University of Basel

Faculty of Psychology

Antecedents of Perceived Stress in Technology Use

Master Thesis

Alexander Ruch, B.Sc.

Department of Psychology,

Center for Cognitive Psychology and Methodology,

University of Basel, Switzerland

Supervisors: Alessia Ruf, M.Sc. & Prof. Dr. Klaus Opwis

Spring Semester 2020

Correspondence:

alexander.ruch@unibas.ch

Abstract

The perception of stress in technology use is a widespread phenomenon with potentially detrimental subsequent effects on health, especially in psychopathology. Together with the continuously increase of technology use, the identification of antecedents of *Perceived Stress* (PS) is pivotal to make inferences for possible preventive actions. One highly relevant field of technology use is *Computer-Mediated Learning* (CML). In this work, constructs derived out of four aspects that are crucial for CML use and PS are combined and tested in a path model: the amount of engagement in CML in general (*CML Use*), the attitude towards using CML (*CML Acceptance*), cognitive processing demands (*Mental Effort* and *Perceived Information Overload* (PIO)) and trait characteristics (*Trait Rumination*). Two studies were conducted. The main study included 177 subjects between 18 to 53 years of age that reported about their general use of CML, the cooccurring extent of PS and the other mentioned constructs through questionnaires. Study 2 included 103 subjects, that were between 17 to 71 years old. There, a reduced part of the path model, including CML Use, Mental Effort, PIO and PS was tested after the subjects were using a specific e-learning software. The results of the main study show that CML Acceptance has a weakening effect and Trait Rumination a reinforcing effect on PS in CML use, although these findings need further investigation due to methodological limitations. Mental Effort and PIO did not have substantial effects on PS in both studies. These results suggest that it is especially important to take aspects of acceptance and trait characteristics (Trait Rumination) of CML users into account when considering the implementation of preventive actions regarding the design of CML software and work environments to reduce PS.

Keywords: Information and Communication Technology, Computer-Mediated Learning, Stress, Information Overload, Cognitive Load, Mental Effort, Acceptance, Rumination

Introduction

Information and Communication Technology (ICT) use has massively increased in the past years (e.g., Vorderer & Kohring, 2013), and will most likely continue so in the future, since digital transformation has long become a top priority in economics and politics (Selwyn, Gorard, & Furlong, 2006). This increase in ICT use is strengthened through a social context with corresponding motivational factors affecting the individual (Wang & Chen, 2012). Examples of this motivational factors are the *Need for Relatedness*, *Competence* and *Autonomy* (e.g., Reinecke, Vorderer, & Knop, 2014) as described as the basic human needs by the Self-Determination Theory (Ryan & Deci, 2000). Further, also the attempt of increasing *Social Capital* (Ellison, Vitak, Gray, & Lampe, 2014) and the *Fear of Missing Out* (an aspect of social pressure; Przybylski, Murayama, DeHaan, & Gladwell, 2013). Criticism of this trend of increasing ICT use arise for example from the accompanied imperatives emanating from *digital conformism*, that include the proclamation of the lack of alternatives of using technology and subsequent processes of conformity in form of occupational and social pressure (Seppmann, 2017). This progression, with more or less subtle dictates, raises increasing quantities of questions on psychological aspects of ICT use, as it is more and more unrealistic to not be obligated in some way to use ICT, at least in an occupational environment and in learning (de Sousa, 2019). Therefore, it is important to find ways to improve the interaction with ICT by minimizing potential harm to its users. Beside benefits (including the satisfaction of needs derived from motivational factors), there are several risks of harm caused by ICT use. Apart from physical risks coming from the domain of ergonomics (see e.g., Harris & Straker, 2000), psychological risks, especially the perception of stress, also termed as Perceived Stress (PS; Cohen, Kamarck, & Mermelstein, 1983), must be considered. It has been shown that PS in ICT use is related to anxiety (e.g., Reinecke et al., 2018), depression (e.g., Thomée, Eklöf, Gustafsson, Nilsson, & Hagberg, 2007) and burnout (Reinecke et al., 2017). There are a variety of additional terms that are used to describe technology-induced PS, for example the term *Digital Stress*, that is defined as *"stress reactions elicited by environmental demands originating from ICT use"* (Reinecke et al., 2017, p. 3), which is quite similar to the definition of the older and widely used term *Technostress: "Stress caused by an inability to cope with the demands of organizational computer usage"* (Tarafdar, Tu, & Ragu-Nathan, 2010, p. 304). The notion in the definition of the Digital Stress concept implies certain environmental demands that lead to stress in ICT use. Reinecke et al. (2017) further identified and tested the two constructs *Communication Load* (e.g. the number of sent and received social media messages or private e-mails) and *Internet Multitasking* (the concurrency of ICT use and other activities). Their results showed that these constructs increase stress and are moderated by age. The present work intends to identify further potential constructs that influence the relation between ICT use and stress (here defined as PS) by testing a proposed research model, to get a more comprehensive insight in the relations between ICT use and PS. Four potential constructs derived from related theories are considered: (1) *Information Overload*, (2) *Cognitive Load*, (3) *Acceptance* (of ICT) and (4) *Rumination*. An overview of all constructs with corresponding theories is displayed in Table 4. The corresponding considerations of the inclusion of these constructs are as follows: As visible in the definition of Technostress, coping with demands while using ICT may be a crucial factor in the forming of stress. To account for this, the constructs (1) Information Overload (Lipowski, 1975) and (2) Cognitive

Load (Sweller, 1988) were added to the model, since both are useful to characterize certain types of (cognitive) demands in the interaction with ICT for the user. While Information Overload considers information loss occurring due to sensory memory strain (too much information to process), Cognitive Load (or *Overload*) refers to an aggravated exchange between prior existing knowledge and new information in the long-term memory (Chen, Pedersen, & Murphy, 2011). Furthermore, a central concept of influential stress models is that of *Coping*, considered in the present study with the Transactional Model of Stress and Coping (TMSC; Folkman & Lazarus, 1984), is also explicitly stated in the definition of Technostress (Tarafdar et al., 2010). According to the TMSC, coping relates to an evaluation of the demands provided through the environment as being harmful (or beneficial). Depending on this perception, PS is shaped (Lazarus & Folkman, 1987). To take into account and integrate this aspect of PS, the two constructs of (3) Acceptance (of ICT) and (4) Rumination are additionally included in the research model. Acceptance (of ICT) may also affect PS through coping evaluation processes. Rumination, as defined in the Goal Progress Theory (GPT; Martin & Tesser, 1996) and as used in the present work, depicts a trait, that describes an individuals' predisposition to response to failures regarding satisfactory progress towards goals (Smith & Alloy, 2009). This in turn is a potential candidate to influence the PS reaction when environmental demands challenge goal attainment and further coping (Martin & Tesser, 1996).

In sum, the main goal of the present study is to contribute to the identification of constructs involved in the relation between ICT use and PS. Therefore, these constructs are combined and tested in a path analysis. This form of analysis is designed to test theoretically derivated models of causal relations between variables or constructs (Denis & Legerski, 2006) and is therefore well suited for the purpose of this research. The proposed path model is referred to as the research model.

As ICT is a not accurately defined and a vastly general term, accordingly also ICT use, the research model is tested in a learning context. As mentioned before, learning is identified as an important field where ICT use is pushed wieldy, especially in schools and universities, where students (have to) adapt to this progression (Tiernan, 2015). Investigating the potential harm originating from PS in a learning context is considered as highly relevant. To account for this learning context, the denotation of ICT use for learning is adapted to that of Computer-Mediated Learning (CML; e.g. used in Whiteman, 2002).

The research model is defined through theoretical deliberations; thus, a focus of this work is set on reviewing the involved constructs and their underlying theories.

Theoretical Framework

In this theoretical framework, the constructs that are included in the research model are presented. First, the terms ICT and CML will be discussed in detail, before their use and acceptance are described. As acceptance of technology is closely related to attitude research, the most important theories in this field are reviewed. Afterwards, PS, Cognitive Load, Information Overload, Rumination and their underlying theories are presented in greater depth.

ICT, CML, its use and acceptance

To clearly define the context of the present work, the terms ICT and CML are elaborated and deliberations about their usage are introduced, followed by theories about attitudes and acceptance of technology.

ICT and CML definitions

As the focus is set on the use of technology in the field of computer-based education, the term Computer-Mediated Learning (CML) is used in the following described studies. But first, a step back for approaching the field of technology is needed. When talking about technology, an approach to specify and categorize the use of it arises from the concept of Information- and Communication Technology (ICT), which is used in a large variety of contexts. ICT includes a derivation of the broader term *Information Technology*, aspects of describing economic development, personal and business use and education. In an attempt to illustrate this broad field of ICT, Zuppo (2012) proposed a hierarchy, which is shown in Figure 1.

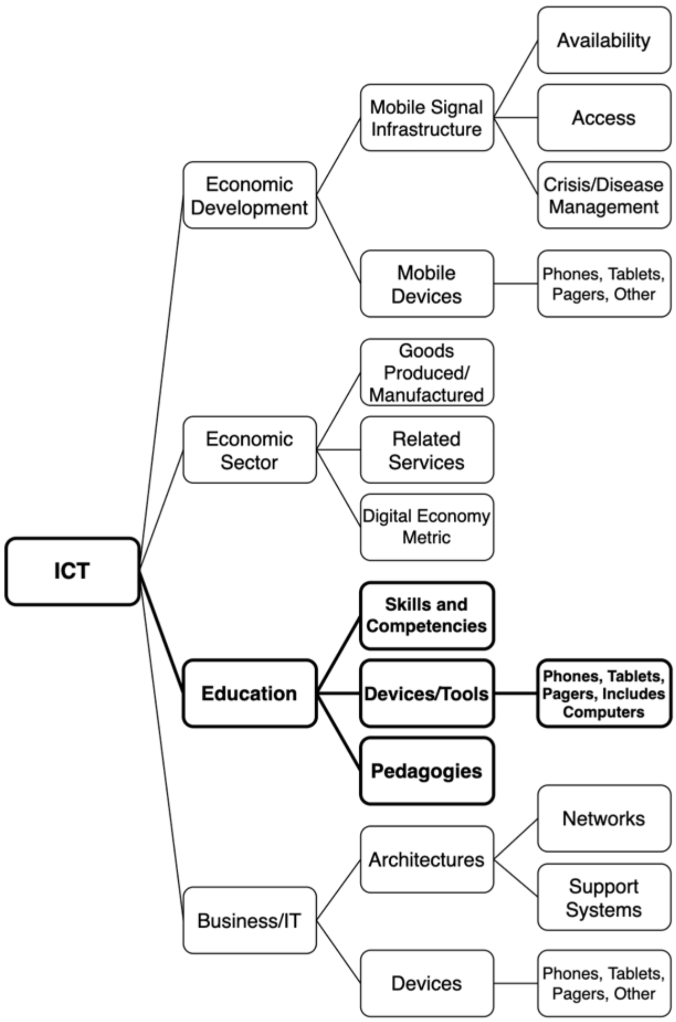

Figure 1: Categorization of Information- and Communication Technology, derived from Zuppo (2012). The relevant *Education* segment is marked in bold.

The above illustration suggests that it is important to specify the term ICT to avoid any possibilities of confusion by its usage. Here, because of its central importance to this work, solely the *Education* category is covered in the meaning of ICT, including the sub-categories:

- *Devices and Tools*: The actual usage of information processing devices, including desktop computers, laptops, tablets and smartphones.
- *Skills and Competencies*: The specific amount of skills and competencies that are required to use ICT in a proper way, or the lack of them.
- *Pedagogies*: ICT methodologies in educational pedagogies and teaching (e.g., e-Learning).

At this point, it is important to mention, that the “C” in ICT, which stands for Communication, is not necessarily included in all applications that refer to the term (Zuppo, 2012). ICT is used in many publications and corresponding studies this work refers to, without an adjustment to the context, for example in learning. To the authors opinion, this may potentially lead to confusion of study subjects that are confronted with the term. Other terms such as *ICT-based learning* (e.g. used in Selwyn et al., 2006) fit better to the context of the present work, whereas it may also be difficult to understand. As a further alternative, the term CML was identified and finally chosen to be used, as it facilitates a clearer understanding for the investigated study issue of the research model. The term CML has also already been used in a wide range of studies (e.g., Whiteman, 2002). When referring to CML here, the ICT education sub-categories (Figure 1) are covered. This term includes also the concept of *Computer-Supported Collaborative Learning* (CSCL), which sets its emphasis on the social interaction while using technology (computers) for learning purposes. CSCL is relevant in one of the conducted studies in the present research (see methods section of study 2). CML is used as an umbrella term, which includes the aspects of CSCL and is circumscribed by the context of ICT in education.

