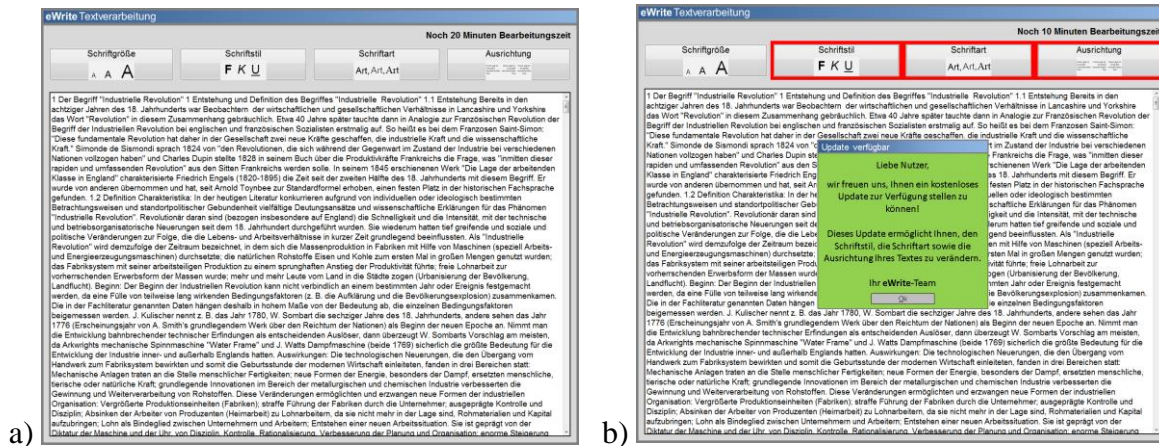


Figure 3-2: Sample Screenshots of Text Editor – a) Group A (Control Group, no Updates) b) Group B (One Feature Update) after 10 min.8

The simplifications in functionality and user interface of our experimental software were made on purpose and followed similar IS studies (e.g., Murray and Häubl 2011). This simplified setting enabled us to establish a controlled environment and unmistakably ascribe any observed changes in the dependent variables (CI, SAT, PU) directly to our experimental treatments. The text which had to be formatted in the experimental task was a historical text about the Industrial Revolution. We consider this type of text, just like the program features, to be a ‘neutral’, objective one, compared for example to a newspaper article about a current event, which is often an emotive one. Furthermore, the text was long enough—as the pilot test showed—to keep the participants busy throughout the entire twenty minutes. Thus, we ensured that the participants could not complete their task too quickly and might have had to wait, which could have confounded our results. The participants were also instructed that they did not need to format the entire text, but to focus on the formatting quality, which in turn fostered the comprehensive use of all available program features.

A pilot test with 12 subjects was conducted to ensure that all of the treatments were manipulated according to the experimental design (Perdue and Summers 1986). Specifically, subjects were asked about the functional equivalence of the individual updates, ease of use of the text-formatting editor and comprehensibility of instructions and items. Feedback and suggestions were obtained from participants after they had completed the pre-test experiment. The word-processing program and the questionnaire were accordingly revised for the main test.

<sup>8</sup> The green notification at the center of the screen informed the participant about the update and its content. In the case of a feature update (groups B and C), it briefly describes the added functionality (e.g. ‘This update enables you to change the font style.’).

### 3.4.3 Measures

#### 3.4.3.1 *Dependent Variables*

We used validated scales with minor wording changes for all constructs, capturing the core part of the IS continuance model (CI, PU, SAT) (Bhattacharjee 2001). Measures for CI were adapted from Bhattacharjee (2001): CI1. *I intend to continue using eWrite rather than discontinue its use*; CI2. *My intentions are to continue using eWrite than use any alternative means*; CI3. *If I could, I would like to discontinue my use of eWrite* (reverse coded). Measures for PU and SAT were based on Kim and Son (2009): PU1. *Using the features of eWrite enhanced my effectiveness in completing the task*; PU2. *Using the features of eWrite enhanced my productivity in completing the task*; PU3. *Using the features of eWrite improved my performance in completing the task*. SAT1. *I am content with the features provided by the word-processing program eWrite*; SAT2. *I am satisfied with the features provided by the word-processing program eWrite*; SAT3. *What I get from using the features of the word-processing program eWrite meets what I expect for this type of programs*. Because constructs were measured with multiple items, summated scales based on the average scores of the multi-items were used in group comparisons (Zhu et al. 2012). Unless stated otherwise, the questionnaire items were measured on 7-point-Likert-scales anchored at (1)=strongly disagree and (7)=strongly agree.

#### 3.4.3.2 *Control Variables and Manipulation Check*

In our study, we control for the impact of usage intensity of word-processing programs in real life, frequency of updates in real life for productivity software/entertainment software and desktop computer/smartphone and computer self-efficacy (Marakas et al. 2007) on CI. Furthermore we examined participant's motivation to process information with one item (Suri and Monroe 2003), because this variable may also influence the response behavior of the participants and, thus, the validity of the results. Moreover, after conducting the experimental task, participants were asked to what extent they had understood: 1) the instructions in the experiment and 2) the items' formulation. We included these control variables as well as the subjects' demographics as covariates to isolate the effects of the manipulated variables. Finally, we included two questions as manipulation checks: 1) *What was the experimental task? (formatting the entire text or formatting the text as appealingly as possible)* and 2) *How many updates did you receive during the experiment? (no updates, one update, or three updates)*.



### 3.4.4 Participants, Incentives and Procedures

90 participants were recruited from the campus of a large public university in Germany. Participants received 5€ for their participation in the lab experiment. In order to align their motivations to properly fulfil the experimental task, 3 x 50€ Amazon vouchers and an iPad Mini were announced as rewards for the four most appealingly edited texts. Five participants were excluded from the sample based on the manipulation checks. We therefore used a sample of 85 subjects in the following analysis. Of the 85 subjects, 31 were females. The participants' age ranged from 18 to 36, with an average value of 23.85 ( $\sigma=3.34$ ). 78 participants were university students, two participants were high school students, five were employees and one was self-employed. Three participants refused to state their occupation. The educational backgrounds of the participants were diverse, including physics, arts, law, management, medical science, biology, geography etc. 51% of the subjects ( $n=44$ ) use word-processing programs from one up to five hours per month, 28% between five and 30 hours ( $n=24$ ), and 14% more than 30 hours per month ( $n=12$ ). 80% rated their computer skills as high to very high. 4% believed they had a rather low competence in using computers.

When participants arrived at the laboratory, they were randomly assigned to a treatment/control group. All instructions and questionnaire items were presented on the computer screen in order to minimize the interaction with the supervisor of the experiment, and thus to reduce error variance to a minimum. They then completed a pre-experimental questionnaire including demographic variables such as gender and age, as well as some control variables such as motivation to process information. In order to ensure comparable initial conditions, participants were further presented with a program tutorial (a program screen similar to that of the actual experimental task). In this tutorial, the initially available features (depending on the experimental condition) were presented and each one was explained in a text bubble. Before they could proceed, all participants had to try out each available feature at least once by formatting a short sample text, ensuring that each participant had understood the program's functionality. On the next two screens, the actual experimental scenario and task, the time available to complete the task, and the results-based incentives were introduced. After having read these instructions, the participants could manually start the actual experimental task by clicking on a button. After having worked 20 minutes on the experimental task, they were automatically redirected to the post-experimental questionnaire, which contained the measurement of all dependent variables (quantitative and qualitative), all remaining control variables, and the manipulation checks. Finally, they were compensated for their participation and debriefed.

## 3.5 Data Analysis and Results

### 3.5.1 Control Variables and Manipulation Check

Based on the results of a series of Fisher's exact tests, we could conclude that there was no significant difference across the three experimental conditions in terms of gender ( $p>0.1$ ), age ( $p>0.1$ ), intensity of using word-processing programs ( $p>0.1$ ), attitudes toward productive ( $p>0.1$ ) and entertainment software ( $p>0.1$ ), as well as frequencies of the received updates (desktop/productive:  $p>0.1$ ; desktop/entertainment:  $p>0.1$ ; smartphone/productive:  $p>0.1$ ; smartphone/entertainment:  $p>0.1$ ). Furthermore, based on a series of ANOVA tests, we found no significant differences across the three experimental conditions regarding the task-relevant control variables motivation to process information ( $F=0.05$ ,  $p>0.1$ ), understanding of instructions ( $F=0.07$ ,  $p>0.1$ ) and items' formulations ( $F=0.21$ ,  $p>0.1$ ). It is therefore reasonable to conclude that participants' demographics and task-relevant controls were homogeneous across the three conditions and thus did not confound the effects of our experimental manipulations. Prior to testing the hypotheses, a manipulation check was performed to examine whether our experimental treatments worked as intended. Participants had to state whether they had received 1) one feature update, 2) three feature updates or 3) no update. As mentioned above, in five observations, the wrong condition was ticked, which led to their exclusion from the final sample (three subjects have stated to be in group C, while being in group A and two subjects claimed to be in group B while being in group C). Overall, the results from our manipulation checks suggest that our experimental treatments were successful.

### 3.5.2 Measurement Validation

Because we adopted established constructs for our measurement, confirmatory factor analysis (CFA) was conducted to test the instrument's convergent and discriminant validity for the dependent variables (Levine 2005). Table 3-1 reports the CFA results regarding convergent validity using SmartPLS, version 2.0 M3 (Chin et al. 2003; Ringle et al. 2005) for the core constructs.<sup>9</sup>

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<sup>9</sup> Computer self-efficacy and other control variables also satisfied the criteria regarding Cronbach's Alpha, AVE and Cross Loadings. Items, scale specifications and results from discriminant validity analysis can be obtained from the authors.

Table 3-1: Results of Confirmatory Factor Analysis for Core Variables.

Variables	Number of Indicators	Range of Standardized Factor Loadings*	Cronbachs Alpha	Composite Reliability ( $\rho_c$ )	Average Variance Extracted (AVE)
<b>Continuance Intention (CI)</b>	3	0.783 - 0.900	0.802	0.883	0.716
<b>Satisfaction (SAT)</b>	3	0.898 - 0.928	0.895	0.935	0.827
<b>Perceived Usefulness (PU)</b>	3	0.853 - 0.910	0.845	0.906	0.762

\* All factor loadings are significant at least at the  $p < 0.01$  level

The constructs were assessed for reliability using Cronbach's alpha (Cronbach 1951). A value of at least 0.70 is suggested to indicate adequate reliability (Nunnally 1994). The alphas for all constructs were well above 0.7. Moreover, the composite reliability of all constructs exceeded 0.70, which is considered the minimum threshold (Hair et al. 2011). Values for AVEs for each construct ranged from 0.709 to 0.889, exceeding the variance due to measurement error for that construct (that is, AVE exceeded 0.50).

### 3.5.3 Hypotheses testing

To test our hypotheses, we conducted one-way ANOVAs with planned contrast analyses with IBM SPSS Statistics 20. Table 3-2 presents the mean values of the main constructs for groups A, B and C.

Table 3-2: Mean Differences and Significance Levels.

Mean Values for Groups				Mean Differences and Significance Levels	
	No Update (A), n=27	One Feature Update (B), n=30	Three Feature Updates (C), n=28	B-A	C-A
<b>PU</b>	4.51	4.76	4.77	0.25	0.26
<b>SAT</b>	4.71	5.32	5.05	<b>0.61**</b>	0.34
<b>CI</b>	5.66	6.17	5.91	<b>0.51**</b>	0.25

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$  (one-sided); ANOVA-tests with planned contrast analyses

In hypothesis 1, we claimed that software that receives additional functionality via incremental feature updates will induce higher user CI compared to software that includes all these features right from the first release. The experiment's results indicate that on average,

participants' CI in group B (one update) was significantly higher than participants' CI in group A (no updates). Hence, hypothesis 1 is supported. Moreover, hypothesis 2 posits that if delivered too frequently, incremental feature updates do not increase CI any more but rather have an adverse effect on it. As hypothesized, our results show (see Table 2) that a high update frequency (i.e., in our case, three feature updates in the given timeframe; group C) is not perceived more positively than the no update condition (i.e. group A) in terms of CI. Hence, hypothesis 2 is supported. Furthermore in order to test our mediation hypotheses we ran a serial multiple mediator analysis (Hayes 2013) on a sub-sample that included only groups A and B (n=57) with SAT and PU as mediators, while controlling for all direct and indirect paths between the mediators and CI. The results from a bootstrapping analysis in Table 3-3 reveal that only the indirect effect path (3) from low-frequency feature updates via SAT to CI was significant. Moreover, the direct effect of feature updates on users' CI became insignificant after inclusion of SAT, suggesting full mediation (Hayes 2013). PU, on the contrary, was not influenced by our treatment (i.e., low-frequency feature updates, group B) and was therefore not capable to predict the influence of feature updates on CI. Hence, hypothesis 3 is supported.

Table 3-3: Results from Serial Multiple Mediation Analysis, Groups A and B (Bootstrapping Results\* for Indirect Paths).

<b>Indirect effect paths</b>	<b>Effect z</b>	<b>Boot SE</b>	<b>LLCI</b>	<b>ULCI</b>
(1) Feature Updates → PU → CI	0.015	0.060	-0.049	0.243
(2) Feature Updates → PU → SAT → CI	0.045	0.069	-0.067	0.218
<b>(3) Feature Updates → SAT → CI</b>	<b>0.157</b>	<b>0.120</b>	<b>0.039</b>	<b>0.492</b>
Note: *We conducted inferential tests for the indirect effect paths based on 1.000 bootstrap samples generating 95% bias-corrected bootstrap confidence intervals (LLCI=Lower Limit/ULCI=Upper Limit of Confidence Interval), n=57.				

### 3.6 Discussion

This study sought to achieve three main objectives: (1) to examine the effects of feature updates on users' intentions to continue using an information system (i.e., whether there is a discernible effect from updates), (2) to investigate crucial boundary conditions (i.e., when there is an effect from updates and when not), and (3) to unravel the explanatory mechanism through which such an effect occurs (i.e., how such an effect from updates operates). To achieve these objectives, we drew on the IS continuance model that is embedded in the expectation-confirmation theory and investigated our hypotheses based on a controlled lab experiment.

Drawing on the advantages of the experimental method, which allows to isolate the effects of manipulated stimuli on user responses from other confounding variables and thus to unveil causal relationships, we found that continuance intention was significantly higher in the update condition (group B) than in the non-update condition (group A). This increase in CI in group B compared to group A can be interpreted as being a somewhat counter-intuitive finding because participants who received feature updates (group B) were objectively disadvantaged compared to the participants who had all functionalities right with the first release (group A): during the limited 20 minutes of the experiment, group B had in sum fewer features per time to accomplish their text-formatting task compared to group A. Despite this objective disadvantage, participants in group B showed significantly higher scores in CI which indicates the presence of a positive, somewhat non-rational effect (Fleischmann et al. 2014) of feature updates on users' CI—a finding that challenges the idea of a 'rational user' in the IS continuance literature (Ortiz de Guinea and Markus 2009; Bhattacharjee and Barfar 2011; Ortiz de Guinea and Webster 2013). Furthermore, our experiment identifies a crucial boundary condition to the positive effect of feature updates on users' CI: update frequency. In this regard, our results indicate that there is a tipping point for the optimal number of updates in a given time frame. Specifically, a too frequent delivery of feature updates seems to annihilate the mechanism of positive disconfirmation by turning updates into expected events that no longer surprise users. Finally, we could demonstrate that the positive effect of feature updates on CI was fully mediated by user's SAT, emphasizing the role of affect in continuance decisions. The results regarding PU in group B, however, might seem counter-intuitive at first: Despite the fact that our experimental treatment was a manipulation of the core functionality of the software, we could not observe any significant differences in PU between the treatments. However, a closer analysis reveals that this finding is comprehensible and in line with hypothesis 3. Because participants were asked to state their PU *after* they had completed the experimental task, their evaluation of PU was based on the same set of features, i.e. at this point of time, groups A, B and C had all four and thus the same set of features at their disposal.

### 3.6.1 Implications for Research

The paper makes three main contributions to the literature. First, our main contribution lies in the detection of a positive user reaction to feature updates. Specifically, delivering incremental feature updates in a given timeframe has a stronger and more positive impact on IS users' continuance intentions compared to situations in which the entire feature set is

provided at once and right away with the first release. In addition, our findings imply that update frequency is a crucial boundary condition for the identified positive effect of feature updates such that above and beyond a specific tipping point of update frequency, users' CI decreases to a point where they no longer perceive a relative advantage of feature updates compared to non-update versions of the software. Our second main contribution lies in shedding light on the explanatory mechanism behind the identified effect of feature updates on CI. Specifically, we find out that this positive effect primarily works via the affective component (SAT) rather than the cognitive component (PU) of the continuance model. This finding once again emphasizes the still underestimated role of affect in both the IS continuance and IT management literature. Nevertheless, we show that the identified positive effect of feature updates still depends on the presence of PU, so that PU can be seen as necessary and SAT as sufficient condition for its occurrence. Our third contribution consists in the extension of the predominant view of information systems in post-adoption literature from a mostly monolithic and static one to a finer-grained and more dynamic perspective by showing how an alterable and malleable information system might influence users' attitudes and behaviors over time. In doing so, we answer several calls of IS scholars (e.g., Jasperson 2005; Benbasat and Barki 2007 etc.) to consider the granularity of information systems in research studies and how IS evolve over time. As such our study offers a novel complement to the existing IS post-adoption literature by showing that user attitudes and behaviors change over time, as the IT artifact's nature and composition evolves over time through feature updates.

### **3.6.2 Implications for Practice**

Our results also have important implications for practice. First, despite the extensive use of feature updates by vendors to maintain, alter and extend their products after they have already been rolled out, it is surprising to find that insights on how these updates are perceived and evaluated by users are still scarce. This apparently leaves practitioners puzzled and without guidance. From the results of our experimental study we can conclude that it might be advisable for vendors to distribute software functionality over time via updates, because feature updates can induce a positive affective state of surprise, which, in turn, increases users' CI. For vendors, users with a high CI are a particularly desirable goal because these are the loyal, returning customers who ensure the long term profitability of their businesses in the highly competitive software industry. Moreover, a high CI is particularly important for the increasing share of subscription-based business models in the software industry (Veit et al.,

2014). However, while the identified positive effect of feature updates seems to be a useful measure for software vendors to keep their customers satisfied and 'on board', it also needs to be well understood and correctly applied in order to achieve the desired outcomes. The findings of this study reveal that this effect works only if users are really surprised when receiving an update (positive disconfirmation). Too frequently delivered updates seem to cancel out this positive effect, because they are no longer unexpected. Consequently, software vendors can learn from this study's results that there is an optimum corridor for the number of updates delivered in a given time frame that increases users' continuance intentions. They should therefore test where this optimal corridor for their specific software lies so that updates can be performed repeatedly, while still being perceived as surprising. It should also be noted that vendors should not overdraw holding back functionality. Starting out with a too small feature set might render the first release of a software almost useless and lead to discontinuation before the program can be updated or even prohibit the adoption in the first place. Finally, for vendors, our findings highlight an additional benefit from using a modular architecture for their software. Aside from flexibility in the development and maintenance, a modular architecture also facilitates benefiting from the positive effect of feature updates on customer loyalty, because features that are encapsulated in discrete modules are technically easier to segregate from the software. Moreover, such modules may be delivered in small packages (updates) and can be integrated easily in existing systems that are already being used.