ICT/CML use

As stated before, the use of ICT/CML is constantly rising, which gives health related questions a growing relevance. Consequences on health, for example symptoms of depression and sleep disturbances (Thomée et al., 2007), are of particular interest, since the usage and dissemination of technology in the daily live takes such a prominent role in the society. As this work is written, the 2020 SARS-Cov-2 (Severe acute respiratory syndrome coronavirus 2) pandemic outbreak and resulting public lockdowns around the globe are taking place (World Health Organization, 2020). In the course of this event, subsequent provisions to deal with spreading control or prevention regarding similar events in the future are wieldy discussed (Basilaia & Kvavadze, 2020). Through this event, it is likely that ICT/CML use will be fostered even more. As for example, many world regions closed schools and home schooling with CML technologies gaining a central role in the attempts to diminish the shortcomings of these closings, as it was also observed during the 2003 SARS pandemic in Hong Kong (Wong, 2004). It is reasonable to believe that this development will have lasting effects of learning practices also after the crisis, at least in countries with sufficient available ICT resources (compare with Zuppo, 2012). Moreover, when taking considerations about voluntariness of ICT/CML use aside, there are identified demographic mediators that influence ICT use, which are age, experience, gender and educational levels (Helsper & Eynon, 2010). Also, demographic characteristics influence motivational factors of ICT use (for age see Reinecke et al., 2017).

After the relevance of ICT/CML use research has been shown, the next step is to discuss its acceptance, which is assumed to play a key role in the relation to PS.

ICT/CML Acceptance and attitude research

From a psychological point of view, a central role for the establishment of ICT/CML use is its acceptance by individuals (Davis, 1985). A significant impact in acceptance is attributed to the *Mere Exposure Effect*, which describes that more familiarity through frequent exposure to something (e.g. CML) leads to an increased general preference for it (Zajonc, 1968). While the influence of the Mere Exposure Effect is incorporated in attitude and acceptance theories (see below), there are more complex and differentiated approaches to the mechanisms of acceptance originating from attitude research, which is reviewed hereafter. Attitude is inherent in the generalized psychological definition of acceptance, that is *"a favorable attitude toward an idea, situation, person, or group"* (VandenBos, 2007, p. 6). However, this definition needs further investigation to fully understand its coherences and how it is used in the present research model.

In this section, in-depth inspections of selected attitude and acceptance theories are presented to give an overview of the corresponding models and their progressions, with the goal of highlight their importance and further to elaborate how the term acceptance is used in this work in detail. Taking the before clarified progression of ICT/CML use into account, its acceptance by users has gained particular interest by researchers and has become a mature research area in the field of *Information Systems* (Venkatesh, Morris, Davis, & Davis, 2003). As a result of this development, various theories have been established to explain how acceptance is manifested in technology use. The theories have either been directly developed to ICT Acceptance (e.g., Davis, 1985) or are of a more general kind coming from research on attitudes, intentions and their interplay with behavior (e.g., Fishbein, 1967). Especially mentionable in the field of Human-Computer Interaction (HCI) is the Technology Acceptance Model (TAM; Davis, 1985). The gain of this model was to find variables that mediate between the actual use of computer-based systems and the system characteristics, to examine how these variables are related, and how they can be measured prior to their implementation in organizations (Davis, 1985). Before getting into details about TAM, it is crucial to mention that TAM uses theoretical foundations originating by the work of Martin Fishbein and Icek Ajzen on attitudes and the prediction of behavior (Fishbein, 1967) that resulted in the Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975). TRA has been later on refined to the Theory of Planned Behavior (TPB; Icek Ajzen, 1991), which was developed after the TAM. The theories are presented in the following order: (1) TRA, (2) TPB, (3) TAM and (4) further developed TAM theories.

Starting with TRA, Figure 2 shows the corresponding schematic diagram. For explanations of the single components, see Table 1. TRA aims to explain and predict overt behavior of individuals, which is determined by intention. Intention in turn is formed by an *Attitude Toward a Behavior* (ATB) as well as from *Subjective Norms*. The respective degree of influence of ATB and Subjective Norms on intentions is guided by their relative importance (Fishbein, 1967). Things like demographics and personality traits are not considered directly in the model, but as external variables. This is also the case for the so-called *Attitude Toward an Object* (ATO; also called attitudes toward targets; Kan & Fabrigar, 2017). The distinction between ATB and ATO is of particular importance and is looked at following the presentations of the theories.

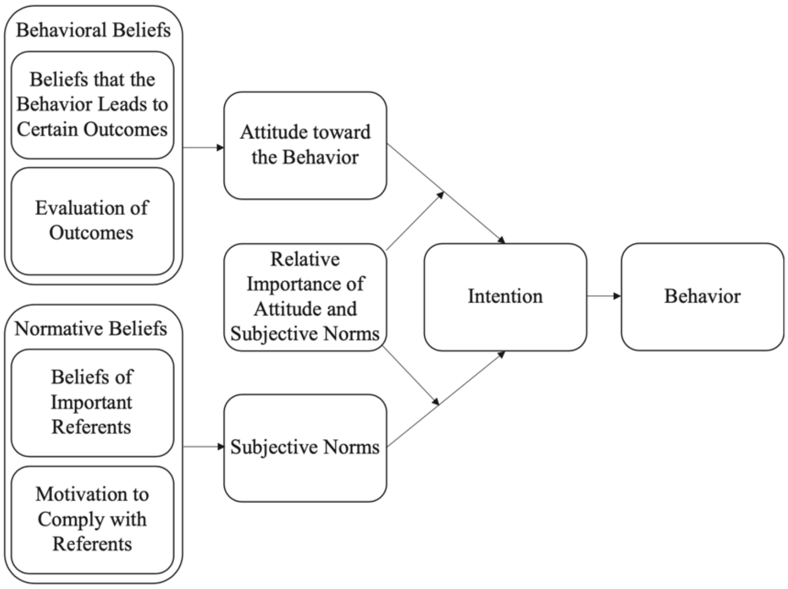

Figure 2: Schematic diagram of the Theory of Reasoned Action (TRA; H. Ajzen & Fishbein, 1980). Adapted from Kan and Fabrigar (2017, p. 2).

As mentioned, the TRA, has then been further developed to the TPB. The difference to TRA lies in the addition of the construct *Perceived Behavioral Control* (see Table 1), that represents a third determinant (beside ATB and Subjective Norms) crucial for the formation of intention and behavior. The inclusion of this additional construct to the TPB, results from critique about the TRA, suggesting that it only focuses on behavior that is formed under high level of volitional control (Kan & Fabrigar, 2017). The authors recognized that this level of control can differ/be absent across behaviors and thus revised their theory accordingly (Icek Ajzen, 1985). Beside this additional construct, the structure and the other components proposed by the TRA also applies to TPB. For the schematic diagram of TPB, see Figure 3.

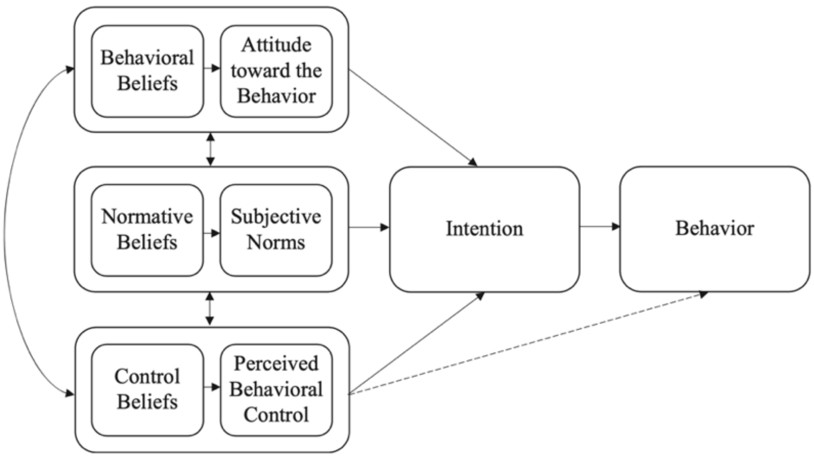

Figure 3: Schematic diagram of the Theory of Planned Behavior (TPB; Icek Ajzen, 1991). Adapted from Kan and Fabrigar (2017, p. 4).

Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB)		
Component	**Definition**	**Implications**
Attitude Toward a Behavior (ATB)	The evaluation by the individual to perform an action or set of actions. Aggregate of beliefs that the behavior leads to a certain outcome (likelihood) and the evaluation (positive/negative) of that outcome.	- Attitude is aimed toward the behavior, not the object associated with the behavior - Determined by *Behavioral Beliefs*
Subjective Norms	The perception of the individual that most people who are important to him/her think he/she should or should not perform the behavior in question.	- Determined by *Normative Beliefs* and the motivation to comply with specific referents - The activation of normative information from memory influences the perception of an attitude object/event
Intention	The likelihood to actually perform a behavior as perceived by the individual.	- Most proximal determinant of behavior - All other predictors are mediated by intention - Behavior is seen as always deliberate, due to the mediation by intentions - If determinants (Subjective Norms or ATB) are in disagreement, the determinant of intention with the greater weight will be more influential on intention
Only in TPB: **Perceived Behavioral Control (PBC)**	The perception by Individuals about the ease or difficulty of performing the behavior of interest.	- Exists beside one's *Actual Behavioral Control* (ABC; the ability to perform a behavior determined by external factors). But when PBC is an accurate indication for ABC, it directly influences the actual behavior - Determined by *Control Beliefs*, which are the presence or absence of factors that facilitate or hinder performance of a behavior
Behavior	Individuals overt action or set of actions. Construed of *action*, *target*, *context* and *time*.	- Distinction between behavior and outcome important

Table 1: Definitions of TRA and TPB constructs. Adapted from Kan and Fabrigar (2017) & Icek Ajzen and Fishbein (1973).

Beside strong support provided by meta-analyses (e.g., Armitage & Conner, 2001), various kinds of criticism has been formulated for both TRA and TPB (Kan & Fabrigar, 2017). One critique gained much attention and is a good example of the underlying central problem of TRA/TPB: The absence of the influence of past behavior and habits on intention and behavior, for which evidence was found (e.g., Ouellette & Wood, 1998), and that is also proposed in the Mere Exposure Effect (Zajonc, 1968). Although there is strong evidence for the predictive power of the three proposed determinants of intention (ATB, Subjective Norms and Perceived Behavioral Control), the exclusion of e.g. influences of past behavior led to the conclusion that further determinates may exist that are as strong or even stronger predictors of behavior (Kan & Fabrigar, 2017).

After this introduction to TRA/TPB, it is crucial to set a connection to the research field of ICT acceptance, that developed their own specific models in the context of attitude-behavior relations. The most widespread model in the technology sector and a derivate from the TRA (Taherdoost, 2018) is the Technology Acceptance Model (TAM; Davis, 1985). TPB was developed after TAM. Its structure is shown in Figure 4 and definitions of the individual components are explained in Table 2.

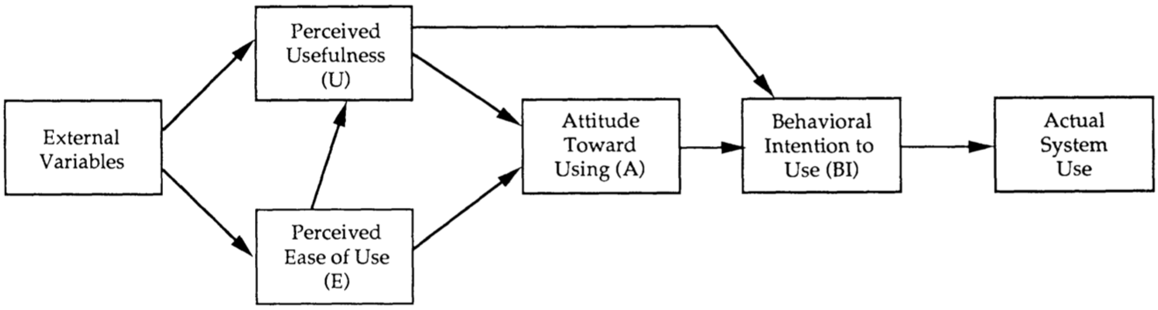

Figure 4: Technology Acceptance Model (TAM). Adapted from Davis, Bagozzi, and Warshaw (1989, p. 985).