### **3.6.3 Limitations and Future Research**

Four limitations of this study are noteworthy and provide avenues for future research. First, in our experiment, we utilized a self-developed, simplified word-processing program with homogeneous and functionally equivalent features to reduce confounding effects and isolate the impact of updates. Nevertheless, to better resemble real-world update practices of software vendors, future studies could investigate more complex programs and deliver more innovative features instead of the basic and well known features that we used. Second, we identified update frequency as a crucial boundary condition to the positive effect of feature updates on users' CI. Future studies are encouraged to specify further possible boundary conditions. For example, they could distinguish between different types of feature updates (e.g. common and extraordinary features), different types of update notifications (e.g. no, unobtrusive or obtrusive notifications), different initial feature endowment, or different competition situations (e.g. many or few competing vendors). Third, the positive effect of

feature updates on users' CI was shown to work for productivity software (word-processing). Future research is encouraged to show whether the same effect occurs also for hedonic (e.g. entertainment) software. Because this positive effect of feature updates occurred in software with a low affective quality (word-processing), we are confident that it might have an even stronger impact on CI for entertainment software, which is more emotionally charged. Finally, we conducted a controlled laboratory experiment with the purpose to make a first step towards exploring the causal effect of feature updates on IS continuance, presenting results with a high internal validity. This, however, came at the price of some reasonable but strict assumptions, such as the evaluation of the program taking place at the same time for all users and only after all users had access to the same set of features. Future studies are encouraged to complement the findings of this study by conducting longitudinal field experiments or case studies, in order to advance the external validity of our findings. Also laboratory experiments conducted on longer time spans (e.g. over some weeks) with users' evaluations measured at several points in time could provide additional evidence for the robustness of the positive effect of feature updates on users' CI.

### **3.6.4 Conclusion**

Feature updates have become a pervasively used instrument of software vendors to maintain, alter and extend their products over time. Despite their prevalence in private and business IT usage contexts, however, feature updates' effects on crucial user reactions in the IS post-adoption context have remained largely unexplored. This study is not only the first to demonstrate that feature updates have the potential to increase users' CI above and beyond a level generated by monolithic software packages that are delivered with the entire feature set at once; it also reveals update frequency as a crucial boundary condition to this phenomenon. Specifically, the identified positive effect on CI is weakened by an increasing update frequency. Furthermore, this study explains the underlying mechanism of why and how feature updates influence users' CI. In summary, it represents an important first step towards better understanding the nature of feature updates and how they affect user reactions over time, and may therefore serve as a springboard for future studies on feature updates in the context of IS post-adoption research.



## 4 Article 3: Software Updates and Update-Effect in IS Continuance

**Titel:** The Role of Software Updates in Information Systems Continuance – An Experimental Study from a User Perspective.(2016)

**Authors:** Fleischmann, Marvin, Ludwig-Maximilians-Universität München, München, Germany  
Amirpur, Miglena, Technische Universität Darmstadt, Darmstadt, Germany  
Grupp, Tillmann, Technische Universität Darmstadt, Darmstadt, Germany  
Benlian, Alexander, Technische Universität Darmstadt, Darmstadt, Germany  
Hess, Thomas, Ludwig-Maximilians-Universität München, München, Germany

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### Abstract

Although software updates are a ubiquitous phenomenon in professional and private IT usage, they have to date received little attention in the IS post-adoption literature. Drawing on expectation-confirmation theory and the IS continuance literature, we investigate whether, when and how software updates affect users' continuance intentions (CI). Based on a controlled laboratory experiment, we find a positive effect of feature updates on users' CI. According to this effect, software vendors can increase their users' CI by delivering features through updates after a software has been released and is already used by customers. We also find that users prefer frequent feature updates over less frequent update packages that bundle several features in one update. However, the positive effect from updates occurs only with functional feature updates and not with technical non-feature updates, disclosing update frequency and update type as crucial moderators to this effect. Furthermore, we unveil that this beneficial effect of feature updates operates through positive disconfirmation of expectations, resulting in increased perceived usefulness and satisfaction. Implications for research and practice as well as directions for future research are discussed.

**Keywords:** software updates, IT features, IS continuance, IS post-adoption, expectation-confirmation theory

## 4.1 Introduction

In recent years, software vendors have increasingly leveraged software updates as a measure to modify and enhance their software products, while they are already being used by their customers. This phenomenon is particularly prevalent in the area of mobile applications and operating systems, but updates have also been used long before in the desktop space. Apple iPhone users, for instance, regularly receive updates for their apps. On the desktop, web browsers such as Google Chrome and Mozilla Firefox continuously receive updates, which extend their functionalities. Other examples include Microsoft Windows, the Adobe Reader and Sun's Java platform which all regularly receive updates to close security gaps or fix minor flaws.

This ubiquitous use of updates by software vendors in practice reflects in a large body of research on the technical design of software, its maintenance and management. Research on software engineering (Sommerville 2010), including software product lines (Clements and Northrop 2002), software release planning (Svahnberg et al. 2010) and software evolution and maintenance (Mens and Demeyer 2008) explores how and when software functionality should be developed and delivered in order to maintain the technical integrity of the software and optimize the vendor's production process. While this stream of research does account for customer needs, its primary focus lies on the supply side, exploring technical design aspects of software. There is as yet, however, little understanding of the user's perspective on software updates—the demand side. In particular, the behavioral dimension, i.e., how updates are perceived by users is still an under-explored area that has so far received only minimal research attention (Hong et al. 2011; Sandberg and Alvesson 2011). Investigating the effect of software updates on users' beliefs, attitudes and behaviors regarding an information system (IS), however, might be beneficial for software vendors and of particular interest in the post-adoption context, because users' continuance decisions (i.e., customer loyalty) are strongly influenced by their experiences made during actual IS use (Bhattacharjee and Barfar 2011). For software vendors, shedding light on the role of software updates for the IS continuance decision can thus result in a better understanding of how to deliver updates to users in order to achieve desirable performance outcomes such as higher user loyalty and sustained revenue streams.

From a research perspective, a better understanding of software updates from a user's perspective has the potential to increase the explanatory and predictive power of existing post-adoption theory. In conjunction with pre-adoption and adoption, post-adoption research

constitutes IS usage, one of the most mature fields in IS (Jasperson et al. 2005). However, compared to research on pre-adoption and adoption decisions, post-adoption studies still remain sparse. Many scholars have thus called for studies that explicitly focus on post-adoptive phenomena (e.g., Benbasat and Barki 2007). Furthermore, researchers studying IS post-adoption phenomena often tend to conceptualize information systems as a monolithic and coarse-grained black box, rather than as collection of specific and finer-grained features that are dynamic and alterable over time. However, understanding the granularity of software and its changes through software updates would help explain how users' beliefs, attitudes, and behaviors fluctuate over time as a result of the dynamic nature of information systems. In addition, the focus on changes in beliefs, attitudes and behaviors, emanating from the IT artifact itself rather than from other IT-unrelated environmental stimuli, is a response to several calls for research from IS scholars who criticize the negligence of the IT artifact's role in IS research (Benbasat and Zmud 2003; Hevner et al. 2004; Orlikowski and Iacono 2001). From a theoretical perspective, it is not only important to explore *whether* software updates have an effect on users' beliefs, attitudes and behaviors towards the software and their continuance intentions (CI) in particular. It is equally important to examine *when* and *how* these effects might occur, thus providing a profound theoretical explanation as well as the possibility to predict user reactions towards software updates. Against this backdrop, our objective is to study software updates as a measure by which a vendor can provide maintenance for or extend the functionality of its software over time, while it is already being used by customers. To the best of our knowledge, software updates and their effects on users' IS continuance decisions are thus far still underexplored in the IS post-adoption context. We therefore seek to address this research gap by examining the questions of *whether, when and how software updates influence users' IS continuance intentions*.

In line with the mentioned research gaps, we contribute to prior research in three important ways. First, our overarching contribution is to advance the predominant view of information systems in post-adoption literature from a mostly monolithic and static to a finer-grained and more dynamic perspective by showing how a functionally malleable information system might influence users' beliefs, attitudes and behaviors over time. As such, we also accentuate the changing nature of the IT artifact for users' CI and thus explicitly consider the software product lifecycle in our theorizing. Second, we identify substantially different user reactions to different update types and modes of delivery. While feature updates increase users' continuance intentions, technical non-feature updates (e.g. bug fixes) have no effect on the intention to continue using the software. Moreover, we find that users prefer features to be

delivered in individual updates over a delivery of features in larger but less frequent update packages comprising several features. Update type and frequency thus seem to moderate the effect of software updates on users' continuance intentions. Third, we not only investigate the direct effect of software updates on CI; we also open up the theoretical black box of *how* software updates influence IS continuance intention by highlighting the complementary roles of cognition and affect. From a practitioner's perspective, our study offers implications for software vendors on how to deliver software updates in order to increase their customers' loyalty (i.e., CI). We not only provide guidelines on which actions to take, but also on which measures to avoid in order to benefit from the positive effect of feature updates on users' CI.

## 4.2 Theoretical Foundations

### 4.2.1 Software Updates

Consistent with previous research (e.g., Dunn 2004), we consider software updates to be self-contained modules of software that are provided to the user for free in order to modify or extend software after it has been rolled out and is already in use. Software updates are thus not discrete and stand-alone programs but rather integrate into the base software once they are applied to it. In practice, software updates are applied to different types of software, such as system software (e.g., operating systems, drivers) or application software (e.g., office suites) and on different platforms (e.g., desktop computers, mobile devices). With varying terminology (e.g. update, upgrade, patch, bug fix, or hotfix), the concept of software updates is repeatedly addressed throughout the software engineering literature (Sommerville 2010), such as software release planning, software maintenance and evolution and software product lines (Svahnberg et al. 2010; Shirabad et al. 2001; Weyns et al. 2011).

In contrast to this rich stream of technical literature dealing with software updates from the developers' perspective, the customer perspective has received less attention (Morgan and Ngwenyama 2015). Specifically users' perceptions of updates have so far been explored only sparsely. This reflects in few IS studies dealing with updates. Hong et al. (2011), for example, explore user's acceptance of information systems that change through the addition of new functionality. Benlian (2015), on the other hand, explores different IT feature repertoires and their impact on users' task performance, but does not consider changes in functionality through updates. Other IS studies that found updates to influence usage behaviors, have often pushed them to the sidelines, treating them as control variables for investigating other phenomena (e.g., Claussen et al. 2013). Existing IS research has, however, not explored the

specific impact of updates on users' beliefs and attitudes regarding an IS. Specifically, the impact of different modes of delivery (e.g., frequency of updates) and different update types have so far not been explored.

Concerning the present study, we distinguish between two basic types of software updates: feature updates and non-feature updates (e.g., Microsoft 2015). Feature updates change the core functionality of software to which they are applied. Functionality can be added to or removed from the original version of the software and refers to distinct, discernible features which are deliberately employed by the user in accomplishing the task for which he uses the software. The Facebook app for smartphones and tablet computers provides an example for this type of update. In a 2013 update, it received a comprehensive instant messaging feature (Etherington 2013). An example from the desktop space example is the 'tab sync' functionality, which was added to the browser Google Chrome in 2012 via a feature update. It enabled users to synchronize websites (tabs) across different computers and mobile devices to seamlessly continue browsing when switching devices (Mathias 2012). In contrast to feature updates, technical non-feature updates do not change the core functionality of software but only correct flaws (e.g., bug fixes) or change software properties that are not directly related to its core functionality (e.g., improvements in stability, security or performance) (Popović et al. 2001). Thus non-feature updates usually do not directly affect the user's interaction with the software and therefore the changes in the software are often not even evident to the user. Moreover, non-feature updates often fix problems that concern only a small number of users, use cases or setups but have no consequence for the majority of users. Examples for this type of update are the 'hot fixes' that Microsoft regularly distributes via its Windows Update service.

#### **4.2.2 Information Systems Continuance**

Together with research on users' pre-adoption activities and the adoption decision, post-adoption research constitutes the research field IS usage—one of the most mature fields in IS (Jaspersen et al. 2005). Post-adoption research explores users' beliefs, attitudes, and behaviors around the continued use of an IS (Karahanna et al. 1999; Bhattacharjee 2001). In this regard, the term information systems continuance refers to "*sustained use of an IT by individual users over the long-term after their initial acceptance*" (Bhattacharjee and Barfar 2011, p. 2). To explore users' intentions to continue or discontinue using an IS, Bhattacharjee (2001) adopts expectation-confirmation theory (ECT) (Locke 1976, Oliver 1980, 1993, Anderson and Sullivan 1993). In Bhattacharjee's (2001) model, a user's intention to continue using an IS

(CI) is the core dependent variable. It is positively influenced by satisfaction (SAT) and perceived usefulness (PU). PU captures the expectations about future benefits from IS usage (Bhattacharjee and Barfar 2011) and has a positive impact on SAT and CI (Bhattacharjee 2001). While SAT represents the affective part of the continuance model, PU rather represents the cognitive one. The concept of PU has been carried over from adoption theory (Davis et al. 1989). Perceived ease of use (PEoU), which is the second main driver of technology adoption is, however, not part of the IS continuance model. While ease of use is an important determinant of individual technology adoption decisions (i.e., at earlier stages of use), research has found ambiguous results regarding its effect on continuance decisions (Davis et al. 1989; Bhattacharjee 2001; Hong et al. 2006). Studies even suggest that its influence on usage decisions disappears in later stages of use, once users gain experience with the information system (Karahanna et al. 1999).

The IS continuance model moreover suggests that users compare their pre-usage expectations of an IS with their perception of the performance of this IS during actual usage (Bhattacharjee 2001). If perceived performance exceeds their initial expectations, users experience positive disconfirmation which increases their PU and SAT. If perceived performance falls short of the initial expectations, negative disconfirmation occurs and users' PU and SAT are reduced (Bhattacharjee and Barfar 2011). The concept of positive (negative) disconfirmation thus has two prerequisites—unexpectedness and a positive (negative) experience (Oliver 1980; Bhattacharjee 2001). ECT moreover posits expectations as a relative, subjective reference point or baseline (i.e., not an absolute, objective value) upon which the user makes his comparative judgment (Helson 1964; Oliver 1980).

In its original form, the IS continuance model (Bhattacharjee 2001) has a static perspective on the IS continuance setting, failing to account for a change in user beliefs and attitudes over time. In response to this limitation, Bhattacharjee and Premkumar (2004) introduced a more dynamic perspective, showing that beliefs and attitudes do not only change from pre usage to actual usage but also during the ongoing usage of an IS (Kim and Malhotra 2005). While this dynamic perspective already provides valuable insights into the drivers of post-adoption behavior, it still neglects the IT artifact's changing and malleable nature. Evidence from practice shows, however, that information systems are constantly modified over time, for example, when vendors update and change their software or introduce new software generations. Considering the fact that beliefs and attitudes change over time during the ongoing use as a result of users' experience with the IT (Bhattacharjee and Premkumar 2004),

it is reasonable to assume that a change in the IT artifact may also induce a change in users' beliefs and attitudes toward it. Kim and Malhotra (2005), Kim (2009), Ortiz de Guinea and Markus (2009) and Ortiz de Guinea and Webster (2013), for instance, have provided strong evidence that external factors such as IS-related tasks as well as the IS itself can shape users' beliefs, attitudes and even their affect regarding the IT in later usage stages. In order to investigate the changing nature of the IT artifact and its effect on users' beliefs, attitudes and behaviors during post-adoption use, we explore software updates through the lens of the disconfirmation mechanism in ECT.

### **4.3 Hypotheses Development**

In this section, we develop our hypotheses about how and under which conditions updates can influence users' beliefs and attitudes in post-adoption software usage. Specifically, we explore decisions on continued use or discontinuance in settings where use is not mandated, such as consumer software. To this end, we focus on software updates which are recognized by the user during usage through explicit notification and ignore software updates that are implemented 'behind the scenes'. Within this scope, we further distinguish between two different types of software updates (feature updates and non-feature updates) and two modes of delivery (low and high frequency).

#### **4.3.1 The Effect of Feature Updates on Users' Continuance Intentions**

Research on information system characteristics in post-adoption user behavior has repeatedly identified system design features to affect users' beliefs and attitudes regarding an information system (Saeed and Abdinnour-Helm 2008; Nicolaou and McKnight 2011). We thus argue that a change in information systems characteristics has the potential to also affect a user's beliefs and attitudes regarding this information system. Specifically, we suggest that receiving a free feature update that provides additional functionality which directly serves users in accomplishing their IS-based tasks will be perceived as a positive experience with the software (Goodhue and Thompson 1995; Larsen et al. 2009).

Furthermore, it is reasonable to assume that feature updates are usually not anticipated by users and can thus be perceived as unexpected experiences with the software. Even if a software vendor does provide release plans about future feature updates, we suggest that in practice, most users—and especially consumers—are unlikely to follow such update plans in detail for each and every individual software product they have in use. If feature updates are perceived as unexpected and positive experiences during usage, according to ECT, they

should induce perceived positive disconfirmation (Oliver 1980). Drawing on ECT and the IS continuance model (Bhattacharjee 2001), it is thus plausible that this perceived positive disconfirmation will increase users' CI regarding the updated software.

Regarding our assumptions about feature updates, we acknowledge that in practice, there might be cases, where feature updates are perceived negatively by users. For example, if features are intentionally removed (e.g. because of expired licensing deals), software functionality is unintentionally impaired or updates bring major changes to the software which necessitate users to learn and adjust. Nevertheless, we argue that in most cases, feature updates are intended to enhance the software, help users and are thus perceived positively.

We also acknowledge that receiving feature updates might lead to interruptions in the workflow through notifications or required installations. While previous research on IT events in post-adoption use (Tyre and Orlikowski 1994; Ortiz de Guinea and Webster 2013) and interruptions in human computer interaction (Hodgetts and Jones 2007; Sykes 2011) has found negative impacts from update notifications on users' workflow and their beliefs and attitudes towards the updated system, we suggest that vendors are aware of this and deliberately try to minimize these inconveniences. Moreover, even if updates result in undesired interruptions of workflow, these are one-time events that should be outweighed by the benefits of receiving new, helpful features and their repeated use and contribution to task accomplishment. We thus derive our first hypothesis:

*H1a: Receiving functionality through feature updates after the first release of a software increases users' continuance intentions.*

### **4.3.2 The Role of Frequency in the Delivery of Feature Updates**

New features are often the result of subsequent, incremental software development. When vendors want to deliver new features to their users through updates, they can often choose between different delivery-strategies. A vendor may deliver each individual feature in a separate update, once the feature is developed. Another option is to accumulate a certain number of features and deliver them bundled together in a larger update-package. (Under the latter strategy, the user is assumed to be unaware when individual features are developed and that they might be held back some time until delivery.) Over the course of time, the former option would result in a high update frequency, while the latter results in a low update frequency. Nonetheless, under both strategies, the same amount of features is delivered to users.



While both feature delivery strategies ultimately lead to the same feature endowment for the user, theory implies that these strategies might be perceived differently by the users. More specifically, ECT implies that the positive disconfirmation from a feature update depends on a relative change in functionality compared to a user's subjective reference point (i.e., the pre-update configuration of the software) rather than an absolute change (Helson 1964; Oliver 1980).

Once features are subsequently delivered through updates, each update is likely to elicit positive disconfirmation. Following Adaptation Level Theory (Helson 1964) and ECT (Oliver 1980) which build the basis for the IS continuance model (Bhattacharjee 2001), this high-frequency feature delivery strategy could then lead to a higher level of CI than the low frequency delivery strategy which provides users with the same type and amount of features but bundled in larger update packages. Moreover, if features are delivered through individual updates, they may 'stick out' more than if they are one among many, bundled in a larger update package. The positive contribution of an individual feature may thus be highlighted more and increase CI even further.

A drawback of the high-frequency delivery strategy is that it is accompanied by more frequent interruptions in the workflow by the previously outlined update notifications and installations, for example. However, we suggest, that in practice, the benefits from receiving features outweigh the drawbacks from the interrupted workflow even under the high-frequency delivery strategy where features are delivered individually, accompanied by notifications and other associated drawbacks.<sup>10</sup>

To summarize, because of the nature of the disconfirmation mechanism in ECT, which operates through an evaluation of relative instead of absolute change, users of software that receive functionality via incremental feature updates under a high-frequency update delivery strategy will likely have a higher intention to continue using this software than under a low-frequency delivery strategy even though users receive the same set of features under both strategies.<sup>11</sup> We thus hypothesize:

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<sup>10</sup> We acknowledge that once frequency increases to a certain point, updates may no longer be perceived beneficial. In this extreme case, a decreasing marginal utility from additional features (Nowlis and Simonson 1996) in combination with overly frequent workflow interruptions from notifications and installations, may outweigh the benefits from the feature updates and no longer increase CI or even diminish it. However, the update frequencies which can usually be observed in practice should not reach this point.

<sup>11</sup> In our theorizing regarding hypothesis 1b and 2b, we assume software updates of one type to deliver common (non-)features with equivalence regarding their content across the hypothesized conditions. We make this assumption to properly reflect the practice (free updates do usually not deliver uniquely extraordinary content)

*H1b: Users have a higher continuance intention regarding software that receives features in individual updates compared to software that receives the same set of features in one update package.*

### **4.3.3 The Effect of Non-Feature Updates on Users' Continuance Intentions**

In addition to unexpectedness, the second key component that is required for the positive effect of software updates to occur is the positive experience from an increase in functionality of the software. While non-feature updates are also unexpected events during usage (see hypothesis 1a), they lack the added functionality of their feature update counterparts and are thus unlikely to exert similar positive effects on CI. While such non-feature updates technically alter the software through bug fixes or security improvements, these changes do not directly serve users in accomplishing their IS-based tasks by offering useful functionality. In terms of ECT, this means that non-feature updates do not lead to the necessary perceived relative change in functionality compared to the reference point (i.e., the pre-update configuration of the software) (Helson 1964; Oliver 1980). In sum, we argue that software that receives non-feature updates instead of feature updates will not exert positive disconfirmation. This will, in turn, result in a lower CI compared to the scenarios suggested in hypothesis 1a and 1b. Furthermore, non-feature updates do not only fail to deliver functionality that directly serves users in accomplishing their IS-based tasks. They may even be perceived as unsolicited interruptions in the workflow without being accompanied by any direct benefit for accomplishing the immediate IS-based task (i.e., without additional helpful functionality). This might even diminish CI. We thus hypothesize:

*H2a: Receiving software fixes through non-feature updates after the first release of a software does not increase users' continuance intentions.*

### **4.3.4 The Role of Frequency in the Delivery of Non-Feature Updates**

Following the logic as outlined above, non-feature updates should not increase CI, independent from their frequency of delivery. Moreover, non-feature updates which are delivered with high frequency may even diminish CI since they interrupt users' workflow even more frequently without any direct and immediate benefit. However, we argue that the delivery of updates has nowadays become mostly seamless, minimizing the interruptions in workflow and other downsides from applying updates. Therefore, we suggest that unless non-

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and because previous research has found that uncommon, unique product attributes may bias consumer decisions and thus interfere with our attempt to conceptually isolate the psychological mechanism through which software updates might influence users' continuance intentions (e.g. Dhar and Sherman 1996).

feature updates reach extreme levels of frequency, they will not affect users' CI. We thus hypothesize:

*H2b: Users have the same continuance intention regarding software that receives fixes in individual updates as regarding software that receives the same set of fixes in one update package.*

#### **4.3.5 The Mediating Roles of Disconfirmation, Perceived Usefulness and Satisfaction**

As outlined in the theoretical foundations, ECT (Oliver 1980) applied to the context of the IS continuance model (Bhattacharjee 2001) implies that unexpected feature updates should be perceived by users as helpful 'gifts' from the vendor that exceed their expectations regarding the software. Feature updates thus lead to positive disconfirmation (DISC). Due to their lack of directly helpful content, non-feature updates, however, fail to exceed the users' expectations. The mediating effect of DISC on CI from receiving updates during use is thus conditional to the type of the received update. The relationship between software updates, positive disconfirmation and continuance intentions is therefore one of a moderated mediation where DISC is only increased by updates that contain features (Hayes 2013). Furthermore, according to the IS continuance model, the conditionally increased DISC from feature updates subsequently leads to higher PU and SAT.

PU, which represents the cognitive component of the IS continuance model is a forward-looking construct and captures the future benefits from using the software (Bhattacharjee and Barfar 2011). Feature updates increase PU because they provide a relative improvement of the software by extending its functionality compared to the pre-update state. After the disconfirming feature update, the software thus becomes more useful to achieve present and future tasks. Consequently, this will increase users' intentions to continue using the updated software (CI).

Being a welcomed and surprising 'gift' from the vendor, the positive disconfirmation from feature updates will also reflect in the affective component of the IS continuance model. Users who receive a free update that improves the software with which they work will be more satisfied (SAT) than users who do not receive such a pleasant update (Bhattacharjee and Barfar 2011). These higher levels of satisfaction will also make it more likely that users will return to the updated software for future tasks (CI).

The previously discussed PEOU should, however, not be involved in this mediation mechanism. While additional features from updates extend the functionality of a software and thus increase its usefulness, added features do usually not change the user interface or the overall interaction with the program. They are thus not expected to affect the ease of use of the updated program (Karahanna et al. 1999). To summarize, software updates affect users' continuance intentions (CI) through a causal chain of effects that conditionally originates from the positive disconfirmation of unexpectedly receiving additional functionality during usage (DISC) and is subsequently mediated by perceived usefulness (PU) and satisfaction (SAT). We thus derive our moderated mediation-hypotheses:

**H3a:** *Software updates increase continuance intentions because they positively disconfirm users' expectations regarding the software only when they deliver additional functionality.*

**H3b:** *Positive disconfirmation from receiving additional features through updates leads to higher continuance intentions by increasing perceived usefulness and satisfaction.*

Our theorizing about the impact of software updates on users' continuance intentions is summarized by the moderated multiple-mediation model shown in figure 4-1.

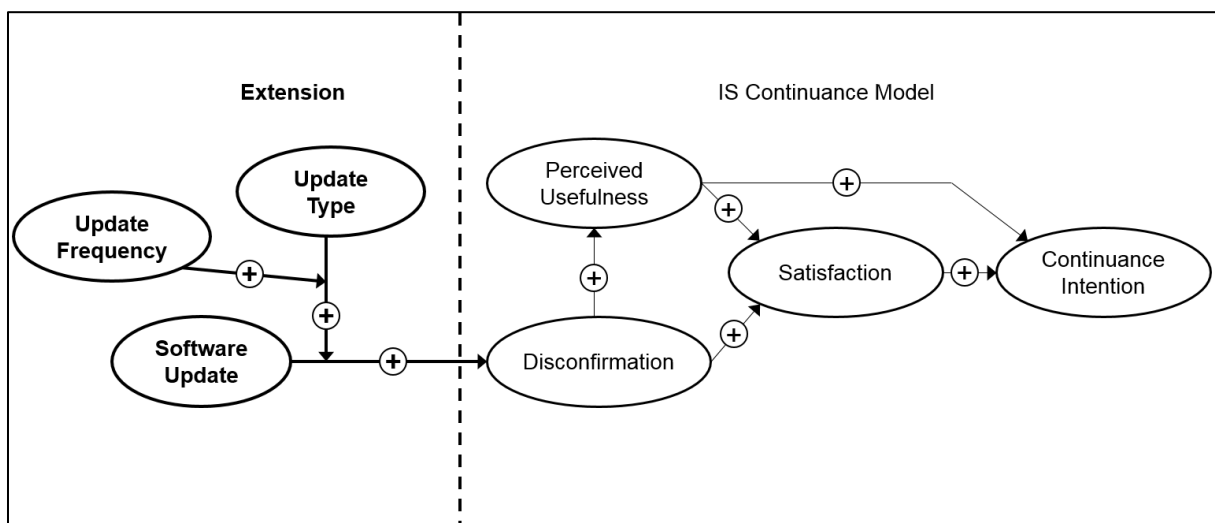


Figure 4-1: Research Model

## 4.4 Method

### 4.4.1 Experimental Design

With the goal to examine the effects of software updates on users' CI as suggested by our hypotheses, we opted for a laboratory experiment that allowed us to investigate and isolate the

causal mechanisms that operate between software updates and attitudinal user reactions. Even though this laboratory setting comes with the downsides of a simplified experimental task and a limited time span of observable usage, it also allows for an accurate identification of the hypothesized effects which we consider as crucial given that this study is the first to explore the effect of software updates on users' continuance intentions. A second reason for choosing an experiment was the indication from theory that, working through affect, the core mechanism behind our proposed effect of feature updates might be outside of their awareness, which made a cross-sectional survey with self-reported measures less suitable. Third, the experimental setting enabled us to account for the claims of numerous continuance researchers to put the IT artifact more at the center of investigation in post-adoption research by using an IS as basis for manipulations.

We thus conducted a posttest-only 2x2 full-factorial between-subjects laboratory experiment with manipulations of update type (feature update vs. non-feature update), update frequency (low frequency vs. high frequency) and a hanging control group (no update) (Malaga 2000; Irmak et al. 2005; Hoffmann and Broekhuizen 2009). 135 participants were recruited at a large public university in Germany to evaluate the impact of software updates on the user's DISC, PU, SAT and CI. The participants used a word-processing program ('eWrite') with a simplified user interface that was developed and tailored to the purposes of this experiment to complete a text formatting task. All experimental groups started with the same software configuration including one feature. The hanging control group (group A) did not receive any updates during the time of the experiment. The first treatment group (B) received three non-features in one update package in the same time span. The second treatment group (C) received three features in one update package. The third treatment group (D) received the same non-features as group B, only spread out over the experimental time span in three individual updates. Lastly, the fourth treatment group (E) received three features in three individual updates spread out over the experimental time span. Figure 4-2 illustrates the experimental implementation.

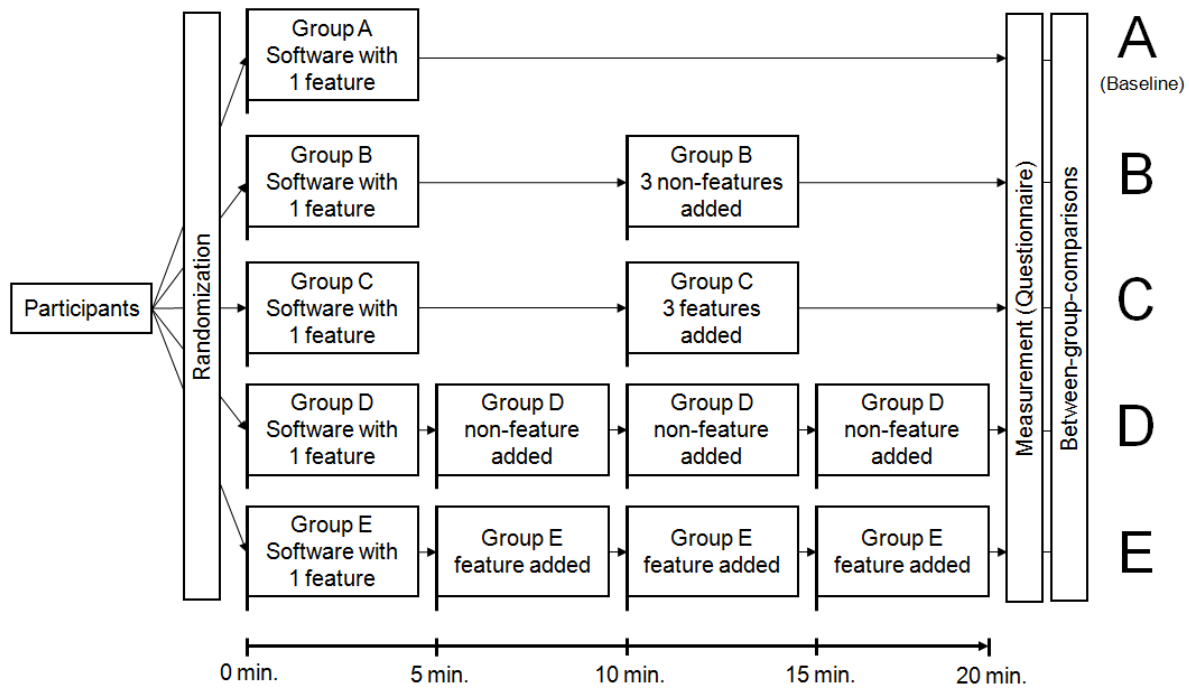


Figure 4-2: Experimental Setup, Groups, and Treatments.

#### 4.4.2 Manipulation of Independent Variables

In our experiment, we used a word-processing program for two reasons: Our first criterion was ensuring a basic familiarity with the program of choice for all participants. Because nowadays almost any young person, especially students, needs to work with word-processing programs, we considered this criterion to be met<sup>12</sup>. Second, to minimize unwanted variance in our response data, we were looking for software features that are preferably value-free, equivalent<sup>13</sup>, and independent (i.e., modular). We used a total of four text formatting features in our word-processing system context: 1) font size, 2) font style, 3) font, and 4) text alignment, and three non-feature updates: 1) improvement of program stability, 2) elimination of a security gap in the program, and 3) improvement of program speed. By adding new text-formatting functionalities the feature updates were directly related to the experimental task. In contrast, the non-feature updates were not related to the task. They did not change the program at all but only consisted of a notification explaining their alleged content. This implementation was chosen to properly resemble the experience that many users have in practice when receiving non-feature updates (section 2.1). The available time for task

<sup>12</sup> Section 4.4 shows, that this assumption is clearly met in our sample, as the vast majority of our participants indicated a regular use of word-processing programs and reported high levels competence in the use of word-processing programs.

<sup>13</sup> The scope and importance of the four text formatting functionalities in groups A, C and E for completing the experimental task were held constant in order to avoid potential confounding effects emerging from the nature of the updates' contents. The functional equivalence of the individual feature updates for the text formatting task had been validated in a pre-test study with 52 subjects that were recruited using WorkHub, a crowdsourcing platform similar to Amazon Mechanical Turk (Paolacci et al. 2010). The subjects participated online for a small payment. No significant differences emerged among the four text-formatting features (all  $t < 1$ ).

completion was 20 minutes. In condition B, participants simultaneously received the three non-features in one update ten minutes after having started to work on the task. In condition C, participants simultaneously received features 2, 3, and 4 after ten minutes. In the condition D, participants received the first non-feature update after five minutes, the second non-feature update after ten minutes and the third non-feature update after fifteen minutes. In the condition E, participants received the first feature update (with feature 2) after five minutes, the second feature update (with feature 3) after ten minutes and the third feature update (with feature 4) after fifteen minutes. Participants in each group were informed about updates via a pop-up notification window at the center of the screen. It contained a brief explanation of the update's content and required them to confirm the update by clicking an 'Ok' button before they could proceed with their experimental task. After confirming the notification, participants in the feature-update conditions (C and E) could immediately use the new features. The notification had been included in order to ensure awareness of the software update. Figure 4-3 provides examples of the user interface.



Figure 4-3: Sample Screenshots of Text Editor.

The simplifications in functionality and user interface of our experimental software were made on purpose and followed similar IS studies (e.g., Murray and Häubl 2011). This simplified setting enabled us to establish a controlled environment and unmistakably ascribe any observed changes in the dependent variables (DISC, PU, SAT, CI) directly to our experimental treatments. Nonetheless, such simplifications might also have some downsides. In our case, the participants' evaluations of the experimental word-processing program might have been diminished by associations with widely known, real programs such as Microsoft Word, which are much more refined and feature-rich. In order to mitigate this unwanted effect, we confronted the participants with a hypothetical scenario. Participants were asked to imagine that they were in 1980 and only word-processing programs with similar, basic functionalities were available. To support participants' imagination of this hypothetical scenario, an image of an old computer was positioned below the instructions, since images attract attention and are remembered better than just text (Levin 1981)<sup>14</sup>.

The text which had to be formatted in the experimental task was a historical text about the Industrial Revolution. We consider this type of text, just like the program features, to be a 'neutral', objective one, compared for example to a newspaper article about a current event, which is often an emotive one. Furthermore, the text was long enough—as a pilot test showed—to keep the participants busy throughout the entire twenty minutes. Thus, we ensured that the participants could not complete their task too quickly and might have had to wait, which could have confounded our results. The participants were also instructed that they did not need to format the entire text, but to focus on the formatting *quality*, which in turn fostered the comprehensive use of *all* available program features.

A pilot test with 12 subjects was conducted to ensure that all of the treatments were manipulated according to the experimental design (Perdue et al. 1986). Specifically, subjects were asked about the functional equivalence of the individual updates, ease of use of the text-formatting editor and comprehensibility of instructions and items. Feedback and suggestions were obtained from participants after they had completed the pre-test experiment. The word-processing program and the questionnaire were accordingly revised for the main test.

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<sup>14</sup> As the experiment's results show (see 5.1), the application of this vignette-like scenario seems to have been successful because the majority of subjects reported that they were able to put themselves into this hypothetical setting.



### 4.4.3 Measures

#### 4.4.3.1 *Dependent Variables*

We used validated scales with minor wording changes for all constructs, capturing the core part of the IS continuance model (DISC, PU, SAT, CI) (Bhattacharjee 2001). Measures for CI and DISC were adapted from Bhattacharjee (2001). Measures for PU and SAT were based on Kim and Son (2009). The questionnaire items are provided in Appendix A. Because constructs were measured with multiple items, summated scales based on the average scores of the multi-items were used in group comparisons (Zhu et al. 2012). Unless stated otherwise, the questionnaire items were measured on 7-point-Likert-scales anchored at (1)=strongly disagree and (7)=strongly agree.

To better understand the nature of disconfirmation from receiving the software updates in the four experimental conditions, we additionally applied a qualitative approach. This was done, in order to understand not only if expectations regarding software updates were confirmed or disconfirmed, but also for what reason. We asked participants in group B, C, D and E to first describe (i.e., to typewrite) how they felt when they received updates and, second, what they thought at that moment. We consider this combination of quantitative and qualitative measurement in this initial experimental study important to get a more complete picture of how updates may influence users' DISC, PU, SAT and CI by using the advantages of both measurement types (Venkatesh et al. 2013).

#### 4.4.3.2 *Control Variables*

In our study, we included a set of control variables as well as the subjects' demographics as covariates to isolate the effects of the manipulated variables. Specifically, we controlled for the impact of *usage intensity of word-processing programs* in real life, *frequency of updates* in real life for productivity software/entertainment software and desktop computer/smartphone/tablet and *computer self-efficacy* (Marakas et al. 2007) on CI. We did this because previous research has repeatedly shown that past experiences and expertise with an information system can affect post-adoption beliefs, attitudes and behaviors (Venkatesh and Davis 2000; Jasperson et al. 2005; Kim and Malhotra 2005; Kim and Son 2009) and we wanted to avoid confounding effects to our results from this. We also controlled for PEOU. As outlined before, PEOU has been identified as major driver of usage intentions but should lose its impact in the later stages of usage which we investigate (post-adoption). Nonetheless we sought to ensure that none of our results were confounded by this variable. Furthermore, we examined participant's *motivation to process information* with one item (Suri and Monroe

2003), because this variable may also influence the response behavior of the participants and, thus, the validity of the results. After conducting the experimental task, participants were asked to what extent they had understood *the items' formulation* and to what extent they were *able to put themselves in the hypothetical situation described in the experimental task*. Finally, we included three control questions about the experimental treatments (Appendix B).