Technology Acceptance Model (TAM)		
Component	**Definition**	**Implications**
Perceived Ease of Use	The degree of which the user excepts the target system to be free of effort	- Is influenced by design features/external variables
Perceived Usefulness	User's subjective probability that using a specific application system will increase his or her job performance within an organizational context	- Is influenced by design features/external variables
Attitude Toward Using	User's evaluation of the desirability of his/her using the system	Is equivalent to ATB in TRA/TPB
Behavioral Intention to Use	Equivalent to Intention in TRA/TPB	
Actual System Use	Equivalent to Behavior in TRA/TPB	

Table 2: Definitions of TAM constructs. Adapted from Davis (1989)

In a very clear fashion, Methieson (1991) compared the TPB and TAM approaches to predict behavior in the context of ICT-Acceptance (originally referred to as *Information System-Acceptance*). In his work, three main differences between TPB and TAM have been identified:

1. Varying degree of generality:

In contrast to TPB, TAM predefined a set of *Behavioral Beliefs*, that are identified as crucial for the context of technology acceptance, according to Davis (1989). Those beliefs are *Perceived Usefulness* and *Perceived Ease of Use* (see Table 2). These two specific types of beliefs are just not predefined in TPB (and accordingly also not in TRA). But the theory also proposes the influence of not further defined Behavioral Beliefs (see Figure 3), which means that the two models do not contradict each other, but only vary in the degree of generality. Contrary to TPB, the TAM model allows no inclusion of additional beliefs beside Perceived Usefulness and Perceived Ease of Use. In TPB, relevant beliefs have to be identified in every case before the model can be used with the given issue.

2. Inclusion/Exclusion of social variables:

TAM does not include social variables compared with TPB (Subjective Norms). There are conflicting opinions on these different approaches. While Davis et al. (1989) postulated that Subjective Norms have no significant effect on user acceptance, Mathieson (1991) on the other hand noted that the systematically exclusion of social variables has the flaw to exclude unique variance (that may be important depending on the context) to behavioral intention.

3. Different models of behavioral control:

Again, the difference in the models concerning generality (see point 1) is reflected in the handling with behavioral control variables. In the TAM, there is only one such variable that is proposed to have influence on attitude, which is Perceived Ease of Use, defined as *"the match between the respondent's capabilities and the skills required by the system*" (Mathieson, 1991, p. 179). The TPB is more open to add different kinds of behavioral variables that may be important in specific contexts, which can be differentiated in external (situation-dependent) and internal (e.g. willpower and skill) factors, while Perceived Ease of Use only refers to as an internal factor.

Both models explained intention quite well, but TAM seems to have advantages in explaining ATB of Information Systems. However, Mathiesons' (1991) conclusion about the comparison of TAM and TPB highlights advantages on both sides: "*TAM provides a quick and inexpensive way to gather general information about individuals' perceptions of a system. It can be used to measure general levels of satisfaction across a range of users with diverse interests. TPB delivers more specific information, giving more insight into why an individual or group might be dissatisfied*." (Mathieson, p. 187). Beside this generally favorable validation, TAM also faced a lot of criticism (compare e.g., Taherdoost, 2018). As an result, in 2000, the Technology and Acceptance Model 2 (TAM 2 or *Extension of TAM*; Venkatesh & Davis, 2000) has been proposed, with its main change to include Subjective Norms into the model (see Figure 5). With this step, TAM 2 adjusted itself toward TRA/TPB.

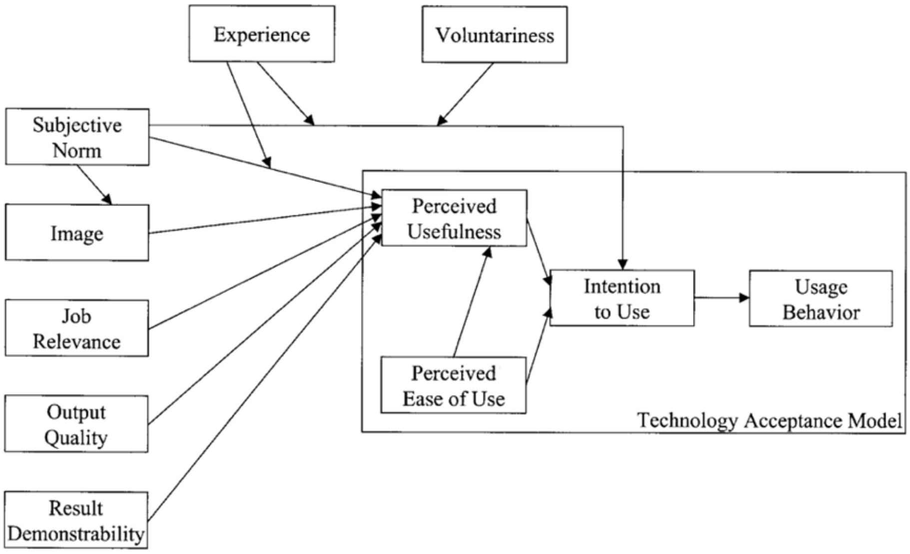

Figure 5: Technology Acceptance Model 2 (TAM2). Adapted from Venkatesh and Davis (2000, p. 188).

TAM models have been further developed and modified, resulting in The Unified Theory of Acceptance and Use of Technology (UTAUT) or the *Final TAM* (see Figure 6; Venkatesh et al., 2003). This model surprisingly excluded ATB from technology acceptance, based on a survey of literature and the conclusion, that Perceived Usefulness is more significant towards behavioral intention (Davis et al., 1989). This can be interpreted as that users have a favorable behavioral intention to use technology if it is perceived as useful, even though their attitude towards behavior is negative (Davis et al., 1989). This is conflicting with the observation of ICT Acceptance being also an social phenomenon, where attitudes play an important and central role (Zhang, Aikman, & Sun, 2008). This conflict could further be a consequence of an underlying conceptual problem, which is that Information Systems literature is mixing up the concept of ATB with ATO, as shown by Zhang et al. (2008). This observation is discussed in detail, as it is crucial for the definition of acceptance in the conducted studies of this work.

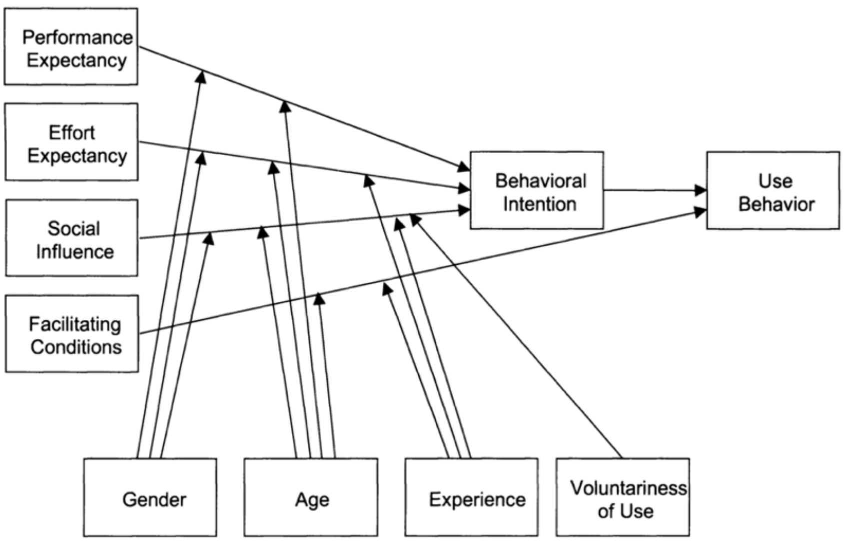

Figure 6: The Unified Theory of Acceptance and Use of Technology Model (UTAUT). Adapted from Venkatesh et al. (2003, p. 447).

Attitude Toward a Behavior (ATB) vs. Attitude Toward an Object (ATO)

As shown in the section about TRA/TPB, it is of particular importance to distinguish between Attitude Toward a Behavior (ATB) and Attitude Toward an Object (ATO), as the latter is only seen as an external variable in the reviewed models, without direct influence on intention and behavior (Kan & Fabrigar, 2017). ATO is defined as the evaluation of a particular entity, differing in the degree of favor or disfavor (Crites Jr, Fabrigar, & Petty, 1994). In contrast, ATB is an individual's evaluative affect (positive or negative feelings) about performing a certain behavior, not about an object itself (Fishbein & Ajzen, 1975). To deepen this further, Zhang et al. (2008) showed in their research, that in the context of ICT Acceptance it is particularly important to make the distinction between ATB and ATO. They were able to show that ATO's effect on behavioral intention is fully mediated by ATB. Beside this, ATO may have some positive influence on ATB. Accordantly, they conclude that ATB is a better predictor of behavioral Intention than ATO. To further underpin this inference, the results shown by Zhang et al. (2008) indicate that ATB does not change even when using a new ICT Software in comparison with a previous similar or an older version of ICT Software, even if ATO changes.

In conclusion, this means that even if an attitude toward an ICT, for example, a particular CML software, is favorable, the attitude toward using this software still can be different (not favorable) and this is crucial for the behavioral intention. Derived from this apparent importance of ATB in ICT Acceptance models, deliberations about its integration in the research model are indicated and displayed in the next section.

The actual CML Acceptance as Attitude Toward a Behavior (ATB)

Which element or definition represents the *actual user acceptance* (that is measured) in the previous described models however, is still unclear, or as mentioned by Sun and Zhang (2006): *"(…) some studies use ATB while others use BI [behavioral intention] or actual usage as the indicator of user acceptance".* As shown, ATB is immanent in forming behavioral intention in most presented models (TRA, TPB, and TAM) and the omission of it in further developed TAM models gained considerable criticism (Zhang et al., 2008). This makes ATB a good candidate to measure actual acceptance, also because of its inherent focus on behavior (in comparison with ATO). Furthermore, there are strong reasons to not decide for behavioral intention or the actual behavior to measure the actual acceptance. Behavioral intention is influenced by Subjective Norms, according to TRA, TPB, TAM2 and UTAUT and thus, undermine the actual acceptance by the user through a distortion potentially coming from social pressure. The same applies to the actual behavior, as it is fully or nearly fully mediated by behavioral intention (compare with model figures). Also, in the context of this work, due to the design of the studies to test the research model, measuring the actual behavior (actual use) as the actual acceptance is not reasonable. This is the case, because subjects are either obligated to use an ICT/CML (study 2) or there is a lack of alternatives in university education, so the behavior is not reflected clearly as acceptance (see the method section for details). Hence, the author chooses ATB for measuring CML acceptance in the research model.

Perceived Stress (PS)

After the insight in definitions concerning ICT/CML, and their use and acceptance, the topic of stress is introduced, as the overarching issue of this work is the relation between CML use and stress perception. Scientific research does not provide a consistent definition of stress (Koolhaas et al., 2011). However, a consensus regarding the meaning of psychological stress was proposed by Steptoe (1991), who defined stress as a complex of emotional and behavioral reactions to psychosocial stimuli (stressors) that are perceived as aversive (from *aversion*; the *“physiological or emotional response indicating dislike for a stimulus. It is usually accompanied by withdrawal from or avoidance of the objectionable stimulus”* (VandenBos, 2007, p. 100). Thus, stress is created through an imbalance between stimuli and psychosocial resources available to the individual. More general, this imbalance is also seen as an *“unfavorable person-environment relationship”* (Lazarus, 1993, p. 8). This may lead to a feeling of distress and the perception of a threat, resulting in an increase in vigilance (prolonged alertness), enhanced anxiety and worrying (McEwen & Wingfield, 2003). There are also psychological concepts, where stress may lead to a positive outcome, if an event is not perceived as aversive (negative interpretation), but as a challenge (positive interpretation) that may lead to a feeling of exhilaration (Selye, 1976). In the present work, the focus is laid on the negative notion of stress, as used for example by Lazarus and Folkman (1987): “*Stress, which primarily concerns negative person-environment relationships, cognitive appraisals, and emotional response states such as fear, anger, guilt, and shame (…)*” (p. 142). As the psychological aspect of stress gives strong emphasis to the subjective nature of the perception of it, the term Perceived Stress (PS) is used in the present work. These deliberations about the stress concept also imply that there are specific physiological correlates to PS. When an event is perceived as stressful, specific physiological reactions automatically occur, which mainly consist of the activation of the autonomic nervous system (e.g. increasing heart rate and sweating) and the endocrine system through the hypothalamic–pituitary–adrenal axis (HPA-Axis; McEwen & Wingfield, 2003; see Figure 8). The HPA-Axis response is ultimately leading to cortisol release, which for example has effects on the suppression of the immune system (McEwen, Nasca, & Gray, 2016) and memory retrieval (de Quervain, Roozendaal, & McGaugh, 1998). Exaggerated HPA-Axis activity through repeated acute stress is associated with health impairment (e.g. neurodegenerative, psychiatric, and metabolic diseases), as feedback mechanisms to control cortisol release is altered (Gianferante et al., 2014).