#### 4.4.4 Participants, Incentives and Procedures

135 participants were recruited from the campus of a large public university at Germany. Each subject received 5€ for participating in the lab experiment. In order to align their motivations to properly fulfil the experimental task, 3 x 50€ Amazon vouchers and an iPad Mini were announced as rewards for the four most appealingly edited texts. Three participants were excluded from the sample based on the control questions. We therefore used a sample of 132 subjects in the following analysis. Of the 132 subjects, 70 were females. The participants' age ranged from 19 to 56, with an average value of 23.47 ( $\sigma=4.20$ ). 125 participants were university students, five were employees and one was self-employed. One participant refused to state his occupation. The educational backgrounds of the participants were diverse, including physics, education, journalism, law, medical science, biology, engineering, sociology etc. 6.1% of the subjects ( $n=8$ ) use word-processing programs less than one hour per month, 31.8% from one up to five hours ( $n=42$ ), 40.9% between five and 30 hours ( $n=54$ ), and 20.5% more than 30 hours per month ( $n=27$ ). One participant refused to state his word-processing program usage.

When participants arrived at the laboratory, they were randomly assigned to a treatment/control group. All instructions were presented on the computer screen in order to reduce the interaction with the supervisor of the experiment. In order to ensure comparable initial conditions, participants were further presented with a program tutorial (a program screen similar to that of the actual experimental task). In this tutorial, the initially available features (depending on the experimental condition) were presented and each one was explained in a text bubble. Before they could proceed, all participants had to try out each available feature at least once by formatting a short sample text, ensuring that each participant had understood the program's functionality. On the next two screens, the actual experimental scenario and task, the time available to complete the task, and the results-based incentives were introduced. After having read these instructions, the participants could manually start the actual experimental task by clicking on a button. After having worked 20 minutes on the experimental task, participants had to complete a paper based questionnaire, which contained

the measurement of all dependent variables (quantitative and qualitative), all control variables such as motivation to process information and perceived ease of use, the control questions and demographic variables such as gender and age. Finally, they were compensated for their participation and debriefed.

## **4.5 Data Analysis and Results**

### **4.5.1 Control Variables and Manipulation Check**

Based on the results of a series of Fisher's exact tests, we could conclude that there was no significant difference across the four experimental conditions and the hanging control group in terms of gender ( $p>0.1$ ), age ( $p>0.1$ ), intensity of using word-processing programs ( $p>0.1$ ), as well as frequencies of the received updates (desktop/productive:  $p>0.1$ ; desktop/entertainment:  $p>0.1$ ; smartphone/productive:  $p>0.1$ ; smartphone/entertainment:  $p>0.1$ ; tablet/productive:  $p>0.1$ ; tablet/entertainment:  $p>0.1$ ). Furthermore, based on a series of ANOVA tests, we found no significant differences across the four experimental conditions and the control group regarding the task-relevant control variables perceived ease of use ( $F=1.395$ ,  $p>0.1$ ), motivation to process information ( $F=1.233$ ,  $p>0.1$ ) and items' formulations ( $F=0.783$ ,  $p>0.1$ ), the extent to which subjects were able to put themselves in the hypothetical situation described in the experimental task ( $F=0.382$ ,  $p>0.1$ ), understanding of the goals of the experiment ( $F=0.998$ ,  $p>0.1$ ) and liking of the utilized text ( $F=0.603$ ,  $p>0.1$ ). It is therefore reasonable to conclude that participants' demographics and task-relevant controls were homogeneous across the four conditions and the control group and thus did not confound the effects of our experimental manipulations.

To examine whether our experimental treatments worked as intended, a separate manipulation check study was performed with 27 other participants from the same population (Shu and Carlson 2014; Zhang et al. 2014). The subjects performed the identical experimental task as the participants of the main study, but answered questions regarding the manipulations instead of the questionnaire of the main study (Yin et al. 2014; Appendix C). Participants in the frequent update conditions indicated significantly higher levels of perceived frequency ( $M_{\text{high}}=5.272$ ) than in the low update frequency conditions ( $M_{\text{low}}=2.500$ ;  $F=16.204$ ,  $p<0.01$ ). Moreover, participants in the feature update conditions indicated significantly higher levels of perceived helpfulness for task completion ( $M_{\text{very}}=5.000$ ) than in the non-feature update condition ( $M_{\text{not}}=1.364$ ;  $F=44.693$ ,  $p<0.01$ ). Overall, the results from our manipulation checks suggest that our experimental treatments were successful.

Prior to testing the hypotheses, we also evaluated the control questions of the main study. As mentioned above, in three observations wrong conditions were stated. This led to the exclusion of those cases from the final sample (one subject had wrongly ticked all control questions, one subject had stated the wrong frequency of updates and one subject claimed to have received an update despite being in a group that did not receive any updates).

#### 4.5.2 Measurement Validation

Because we adopted established constructs for our measurement, confirmatory factor analysis (CFA) was conducted to test the instrument's convergent and discriminant validity for the dependent variables (Levine 2005). Table 4-1 reports the CFA results using SmartPLS, version 2.0 M3 (Chin et al. 2003; Ringle et al. 2005) for the core constructs.<sup>15</sup>

Table 4-1: Results of Confirmatory Factor Analysis for Core Variables.

<b>Variables</b>	<b>Number of Indicators</b>	<b>Range of Standardized Factor Loadings*</b>	<b>Cronbachs Alpha</b>	<b>Composite Reliability (<math>\rho_c</math>)</b>	<b>Average Variance Extracted (AVE)</b>
<b>Continuance Intention (CI)</b>	3	0.826 – 0.904	0.850	0.909	0.770
<b>Satisfaction (SAT)</b>	3	0.920 – 0.965	0.937	0.960	0.889
<b>Perceived Usefulness (PU)</b>	3	0.910 – 0.916	0.902	0.938	0.835
<b>Disconfirmation (DISC)</b>	3	0.837 – 0.887	0.823	0.894	0.738
<b>Perceived Ease of Use (PEOU)</b>	3	0.673 – 0.866	0.736	0.840	0.640

Note: \* All factor loadings are significant at least at the  $p < 0.01$  level

The constructs were assessed for reliability using Cronbach's alpha (Cronbach 1951). A value of at least 0.7 is suggested to indicate adequate reliability (Nunnally et al. 1994). The alphas for all constructs were well above 0.7. Moreover, the composite reliability of all constructs exceeded 0.7, which is considered the minimum threshold (Hair et al. 2011). Values for AVEs for each construct ranged from 0.738 to 0.889, exceeding the variance due to measurement error for that construct (that is, AVE exceeded 0.5). Thus, all of the constructs met the norms for convergent validity. In addition, for satisfactory discriminant validity, the square root of average variance extracted (AVE) from the construct should be greater than the variance shared between the construct and other constructs in the model (Fornell and Larcker 1981).

<sup>15</sup> For brevity, we omitted items and/or detailed scale characteristics for computer self-efficacy and other control variables. These scales also satisfied the criteria regarding Cronbach's Alpha, AVE and Cross Loadings. Items and respective scale specifications can be obtained from the authors upon request.

As seen from the factor correlation matrix in Table 4-2, all square roots of AVE exceeded inter-construct correlations, providing strong evidence of discriminant validity. Hence, the constructs in our study represent concepts that are both theoretically and empirically distinguishable.

Table 4-2: Means, Standard Deviations, and Correlation Matrix for Core Variables

Latent construct	M	SD	1	2	3	4	5
(1) Continuance Intention (CI)	5.690	1.448	<b>0.877</b>				
(2) Satisfaction (SAT)	4.112	1.829	0.499***	<b>0.888</b>			
(3) Perceived Usefulness (PU)	4.130	1.569	0.495***	0.741***	<b>0.835</b>		
(4) Disconfirmation (DISC)	3.822	1.450	0.471***	0.630***	0.673***	<b>0.859</b>	
(5) Perceived Ease of Use (PEoU)	5.631	1.364	0.327***	0.461***	0.617***	0.361***	<b>0.800</b>

Note: Bolded diagonal elements are the square root of AVE. These values should exceed inter-construct correlations (off-diagonal elements) for adequate discriminant validity; \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

### 4.5.3 Hypotheses Testing

In order to test our hypotheses, we conducted one-way ANOVAs with planned contrast analyses with IBM SPSS Statistics 23. Table 4-3 presents the mean values of the dependent variables for groups A, B, C, D and E.

Table 4-3: Mean Values for Dependent Variables

	No Update, One Feature (A), n=26 (Control)	One Non-Feature Update (B), n=26	One Feature Update (C), n=27	Three Non-feature Updates (D), n=26	Three Feature Updates (E), n=27
DISC	3.141	3.295	4.383	3.269	4.852
PU	3.603	3.731	4.321	3.795	5.062
SAT	3.718	2.923	4.716	3.500	5.506
CI	5.256	5.141	5.876	5.795	6.395

Table 4-4 presents the deviations of the mean values of these dependent variables from the hanging control group (A), which received no update during usage.

Table 4-4: Mean Differences from Baseline (No Updates, Control Group A) and Significance Levels

	<b>B-A</b>	<b>C-A</b>	<b>D-A</b>	<b>E-A</b>
<b>DISC</b>	0.154	<b>1.242***</b>	0.128	<b>1.711***</b>
<b>PU</b>	0.128	<b>0.719**</b>	0.192	<b>1.459***</b>
<b>SAT</b>	<b>-0.795*</b>	<b>0.998**</b>	-0.218	<b>1.788***</b>
<b>CI</b>	-0.115	<b>0.620*</b>	0.539	<b>1.139***</b>

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$  (one-sided); ANOVA-tests with planned contrast analyses

Table 4-5 provides the mean differences between feature and non-feature update treatment groups with low update frequency (C-B) and high update frequency (E-D).

Table 4-5: Direct Comparisons of Update Types

	<b>C-B</b>	<b>E-D</b>
<b>DISC</b>	<b>1.088***</b>	<b>1.583***</b>
<b>PU</b>	<b>0.590*</b>	<b>1.267***</b>
<b>SAT</b>	<b>1.793***</b>	<b>2.006***</b>
<b>CI</b>	<b>0.735**</b>	<b>0.600**</b>

Note for 6: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$  (one-sided); ANOVA-tests with planned contrast analyses

Correspondingly, Table 4-6 presents the mean differences between low-frequency updates and high-frequency updates for feature updates (E-C) and non-feature updates (D-B).

Table 4-6: Direct Comparisons of Update Frequencies

	<b>E-C</b>	<b>D-B</b>
<b>DISC</b>	<b>0.469*</b>	-0.026
<b>PU</b>	<b>0.741*</b>	0.064
<b>SAT</b>	<b>0.790**</b>	0.577
<b>CI</b>	<b>0.519*</b>	<b>0.654**</b>

Note for 6: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$  (one-sided); ANOVA-tests with planned contrast analyses

Because participants were randomly assigned to one of the experimental groups and everything except the treatment was held constant across the groups, any of the observed differences between the groups regarding the dependent variables can be ascribed to our update treatments. In hypothesis 1a, we claimed that software that receives additional functionality via feature updates will induce higher user CI compared to software that does not receive updates. The experiment's results indicate that on average, participants' CI in

groups C (one feature update) and E (three feature updates) was significantly higher than participants' CI in group A (no updates). This can be seen from Table 4 (C-A, E-A). This result is further supported by the significant differences between the different update types found from the comparisons between groups B and C (C-B) as well as D and E (E-D). Table 5 shows these. Hence, hypothesis 1a is supported.

Moreover, hypothesis 1b posits that users prefer a high-frequency delivery of feature updates over a low-frequency delivery. As hypothesized, our results in Table 6 (see E-C) show that a high update frequency (i.e., three individual feature updates in the given timeframe; group E) was perceived more positively than the low update frequency condition (i.e., group C with one update comprising three features) in terms of CI. Hence, hypothesis 1b is supported.

With hypothesis 2a, we addressed the impact of non-feature updates on CI, claiming that users in these conditions (groups B and D) would not have a significantly higher CI compared to users in the no update condition (group A). In support of hypothesis 2a, the experiment's results in Table 4 indicate that on average, participants' CI in groups B and D was not significantly different from group A (B-A, D-A).

Hypothesis 2b claims that there is no difference in the users' perception between low-frequency and high-frequency non-feature updates terms of CI. Contrary to hypothesis 2b, participants showed on average higher levels of CI in the high-frequency non-feature update condition, compared to the corresponding low-frequency non-feature update condition (Table 6, D-B). It should however be noted that this does not mean that high-frequency non-feature updates have an overall positive effect (see supported hypothesis 2a). Moreover, other mean differences in CI that were found significant (Tables 4-6) were accompanied by significant changes in DISC, PU and SAT. This is not the case here (Table 6, D-B).

In order to test our mediation hypotheses (hypothesis 3a and 3b) a serial multiple mediator analysis (Hayes 2013) was performed on a sub-sample that comprised groups A and E<sup>16</sup> (n=53). To analyze the mediating effects of DISC, PU and SAT, we used PROCESS, a regression-based approach developed by Hayes (2013). PROCESS uses bootstrapping procedures for estimating direct and indirect effects. Figure 4-4 and Table 4-7 provide an overview of the analyzed conceptual model with direct and indirect paths. As recommended by Hayes (2013), path coefficients are unstandardized because the independent variable (feature updates) is dichotomous. The results reveal that only the two indirect effect paths (1,

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<sup>16</sup> Group E was selected for analysis over group B because the condition (with three updates) better resembles a real world situation of repeatedly and frequently updated software.

4) from high-frequency feature updates via DISC to CI and via DISC, PU and SAT to CI were significant. Moreover, the direct effect of feature updates on users' CI became insignificant after inclusion of the complete path, suggesting at least partial mediation (Hayes 2013). Hence, hypothesis 3a is fully supported. The significant effects of PU and SAT moreover support hypothesis 3b. The existence of path 1 (i.e., the direct connection between DISC and CI) was, however, not predicted by theory.

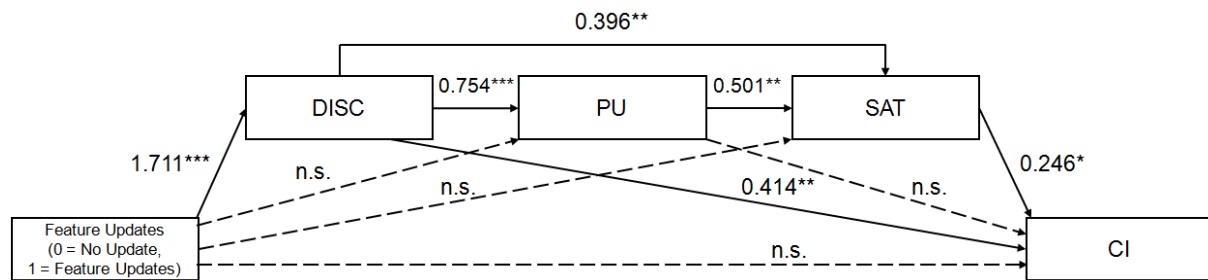


Figure 4-4: Mediation Analysis for Groups A and E

Note: Dashed lines indicate non-significant paths; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Table 4-7: Results from Serial Multiple Mediation Analysis, Groups A and E

Indirect effect paths	Effect z	Boot SE	LLCI	ULCI
(1) Feature Updates → DISC → CI	<b>0.709</b>	<b>0.444</b>	<b>0.053</b>	<b>1.885</b>
(2) Feature Updates → DISC → PU → CI	0.014	0.266	-0.451	0.657
(3) Feature Updates → DISC → SAT → CI	0.166	0.159	-0.012	0.660
<b>(4) Feature Updates → DISC → PU → SAT → CI</b>	<b>0.159</b>	<b>0.126</b>	<b>0.037</b>	<b>0.555</b>
(5) Feature Updates → PU → CI	0.002	0.074	-0.145	0.186
(6) Feature Updates → PU → SAT → CI	0.021	0.056	-0.053	0.217
(7) Feature Updates → SAT → CI	0.094	0.144	-0.076	0.564

Note: Bootstrapping results for indirect paths; We conducted inferential tests for the indirect effect paths based on 1.000 bootstrap samples generating 95% bias-corrected bootstrap confidence intervals (LLCI=Lower Limit/ULCI=Upper Limit of Confidence Interval),  $n=53$ .

Finally, and complementary to the quantitative data, results from the collected qualitative data revealed that participants in group B reported the following feelings: “I was confused and felt unsure. I did not know what to do”, “I was confused because the update did not bring evident changes”, while participants in group D reported the following: “[...] At first I was surprised and happy, but then every time I hoped for new features. That was very disappointing then”, “surprised, annoyed and disturbed”. In contrast participants in group C and E felt “pleasantly surprised”, “happy, that now more options are available to edit the text”, and also “confused, delighted, overstrained, satisfied”, as well as “surprised, because of



*unexpectedness*”. This difference in the perception of updates between the treatments is also reflected in what participants thought. While participants’ predominant statements in group B were mirrored by the following statements: “[...] *Bug fixing is mostly not evident to me as a user. Therefore the question of meaningfulness rises. Was the update necessary?*” and in group D by the following: “*They interrupted my work and only security issues were fixed. No new functionality was added*”. A different opinion tendency could be observed in group C and E: “*The use of new features provides better results, but requires somewhat more time*” and “*Now I can better structure the text, what will be the next update?*” These qualitative findings confirm and further illustrate the reported quantitative results regarding the positive effect of feature updates on DISC, PU and SAT and the disturbing effect of non-feature updates that fail to deliver useful functionality. Such updates seem to leave participants confused, particularly in low frequency settings. These participants’ statements can be considered as representative for groups B, C, D and E respectively, as our detailed analysis of all statements has revealed.

## 4.6 Discussion

This study sought to achieve three main objectives: (1) to examine the effects of software updates on users’ intentions to continue using an information system (i.e., *whether* there is a discernible effect from updates), (2) to investigate crucial moderators of this effect (i.e., *when* there is an effect from updates and when not), and (3) to unravel the explanatory mechanism through which such an effect occurs (i.e., *how* such an effect from updates operates). To achieve these objectives, we drew on the IS continuance model that is embedded in the expectation-confirmation theory and investigated our hypotheses based on a controlled lab experiment.

Drawing on the advantages of the experimental method, which allows to isolate the effects of manipulated stimuli on user responses from other confounding variables and thus to unveil causal relationships, we found that receiving software updates during usage can significantly alter users’ intentions to continue or discontinue using an IS—a finding that complements existing post-adoption research that has previously often assumed monolithic IS which remain static over time (Bhattacharjee and Premkumar 2004; Kim and Malhotra 2005). However, our analysis also revealed that not all software updates exert this effect. Only in the feature-update conditions (groups C and E) CI was significantly higher than in the non-update condition (control group A). Non-feature updates (groups B and D) could not increase users’ CI compared to the no-update condition (control group A). This significant increase in CI in

groups C and E also persisted when compared to the non-feature update conditions (groups B and D), identifying update type as a distinct and crucial moderator to the effect of software updates on CI.

Receiving a helpful feature through an update was viewed by participants in groups C and E as direct benefit, enabling them to better accomplish their text formatting task. This positive response persisted despite the drawbacks which were associated with the updates. Update notifications interrupted the participants in their workflow and since they received these additional features only during use (5, 10 or 15 minutes after they had started their text-formatting task), some of the formatting work which they had done prior to the update had to be redone to apply the new features. Since they were unrelated to the text-formatting task and did not have any direct or immediate relevance, non-feature updates were not viewed as beneficial by participants.

Furthermore, our experiment also found significant differences between the two feature-update conditions (groups C and E), identifying update frequency as second crucial moderator to the effect of software updates on users' CI. Participants in group E showed significant higher scores of CI compared to group C, despite the fact that both groups received the same type and amount of features through updates. This particular finding seems counter intuitive at first. Even though participants in group E received the first additional feature 5 minutes earlier than group C, they received their third additional feature 5 minutes later than group C, eradicating any advantage from earlier access to some functionality. Participants in group E were even interrupted in their workflow more often (three times, i.e. every 5 minutes) than group C (only once, i.e. after 10 minutes) and additionally had to repeatedly cope with changes in the text-editing software (three times, i.e. every 5 minutes).

In our further analysis of the participants' positive response to feature updates, we could demonstrate that this effect was mediated by user's DISC, PU and SAT. Groups C and E seemingly perceived the feature updates as unexpected, positive events during their usage, which exerted a positive disconfirmation of their initial expectations regarding the used text-editing software. These additional features subsequently also lead to a higher perceived usefulness. This in turn increased user satisfaction and ultimately concluded this causal chain of effects by leading to higher intentions to continue using the program for future text-formatting tasks. Considering the previously discussed roles of update type and update frequency, we thus identified a moderated mediation mechanism through which updates that deliver additional features increase users' continuance intentions. Our mediation analysis

confirms the explanatory power of Bhattacharjee's (2001) IS continuance model—even in complex post-adoption settings where users' beliefs and attitudes fluctuate over time alongside changes in the system characteristics of the employed IS.

#### **4.6.1 Implications for Research**

The paper makes three primary contributions to the literature. First, our overarching contribution lies in the extension of the predominant view of information systems in post-adoption literature from a mostly monolithic and static one to a finer-grained and more dynamic perspective by showing how an alterable and malleable information system might influence users' attitudes and behaviors over time. In doing so, we answer several calls of IS scholars (e.g., Jaspersen 2005; Benbasat and Barki 2007 etc.) to consider the granularity of information systems in research studies and how IS evolve over time. As such our study offers a novel complement to the existing IS post-adoption literature by showing that user attitudes and behaviors change, as the IT artifact's nature and composition evolves over time through software updates. Our second main contribution lies in the detection of a positive user reaction to software updates. Specifically, delivering software features to users through updates during usage can increase their intentions to continue using the information system. We investigate this effect in great detail by identifying update type and update frequency as crucial moderators. Regarding update type, our findings imply that only feature updates can exert this effect. Due to their insufficient level of usefulness for task completion, non-feature updates cannot induce a similar positive user response. Aside from update type, we found that update frequency is a crucial moderator to the identified positive effect of feature updates such that users prefer the frequent delivery of individual features over bundling them in larger update packages and delivering them less frequently. Our third contribution consists in shedding light on the explanatory mechanism behind the identified effect of software updates on CI. Specifically, we found that the positive effect of feature updates on CI involves both, the cognitive (PU) and the affective component (SAT) of the IS continuance model and originates from a positive disconfirmation of expectations (DISC). DISC, which starts this causal mediation chain, furthermore consists of two crucial components: unexpectedness and a positive experience. While unexpectedness is the necessary condition, its occurrence alone is not enough for DISC to occur (see non-feature update conditions, groups B and D). In order to initiate the mediation chain which leads to an increase in CI, software updates need to be perceived as helpful by the users (see feature update conditions, groups C and E). This makes

a positive experience the second crucial component of DISC and identifies it as the sufficient condition for initiating this mediation mechanism.

#### **4.6.2 Implications for Practice**

Our results also have important implications for practice. First, despite the extensive use of software updates by vendors to maintain, alter and extend their products after they have already been rolled out, it is surprising to find that insights on how these updates are perceived and evaluated by users are still scarce. This apparently leaves practitioners puzzled and without guidance. From the results of our experimental study we can conclude that it might be advisable for vendors to distribute software functionality over time via updates, because feature updates can induce a positive state of surprise, which, in turn, increases users' CI. For vendors, users with a high CI are a particularly desirable goal because these are the loyal, returning customers who ensure the long term profitability of their businesses in the highly competitive software industry. Moreover, a high CI is particularly important for the increasing share of subscription-based business models in the software industry (Veit et al., 2014). However, while the identified positive effect of feature updates seems to be a useful measure for software vendors to keep their customers satisfied and 'on board', it also needs to be well understood and correctly applied in order to achieve the desired outcomes. Software vendors should be aware of the fact that the discussed positive effect of updates can only be achieved with feature updates. Updates must deliver actual useful functionality for users. Non-feature updates may even have the potential to diminish CI, when they are perceived as unsolicited interruptions in the workflow. Vendors should therefore have a clear understanding which updates are perceived as really useful by users and which ones not. The findings of this study also reveal that vendors should spread the delivery of features over several individual updates instead of bundling them in one larger update package that delivers them all at once. Each individual update that delights users with new functionality can induce its own unexpected, positive experience. In sum, these individual experiences seem to supersede the impact of a larger update package containing the same set of features. Finally, for vendors, our findings highlight an additional benefit from using a modular architecture for their software. Aside from flexibility in the development, a modular architecture is beneficial, because features that are encapsulated in discrete modules are technically easier to deliver as updates and can be integrated easily in existing systems that are already being used.

### 4.6.3 Limitations and Future Research

Four limitations of this study are noteworthy and provide avenues for future research. First, in our experiment, we utilized a self-developed, simplified word-processing program with homogeneous and functionally equivalent features and a single measurement at the end of a predefined usage time in order to reduce confounding effects and isolate the impact of updates. Nevertheless, research settings with repeated updates and participants' evaluations measured at several points in time could help to understand the identified user reactions even better. Moreover, to increase generalizability and to better resemble real-world update practices of software vendors, future studies could investigate more complex word-processing programs and specify the identified moderators (e.g., tipping points in frequency) even more precisely. They could further distinguish between different types of feature updates (e.g., common features, extraordinary features), different types of update notifications (e.g., no notification, unobtrusive notifications, obtrusive notifications), different initial feature endowments, if information about updates already plays a role in the software selection decision (e.g., before usage vs. after usage) or what effect update packages consisting of features and non-features and the specific composition of such bundles could have. Second, to avoid that an existing positive effect of feature updates on CI might remain undiscovered due to our experimental program's simplified feature set, we put participants in the hypothetical situation of a market where feature-rich and refined programs such as Microsoft Word or Open Office were not available. Although our subjects could reportedly put themselves well into this scenario, future research should replicate our findings by using a research design without a hypothetical scenario.<sup>17</sup> Third, the positive effect of feature updates on users' CI was shown to work for productivity software (word-processing). Future research is encouraged to show whether the same effect occurs also for hedonic (e.g., entertainment) software. Because this positive effect of feature updates occurred in software with a low affective quality (word-processing), we are confident that it might have an even stronger impact on CI for entertainment software, which is per se more emotionally charged. Finally, we conducted a controlled laboratory experiment with the purpose to make a first step towards exploring the causal effect of software updates for information systems continuance, thus presenting results with a high internal validity. Future studies are encouraged to

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<sup>17</sup> It should, however, also be noted that in the case of this study, these simplifications with regard to task and time are not necessarily a disadvantage for the generalizability of its results: As participants showed the hypothesized positive responses to updates even in our artificial setting, they might be even more likely to show these responses in a real world usage scenario.

complement the initial findings of this study by conducting longitudinal field experiments or case studies, in order to advance the external validity of our findings.

#### **4.6.4 Conclusion**

Software updates have become a pervasively used instrument of vendors to maintain, alter and extend their products over time. However, despite their prevalence in private and business IT usage contexts, software updates' effects on user reactions in the IS post-adoption context have remained largely unexplored. This study is not only the first to demonstrate that software updates have the potential to increase users' CI; it also reveals update type and update frequency as crucial moderators. Specifically, the identified positive effect on CI can be elicited only by functional feature updates and users prefer a high update frequency. Furthermore, this study explains the underlying mechanism of why and how software updates influence users' CI. In summary, it represents an important first step towards better understanding how software updates affect user reactions over time and may therefore serve as a springboard for future studies on software updates in the context of IS post-adoption research.

## 5 Article 4: Purchase Pressure Cues and E-Commerce Decisions

**Title:** Buying under Pressure: Purchase Pressure Cues and their Effects on Online Buying Decisions (2015).

**Authors:** Amirpur, Miglena, Technische Universität Darmstadt, Darmstadt, Germany  
Benlian, Alexander, Technische Universität Darmstadt, Darmstadt, Germany

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### Abstract

Although purchase pressure cues (PPC) that signal limited time (LT) or limited product availability (LPA) are widely used features on e-commerce websites to boost sales, research on whether and why PPCs affect consumers' purchase choice in online settings has remained largely unexplored. Drawing on the Stimulus-Organism-Response (S-O-R) model, consumer decision-making literature, and prospect theory, we conducted a controlled lab experiment with 121 subjects in the context of Deal-of-the-Day (DoD) platforms. We demonstrate that while LT pressure cues significantly increase deal choice, LPA pressure cues have no distinct influence on it. Furthermore, our results show that perceived stress and perceived product value serve as two serial mediators explaining the theoretical mechanism of why LT pressure cues affect deal choice. Complementary to these results, we provide evidence that higher perceived stress is accompanied by significant changes in consumers' physiological arousal. Further theoretical and practical implications of our findings are discussed.

**Keywords:** Purchase pressure cues, limited time, limited product availability, deal choice, e-commerce, physiological stress, lab experiment

## 5.1 Introduction

E-commerce websites become an increasingly important channel for commercial transactions (Mukherjee et al. 2012). More than 45% of Internet users in the United States and Europe already purchase goods online (Kollmann et al. 2012; Poncin et al. 2013) and global sales via B2C e-commerce channels increased in 2014 by more than 20% over the last year reaching a new record level of \$1.5 trillion (eMarketer 2014). As competition among online shopping websites for regular and new customers has intensified in the last couple of years, providers employ various strategies to keep customers on their websites and encourage them to complete transactions (Benlian et al. 2012). One pervasively used strategy is the deployment of so-called purchase pressure cues (PPC) which are graphical depictions on websites that attempt to subliminally put customers under pressure to make a transaction and ultimately boost sales (Benlian 2015). Ebay's core feature, for example, is its auction mechanism that is visually depicted via a countdown clock signaling that customers are running out of time to make a deal. Moreover, Deal of the Day (DoD) websites have become one of the latest Internet hypes offering discounted deals for a wide range of products and services such as ticketed events or cosmetics (Parsons et al. 2014; Xueming et al. 2014). Groupon, for example, the leading DoD platform with 54 million active customers worldwide and revenues of \$3.2 billion in 2014, has been one of the fastest growing Internet sales businesses in history (Krasnova et al. 2013). Core visual PPCs used on these websites for example signal the limited time available for the deal or whether the deal is available in limited quantities (Byers et al. 2012). Despite the broad use of such PPCs on e-commerce websites, however, it is surprising to find that practical recommendations on the differential impact of such cues are still scarce, leaving practitioners puzzled and without guidance.

Although decision-making under pressure has a long tradition in psychology and marketing research, previous literature has mainly focused on offline contexts such as retail stores (e.g., Byun and Sternquist 2012). However, several studies show that because of the absence of experiential information in the Internet, there are systematic differences in customer attitudes and behavior for products and services chosen online versus offline that requires investigating PPCs' distinct effects in online contexts, which has also been echoed by several research scholars (Kim and Krishnan 2015; Degeratu et al. 2000; Venkatesh et al. 2003). For example, whereas sensory search attributes (e.g., the fit and feel of clothing) have lower impact on choices online, non-sensory attributes (e.g., factual information about tangible product features) have a relatively higher impact (Degeratu et al. 2000). Moreover, price sensitivity



has been found to be higher online than offline and also brand names typically have a stronger impact online than offline (Venkatesh et al. 2003). Finally, a competing offer is just a few clicks away on the Internet, so that customers are likely to find what they are looking for on a competitor's site if an e-tailer fails to satisfy their needs immediately (Harris et al. 2006).

The few existing studies that have examined PPCs in online (i.e., e-commerce) contexts have left inconclusive findings and many open questions about whether and which PPCs effectively influence online customers' buying decision (e.g., Jeong and Kwon 2012). Are limited time (LT) pressure cues, for example, more effective than limited product availability (LPA) cues? Both PPC are well examined in the traditional brick and mortar shopping context and are widely used on e-commerce platforms (Byers et al. 2012). Their proliferation on e-commerce platforms could be explained by vendors' speculations about their effectiveness in both offline and online world. Due to the discussed differences between online and offline environment, however, these speculations cannot simply be accepted without further ado. In fact, the *actual* role of LT and LPA for affecting online customers' buying decisions remains largely unexplored so far. Moreover, to the best of our knowledge, research that explicates the mechanism through which PPCs affect consumers' decision-making behavior in e-commerce is scarce as well. Uncovering the explanatory mechanism linking the effects of PPCs to customers' buying decisions is however important to better understand why some types of PPCs are effective and why others are not. Given the existing research gaps and the missing guidance for practice, research that focuses on *whether* and *why* PPCs affect buying decisions on e-commerce platforms is thus of significant value for researchers as well as practitioners. The objective of our study is therefore to address these gaps guided by the following research question: *Which purchase pressure cues are effective in influencing consumers' online buying decisions and why?*

To answer the research question and to address the identified gaps in research and practice, we conducted a laboratory experiment with one control and two experimental groups exposed to different PPCs (i.e., LT and LPA pressure cues). We used a self-programmed, simulated version of the Groupon website as experimental setting in order to increase the ecological validity of our experiment. We found that LT pressure cues—but not LPA pressure cues—were effective in influencing consumers' purchase decisions. Furthermore, we could demonstrate that neither perceived stress, nor perceived product value alone provided an empirically validated explanation for the positive effect of LT pressure cues on consumers'

deal choice. Only when considered together and in consecutive order, perceived stress and perceived product value could be shown to represent a valid explanatory mechanism.

Our study offers potentially useful contributions to both research and practice. First, it contributes to existing literature related to decision-making under pressure—which is widely advanced in the offline retail context but largely unexplored in e-commerce research (e.g., Eckhardt et al. 2013)—by examining the differential effectiveness of PPCs on e-commerce websites. Second, and more broadly, our study significantly adds to IS research by disentangling the explanatory mechanism through which IT-based pressure cues impact individual decision-making, which goes beyond previous studies that treated the relationship between such cues and decision-making behaviors largely as a black box (e.g., Ahituv et al. 1998). Third, by examining how and why different PPCs affect consumers' buying decisions on commercial websites, this study provides practitioners with specific recommendations on how to design sales-efficient e-commerce websites that enhance online consumers' likelihood to complete a deal.

We begin by reviewing previous literature on decision-making under pressure and purchase pressure cues in offline and online contexts, representing the theoretical foundations of this paper. Then, we present our research model and develop hypotheses on direct and indirect relationships between PPCs and consumers' buying decisions. Further, we outline the design and report the results of a lab experiment with 121 subjects. After discussing the main findings of our study, the paper highlights implications for research and practice and concludes by pointing out promising areas for future research.

## **5.2 Theoretical Foundations**

### **5.2.1 Decision-Making under Pressure and Purchase Pressure Cues**

It is widely acknowledged that consumer decisions are complex activities that are influenced by situational and environmental conditions (Payne 1982; Zakay 1993). Such conditions can for example be resource constraints like time, money and information, which can have a systematic and significant influence on human decision-making (Böckenholt and Kroeger 1993). Psychology and marketing research have quite a long tradition of studying decision-making under restrictive conditions (e.g., Easterbrook 1959; Edland 1985; Kerstholt 1994; Svenson 1985; Svenson et al. 1985; Wright 1974) and have provided valuable contributions to research on decision-making under pressure in areas such as judgment (e.g., Edland 1985), negotiation and mediation (e.g., Carnevale and Lawler 1986), creativity research (e.g.,

Mandler 1984), health (e.g., Henry and Stephens 1977), and aviation (e.g., Yates and Curley 1985). Wright (1974) for example found that under high environmental pressure conditions, subjects changed their strategies, used more negative evidence and drew on fewer decision attributes than in non-constraint conditions when making their judgments. Furthermore, several scholars (e.g., Svenson et al. 1985; Kerstholt 1994; Easterbrook) could uncover and validate the human tendency to focus on central and salient rather than on peripheral information under experienced psychological stress, thus applying different rules of thumb when making a decision (Svenson and Maule 1993).

The potential of pressure situations to influence consumers' decision-making process has also been recognized in the retail and commerce sector for decades to deliberately nudge consumers to a positive purchase decision (e.g., Dawar and Parker 1994; Inman et al. 1990; Lynn 1991; Zhu et al. 2012). These practices often take place through the use of pressure cues, also called "persuasion claims" (Jeong and Kwon 2012), which refer to signals used by marketers to persuade people to buy. Several pressure cues have been examined in the marketing literature ranging from warranties to information on product popularity with much of the emphasis being at studies on PPCs that contain a time or scarcity component such as time pressure or product availability pressure cues (e.g., Dhar and Nowlis 1999; Suri et al. 2007; Suri and Monroe 2003).

This stream of research has accumulated valuable insights about the effects of different pressure cues on human reactions over the last two decades with a primary focus on stimuli located in individual's physical environment (Byun and Sternquist 2012). Little attention, however, has been paid to study pressure cues and their effect mechanisms in *online* contexts, even though several scholars have recently called for more closely investigating this fundamental phenomenon that is part of many people's daily lives (Aggarwal and Vaidyanathan 2003; Byun and Sternquist 2012). Specifically, IS research has paid little attention to study pressure cues (e.g., as embedded in IT artifacts such as commercial websites) and, to the best of our knowledge, there are as yet only few papers that have specifically addressed their effects on human decision-making. Benbasat and Dexter (1986) were among the first to investigate the effectiveness of color and graphical cues used in information systems under varying time constraints independent of any particular context. Other scholars investigated the effects of time pressure on decision-making in the context of decision support systems (e.g., Ahituv et al. 1998; Adya and Phillips-Wren 2009; Marsden et

al. 2006), crisis management systems (Sniezek et al. 2002) and private IS usage (Eckhardt et al. 2013).

In summary, despite the long history in studying human decision-making under pressure in various disciplines, previous studies have mostly examined single types of (purchase) pressure cues in isolation (i.e., without comparing different kinds of pressure cues), predominantly in the offline context (i.e., stimuli embedded in consumers' physical environment) and as a black box (i.e., without unveiling the explanatory mechanism through which pressure cues affect consumers' decision-making). As such, while this research has unquestionably yielded a wealth of knowledge, the fact remains that fundamental questions on *the relative effectiveness of purchase pressure cues*—as part of an IT artifact—and their *underlying effect mechanisms* on consumer decision-making, especially in the context of e-commerce, have remained relatively unexplored.

### **5.2.2 Purchase Pressure Cues as Environmental Signals**

With the aim of examining the effects of PPCs on users' product choice behavior on commercial website, we draw on the Stimuli-Organism-Response (S-O-R) model in environmental psychology (Mehrabian and Russell 1974). The S-O-R model posits that the various stimuli within a shopping environment together influence a consumer's cognitive and/or affective processes (organism), which in turn determine the consumer's responses. Stimuli are contextual cues external to the consumer that attract his or her attention (Belk 1975). Stimuli may manifest themselves in various forms, for example, as a price tag, a product display or a store's visual design (Jacoby 2002). In the context of commercial websites, stimuli pertain to the design features of websites with which consumers interact, such as website quality signals (Wells et al. 2011) or a web-based recommendation system's trade-off transparency (Xu et al. 2014). The organism refers to the intervening processes (e.g., cognitive and emotive systems) between the stimuli and the reaction of the consumer. Response refers to behavioral responses, such as the acquisition of products, or internal responses that may be expressed, such as perceptions and/or behavioral intentions (Mehrabian and Russell 1974). Past psychology and marketing research have widely adopted the S-O-R model with promising results to model the impact of environmental stimuli on consumer responses in both offline and online shopping contexts (e.g., Eroglu et al. 2001; Eroglu et al. 2003; Fiore and Kim 2007). Several IS studies also drew on the S-O-R paradigm as a theoretical framework to explain how website features may affect consumers' internal

preferential choice processes and their resulting choice behaviors (Parboteeah et al. 2009; Xu et al. 2014), with their findings supporting its applicability.