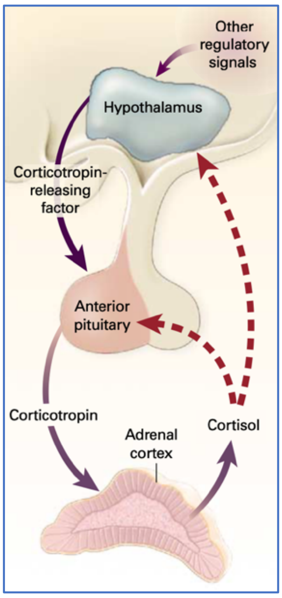

Figure 7: The HPA-Axis with its main cascade of transmitter release in response of stress. Corticotropin-releasing factor (hormone) from the hypothalamus initiate corticotropin (adrenocorticotropic hormone) production and its release in the bloodstream, leading to cortisol release from the adrenal cortex and includes a feedback mechanism (which can be corrupted in stress-related disorders such as depression) to regulate further transmitter release. Adapted from Yehuda (2002, p. 111)

As mentioned above, PS is occurring as an unfavorable person-environment relationship (Lazarus, 1993). In the influential Transactional Model of Stress and Coping (TMSC; Folkman & Lazarus, 1984), the focus of PS (or more generally also of emotions) is set on this relationship between a person and properties coming from the environment, and PS only results in the transaction between those two. Lazarus and Folkman (1987) stated: *"in the relationship their independent identities are lost in favour of a new condition or state"* (p. 142), e.g. threat or stress. This notion has important implications to the research model, as the included constructs influence this person-environment relationship transaction and may determine PS levels of individuals. While the constructs Information Overload and Cognitive Load are probably more likely be fueled by environmental demands, ICT/CML Acceptance (ATB respectively) and Rumination are characteristics of a person (for details see the hypotheses section). Along with this aspect of the person-environment relationship, TMSC further defines subjective perception of stress in more detail. PS as defined in the present work refers to these deliberations. The perception of stress is determined through the process of the so-called *Cognitive Appraisal*, that is defined as the evaluation about the significance of perceived information for one's self (Lazarus & Folkman, 1987). Cognitive Appraisal is segmented into two parts, *Primary Appraisal* and *Secondary Appraisal*. Primary Appraisal describes the evaluation about an environment demand as harmful (e.g. threatening) versus beneficial (e.g. challenging). This evaluation tends to an outcome in the direction of harm if goal achievement (or commitment) by the person is prevented by obstacles coming from the environment (Lazarus & Folkman, 1987). Secondary Appraisal on the other hand, describes the subsequent evaluation of capabilities to cope with the given environment demand (improve of the person-environment relationship) and determines the perceived control over the situation. These cognitive appraisal processes thus determine PS, including the physiological reactions as described before (McEwen, 1998). In this work, CML Use represents an environmental demand and Cognitive Appraisal processes account for PS, while potentially is modified by the other constructs of the research model, also elucidated in the hypotheses section.

To this point, the two "poles" of the research model (CML Use and PS) and their underlying proposed casual flow (as represented in a path model, see Figure 10), were introduced. Also, the first construct that functions in between them, CML Acceptance was discussed. Next, the constructs that account for the aspect of cognitive demands are presented: Cognitive Load and Information Overload. They are also placed between CML Use and PS (and CML acceptance).

Cognitive Load and Mental Effort

The term Cognitive Load originated from the corresponding Cognitive Load Theory (CLT; Sweller, 1988). CLT has been formulated for the sake of providing guidelines for designing learning material by improve their quality through the reduction of working memory demands (Sweller, 1988). Working memory is defined as a *"brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning"* (Baddeley, 1992, p. 556) including the capability to transfer into, and retrieve from long-term memory (Baddeley, 2006). The assumption of a limited capacity of working memory (or short-term memory, as this memory concepts are overlapping; Miller, 1956), is one central aspect of the CLT (Sweller, Van Merrienboer, & Paas, 1998). On the other hand, long-term memory is theoretically assumed to have unlimited capacity (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Long-term memory in the context of CLT functions as a provider of knowledge structures that are used to organize and guide cognitive processing in learning (Executive Guidance; Kalyuga, 2009). Cognitive Load takes place in the interaction between working memory and long-term memory and the process of constructing new knowledge, or the failure of doing so (Sweller et al., 1998), as depicted in Figure 9. Only when Cognitive Load is low (a minimized risk of Cognitive Overload), new knowledge can be formed successfully (Sweller, 2011). To transfer prior knowledge to new situations and the possibility to create new knowledge, a process named *Schema Construction* takes place, where multiple information elements are being chunked into a *Cognitive Schema* that represents a new single element (Sweller, 2011). This process occurs automatically. The advantage of this chunking of multiple elements into schemata lies in their ability to bypass the limited capacity of working memory (Sweller, 1988). As the amount of Cognitive Load and the subsequent construction of new knowledge is depended on prior knowledge (also represented as schemata) that is stored in the long-time memory, the lack of it can be compensated by instructions in learning materials (Paas et al., 2003). In the origins of CLT, the focus was set on the appropriate design of instructions of learning material to set Cognitive Load to a level, where new knowledge can be acquired in an optimal way (Sweller, 2011).

In conclusion, the main notion of the CLT is that Cognitive Load can be reduced by already existing schemata that guide the acquisition of new knowledge or if particular designed introductions (that take the limited capacity of working memory into account) are utilized (Sweller, 2011).

As the scope of the present research is set to Cognitive Load in the narrower sense and not primarily on its implication to instruction design, a more precise approach to its definition is needed. A generalized approach (on basis of CTL elements) to define Cognitive Load resulted in a multidimensional construct that specifically represents the load (strain) that is imposed on a learner's cognitive system, when performing a particular task (Paas & Van Merriënboer, 1994). Figure 8 displays a schematic view on the aspects of this cognitive load construct and Table 3 gives explanations to the particular corresponding elements.

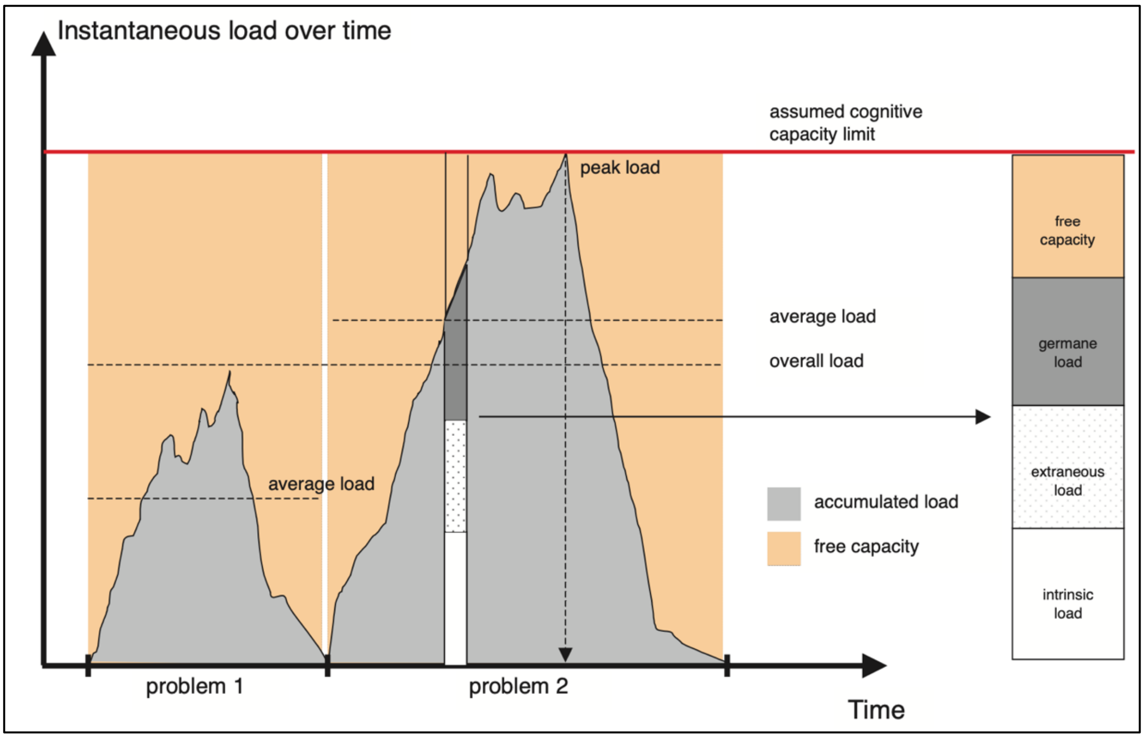

Figure 8: Attributes of Cognitive Load. Adapted from Paas et al. (2003, p. 65).

Cognitive Load		
Component	**Definition**	**Implications**
Instantaneous Load	The dynamics of Cognitive Load which fluctuates each moment someone works on a task (y-Axis in Figure 8).	
Intrinsic Load	Part of Cognitive Load originating from element interactivity, determined by an interaction between the nature of the material being learned and the expertise of the learners.	It cannot be directly influenced by instructional designers.
Extraneous Load	The extra load beyond the Intrinsic Load mainly resulting from poor instruction design.	Under direct control of instructional designers
Germane Load	The load related to processes that contribute to the construction and automation of schemas.	Under the direct control of instructional designers
Peak Load	The maximum value of Instantaneous Load while working on the task.	
Accumulated Load	Total amount of load that the learner experiences during a task.	
Average Load	Mean intensity of load during the performance of a task	
Overall Load	The perceived load based on the whole working procedure or the mapping of instantaneous load or accumulated and average load in the learner’s brain.	Also called **Mental Effort** and used in corresponding subjective rating scales.

Table 3: Definitions of Cognitive Load components. Adapted from Paas et al. (2003).

As mentioned in the implications in Table 3, the three components *Intrinsic Load*, *Extraneous Load* and *Germane Load* are parts of Cognitive Load that are proposed to account for the design of instructions and are assumed on a solely theoretical basis (Sweller, 2011). Thus, they are not relevant in the context of this research. What is relevant, are the components that reveal quantity properties of Cognitive Load as perceived by the individual, which are the components *Peak Load*, *Accumulated Load*, *Average Load* and *Overall Load* (compare with Figure 9). As Overall Load gives special notion to the coverage of whole working procedures (including multiple tasks) and to its clear subjective nature (Paas et al., 2003), this component of Cognitive Load is tested in the proposed research model. Beside that theoretical deliberations, Paas et al. (2003) mentioned that Cognitive Load has in fact only been able to be measured in its Overall Load. Researchers were not able to measure the individual components of Cognitive Load with any measurement technique (neither with rating scales, nor with physiological- or task- and performance-based-techniques). Theoretically, to measure the total Cognitive Load as an multidimensional construct over a defined timespan, a combination of an continues rating of Instantaneous Load and performance-based measures would be required, because more effort can be invested by the individual (within the boundary of cognitive capacity) to cope with increased task demands and thus, Cognitive Load changes dynamically (Paas et al., 2003). As this is practically not feasible, subjective rating scales are often used with the measurement of the Overall Load to illustrate Cognitive Load (Paas & Van Merriënboer, 1993). To account for this simplification, the term Mental Effort (which represents the Overall Load) is used in literature (and also in the present work) instead of Cognitive Load. Paas et al. (2003) formulated the connection of Mental Effort and Cognitive Load as follows: *“Mental effort is the aspect of cognitive load that refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task; thus, it can be considered to reflect the actual cognitive load”* (p. 64).