As such, the S-O-R model serves as an appropriate foundation for our own research model (Figure 5-1). Following the logic of the S-O-R paradigm, this study operationalizes limited time and limited product availability cues on websites as environmental stimuli, which are two pervasively used purchase pressure cues embedded in e-commerce websites; organism as the user’s physiological and cognitive reactions to the stimuli; and response as the user’s product choice behavior on the commercial website. We elaborate on the stimuli (i.e., limited time and limited product availability cues) and their conceptual underpinnings in the next two subsections, and theorize on the intervening process (organism) and users’ responses in the hypotheses development section.

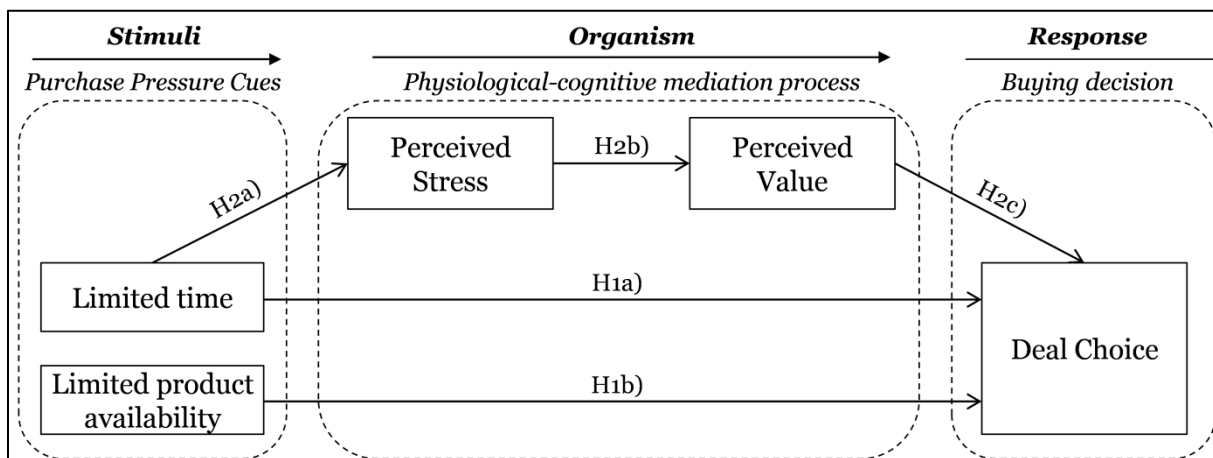


Figure 5-1: Research Model

### 5.2.3 Limited Time (LT) Pressure Cues

Limited time (LT) or simply time pressure has been defined as the perceived constriction of the time available for an individual to perform a given task and as a form of stress expressed in the perception of being hurried or rushed (Ackerman and Gross 2003; Iyer 1989). In these definitions, emphasis is placed on humans’ *perceptions* of time pressure, since that is what will alter an individual’s information processing mode (Ordonez and Benson 1997). LT pressure cues have been studied as environmental signals predominantly in the marketing field (e.g., time-limited sales promotions, discounts, or coupons) with most attention being paid to the offline retail context. Suri and Monroe (2003), for example, found in a consumer electronics setting that when low time pressure is signaled, individuals are likely to process information for product assessment and adoption decisions systematically. An increase in time pressure from this low level, however, results in a decrease in systematic information

processing, thereby increasing the likelihood of heuristic processing to simplify the cognitive task. As described by Simon (1990, p.11), heuristics are “methods for arriving at satisfactory solutions with modest amounts of computation.” Heuristics are sometimes also referred to as rules of thumb. Similarly, Byun and Sternquist (2012) argue that the strategy used by several fast fashion retailers such as H&M and ZARA to offer products just for a limited time creates a perception of perishability and scarcity, which in turn affects consumers’ anticipated gains and losses of buying alternatives, thus leading to in-store hoarding and purchase acceleration. What is more, this study and others indicate that decision makers under time pressure use fewer but more important attributes, less complex decision rules, weight negative aspects more heavily, take fewer risks, and reduce their information searching and processing (Ahituv et al. 1998).

LT pressure cues are also a widespread phenomenon in the online retail context. Not only DoD platforms are using such cues on their websites (e.g., [groupon.com](http://groupon.com), [livingsocial.com](http://livingsocial.com), [dailydeal.com](http://dailydeal.com)), but also auction websites like Ebay ([ebay.com](http://ebay.com)) or QuiBids ([quibids.com](http://quibids.com)), as well as e-commerce companies like Amazon ([amazon.com](http://amazon.com)). Despite their prevalence on commercial websites, only few studies in IS research have investigated time pressure cues on human decision-making. Those few studies, however, have focused on user reactions in non-commercial environments (Eckhardt et al. 2013; Marsden et al. 2006). As such, to the best of our knowledge, there is still a lack of research on the role of LT pressure cues for affecting consumers’ buying decisions on e-commerce websites.

#### **5.2.4 Limited Product Availability (LPA) Pressure Cues**

Limited product availability (LPA) pressure cues refer to written statements or visual icons attached to products that inform consumers that only a limited number of products remain in stock and are thus available for purchase. In the e-commerce context, for example, typical displays are “only 3 left in stock. Order soon” ([amazon.com](http://amazon.com)), “1 ticket left at this price” ([expedia.com](http://expedia.com)), “sell out risk high!” ([overstock.com](http://overstock.com)), and “only 4 deals left” ([groupon.de](http://groupon.de)) (Jeong and Kwon 2012).

Significant effects of LPA pressure cues on consumers’ purchase intentions could be demonstrated in several studies for the offline, in-store context (e.g., Suri et al. 2007; Verhallen and Robben 1994). For example, Suri et al. (2007) found that under LPA pressure, consumers’ perceptions of quality and monetary sacrifice exhibit different response patterns, depending on the relative price level and consumers’ motivation to process information, which, in turn, affects purchase intention. In contrast, the few findings that exist for the online

retail environment have been inconsistent and sometimes contradictory to those of the offline context. Jeong and Kwon (2012), for example, could not confirm a significant relationship between the presentation of LPA pressure cues and consumers' purchase intentions. They conjectured that this was primarily due to low message credibility of the LPA cues. In other words, when persuasion claims such as LPA cues are not perceived as credible information, consumers do not infer product quality from the claim. Because the assessment of product availability is more restricted in online shopping environments, the authors argued that consumers may consider limited availability claims rather as a marketer's manipulative tactic to stimulate sales. Such suspicion about firms' ultimate motives or deceptive intent may then lead to resistance among consumers that attenuates purchase intentions (Cheung et al. 2012). Given that their argumentation was mainly based on speculation, Jeong and Kwon (2012) strongly advised researchers to further their inquiry into the (lack of) effectiveness of LPA pressure cues and the potential reasons thereof.

### **5.3 Hypotheses Development**

We derive our hypotheses by adopting a two-step approach which is commonly used when applying the S-O-R paradigm (MacKinnon 2008): First, and based on a simplified S-R logic (excluding the 'O'), we hypothesize the direct effects (i.e., the *relative effectiveness*) of LT and LPA pressure cues (stimuli) on consumers' deal choice (response) on e-commerce websites. Second, introducing the 'organism' component of the S-O-R framework, we investigate the indirect effects and thus the explanatory mechanism through which PPCs affect consumers' deal choice.

#### **5.3.1 Direct Effects of LT and LPA Pressure Cues on Deal Choice**

Previous research on decision-making under time pressure has found that requiring individuals to make decisions within a limited time frame usually evokes pressure and higher stress (e.g., Ahituv et al. 1998; Edland and Svenson 1993). Ackerman and Gross (2003) furthermore reported that time pressure may change the level of arousal which, in turn, induces perception of psychological stress. It is this change in the level of physiological arousal—also referred to as *core affect* (Ortiz de Guinea and Webster 2013; Russell 2003)—that triggers and directs subsequent heuristic cognitive processing wherein individuals use fewer but more salient attributes, apply less complex decision rules, and reduce their information searching and processing (Simon 1959). Based on this notion of heuristic information processing, we argue that the provision of LT pressure cues—as salient signals in

consumers' visual field—will influence consumers' decision-making such that they are likely to push them to increasingly consider buying the presented product (i.e., make a deal), resulting in rapid-fire reasoning (Malhotra 2010). In line with this reasoning, we propose that in e-commerce contexts, the presence of LT pressure cues on a product webpage will cause consumers to have a higher tendency to buy the presented product and thus lead to a higher proportion of consumers completing the deal:

**H1a:** *Websites with LT pressure cues will cause higher deal choice shares than websites without LT pressure cues.*

In contrast to LT pressure cues, we argue that LPA pressure cues will not be effective in increasing consumers' deal choice shares compared to situations without LPA pressure cues because of two countervailing effects that cancel each other out. On the one hand, according to commodity theory and scarcity effects, scarce products are typically perceived to be more valuable and desirable (Brock 1968; Lynn 1991). In this regard, LPA pressure cues on websites may convey a scarcity signal reducing one's freedom to possess the product, and subsequently inducing psychological reactance in the consumer's mind. Once the consumer perceives the limited availability claim as a threat to his or her freedom of ownership, the consumer is likely to develop an intention to purchase the product in order to reestablish the threatened freedom (Brehm and Brehm 1981). Thus, based on these arguments, one should expect that LPA pressure cues would increase the likelihood of purchasing products. On the other hand, however, signaling product availability to consumers in e-commerce contexts has been shown to be perceived as fake and deceptive such that consumers do not infer product quality from these claims (Jeong and Kwon 2012). In contrast to LT pressure cues whose inner workings can be reconstructed and validated by consumers even in online environments (e.g., consumers can follow the deal over time and recognize whether deal time has been manipulated or not), LPA pressure cues are based on information (i.e., stock-keeping unit/warehousing data) that are at the exclusive disposal of the provider such that consumers are not able to validate this information before or after a transaction (Jeong and Kwon 2012). Given these contrasting explanations for the effects of LPA cues on consumers' decision-making, we cautiously posit that the presence of a LPA pressure cue on a product webpage will *not* cause consumers to have a higher tendency to buy the presented product and complete the deal. We thus hypothesize:

**H1b:** *Websites with LPA pressure cues will not cause higher deal choice shares than*



*websites without LPA pressure cues.*

After hypothesizing the proposed direct effects of LT and LPA pressure cues on consumers' deal choice in e-commerce, we proceed to explore the explanatory mechanism (i.e., the 'O' component of the S-O-R framework) through which the expected effect of LT pressure cues may operate. We thereby focus on LT pressure cues, because, as hypothesized above, we argue (and later also demonstrate) that LPA pressure cues won't be effective in influencing consumers' deal choice.

### **5.3.2 The Mediation Process between LT Pressure Cues and Deal Choice**

Overall, we argue that LT pressure cues will have an impact on deal choice by first increasing consumers' stress level (i.e., psychophysiological effects) which then translates into higher perceived product value (i.e., cognitive evaluations). This serial effect chain of physiological arousal and cognitive product assessment will finally affect deal choice.

Previous literature on consumer decision-making has found that LT pressure cues are usually perceived as environmental stressors that limit individuals' information processing capabilities and increase feelings of unease and discomfort (Edland and Svenson 1993). Individuals feel more constrained when they have not enough time to gather all relevant information and to evaluate alternative decision options because of the fear that their decision might be wrong or lead to negative consequences (Dhar and Nowlis 1999; Huber and Kunz 2007). In this regard, it has been shown that the first step in the emotional registration of stimuli "*is attention—not necessarily conscious attention but literally that the actor's sensory organs are oriented to take in the stimulus*" (Elfenbein 2007, p. 322). Although somewhat counterintuitive but empirically validated in previous studies (Obrist 1981; Ortiz de Guinea and Webster 2013), such emotional responses to attention-evocative stimuli (such as pressure cues) typically involve a *decrease* in physiological arousal reflected in lower heart rates or skin conductance. Applied to our research context, buying under time pressure may thus trigger participants to automatically pay attention to specific attributes of the purchase environment reducing bodily activity such as heart rate (Beauchaine 2001; Porges 1995), while simultaneously increasing consumers' stress level. In line with these arguments, we posit that online consumers who encounter an interface including LT pressure cues will

experience higher perceived stress<sup>18</sup> as compared to individuals who interact with an interface that lacks such cues. Thus, we suggest that:

**H2a:** *Websites with LT pressure cues will increase online consumers' perceived stress.*

As mentioned earlier, previous studies on decision-making under pressure have shown that consumers use cognitive shortcuts and draw on specific heuristics to reduce the cognitive complexity of the task. When faced with time constraints that trigger higher stress levels, they for example tend to filter information more selectively such that they focus on more important and/or more salient attributes, as well as on negative information (Dhar and Nowlis 1999). In the case of e-commerce websites that include salient LT pressure cues (e.g., a clock display counting down time), consumers have the tendency to regularly pay attention to such cues to check how much time is left to be still eligible for buying the presented product. Such perceptions of “running out of time” have been shown to evoke relatively greater feelings of loss or regret about a potentially missed opportunity of making a good deal (Aggarwal and Vaidyanathan 2003). This basic human reaction is rooted in prospect theory that predicts that because of individuals' loss aversion propensity, they associate greater psychological discomfort with losses than pleasure with gains (Kahneman and Tversky 1979). Along the same lines, consumers under time pressure react to perceived limited time by weighing the anticipated gains of buying and anticipated losses of not buying a product, ultimately responding, however, more strongly to anticipated losses than to anticipated gains. Inman and McAlister (1994), for example, found that as the expiration time of a possible product deal nears, initially perceived gains from time-limited promotions are reframed as losses, because the possibility of losing the opportunity to take advantage of the deal increases. Due to such increasing feelings of missing a favorable opportunity (e.g., buying a discounted product) with increasing time scarcity, the product under consideration is likely to become relatively more attractive to consumers—hence, consumers' appreciation of a product's value (i.e., their overall assessment of the utility of a product or service) increases (Suri and Monroe 2003). In the light of human beings' tendency to feelings of loss aversion and based on previous empirical findings, we propose that consumers with higher stress levels (that were evoked by LT pressure cues) will be more likely to perceive the presented product as being more valuable, all else being equal. Thus, we hypothesize that:

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<sup>18</sup> In this study, we hypothesize that LT pressure cues affect consumers' *perceptions* of stress. As a validation check for our results, however, we will also test whether LT pressure cues influence consumers' *physiological* stress reactions, expecting a decrease in arousal levels (i.e., heart rate) by subjects who were exposed to LT pressure cues.

*H2b: Online consumers with higher perceived stress levels will have higher value perceptions of a product presented on an e-commerce website.*

Finally, consumer decision-making as well as IS research has shown that when consumers perceive a product as being more valuable, they are usually more inclined to think that they can draw a higher utility out of a product's consumption (Kim et al. 2007; Sweeney and Soutar 2001). Likewise, utility theory suggests that higher product utility increases the likelihood of consumers to buy a product, all else being equal (Varian and Repcheck 2010). Consistent with this logic, we hypothesize that consumers with higher value perceptions of a product will be more likely to buy this product and complete a deal than consumers with lower value perceptions:

*H2c: Online consumers with higher value perceptions of a product presented on an e-commerce website will be more likely to buy the product.*

In summary, considering H2a-H2c together, we thus expect that LT pressure cues will affect consumers' deal choice through a serial, physiological-cognitive mediation process with perceived stress and perceived product value being key explanatory constructs.

### **5.3.3 Control Variables**

We controlled for several other factors in our experiment. Perceived product quality, susceptibility to interpersonal influence, consumer impulsiveness, experience with/attitudes toward online shopping and perceived information credibility have also been shown to influence consumers' deal choice (Bearden et al. 1989; Chen 2008; De Valck et al. 2009; Flanagin and Metzger 2000; Konradt et al. 2012; Madhavaram and Laverie 2004; Puri 1996; Soopramanien and Robertson 2007). We included these variables as well as the demographics of the subjects to isolate the effects of the manipulated variables.

## **5.4 Research Methodology**

### **5.4.1 Experimental Design and Product Selection**

The proposed hypotheses were tested based on a laboratory experiment. We employed a 3 x 1 between-subjects design with one control group and two experimental groups exposed to different PPCs (i.e., LT and LPA pressure cues). Against the background of our research question, we preferred a between-subjects design to avoid practice and fatigue effects that can plague within-subjects designs and to lower the chances of participants working out the aims

of the experiment and thus skewing the results (Kirk 2012). We used a self-programmed, simulated version of the Groupon website as experimental setting in order to increase the ecological validity of our experiment.

We chose energy drinks—featured as a brand new product launch in the market—as main deal product because of two main reasons. First, according to Kirmani and Rao (2000), experience goods whose quality is unknown or difficult to assess before consumption are particularly useful for examining the effects of purchase pressure cues. Second, given that we conducted a lab experiment with students as subjects, we had to find a product that fitted the basic needs of students (in this case the need for concentration and endurance during exam preparations), while being affordable at the same time. As such, we created a new brand for an energy drink called “Star Energy” with unique product characteristics and also designed distinct product pictures for our experimental website. As a validation procedure, we conducted a pretest (n=19) to verify the acceptance of this product among students. 16 out of 19 students clearly expressed that they found this new product appealing and that they could imagine buying this new product from DoD websites such as Groupon<sup>19</sup>. In sum, the pretest confirmed the adequacy of a newly created energy drink as main deal product for our lab experiment.

#### **5.4.2 Manipulated Stimuli**

Ordonez and Benson (1997) claim that setting a time constraint is not enough to ensure that subjects feel time pressure. Time constraint exists whenever there is a time deadline, even if the person is able to complete the task in less time. Time pressure indicates that the time constraint induces some feeling of stress and creates a need to cope with the limited time. Thus, it is possible to have a time constraint without exerting time pressure (Noda et al. 2007). Consequently and as already highlighted in the definitions of LT and LPA, it is the *perception* of a product being scarce (LPA) and available only for a limited time (LT) that induces psychological stress. By carefully selecting and testing the characteristics of our two PPCs, we took two rigorous measures to increase the likelihood that the subjects were going to perceive the PPCs on the experimental website as intended.

First, to determine how much remaining time and how many remaining products were respectively inducing adequate perceptions of psychological stress, we conducted a second pretest (n=17) employing a within-subjects design using a similar scenario as in the main

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<sup>19</sup> We used the wording “DoD websites such as Groupon” in order to pretest the overall acceptance of DoD websites.

experiment. 10 variants of LT pressure cues (i.e., from 30 seconds to 5 minutes, in 30 seconds increments) and 10 variants of LPA pressure cues (i.e., from 4 to 104 available products, in 10 product increments) were each incorporated into a Groupon website presenting the Star Energy deal. These different DoD website versions were then randomly presented to the subjects who were asked to evaluate how much pressure they felt on this website (on a 7-point Likert scale anchored at 1=low to 7=high). Each subject was therefore exposed to 10 LT and 10 LPA pressure cues in a randomized order. Based on subjects' responses, we selected one LT pressure cue (i.e., 1 minute as remaining time for making a deal as subjects would enter the experimental webpage) and one LPA pressure cue (i.e., "only 4 deals left") to be used in the main experiment. Second, to ensure that our treatments would be recognized as typical PPCs on websites, we chose a dynamic implementation for both LT and LPA pressure cues such that the remaining time to make a deal and the remaining amount of deals on the website were decremented evenly over the time frame of the subjects' exposure to the experimental website. Figure 2 depicts characteristic displays of the three conditions in our experiment.