Cognitive Load, or Mental Effort respectively, has important implications in the context of learning, as it is able to provoke *Procrastination* (the voluntarily delay of an intended course of action despite expecting to be worse off for the delay). In procrastination, a task (the procrastinated task) with a high amount of mental demands is replaced with substitute activities that are low in mental demands with the goal of reducing Mental Effort for short-term mood optimization (Reinecke et al., 2018).

Perceived Information Overload (PIO)

In theories concerning Cognitive Load and Mental Effort, a focus is set on existing knowledge and schemata in long-term memory, or the absence of it, that account for cognitive capacity strains (see last section), but not on strains exclusively originating from the amount of incoming information. To account for this, the concept of Information Overload is introduced. Information Overload has a variety of definitions, as it is being investigated in different science disciplines (Eppler & Mengis, 2004). However, Eppler and Mengis (2004) noted in a review, that the overall equality of Information Overload definitions lies in the simple notion of receiving too much information to handle properly. This also results in the formulation of other similar terms like *Sensory and Information Inputs Overload* (Lipowski, 1975), Communication Overload (Meier, 1963) or *Knowledge Overload* (Hunt & Newman, 1997). As to the authors knowledge, the origins of Information Overload are primarily to be found in the disciplines of Information Theory and decision-making and refer to the problem of understanding a certain issue, while dealing with too much information about that issue and being unable to make decisions in an effective way (Schroder, Driver, & Streufert, 1967). In this work, the term Information Overload is considered from a psychological view with a focus on psychopathology, primarily referring to the Sensory and Information Inputs Overload (SIIO) concept of Lipowski (1975). This concept is making a distinction between sensory inputs, as only physical stimuli without an informational quality, and information inputs connoting symbolic stimuli intended as messages and meaningful communication. Although a sharp distinction between the two input forms is not possible and they overlap, information inputs will be in focus here as the main contribution to a possible occurrence of Information Overload. To get more precise, information inputs will be viewed from a memory processing perspective, as described as follows. Information Overload leads to information loss in sensory and working memory, which takes place through the attention process of the individual (Misra & Stokols, 2012), schematically displayed in Figure 9. Sensory memory is a *"brief storage of information from each of the senses, in a relatively unprocessed form beyond the duration of a stimulus, for recording into another memory or for comprehension"* (VandenBos, 2007, p. 965). Similar to Cognitive Load, the limited capacity of memory is crucial (Sweller et al., 1998). The concept of Information Overload can be linked to the Cognitive Load part of Extraneous Load (see Table 3) in instruction design (Chen et al., 2011). In order to provide examples of factors that may contribute to Information Overload, Chen et al. (2011) identified four different elements in students online learning activities, as they use computer-mediated communication: Limited learner readiness (e.g., Paulo, 1999), quantity of information (e.g., Vonderwell & Zachariah, 2005), quality of information (e.g., Sweller, 1994) and medium interface properties (e.g., DeStefano & LeFevre, 2007).

As the real amount of information an individual has to deal with may not be measured appropriately (Chen et al., 2011), a differentiation between Information Overload and Perceived Information Overload (PIO) is made. In this work, PIO is defined as *the perception* by an individual of being exposed to a too high amount of information to deal with, because the subjective aspect of the perception of an overload with information coming to an individual is more in line with the research done here. This differentiation is also made, because it would be too reductionistic to diminish the functioning of the human organism to an information-processing system of limited channel capacity (Lipowski, 1975). Note that in other research, the term PIO has already been used, but is equated with the perception of stress (Misra & Stokols, 2012), which is explicitly not the case in this work, as the research model is designed to investigate several constructs (e.g. Cognitive Load) to account for the perception of stress in the use of CML. However, the general notion that Information Overload is connected to stress (Misra & Stokols, 2012) is inherited.

Comparison of Cognitive Load and Information Overload

As shortly broached before, overlaps between the concepts of Information Overload and Cognitive Load become apparent. In an attempt to solve this impreciseness, Chen et al. (2011) conclude, that Information Overload can be seen as an precursor of Cognitive Load and both rely on the emphasis of the limited capacity of working memory, with additional recognition of a limited capacity also of sensory memory in Information Overload. They summarize in their research made in a learning context: *"In brief, cognitive overload is the load imposed on students during content learning, whereas Information Overload is the 'noise' preventing students from learning content"* (p. 104). Subsequently, they proposed a distinction on the level of memory processing, as displayed in Figure 9. The distinction is not exclusive and both constructs include the emphasis on the limitation of working memory.

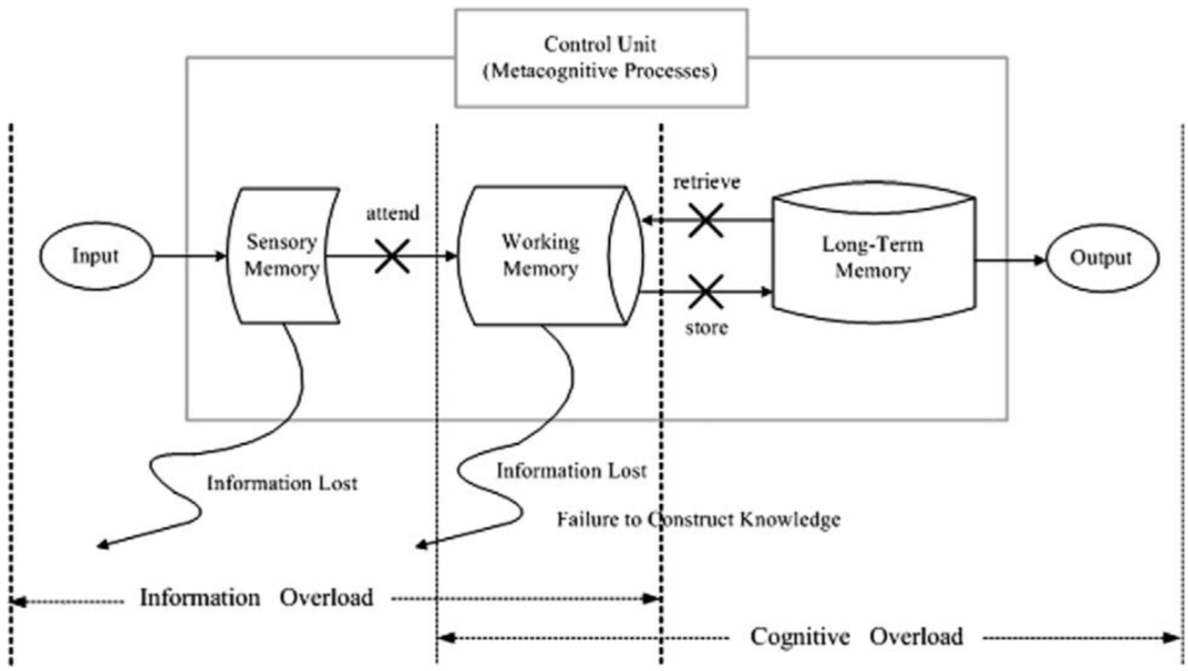

Figure 9: Comparison of Information Overload and Cognitive Load from a memory perspective. Adapted from Chen et al. (2011, p. 103).

As these two concepts are at least partly distinct in theory, it is intended to investigate different effects of these constructs in the research model.

Trait Rumination

The last construct included in the research model, is that of Rumination. Rumination is mostly known by its core definition as *"repetitive and unwanted past-centered negative thinking"* (Gianferante et al., 2014, p. 244). Also, Rumination represents a multifaceted construct and is - dependent on the underlying theory - defined differently (Smith & Alloy, 2009). As of the vast field in which rumination is being researched, some theories will be broached. First, we take a closer look at Nolen-Hoeksemas' Response Style Theory (Nolen-Hoeksema, 1991), which is the most prominent theory of Rumination (Smith & Alloy, 2009) and where the term Rumination has its origins in the field of psychology (Nolen-Hoeksema & Morrow, 1991). The Response Style Theory has been developed in the context of cognitive vulnerability to depression and prolonged recovery, where Rumination is a *"mode of responding to distress that involves repetitively and passively focusing on symptoms of distress and on the possible causes and consequences of these symptoms"* (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008, p. 400). This notion highlights the stress and health related relevance of rumination. The emphasis on Rumination representing a crucial component in depression vulnerability may be moderated by metacognitive believes about Rumination itself, that those believes can be in a positive or negative manner (Papageorgiou & Wells, 2003). The explicit consideration of metacognition on the one hand, and the emphasis on vulnerability to depressive symptoms are common properties of the definition of Rumination in many theories (Smith & Alloy, 2009). In the Goal Progress Theory (GPL; Martin & Tesser, 1996) the aspect of health vulnerability expresses itself in the question if Rumination is distracting and distressing (Smith & Alloy, 2009). Besides that, in the GPT, not a mood-induced reaction is in focus, but rather the response to failure to progress satisfactorily towards a goal (Smith & Alloy, 2009). The response expresses itself as the level of occurring Rumination (repetitive and unwanted past-centered negative thinking). Thus, the GPT is formulated in the context of self-regulation (Martin & Tesser, 1996). This definition is also in line with the characterization in a review about competing theories and aspects of rumination by Smith and Alloy (2009): *“It was suggested that rumination is best characterized as a stable, negative, broadly construed way of responding to discrepancies between current status and target status.”* (p. 14). This emphasis of the discrepancies between current status and target status reflects itself in the focus of questions regarding goal attainment as used in the GPT. As goal attainment is most relevant in a learning context (e.g., Oettingen, Hönig, & Gollwitzer, 2000), GPT is chosen to serve best to measure Rumination in the present work. As indicated in the above quote by Smith and Alloy (2009) and also inherent in the GPL and most other theories of Rumination, is that it is conceptualized as occurring in the form of a stable trait. When a Rumination trigger occurs, it will present itself in its stable, individual characteristics in a person (Smith & Alloy, 2009). Cause of this conclusion and to highlight this properly, the term *Trait Rumination* is used here to represent the construct.

At to this point, all constructs that are used in the research model (depicted in Figure 10) were presented. To give an overview, the constructs, their definitions and theoretical references are summarized in Table 4.

Constructs Overview			
Research Model Construct	**Research Model Definition**	**Original Construct**	**Theoretical Background**
CML Use	The pattern of the usage of Computer-Mediated Learning	-	-
Perceived Stress (PS)	A complex of emotional and behavioral reactions to stimuli (stressors) that are perceived as aversive, resulting in an imbalance between stimuli and resources available to the individual.	Stress	Stress (Steptoe, 1991); Transactional Model of Stress and Coping (TMSC; Folkman & Lazarus, 1984)
CML Acceptance	The attitude toward using CML.	Attitude Toward a Behavior (ATB)	Theory of Reasoned Action (TRA; H. Ajzen & Fishbein, 1980); Theory of Planned Behavior (TPB; Icek Ajzen, 1991); Technology Acceptance Model (TAM; Davis, 1985)
Mental Effort	The perceived Cognitive Load (working memory load in the interaction with knowledge production in the long-term memory) based on a whole working procedure.	Overall (Cognitive) Load / Mental Effort	Cognitive Load Theory (CLT; Sweller, 1988); Overall Load/Mental Effort (Paas & Van Merriënboer, 1994)
Perceived Information Overload (PIO)	The perception by an individual of being exposed to a too high amount of information to deal with.	Information Overload	Sensory and Information Inputs Overload (SIIO; Lipowski, 1975)
Trait Rumination	Repetitive and unwanted past-centered negative thinking as a stable response to failure to progress satisfactorily towards goals	Rumination	Goal Progress Theory (GPT; Martin & Tesser, 1996)

Table 4: Overview of all constructs included in the research model.

Aim of this research and hypotheses

The aim of this research is the investigation of how technology use, here explicitly in the form of Computer-Mediated Learning (CML Use) is related to Perceived Stress (PS) by testing potential antecedents. This is an important field of research, since people are more and more using CML, and maybe even are obligated to do so (see section about ICT/CML use). Considerations about the impact of this usage on health and quality of life aspects and ways to improve these interactions are crucial. To the authors opinion, one important aspect that needs to be taken into account when looking at the connection between the usage and the stress reaction in technology use, plays the level of its acceptance (the attitude to use technology/CML) by a person. The level of acceptance can be formed for example with previous positive experiences in technology use (Zajonc, 1968), leading to a lower vulnerability to potential stress reactions (Folkman & Lazarus, 1984). Because of this, the influence of CML Acceptance on PS is tested. Technology, in particular CML, is potentially very complex because of its inherent interactivity nature and may result in high demands to cognitive systems (e.g. working memory and long-term memory interactions). Especially since many types of CML possibilities (e.g. a specific software) may not be designed well or users are overchallenged by its usage, cognitive systems come to their limits and a failure to construct knowledge results - the Mental Effort that need to be invested is too high (see section Cognitive Load and Mental Effort). Another most relevant aspect of CML is that it possibly leads to a too high amount of information to process by individuals. This is especially the case when learning contains the processing of information coming from the internet, where virtually an infinite amount of information is available. Perceived Information Overload (PIO) account for this deliberation. Information Overload has already been brought into direct connection with stress (Misra & Stokols, 2012), but to the knowledge of the author, there is no research being done to this point, where Mental Effort and PIO are being tested simultaneously for their impact on PS, with the intention to possibly identify different contribution of these constructs to PS. This intention to identify different contribution of Cognitive Load (Mental Effort) and Information Overload arises from the proposed distinction of these constructs by Chen et al. (2011), displayed in Figure 9. Investigating the interplay between demands on cognition (Mental Effort and PIO), Acceptance and PS in CML use is the core aim of this research.

Additionally, to account for considerations about finding traits in people that may also alter the relation between CML use and cooccurring PS, Trait Rumination is included to the research model. The deliberation here is, that goal attainment is an important aspect of learning activities, also in CML. A trait that leads to *"repetitive and unwanted past-centered negative thinking"* (Gianferante et al., 2014) when failures to progress satisfactorily towards goals occur, might interfere with cognitive processes (Mental Effort and PIO) in learning activities and further also in acceptance and PS.

For every direct effect between the constructs, corresponding hypotheses regarding a positive or negative relation is formulated. These hypotheses are arranged sequentially in correspondence to the causal flow of the research model (compare with Figure 10). The conducted studies were guided by the following hypotheses.

Hypothesis 1: CML Use and CML Acceptance

According to the extensive researched principles of the Mere Exposure Effect, the repeated exposure of the individual to a stimulus object and its enhanced accessibility to the individual's perception (Zajonc, 1968), *"repeated exposure to a stimulus is sufficient to improve attitudes toward that stimulus"* (Moreland & Topolinski, 2010). Hence, an increase in acceptance through elevated usage of CML is expected. As an example, for evidence in the technology research sector, Zhang et al. (2008) showed the importance of attitude toward using (Attitude Towards a Behavior (ATB)) an ICT Software, if a similar ICT Software has already been used before. Thus, it is hypothesized that more individual experience with CML in general leads to an enhanced acceptance for its use.

H1: CML Use is positively related to CML Acceptance

Hypothesis 2: CML Use and Mental Effort

It is expected that more experience in CML use has a cushioning effect on Mental Effort. This conclusion is derived from deliberations about the amount of prior knowledge and preexisting schemata (Sweller, 2011) of the appropriate use of CML that is available to the individual. The extent of this prior knowledge and preexisting schemata, which in this context here is formed with previous CML use, may diminish failures to construct new knowledge by reducing the strain of retrieval and storage processes between working memory and long-term memory (compare with Figure 9), which is equivalent to lower Mental Effort.

H2: CML Use is negatively related to Mental Effort.

Hypothesis 3: CML Use and Perceived Information Overload (PIO)

Similarly to H2, in H3 it is also assumed that prior knowledge/preexisting schemata also have an effect on PIO. This is derived from the notion that schemata stored in long-term memory are functioning as organizers that support the interpretation of new sensory input and link it to those already existing schemata (Vonderwell & Zachariah, 2005). Incoming information are guided by these existing schemas in their selection and processing, so learning activities can be organized in an efficient way (Kalyuga, 2009). Thus, an enhanced extent of previous CML use is expected to reduce PIO through the efficient selection of perceived information.

H3: CML Use is negatively related to PIO.

Hypothesis 4: Mental Effort and CML Acceptance

The Technology Acceptance Model (TAM) proposes Perceived Ease of Use and Perceived Usefulness as direct antecedents of ATB (Davis, 1985; compare with Figure 4), which is used synonymously with CML Acceptance in the present work. Both of these antecedents are proposed to be determined and influenced by external variables. Hence, the hypothesis here is, that Mental Effort functions as one of these possible external variables and negatively influences ATB through Perceived

Ease of Use. More precisely, as higher Mental Effort is, the attitude towards using CML (respectively accepting to use CML) drops, since the experience of CML interactions is assumed to be aggravated.

H4: Mental Effort is negatively related to CML Acceptance.

Hypothesis 5: Perceived Information Overload (PIO) and CML Acceptance

This hypothesis assumes the same influence from PIO on Perceived Ease of Use and Perceived Usefulness and further to CML Acceptance, as also proposed for Mental Effort (see H4). When PIO is on average increased in the use of CML, the acceptance of CML decreases.

H5: PIO is negatively related to CML Acceptance.

Hypothesis 6: Trait Rumination and CML Acceptance

Elevated manifestation of Trait Rumination in a person results in more repetitive and unwanted past-centered negative thinking about failures in goal attainment (Smith & Alloy, 2009), regarding to the Goal Progress Theory (GPT; Martin & Tesser, 1996). As goal attainment is inherently important in learning activities (e.g. in setting learning goals; Oettingen et al., 2000), it is so in CML. It is therefore hypothesized that heightened Trait Rumination, with the thought that goal attainment failure experiences in CML use are not fully avoidable, undermines fluent learning (MacIntyre & Blackie, 2012). Thus, it is assumed that a negative influence on the acceptance of using CML through poorer interaction experience results.

H6: Trait Rumination is negatively related to CML acceptance.

Hypothesis 7: Trait Rumination and Mental Effort

The deliberations indicated in H6 are also of relevance in the influence of the manifestation of Trait Rumination on Mental Effort. As rumination occupies cognitive resources as it "*refers to interfering and persisting thoughts that may prevent an individual from initiating or sustaining a particular behavior*" (MacIntyre & Blackie, 2012, p. 537), these resources are assumed to lead to a lower capability to process information and increase Mental Effort. This is in line with the notion of the GPT, that propose that Rumination is formed through information related to incomplete goals (Martin, Tesser, & McIntosh, 1993). Hence, these thoughts remain present in the individuals' working memory and long-term memory interaction and potentially contribute to the limitation of possible processing of current learning tasks. People high in Trait Rumination are hypothesized to be more easily vulnerable to higher Mental Effort and therefore have more experience with it, especially in learning activities where goal attainment plays an important role.

H7: Trait Rumination is positively related to Mental Effort.

Hypothesis 8: Trait Rumination and Perceived Information Overload (PIO)

Analogous to H7, it is hypothesized that PIO is elevated through Rumination about information related to incomplete goals (Martin et al., 1993). The resulting occupied cognitive resources lead to a lower capability to handle incoming information from sensory inputs and increase PIO.

H8: Trait Rumination is positively related to PIO.

Hypothesis 9: CML Acceptance and Perceived Stress (PS)

According to the Transactional Model of Stress and Coping (TMSC; Folkman & Lazarus, 1984), PS is a manifestation of an unfavorable person-environment relationship that is leading to a feelings of distress (Lazarus, 1993). The use of CML, that is possibly even involuntarily, can be seen as an environmental demand. On the other hand, the acceptance of CML is a characteristic of a person. This resulting relationship is able to be unfavorable when the person's acceptance is low, leading to a Primary Appraisal (the evaluation about an environment demand as harmful versus beneficial) about the environment demand (CML use) as being harmful. Also, the Secondary Appraisal (the evaluation of capabilities to cope with the given environment demand) also is expected to result in a negative outcome, as low acceptance has at least some influence from past experience (e.g. from the Mere Exposure Effect; Zajonc, 1968), as also highlighted in H1. Secondary Appraisal then evaluates the coping capabilities as low. Both, low Primary and Secondary Appraisal lead to increased PS. Conversely, elevated CML Acceptance lowers PS, which is formulated in this hypothesis.

H9: CML Acceptance is negatively related to PS.

Hypothesis 10: Mental Effort and Perceived Stress (PS)

Analogous to H9, the notion of possible unfavorable person-environment relationship is also applicable to the relation of Mental Effort and PS. As high Mental Effort increases memory strain (in interaction processes between working memory and long-term memory in the construction of new knowledge; Sweller et al., 1998), it is expected that it leads to a Primary Appraisal interpretation of the environment demands as harmful. Thus, increased Mental Effort leads to increased PS.

H10: PCL is positively related to PS.

Hypothesis 11: Perceived Information Overload (PIO) and Perceived Stress (PS)

Similar to H9 and H10, it is assumed that PIO influences Primary Appraisal in a negative way. In addition, it seems possible that Secondary Appraisal is prevented by memory (sensory- and working memory) strain caused by PIO. This results in the hypothesis of a positive relation between PIO and PS. As evidence from the context of psychopathology, in the use of mobile social networking sites, Information Overload is shown as a significant predictor of depressive symptoms and further negative influence on the individuals' well-being (Matthes, Karsay, Schmuck, & Stevic, 2020). This is relevant, as depressive symptoms highly correlate with PS (e.g., Reinecke et al., 2018). Furthermore, Lipowski

(1975), in his important review on information overload, already concluded: *"It is reasonable to conjecture that repeated exposure to information-input overload, with its concomitant physiological arousal, is a potential health hazard and a suspected risk factor for the development, course, and outcome of chronic cardiovascular diseases, which are highly prevalent in technological societies.*" (p. 208) and "*The overload is contributed to by the exponential growth of scientific information and its dissemination by information-transmitting industries."* (p. 209). A variation of the definition of Information Overload, also proposed by Lipowski (1975), highlights the possible closeness between PIO and PS: *"Information overload is a category of psychosocial stress brought about by excess of symbolic stimuli relative to the individual's processing capacity."* (p. 219).

H11: PIO is positively related to PS.

Hypothesis 12: Trait Rumination and Perceived Stress (PS)

From the viewpoint of the TMSC (Folkman & Lazarus, 1984), like in all relations to PS in the present research model, the person-environment relationship aspect is also crucial for Trait Rumination, as it is a person characteristic and negatively influence Cognitive Appraisal (Primary and Secondary Appraisal). Beside this theoretically assumption, evidence shows that post-stress state rumination (which occurs more in individuals high in Trait Rumination) leads to an exaggerated HPA axis response pattern (Gianferante et al., 2014; compare with Figure 7). Furthermore, individuals high in Rumination (as a trait) are more likely to interpret events in their life as stressful (Lok & Bishop, 1999). Hence, CML interactions are affected in an increase in PS when the individual has the tendency to ruminate.

H12: Trait Rumination is positively related to PS.

Methods

To test the formulated hypotheses, two studies were conducted. The main study tested the entire research model, as displayed in Figure 10. The focus of the main study was set to the experience participants had with Computer-Mediated Learning (CML) in general. Study 2 only covered a part of the research model (see Figure 11), the relation of CML Use, cognitive demands (Mental Effort and Perceived Information Overload (PIO)) and Perceived Stress (PS). The collection of the data of study 2 took place directly after the participants were exposed to a specific CML software. Both studies are presented in detail.

Experimental Design (Main study)

A path model was designed on the basis of the corresponding formulated hypotheses with the associated effect directions (positive (+) or negative (-)). CML Use and Trait Rumination were defined as exogenous variables (which are variables that have origins to their characteristics solely from outside of the model), that are placed at the beginning of a hierarchical path model with a one directed causal flow that ends at the variable PS. Direct effects (represented as path coefficients) through Mental Effort, PIO and CML Acceptance were in the scope of the analysis.