### 5.4.3 Measured Variables and Measurement Validation

For the central dependent variable of our study, consumers' deal choice, we used *actual deal choice* instead of *intention to complete the deal* (Morrison 1979) to capture a more objective outcome variable. In our experiment, participants were instructed that they can freely choose to buy (by clicking on the "buy"-button) or not to buy the product (by proceeding to the questionnaire). For the measurement of perceived value, we adopted an established scale from Suri and Monroe (2003), consisting of the following three items (Cronbach's alpha=0.85; Average Variance Extracted=0.77): 1. *I think that given the attributes of Star Energy, it is a good value for money*; 2. *At the advertised price, I feel that I am getting a good quality energy drink for a reasonable price*; 3. *If I bought Star Energy at the advertised price, I feel I would be getting my money's worth*. All items were measured on a seven-point Likert scale anchored at 1= strongly disagree and 7 = strongly agree.



Figure 5-2: Displays of DoD website and PPCs for control and experimental groups

Perceived psychological stress was measured by a single item (Bergkvist and Rossiter 2007; Svenson et al. 1990): *“I feel stressed”*, before and directly after the deal choice. To substantiate the results of this self-reported variable, we additionally captured subjects’ heart rate as a direct and objective physiological measurement for the duration of the experiment. Pulse signals (Heart Rate Variability, HRV) were continuously recorded with an Electrocardiographic (ECG) recording device using a lead 1 method with electrodes placed on the middle three fingers of the left or right hand (Andreassi 2007). The HRV-sensor of the device measures the volume of blood in the finger. The handling of the heart rate data followed a conservative design. This conservative method consisted of standardizing the heart rate data after completing the task, and dividing these deviations by the baseline level (Schneider 2008). The measure for the heart rate thus indicated a proportional deviation from baseline levels in actual units. Following common practices in the measurement and analysis of heart rate data in experimental research (Ortiz de Guinea and Webster 2013), we used the time interval of 30 seconds before and after subjects’ exposure to our treatments to evaluate the recorded data.

Regarding our control variables, which were measured on the same scale as perceived value, we adopted established measurements from prior literature. Perceived product quality was measured with 4 items adopted from Kirmani and Zhu (2007). Perceived website credibility was measured using a 3-item scale adopted from Flanagin and Metzger (2000). Susceptibility for interpersonal influence was measured using a 4-item scale from Bearden et al. (1989). We

measured consumer impulsiveness with the 12-item scale developed by Puri (1996). Finally, attitudes toward online shopping were measured drawing on a 7-item scale from Soopramanien and Robertson (2007). We found that all self-reported scales in this study had strong psychometric properties. All factor loadings were greater than 0.70, Cronbach's alpha values were all greater than 0.77, and AVE values were all greater than 0.62<sup>20</sup> (Fornell and Larcker 1981).

Finally, we developed measurement items for perceived LT pressure cues (*"I could recognize a clock next to the Star Energy product picture that depicted the remaining time for this deal"*) and perceived LPA pressure cues (*"I could recognize a visual cue next to the Star Energy product picture that depicted the amount of left deals for this product"*) by following the approach developed by Moore and Benbasat (1991). These two items were applied to check the manipulations of LT pressure cues and LPA pressure cues in the experiment and, thus, to ensure that our treatments worked as intended. Finally, we measured whether the participant were suspicious about the cause of the experiment with a single item (*"I have a clear idea of what the objectives of this experiment are"*).

#### **5.4.4 Participants, Incentives and Procedures**

A total of 134 college students were recruited for our laboratory experiment from the campus of a large public university in Germany in exchange for a monetary incentive of 5 Euro that they could either keep or spend for the deal. Furthermore, the subjects had the chance to win an iPad Mini in a raffle that was conducted after completion of the entire lab experiment. We deemed the use of a student sample appropriate for this study, because college students are likely to represent typical online consumers on DoD websites and to show similar buying patterns for the offered product category in our experiment compared to non-student samples (Jeong and Kwon 2012). 8 subjects reported inconsistent information while completing the questionnaire and 5 subjects were excluded based on the results of the manipulation checks (4 subjects stated to have a clear idea of the objectives of the experiment). Hence, we used a sample of 121 subjects in our final analysis. Of the 121 subjects, 93 were males and 28 were females. Their average age was 23.54 years ( $\sigma=5.22$ ). The average reported years of experience with online shopping was 3.60 ( $\sigma=1.36$ ) and, on average, subjects bought 4.19 ( $\sigma=2.69$ ) products online in the last month. Almost 60% of the subjects were familiar with Groupon.

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<sup>20</sup> For brevity, we omitted the items for the control variables. They can be obtained from the authors upon request.

The field experiment proceeded in four major steps. First, upon arrival at the lab, all subjects received the abovementioned 5 Euro compensation fee, were randomly assigned to a computer desk (i.e., to either the control or one of the two treatment groups) and then connected to the ECG recording device. Second, before subjects were exposed to the experimental website, they were first asked to fill in a pre-experimental questionnaire containing basic questions on socio-demographic data. Then, all participants were presented with an identical sample Groupon webpage that displayed the main components of this DoD website. This was done to allow participants to establish a common frame of reference in order to ensure that the context and background of their experimental experiences were homogeneous across treatments and the disparities across different treatments were caused only by different treatment stimuli (Helson 1964). Third, after viewing the sample webpage, subjects were instructed to put themselves into the perspective of a student learning hard for her exams and searching online for a (legal) stimulant to improve concentration and learning capabilities. As it happened, the student found a DoD website that featured a brand new energy drink. After the scenario presentation, participants were informed that in the next step they would be redirected to the experimental website where they had to make a deal decision under the varying conditions given. In the case participants made a deal and purchased the energy drink, they had to pay the deal with their own money. In the case they were not willing to make a deal, they waited until the deal ended and a window popped up with a link to proceed. Fourth, after making a deal (or no deal) choice, subjects proceeded to complete a post-experimental questionnaire containing the study's principal variables. Finally, subjects were debriefed and thanked for their participation.

## **5.5 Data Analyses and Results**

### **5.5.1 Control Variables and Manipulation Checks**

To confirm random assignment of subjects to the different experimental conditions and to rule out alternative explanations, we performed several one-way ANOVAs. There were no significant differences in gender ( $F = 1.25, p > 0.05$ ), age ( $F = 0.35, p > 0.05$ ), education ( $F = 0.35, p > 0.05$ ), monthly income ( $F = 0.61, p > 0.05$ ), experience with online shopping ( $F = 0.40, p > 0.05$ ), products bought online ( $F = 0.74, p > 0.05$ ), and experience with Groupon website ( $F = 0.57, p > 0.05$ ). Also, no significant differences could be found regarding attitudes toward online shopping ( $F = 1.08, p > 0.05$ ), consumer impulsiveness ( $F = 0.59, p > 0.05$ ), susceptibility to interpersonal influence ( $F = 0.60, p > 0.05$ ), perceived product quality ( $F = 0.28, p > 0.05$ ), and perceived stress before exposure to an experimental condition ( $F =$



0.70,  $p > 0.05$ ), indicating that these factors were not the cause of differences in users' deal choice.

Descriptive statistical analysis of the applied manipulation checks revealed that subjects in the LT pressure cue conditions (except for two persons) clearly recognized a clock next to the Star Energy product picture that depicted the remaining time for this deal, whereas subjects in the LPA pressure cue conditions (except for three persons) clearly recognized a visual cue next to the Star Energy product picture that depicted the amount of remaining deals for this product. One way ANOVAs additionally confirmed these findings (both  $p < .05$ ). These results provided strong evidence that the manipulations were successful.

## 5.5.2 Hypothesis Testing

### 5.5.2.1 Direct Effects of Purchase Pressure Cues on Deal Choice

A marginally significant one-sample chi-square test revealed that the choice shares varied across the three experimental conditions ( $\chi^2[2] = 3.28$ ;  $p < 0.10$ ). More importantly, the deal choice share patterns were consistent with our predictions that LT pressure cues are effective in increasing deal choice compared to the control group ( $\chi^2[1] = 5.39$ ;  $p < 0.05$ ), while LPA pressure cues are not ( $\chi^2[1] = 0.329$ ;  $p > 0.05$ ). Figure 5-3 shows that 65.0% of subjects in the LT pressure cue condition chose the deal, while only 47.4% and 48.8% of subjects decided to buy the deal in the control and LPA pressure cue conditions respectively. As such, we could support our two main effect hypotheses formulated in H1a and H1b. A post-hoc analysis also revealed that subjects in the LPA group perceived the deal website significantly less credible than subjects in the LT pressure group ( $t = 1.97$ ;  $p < 0.05$ ) and they did not differ in this respect to subjects in the control group ( $t = 0.87$ ;  $p > 0.05$ ), indicating a potential reason why LPA pressure cues were not effective.

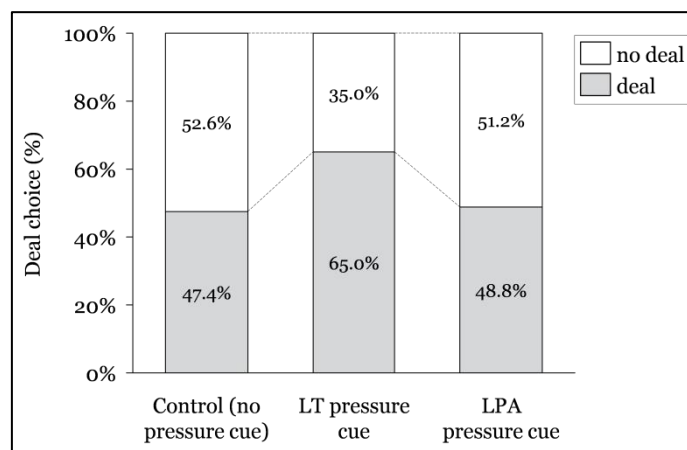


Figure 5-3: Deal Choice Results

Once the effectiveness of LT pressure cues in influencing consumers' deal choice was established, we proceeded to explore the explanatory (i.e., mediation) mechanism through which LT pressure cues impact deal choice.

### ***5.5.2.2 The Mediation Process between LT Pressure Cues and Deal Choice***

Regarding our mediation hypotheses that focused on the explanatory mechanism through which LT pressure cues affect consumers' deal choice, we argued that an increase in perceived stress (accompanied by physiological reactions) and, subsequently, in perceived value of the deal product (a cognitive-evaluative response) are primary reasons for LT pressure cues' impact on deal choice.

To test our first mediator hypothesis (H2a), we conducted a one-way ANOVA ( $F = 3.028$ ,  $p < .05$ ) with planned contrasts. Results from the contrast analysis revealed that subjects in the LT group felt significantly more stress compared to subjects in the control group<sup>21</sup> ( $t = 2.410$ ,  $p < .01$ ), in support of H2a. These results using self-reported data were additionally substantiated by comparing the change in subjects' heart rate across the experimental conditions. A one-way ANOVA with planned contrasts revealed that under time constraints (LT group), subjects' heart rate changed (decreased) significantly ( $t = 1.985$ ,  $p < .05$ ). This was in contrast to the findings for subjects in the LPA condition that did not differ in their heart rate from the control group ( $p > .05$ ).

To examine perceived stress' impact on perceived value of the deal product (H2b), we ran a linear ordinary least squares regression on a sub-sample that included only the LT and control groups ( $N = 78$ ). The results indicated that, in support of H2b, perceived stress significantly increased subjects' perceived product value ( $\beta = 0.175$ ,  $p < .05$ ), all else being equal. Furthermore, the results of a logistic regression ( $\beta = 0.703$ ,  $\exp(\beta) = 2.021$ ,  $p < 0.001$ ) revealed that high perceived product value also significantly increased the odds that consumers, exposed to LT pressure cues, will make a deal on the experimental DoD website, hence supporting H2c.

Finally, following Hayes' (2013) recommended procedure, we ran a serial multiple mediator analysis—again on a sub-sample that included only the LT and control groups ( $N = 78$ )—with perceived stress and perceived value as mediators, while controlling for all direct and indirect paths between the mediators and deal choice. The results of the serial multiple mediator

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<sup>21</sup> As expected, this effect could not be confirmed for participants exposed to LPA pressure cues ( $t = 0.222$ ,  $p > .05$ ).

analysis are depicted in Tables 5-1 and 5-2. The results in Table 1 indicate significant effects of LT pressure cues on perceived stress, of perceived stress on perceived product value, and of perceived product value on deal choice, further validating our results from our previous hypothesis testing. Furthermore, the direct effect of LT pressure cues on consumers' deal choice became insignificant after inclusion of perceived stress and perceived product value, suggesting full mediation (Hayes 2013).

Table 5-1: Results from Serial Multiple Mediation Analysis (Coefficients and Model Summary Information)

Antecedent	$M_1$ (Stress)			$M_2$ (Value)			Y (Deal Choice)		
	<i>B</i>	<i>SE</i>	<i>P</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>
<i>X</i> (LT pressure cues)	0.857	0.335	0.013	-0.102	0.308	0.742	0.254	0.555	0.124
$M_1$ (Stress)	—	—	—	0.295	0.101	0.005	-0.085	0.194	0.659
$M_2$ (Value)	—	—	—	—	—	—	0.879	0.236	0.000
Constant	2.012	0.534	0.012	3.238	0.513	0.000	-4.287	1.302	0.001
	$R^2 = 0.08$ $F(1, 78) = 6.53, p = 0.01$			$R^2 = 0.10$ $F(2, 78) = 4.37, p = 0.02$			<i>Nagelkerke</i> $R^2 = 0.32$ <i>Model</i> $\chi^2[3] = 21.32, p < 0.01$		

The results from a bootstrapping analysis in Table 5-2 show that only the indirect effect path (3) from LT pressure cues via perceived stress and perceived product value to deal choice was statistically significant (i.e., the 95% confidence interval did not include 0), while other potential indirect paths were not. Taken together, these results supported our hypothesis that LT pressure cues' effect on consumers' deal choice is carried over via a serial physiological-cognitive mediation process.

Table 5-2: Results from Serial Multiple Mediation Analysis (Bootstrapping Results\* for Indirect Paths)

Indirect effect paths	<i>Effect z</i>	<i>Boot SE</i>	<i>LLCI</i>	<i>ULCI</i>
(1) LT pressure → Stress → Deal Choice	-0.073	0.209	-0.620	0.231
(2) LT pressure → Value → Deal Choice	-0.089	0.305	-0.790	0.496
(3) LT pressure → Stress → Value → Deal Choice	0.222	0.167	<b>0.039</b>	<b>0.678</b>
<i>Note:</i> *We conducted inferential tests for the indirect effect paths based on 1,000 bootstrap samples generating 95% bias-corrected bootstrap confidence intervals (LLCI = Lower Limit / ULCI = Upper Limit of Confidence Interval).				

## 5.6 Discussion

This work sought to achieve two main objectives: (1) to examine the effects of different salient purchase pressure cues on consumers' buying decisions on commercial websites (i.e., *whether* there is an impact), and (2) to investigate the explanatory mechanism through which these effects occur (i.e., *why* there is an impact). To achieve these objectives, we developed a research model that was embedded in the Stimuli-Organism-Response paradigm (Mehrabian and Russell 1974) and we investigated our hypotheses based on a lab experiment in the context of DoD websites. Drawing on the advantages of the experimental method that allows to isolate the effects of manipulated stimuli on user responses from other confounding variables and thus to unveil causal relationships, we found that LT pressure cues—but not LPA pressure cues—were effective in influencing consumers' purchase decisions. Furthermore, we could demonstrate that neither perceived stress, nor perceived product value alone provided an empirically validated explanation for the positive effect of LT pressure cues on consumers' deal choice. Only when considered together and in consecutive order, perceived stress and perceived product value could be shown to represent a valid explanatory mechanism.

Our study offers several theoretical and practical contributions. From a theoretical perspective, this is, to the best of our knowledge, one of the first empirical studies investigating the differential effects of PPCs on consumers' online buying decisions in e-commerce. In particular, a first major contribution of the paper is a more fine-grained understanding of the impact of LT and LPA pressure cues on consumers' buying decision. Previous studies have predominantly examined single PPCs without comparing their relative effectiveness in the same context and have also focused primarily on stimuli from the physical environment (Aggarwal and Vaidyanathan 2003; Ahituv et al. 1998; Krishnan et al. 2013). The few existing studies that have examined PPCs in e-commerce settings have left partially inconclusive findings about whether and which PPCs effectively influence online customers' buying decisions. Although such previous findings are highly valuable, the e-commerce literature had not yet theorized about how and why PPCs differ in their impact on online consumers' deal choice. By drawing on consumer decision-making literature and prospect theory grounded in the S-O-R logic, this study provides new theoretical perspectives that expand our understanding about the relative effectiveness of PPCs in influencing online consumers' purchase decisions. Notably, this study demonstrated that not all PPCs are equally conducive in affecting deal choice, suggesting the existence of differential effect mechanisms

for different PPCs. More specifically, we could demonstrate that LT pressure cues are effective in influencing deal choice, whereas LPA cues are not. This result adds to previous findings that showed that some pressure cues might be effective in the offline context, but lose their effectiveness when transferred to the online world, given that signals exhibit varying information credibility across different settings (Jeong and Kwon 2012).

A second, broader contribution of this study relates to the theoretical mechanisms through which pressure cues affect individuals' choice behavior. While previous studies in IS research have treated the relationship between pressure cues and decision-making behaviors largely as a black box (e.g., Ahituv et al. 1998), our study explicated the intervening mechanism through which PPCs impact individuals' choice behavior. More specifically, we uncovered a serial mediation process that shows that LT pressure cues first influence consumers' physiological arousal and evoke (perceived) psychological stress. Such psychological stress then affects individuals' cognitive evaluations of the presented product. That is, psychological stress leads consumers to process information heuristically rather than systematically and evokes relatively greater feelings of loss or regret about a potentially missed opportunity (of making a good deal). The salient deal offer therefore becomes increasingly attractive (i.e., valuable), leading, in turn, to a higher probability that consumers ultimately complete the deal. Taken together, by unblackboxing this serial mediation mechanism, we contribute to an advanced understanding about *why* LT pressure cues affect consumers' deal choice behavior in the online context.

Considering the pervasive use of purchase pressure cues on e-commerce websites and the scarce empirical evidence on their effectiveness, the findings of rigorous experimental research should be of high practical value as well. First, our results provide useful guidance for online retailers who wish to deploy effective PPCs that nudge (otherwise indecisive) users towards completing a deal—which, in the absence of PPCs, would most likely not occur. As we could show in our study, not all PPCs are equally conducive in affecting consumers' deal choice. Our findings indicate that providing users with LT pressure cues during inspection of (discounted) products online is significantly more effective than not displaying LT pressure with respect to consumers' deal choice. Thus, a DoD website without LT pressure cues seems to be inferior; that is, LT pressure cues have proven capabilities to significantly change physiological arousal and invoke higher perceived product value in users' interaction with the interface, thus altering their deal choice. E-commerce website providers may thus benefit

from this study by carefully testing and monitoring the relative effectiveness of different PPCs on their own websites.

Second, after investigating a wide variety of current practices of using PPCs online, we could conclude that most PPCs currently used on e-commerce websites appear to be designed based on designers' introspection and intuition rather than on rigorous and comprehensive design procedures or guidelines, thus leading to irregular patterns and implementation styles. What is more, the existing resources for designing user interfaces (e.g., Palmer 2002; Shneiderman and Plaisant 2010) provide only general recommendations rather than specific guidelines on the deployment and design of PPCs. These observations demonstrate the need to create and validate various PPCs in order to better guide practitioners and derive best practices based on theory and rigorous experimental testing. To the best of our knowledge, this study is one of the first that provides web designers with useful practical implications on which and how PPCs should be used to influence consumers' deal choice decisions.