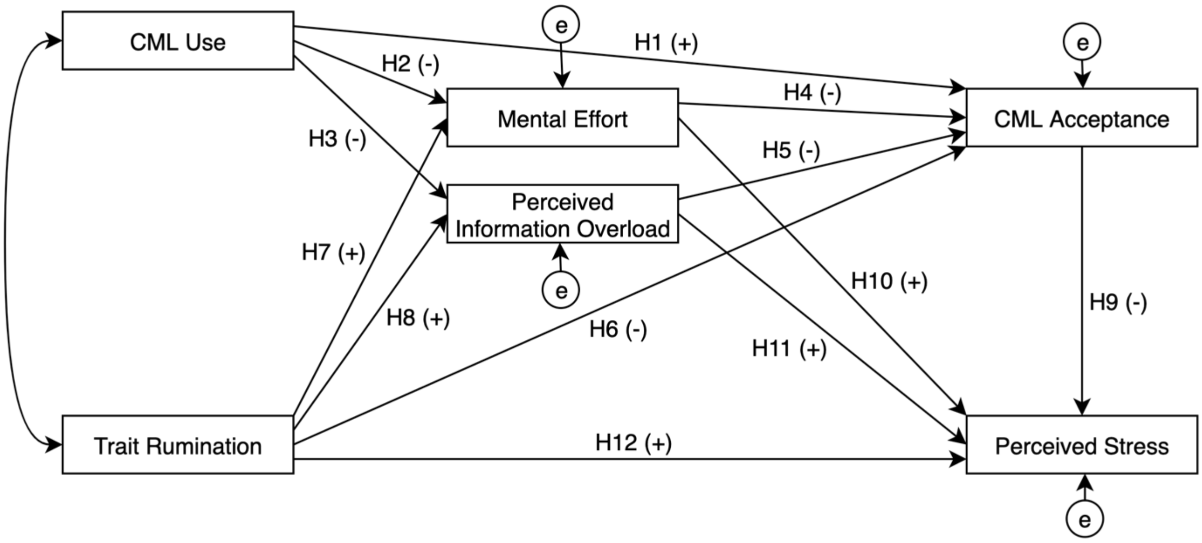

Figure 10: The research model of the main study.

Participants (Main study)

A total number of 187 subjects participated in the study. The participants were mainly recruited from the University of Basel and received course credits as a compensation. To enhance the heterogeneity of the sample (age and education), additionally subjects were recruited via a mailing list of people that already participated in the past in different studies of the Human-Computer Interaction division of the University of Basel and were interested to participate in further studies. These additional subjects could take part in a raffle for two SFr. 100.- vouchers for an online store in Switzerland. To be included in the study, the subjects had to confirm that they have good English language skills and were over 18 years old. 10 subjects have been excluded from the analysis due to their statement of dishonesty in their answers in the questionnaires, which has been evaluated with a control item (Meade & Craig, 2012). The final sample consists 177 participants, with 137 females and 39 males. One subject preferred not to answer to the question about their gender. The mean age was 24.65 years with a range between 18 to 53 years (*SD* = 6.37 years). The highest educational attainment was also surveyed and presents itself as follows: Finished regular school: 3; Matura (Switzerland) / Abitur (Germany): 117; Apprenticeship: 5; Bachelor's Degree: 33; Master's Degree: 18; Doctoral Degree: 1.

Materials (Main study)

The study was conducted online, on the Questback Unipark Portal (unipark.com), that has the specific function of hosting online surveys. The participants were asked to conduct the study on a personal computer, laptop or tablet.

Measurements (Main Study)

To measure the constructs of the research model, questionnaires were chosen and used following literature research and are presented individually. Internal consistency was tested on every Scale, except on Mental Effort (1 item Scale), using Cronbach's Alpha (Cronbach, 1951).

CML Use Measurement

The questions for CML Use refer to past experience of the subjects. The question items were adopted from a questionnaire used in a study by Lu, Zhou, and Wang (2009), where Chinese users' acceptance of instant messaging software were explored. The items were customized by changing the associated object in question from *"instant messaging"* to *"computer-mediated learning".* The following three items were used and rated on 7-point Likert Scales: 1. *How many times do you use computer-mediated learning during a week?* (Scale: Not at all / Less than once a week / About once a week / 2-3 times a week / 4-5 times a week / About once a day / Several times each day). 2. *How many hours do you use computer-mediated learning every week?* (Scale: <1h / 1h-5h / >5h-10h / >10h-15h / >15h-20h / >20h-25h / >25h) 3. *How frequently do you use computer-mediated learning?* (Scale: Extremely infrequent / Quite infrequent / Slightly infrequent / Neither / Slightly frequent / Quite frequent / Extremely frequent). The scale showed good internal consistency (main study: α=.85, study 2: α=.88).

CML Acceptance Measurement

To measure acceptance, question items were adapted from a study by Masrom (2007), in which the Technology Acceptance Model (TAM) were used for the investigation of user acceptance of e-learning as an effective learning tool in universities. As elaborated in the theoretical framework, acceptance was defined as equated with Attitude Towards a Behavior (ATB). Hence, only questions from TAM regarding ATB in the study from Masrom (2007) were used. Again, the wording of the items has been customized by changing *"e-learning"* to *"computer-mediated learning"*. Also, Item 3 has been customized by replacing *"for my course work"* with *"for my learning purposes"* to account for the more general context of the present study. Four items were used and rated on 7-point Likert Scales (Strongly disagree (1) / (2) / (3) / Neutral (4) / (5) / (6) / Strongly agree (7)): 1. *I dislike the idea of using computer-mediated learning.* (Reverse item). 2. *I have a generally favorable attitude toward using computer-mediated learning.* 3. *I believe it is (would be) a good idea to use computer-mediated learning for my learning purposes.* 4. *Using computer-mediated learning is a foolish idea.* (Reverse item). The scale showed good internal consistency (α=.84).

Mental Effort Measurement

The Mental Effort Rating Scale (or Subjective Rating Scale of Mental Effort; Paas et al., 1992) was used to measure Mental Effort. This rating scale, as most subjective rating scales, measures the Overall (Cognitive) Load (that is synonymous with Mental Effort), as shown in Figure 8. It is also described as a working memory load measurement (Paas et al., 2003) and is based on a perceived task difficulty measure (Borg, Bratfisch, & Dorni'c, 1971). As the assessment of the Mental Effort is regarding the past, Schmeck Schmeck, Opfermann, van Gog, Paas, and Leutner (2015) conclude: *"Results showed that the delayed ratings of both effort and difficulty were significantly higher than the average of the six ratings made during problem solving"* (p. 93). Furthermore, Sweller (2011) concluded: "*The simple subjective rating scale, regardless of the wording used (mental effort or difficulty), has, perhaps surprisingly, been shown to be the most sensitive measure available to differentiate the cognitive load (..)."* (p. 74). The Mental Effort Rating Scale consists of only one item and has been customized to the CML context of the present study. It uses a 9-point Likert Scale: 1. *Please rate your amount of mental effort you deal with when you are using computer-mediated learning.* (Scale: very, very low mental effort (1) / (2) / (3) / (4) / (5) / (6) / (7) / (8) / very, very high mental effort (9)).

Perceived information overload (PIO) Measurement

An Information Overload measure was developed by Karr-Wisniewski and Lu (2010) in their research on *Technology Overload* (which, beside Information Overload, consists of Communication Overload and System Feature Overload) and its impact on knowledge worker productivity. The measure consists of the following 3 items and was rated on 9-point Likert Scales (Strongly Disagree (1) / (2) / (3) / (4) / (5) / (6) / (7) / (8) / Strongly Agree (9)) that was customized to the CML context: 1. *I am often distracted by the excessive amount of information available to me when using computer-mediated learning.* 2. *I find that I am overwhelmed by the amount of information I have to process on a regular basis when using computer-mediated learning.* 3. *Usually, my problem is with too much information to synthesize instead of not having enough information when using computer-mediated learning.* The scale showed good to acceptable internal consistency (main study: α=.84, study 2: α=.76).

Trait Rumination Measurement

To measure Trait Rumination based on the Goal Progress Theory (GPT), the Scott-McIntosh Rumination Inventory (Scott & McIntosh, 1999) was used. This inventory was developed with regard to three aspects of thoughts about goal progression, that are; emotion, motivation and distraction. The inventory consists of 9 items to be rated on 7-point Likert Scales (Does not describe me well (1) / (2) / (3) / (4) / (5) / (6) / Does describe me well (7)), that are displayed in Table 5. The scale showed low internal consistency (α=.43) in this study. This has consequences of the interpretability of the results (see discussion/limitation section).

Item #	Question
1	There are some goals that are so important for me to attain that I am strongly motivated to reach them.
2	When I think about unaccomplished goals from my past, I become inspired to work on reaching them.
3	When I think about an important goal that I haven't yet reached, it inspires me to work harder to reach it.
4	I often get distracted from what I'm doing by thoughts about something else.
5	I seldom have difficulty concentrating on a current task. (Reverse item).
6	I rarely become 'lost in thought'. (Reverse item).
7	When I think about an important goal that I have not yet reached, it makes me feel sad.
8	I become angry when I think about goals that I have not yet reached.
9	I rarely get upset at myself when I am having problems reaching important goals. (Reverse item).

Table 5: Scott-McIntosh Rumination Inventory (Scott & McIntosh, 1999).

Perceived Stress (PS) Measurement

To measure PS, the Stress Rating Questionnaire by E. J. Edwards, Edwards, and Lyvers (2015), which is an extended version of the Arousal Rating Questionnaire (M. S. Edwards, Burt, & Lipp, 2006) is used in the present study. This questionnaire was explicitly developed to measure situational stress and consists of five items of bipolar dimensions. 1. *Calm to Nervous.* 2. *Fearless to Fearful.* 3. *Relaxed to Anxious.* 4. *Unconcerned to Worried.* 5. *Comfortable to Tense.* On every item, a 7-point Likert Scale was used with the corresponding terms (e.g. 1. very calm (1) / quite calm (2) / slightly calm (3), neither calm/nor nervous (4) / slightly nervous (5) / quite nervous (6) / very nervous (7)). The scale showed good to excellent internal consistency (main study: α=.83, study 2: α=.91).

Procedure (Main Study)

Participants were guided through the questions on a generated website by the Unipark Software with an *"continue"* button and a progress bar. Following a welcome page, participant confirmed they were over 18 years old and gave informed consent for the processing of their anonymized data. In the next step, demographical data was collected. After this, a scenario was introduced to which the participants could relate when answering the following construct questionnaires, giving the context of the issue of CML in question. The text was as follows: *"When you are learning for different kinds of tasks for your education, you may or may not use technology to a certain degree. These tasks should be used on one or more of the following devices: Tablets, Laptops, Desktop Computers, Smartphones. The usage of those devices for learning purposes will from now on be called computer-mediated learning. The questions will consider how you use the mentioned devices for learning purposes and how you experience those interactions. By validating the interactions with computer-mediated learning, please think about how you feel about your different types of its usage in a general manner. Examples for computer-mediated learning could be using e-learning software, using online libraries to search for information, manipulate documents or taking notes with software applications and so on. Just every type of interaction that includes a computer for your learning purposes. Please select your answer spontaneously without thinking long about it."* Questionnaires relating to different constructs were then presented on different pages in the progress. They were obligated to answer all questions to finish the whole process. There were no time restrictions. After the questionnaires, participants were able to articulate in open questions, what kind of CML interaction they were thinking of when answering the questionnaires and in a second question, what their most common problems are when using CML. After this part was finished, participants indicated if they are honestly able to say that they filled out the survey attentively and if the data should be used. This question originated from the Seriousness Check by Meade & Craig (2012). The answer had no consequence on the collection of the compensation for participation in the study. At the end of the study, information about the compensation was given.

Experimental Design (Study 2)

In addition to the main study, a second one was conducted, with the goal to test a part of the research model of the main study (Figure 11) directly after the exposure to a specific CML software. The focus was set on the role of the influence of cognitive demands (Mental Effort and PIO) on PS. Also, CML Use (that refers to the past experiences of CML use of the participants) was raised.