Finally, our findings on the effectiveness of LT pressure cues to impact consumers' perceived product value and final deal choice should encourage e-business managers and interface designers to spend more effort and resources on choosing and designing PPCs to influence consumers' buying behavior. PPCs should be selected wisely in order to stimulate positive value perceptions, which in turn impact online purchases. By validating the effectiveness of specific PPCs to increase consumers' probability to make transactions on a website, this study confirms that PPCs can be cost-effective solutions to influence consumers' buying decisions above and beyond costly marketing solutions including search engine optimization, viral campaigns, or traditional promotion programs.

### **5.6.1 Limitations, Future Research and Conclusion**

Our results should be interpreted cognizant of six limitations. First, although we used Groupon as experimental website for our study in order to increase its ecological validity, and although we controlled for a potential branding effect with statistical means and through randomization, future research may use more unknown websites that should invoke fewer connotations from previous exposures. Second, consistent with previous research arguing that the use of PPCs may be particularly effective in markets for relatively new and low-cost products (Kirmani and Rao 2000), we created a new and affordable product brand ("Star Energy") for our experiment. Future research could extend and complement our findings by studying the impact of PPCs on consumers' deal choice also for well-known and more

expensive products. In addition, examining the moderating role of product type (e.g., search vs. experience goods) and user characteristics (e.g., product involvement or personality traits) may be an interesting avenue for future research on the effectiveness of PPCs. Third, in our study, we focused just on two PPCs, namely on LT and LPA pressure cues. Further investigations are needed to explore the role of other PPCs that are also often used on e-commerce platforms, such as “Deal Value” (e.g., \$195), “Discount” (e.g., 65%), “Extent of Savings” (e.g., \$126) or “Product Popularity” (e.g., over 5000 bought), as well as their impact when presented in combination. Fourth, although we empirically validated the mediating effect of perceived stress and value in the relationship between PPC and deal choice and ruled out several alternative explanations, complementary qualitative research would be a fertile avenue for future research to more deeply explore serial, physiological-cognitive mediation processes (e.g., Mahnke et al. 2015). Fifth, based on a pretest study, we used fixed starting values for our pressure cues (i.e., 1 minute for LT pressure cues and 4 items left in stock) to adequately simulate high-pressure decision contexts. We were aware, however, that choosing such values would constrain our experimental setting to situations in which consumers come to a product website by chance or on short notice without having experiences from previous website visits. Therefore, future research may alter these fixed starting values to include less pressure-intensive decision scenarios which are also common in e-commerce. Finally, the use of a student sample may limit the generalizability of our findings. Although we consider the use of students subjects to be appropriate because students frequently use e-commerce websites, and because we are examining basic purchasing decisions that should be similar in a more general population of e-commerce users, future research should replicate our studies to examine whether the results hold for subject groups with different demographics.

Despite the vast proliferation of PPCs on e-commerce websites, previous research in e-commerce has paid little attention towards understanding the differential effectiveness of PPCs in affecting consumers’ buying behavior, even though scholars have recurrently called for examining this timely and theoretically interesting topic (Jeong and Kwon 2012). With this study, we made an important first step towards better understanding which PPCs affect consumers’ online buying decisions and why. We hope that it will serve as a springboard for future research studies and also aid online retailers and web designers in crafting more sales-effective e-commerce websites. To the extent that researchers may be willing and able to transfer (parts of) our findings to other product domains and usage settings, our work may also serve as a baseline study that makes it much easier to compare and consolidate findings across studies and contexts.

### **5.6.2 Acknowledgements**

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## 6 Thesis Conclusion

### 6.1 Summary of Key Findings

This thesis was motivated by the growing importance of cognitive biases in IS research and practice, and our limited understanding in IS research regarding their effects on the decision-making process. The purpose of this thesis was to understand what is the current state of research on cognitive biases in the IS discipline, whether cognitive biases influence IS related users' decisions and, if so, how and why. Particularly important in the interplay between users and IT artifact and a focus of this thesis, was the changing nature of both – IS users and IT artifact. In this regard, four studies were conducted, published across four scientific articles. They investigated the role of two particular cognitive bias phenomena for users' decision-making in the IS usage contexts 'personal productivity software' and 'e-commerce'. These studies provided several findings, theoretical insights and contributions. The key findings of each article are briefly summarized in the following.

The **first article** (chapter 2) was focused on identifying and categorizing existing articles on cognitive biases published in top IS outlets in the time period 1992-2012, thus aiming to provide the first comprehensive picture of the current state of research on cognitive biases in IS. We found a clear increase of interest in cognitive bias research in the IS discipline between 1992 and 2012, especially after 2008. The most extensively examined cognitive bias categories were perception and decision biases, and the most prominent IS research context – IS usage with the clusters 'e-commerce' and 'personal productivity software'. Concerning the employed methods for bias measurement, our scientometric analysis disclosed that in the majority of research articles quantitative and objective methods were used. All in all, the results of the first article provided the foundation and framed the research direction of the remaining articles, included in this thesis.

In the **second article** (chapter 3), we examined the effects of feature updates on users' CI. We found a *positive* effect of feature updates on users' CI – the *update-effect*. The findings of this study further disclosed update frequency as crucial boundary condition to this effect. Specifically, exceeding a tipping point of update frequency resulted in decrease in users' CI to a point where users no longer perceive feature update versions of the software as more advantageous compared to non-update versions. Moreover, we found that the update-effect primarily works via the affective component (SAT) rather than the cognitive component (PU)

of the IS continuance model. The results of the study however also showed that it still depends on the presence of PU, so that PU seems to be the necessary and SAT the sufficient condition for the update-effect to occur. Finally, the findings of article 2 encouraged us to identify additional boundary conditions for the update-effect and to elaborate on the role of SAT and PU in its occurrence, more precisely examining their operating mechanism of influence.

In the **third article**, we investigated the role of software updates on users' intention to continue using the software, including feature as well as non-feature updates. We could repeatedly demonstrate the update-effect, identified in article 2. Our analysis however also showed that not all software updates are able to elicit the update-effect. Only in the feature-update conditions CI was significantly higher than in the non-update condition. Non-feature updates could not increase users' CI compared to the non-update condition, identifying update type as a distinct and crucial moderator to the update-effect. In addition, we could confirm the findings of article 2 regarding update frequency as a crucial moderator to the update-effect. Contrary to the results in the second article however, the results in the third article showed that users prefer the frequent delivery of individual features over bundling them in larger update packages and delivering them less frequently. These mixed results disclose potential for future research regarding the role of this moderator for the update-effect. Specifically, the determination of the above mentioned tipping point of update frequency needs further investigation. Furthermore, we could demonstrate that feature updates were perceived as unexpected, positive events during the program usage, which exerted a positive disconfirmation of users' initial expectations regarding the used software. The additional features, added via updates, subsequently enhanced PU, increasing in turn users' SAT and leading to higher intentions to continue using the software.

While the second and third article reported results of experimental studies conducted in the context of '*personal productivity software*', the purpose of the **last article** (chapter 5) was to investigate which purchase pressure cues are effective in influencing consumers' online buying decisions and why, concerning the '*e-commerce*' context. The results of a laboratory experiment with one control and two experimental groups showed that LT pressure cues—but not LPA pressure cues—were effective in influencing consumers' purchase decisions. Moreover, the results of the study disclosed that the positive effect of LT pressure cues on consumers' deal choice could be neither explained through perceived stress, nor through perceived product value alone. We could demonstrate that perceived stress and perceived

product value represent a valid explanatory mechanism only when considered together and in consecutive order.

## 6.2 Theoretical Contributions

Overall, the thesis provides a deeper understanding of the role of cognitive biases for the decision-making process of IS users, considering the changing nature of their beliefs, attitudes and behaviors, as well as the dynamic nature of the IT artifact itself. The studies included in the thesis have been conducted to determine what is the current state of research on cognitive biases in the IS discipline (RQ1), whether cognitive biases influence IS related users' decisions in the IS usage contexts 'personal productivity software' and 'e-commerce', and if so how and why (RQ2).

Regarding RQ1, the overarching contribution of this thesis consists in providing a systematic literature review of research on cognitive biases in the IS field. The resulting comprehensive picture delivers valuable aggregated information about the development of publications on cognitive biases in IS in the last two decades, disclosing increasing research interest. It furthermore shows which cognitive biases were explored in which IS research fields. This not only allows disclosing areas where cognitive biases have already been well investigated, but also areas with no or only few publications on cognitive biases. Consequently, the resulting map of research on cognitive biases in IS enables providing well-grounded avenues for future research and further advancing the IS research discipline. The results of the scientometric analysis presented in this thesis are therefore a meaningful point of departure not only for the remaining three thesis' articles, but also for IS researchers, eager to further investigate the role of cognitive biases in IS.

Moreover, concerning the role of cognitive biases for users' decision-making in the context of '*personal productivity software*', article 2 and 3 make three important theoretical contributions. First, their overarching contribution is to advance the predominant view of information systems in post-adoption literature from a mostly monolithic and static to a finer-grained and more dynamic one, by showing how a functionally malleable information system may influence users' beliefs, attitudes and behaviors over time. Articles 2 and 3 also respond to several calls for research (e.g., Jasperson 2005; Benbasat and Barki 2007 etc.) to consider the granularity of IS and IS's evolvement over time. They accentuate the importance of the changing IT artifact's nature for users' CI, thus explicitly considering the software product lifecycle in their theorizing. As such, both experimental studies offer a novel complement to

the existing IS post-adoption literature by showing that users' attitudes and behaviors change over time, as the IT artifact's nature and composition evolves over time through e.g. software updates. Second, the results of articles 2 and 3 show substantially different user reactions to different update types and modes of delivery. While feature updates increase users' continuance intentions – the bias-driven update-effect, technical non-feature updates (e.g. bug fixes) have no effect on the intention to continue using the software. Moreover, besides update type, update frequency seems to be another crucial moderator for the identified update-effect. More precisely, users prefer the delivery of individual feature updates over the delivery of less frequent update packages, consisting of several features. On the other hand, we could demonstrate that CI diminishes when the number of individual updates exceeds a tipping point in a given timeframe. These mixed results provide avenues for future research studies that are encouraged to further investigate the role of update frequency for the occurrence of the update-effect. Third, besides exploring the direct effect of software updates on CI, the results of articles 2 and 3 also provide evidence of *how* software updates influence IS continuance intention. They further emphasize the complementary roles of cognition and affect that facilitate biased decision-making.

Furthermore, concerning the role of cognitive biases on users' decisions in '*e-commerce*', article 4 contributes to existing literature, related to decision-making under pressure, by examining the differential effectiveness of PPCs on commercial websites. In doing so, it responds to several calls for research regarding the role of constrictions in time and product availability in the online retail context that in many aspects substantially differs from the offline in-store environment (e.g. Shankar et al. 2003). Its results furthermore demonstrate why some PPCs are effective and others are not, i.e. what is their mechanism of influence. Specifically, the results of article 4 emphasize the interplay between physiological arousal, perceived psychological stress, heuristic cognitive processing and perceived product value, and its influence on consumers' purchase decisions.

Taken together, the results of the research articles presented in this thesis allow the general conclusion that cognitive biases are able to take influence on IS users' decisions. They can not only impede a decision's outcome, being considered as systematic errors. On the contrary, the studies' results rather suggest that an appropriate application of cognitive biases can direct decisions to a desired outcome. Furthermore, the articles included in this thesis, emphasize that boundary conditions, e.g. moderating variables, can be crucial for the occurrence of the desired effects of cognitive biases. Therefore they need to be taken into account when

investigating the role of cognitive biases in IS. Finally, the studies' results also disclose some characteristic mechanisms of influence of cognitive biases, showing an interplay between cognitional and emotional components that may be considered in the design of future research studies. Overall, though the studies included in this thesis are focused on single bias-related phenomena, prominent in the IS usage practice, their theoretical contributions are not strictly limited to these phenomena. This is because human's potential for biased decision-making is ranging above and beyond specific situational contexts. In summary, the thesis not only reveals that cognitive biases can affect users' decision-making process. It also shows why these effects occur, thus contributing to existing theories from psychology and IS.

### **6.3 Practical Contributions**

The choice of cognitive biases investigated in this thesis was motivated to great extent by their relevance for the IS usage practice. Therefore, besides the discussed theoretical contributions, the thesis' findings provide interesting recommendations and guidelines for software vendors and online retailers as well. They may use the findings described in this thesis to understand how cognitive biases can be applied in a targeted way to achieve positive revenue effects.

Regarding the 'personal productivity software' context, relying on the thesis' results software vendors are advised to distribute software functionality incrementally, using updates. This would allow them to achieve a positive effect of feature updates on users' CI – the so called *update-effect*. Satisfied software users with higher CI are at the same time the customers with higher loyalty and lower intentions to consider competitors' offers. In the highly competitive software industry this should be considered as desirable advantage. The results of articles 2 and 3 demonstrate which boundary conditions need to be taken into account, in order to achieve this goal. Specifically, vendors need to precisely analyze which updates provide useful functionalities for users and can be perceived as positive surprise, and which ones do not. This is essential, because the update-effect has been shown to work only with feature updates. Furthermore, vendors are also advised to pretest how often features, added to specific software, are still perceived as surprising. The necessity of such pretests is also grounded on the results of this thesis. They show individual feature delivery to be more advantageous compared to the delivery of larger update packages. However, they also indicate that too frequently delivered updates are no longer perceived as unexpected and are therefore not able to elicit the update-effect. Consequently, while software products differ in terms of e.g. type

(entertainment vs. productivity) or target group (experts vs. laymen), the optimum update frequency should be determined for each individual product.

Moreover, regarding the ‘e-commerce’ context, there are up to date only few studies on the effects of purchase pressure cues for commercial websites. Since the research on PPCs is still in its infancy, there is less guidance for online retailers as well. Many open questions regarding PPCs remain, like *Do their application result in higher purchase quotes? Which PPCs are effective, and which are not? Is it advisable to use as much PPCs as possible?*, to name but a few. Generally, the thesis’ results show that PPCs have the potential to influence consumers’ buying decisions. What is more, they provide evidence that PPCs can be the *means of choice* for online retailers to nudge consumers to a buying decision. Online retailers, however, need to be aware that not all PPCs are suitable for achieving this desired outcome. The findings of article 4 indicate that limited time pressure cues, for example, are effective nudges, while limited product availability pressure cues are not. Consequently, spending more effort and resources in the selection and design of PPCs can be considered as a clear advantage leading to desirable revenue outcomes. Vice versa, the excessive use of purchase pressure cues on commercial websites does not necessarily result in higher purchase quotes. On the contrary, it may possibly even evoke confusion, impede customers’ loyalty and eventually lead to the loss of potential customers.

## **6.4 Limitations, Future Research and Conclusion**

Despite the contributions of the thesis to research and practice, some limitations have to be considered when interpreting the findings and implications. First, the studies were conducted in the *IS usage* domain, precisely focusing on the contexts ‘personal productivity software’ and ‘e-commerce’. Future studies may analyze the generalizability of the thesis’ results for other IS domains such as IS management, software development or economic impact of IS. To give an example, since companies increasingly apply IS to arrange and manage their business processes, the IS security context might be worthwhile further exploring (Campbell et al. 2003; Cavusoglu et al. 2004). Specifically, research studies developing debiasing strategies<sup>22</sup> regarding corporate IS security might be expedient.

Second, for the purpose of this thesis, we preferred to investigate the role of cognitive biases for IS users’ decisions on the example of prominent phenomena from the IS usage practice

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<sup>22</sup> Strategies, aiming to improve decision-making and prevent the occurrence of cognitive biases (e.g. Fischhoff 1982)

like software updates and purchase pressure cues. Based on theories from psychology and IS like prospect theory, expectation-confirmation theory and IS continuance literature, we assumed these phenomena to have the potential to elicit biased decision-making. On the one hand, future research studies may adopt this research strategy by further investigating common phenomena from the IS practice regarding their “bias-potential”. On the other hand, well known and investigated cognitive biases like *framing*, *anchoring* or *sunk cost bias*, for instance, could be further explored in different IS fields and industry context, where economic and societal contributions are expected. The results of the scientometric analysis presented in this thesis provide specific suggestions for future research on cognitive biases in IS and could serve here as a meaningful point of departure.

Third, we analyzed the effects of software updates and PPCs in controlled laboratory experiments at a single point of time with the purpose to explore their causal effect for post adoption and online purchase decisions, thus presenting results with high internal validity. Future studies are encouraged to complement these initial findings by conducting longitudinal field experiments or case studies, in order to advance the external validity of the thesis’ findings.

In conclusion, to the best of our knowledge this thesis provides the first systematic overview of research on cognitive biases in the IS literature. It also makes the first step in understanding the interplay between dynamic IT artifacts and changing users’ beliefs, attitudes and behaviors under consideration of biased cognitive processing and decision-making. In doing so, this thesis advances the existing view in the IS literature regarding the role of the human factor in the IS discipline. Furthermore, presenting evidence from different IS usage contexts, the thesis’ results disclose the potential of cognitive biases to impact companies’ product, marketing or corporate security strategies. We therefore hope that our results will encourage future research studies to dive deeper in understanding the role of cognitive biases in IS, and will animate IS practitioners to consider cognitive biases and biased decision-making in their daily business life.

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## Appendix

### Appendix 4.A

*Continuance Intention (7-point Likert scale adapted and modified from Bhattacharjee 2001)*

- CI1** I intend to continue using eWrite rather than discontinue its use.
- CI2** My intentions are to continue using eWrite than use any alternative means.
- CI3** If I could, I would like to discontinue my use of eWrite. (reverse coded)

*Satisfaction (7-point Likert scale adapted and modified from Kim and Son 2009)*

- SAT1** I am content with the features provided by the word-processing program eWrite.
- SAT2** I am satisfied with the features provided by the word-processing program eWrite.
- SAT3** What I get from using the word-processing program eWrite meets what I expect for this type of programs.

*Perceived Usefulness (7-point Likert scale adapted and modified from Kim and Son 2009)*

- PU1** Using eWrite enhanced my effectiveness in completing the task.
- PU2** Using eWrite enhanced my productivity in completing the task.
- PU3** Using eWrite improved my performance in completing the task.

*Perceived Ease of Use (7-point Likert scale adapted and modified from Kim and Son 2009)*

- PEoU1** Interacting with eWrite does not require a lot of mental effort.
- PEoU2** I find it easy to get eWrite to do what I want it to do.
- PEoU3** I find eWrite easy to use.



*Disconfirmation (7-point Likert scale adapted and modified from Bhattacharjee 2001)*

**DISC1** My experience with using eWrite was better than what I expected.

**DISC2** The service level provided by eWrite was better than what I expected.

**DISC3** Overall, most of my expectations from using eWrite were confirmed.

## **Appendix 4.B**

*Control Questions (Self developed)*

- 1) What was the experimental task? (To format the entire text; to format the text as appealingly as possible)
- 2) How many updates did you receive during the experiment? (no updates; one update containing three features; three updates each containing one feature; one update containing three non-features; three updates each containing one non-feature)
- 3) How many features did you have at the end of completion time? (one feature; four features)

## **Appendix 4.C**

*Questions for Manipulation Check Study (Self developed)*

- 1) As how frequent did you perceive the updates that you received during the experiment? (7-point Likert scale; 1=not frequent at all, 7=very frequent, I did not receive any updates)
- 2) As how helpful did you perceive the updates that you received during the experiment? (7-point Likert scale; 1=not helpful at all, 7=very helpful, I did not receive any updates)