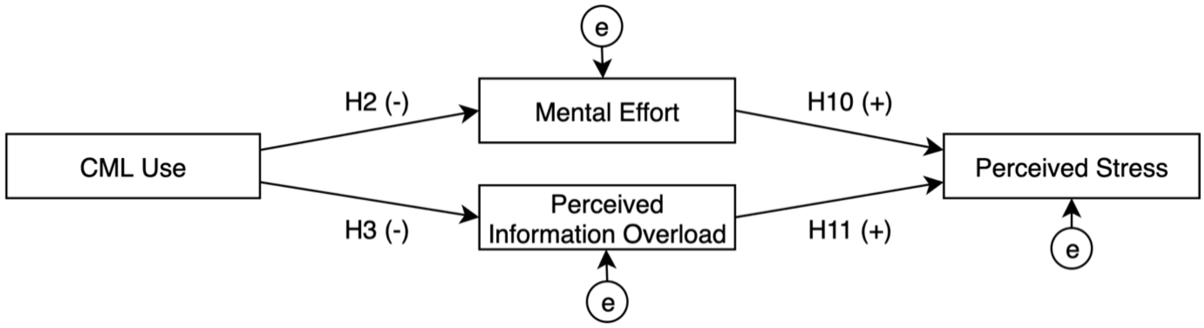

Figure 11: The research model of study 2.

Measurements (Study 2)

The same measurements (questionnaires) for the included constructs as in the main study were also used in study 2 (see main study Measurement section), as well as the same hypotheses of the paths. The study was conducted in German and the corresponding questionnaires were translated accordingly.

Participants (Study 2)

The sample of the conducted study has these properties: 103 participants (77 females, 26 males) with a mean age of 27.16 years and a range of 17 to 71 years (*SD* = 11.07 years). Note that only 88 out of 103 stated their age. Highest educational attainment (differs from main study): Finished regular school: 3; Matura (Switzerland) / Abitur (Germany): 117; Apprenticeship: 5; Bachelor's Degree: 33; Master's Degree: 18; Doctoral Degree: 1.

Materials and Procedure (Study 2)

The study was done in an experimental setting, in which subjects participated in a broader study that was part of a project of the Fachhochschule Nordwestschweiz (FHNW) and was conducted by Alessia Ruf. The goal of this broader study was to investigate in different effects of Computer-Supported Collaborative Learning (CSCL) to learning performance. In the corresponding experiment, participants used a Hypervideo-Software called Frametrail (see Figure 12 for details) as an e-learning tool. The subjects also filled out the questionnaires of the corresponding constructs used in the main study during the experiments. The restrictions of reducing the research model where due to the length of the complete procedure and the more limited subject number.

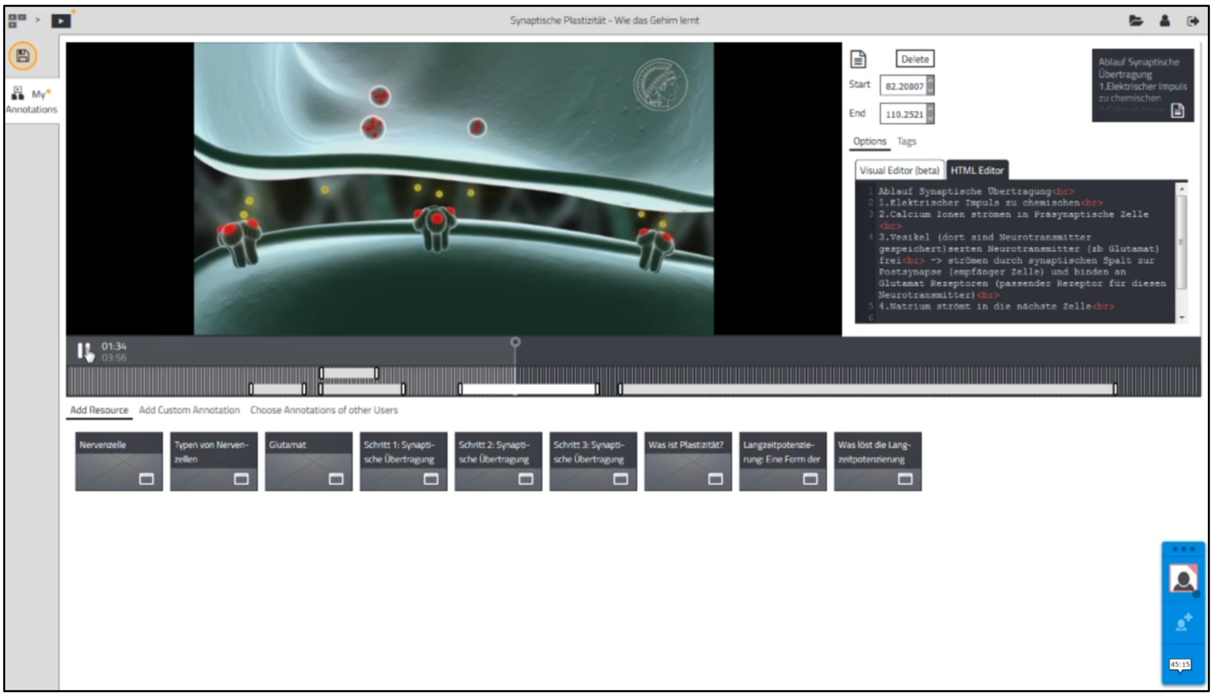

Figure 12: Frametrail browser window.

As a CML-task, participants watched an educational videoclip about neurobiological processes in the formation of memory in a learning context. Participants were either able to put hyperlinks (links to an pop-up window that can be opened by clicking) with further explanations of the matter (row of boxes in Figure 12) and add custom annotations (right textbox in Figure 12) with self-written summaries into the timeline of the videoclip, or learned the video with further explanations without the possibility to enrich the video with hyperlinks or annotations (common video learning condition). Note that there were different settings across the participants. They were randomly assigned to work alone or together in groups of two (connected via Skype) and assigned randomly to groups that either could enrich the video with hyperlinks and annotations or only watch the videoclip and read the further explanation texts. As the hypotheses of the research model stay the same across all conditions from this larger project, data from all participants were used equally.

Data Preparation

The constructs needed to be represented as single measurements in the path analysis. To account for this, all items of the respective measurement scales were averaged for every participant. Based on this resulted new construct representations, the path models were computed.

Results

Main Study

As a first impression and to show correlations of the constructs with demographic variables, Table 6 shows mean values, standard deviations and Pearson's product moment correlation coefficient (Pearson, 1895) among the collected variable data.

	M	SD	1	2	3	4	5	6	7	8
1. Age	24.6	6.37	-							
2. Gender	.78	.42	- .16*	-						
3. Education	2.71	1.14	.55***	-.02	-					
4. CML Use	4.85	1.49	- .23**	.02	-.04	-				
5. CML Acceptance	5.55	.99	.09	.04	.17*	.20**	-			
6. Mental Effort	5.25	1.39	.04	- .03	.04	.14	.03	-		
7. Perceived IO	5.04	1.62	- .04	.10	.07	- .01	- .08	.26***	-	
8. Trait Rumination	4.60	.62	- .15	.19**	- .08	.10	.11	.18*	.21**	-
9. Perceived Stress	3.36	.98	.01	.12	-.02	.00	- .22**	.16*	.25***	.29***

*p<.05; **p<.01; ***p<.001

Table 6: Mean values, standard deviations and correlations. Gender: 0=Male, 1=Female. Education (Highest qualification): 1=Regular School, 2=Matura/Abitur, 3=Apprenticeship, 4=Bachelor’s Degree 5=Master’s Degree, 6= Doctoral Degree

Next, the results of the hypothesized path model of the main study are presented (see Figure 13). By using the R Multivariate Normality Tests Package (MVN) and the corresponding function, the data analysis of the variables shows that there is no multivariate normality present. Estimations based on *Maximum Likelihood* (ML) require that the data has a multivariate normal distribution, otherwise the $\chi2$-Test statistic is overestimated, and the standard error of the parameters are underestimated (Finney & DiStefano, 2006). As this is a quite ordinarily phenomenon (Steinmetz, 2015), there exist robust estimators to deal with such cases, that are extensions of the ML method. The package Lavaan for R (Rosseel, 2012), which is used in this analysis, includes such *Robust Maximum Likelihood* estimators. In the analysis, the estimator with the Yuan-Bentler correction for $\chi2$-Test statistic and Huber-White corrected estimator for standard error (MLR) was used for the fit indices and path coefficients.

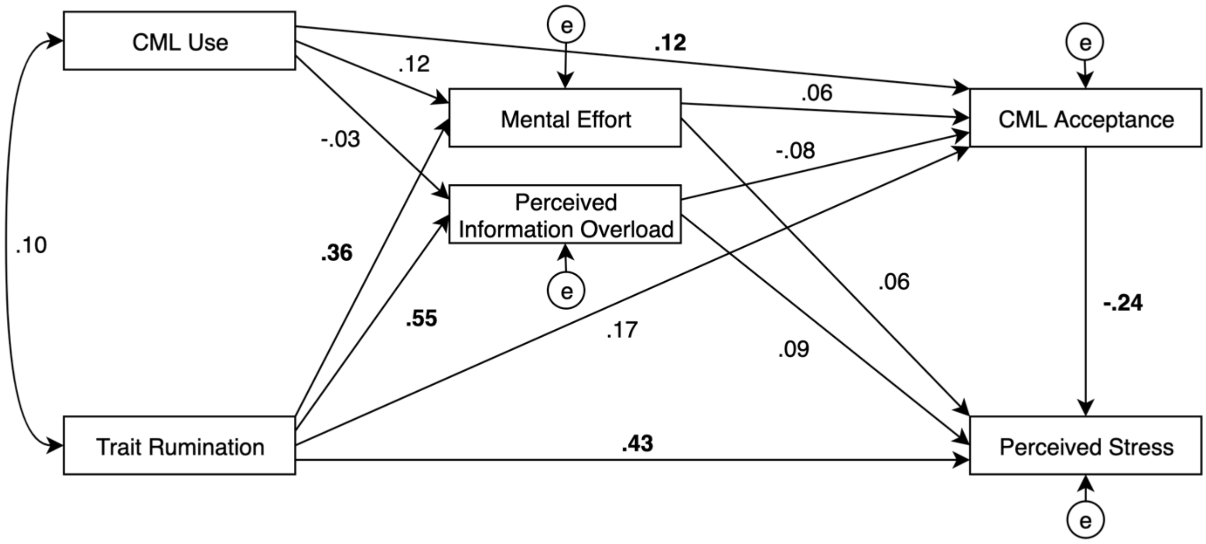

Figure 13: Research model. χ2(2)=9.42, p=.009, χ2/df=4.71, CFI=.86, RMSEA=.15, PCLOSE=.03, SRMR=.05

The model was tested based on χ2 and χ2/df statistics. As additional fit indices, *Comparative Fit Index* (CFI), *Root Mean Square Error of Approximation* (RMSEA) and its significance test (PCCLOSE), and the *Standardized Root Mean square Residual* (SRMR), which has been recommended by Hu and Bentler (1999). The following cut-off values also refer to Hu and Bentler (1999). For the model to show good fit properties, the χ2-value should *not* be significant, χ2/df < 3, CFI should be near or above .98, the RMSEA should be ≤ .06 (better ≤.05) and its significance test (PCLOSE), that tests if RMSEAs null hypothesis of being ≤ .05 can be assumed, shouldn't be significant (> .05). The SRMR is acceptable at ≤ .08. Beside the SRMR, all other used criteria show values below a desired model fit with *χ2(2)*=10.13, *p*=0.006, *χ2/df*=5.06, *CFI*=.86, *RMSEA*=.15, *PCLOSE*=.03 and *SRMR*=.05. With this insufficient fit, path coefficients cannot be interpreted.

Given the misfit of the hypothesized model, the path model was modified on the foundation of modification indices in the output of the Lavaan Package for R structural equation model analysis. The look at the modification indices with values above 4 indicate that the corresponding modification could be able to improve the model fit, but this should only be made step by step (if more than one modification indices is above 4) and only if the given modification can be theoretically reasoned. In the output of the research model, one of the possible modifications underpinned by modification index (value of 9.842) is that the measurement errors (residuals) covariance of Mental Effort and Perceived Information Overload (PIO) should be freely estimated. Following the principle of editing the path model analysis step by step and control for modification indices values after each step, a model with only this modification has been tested (see Figure 14). The theoretical deliberation of doing so is that by freely estimating the covariance of the residuals of these constructs, it could be assumed that Mental Effort and PIO measure a similar concept by their indicators (items), which can lead to a possible problem in the proximity of the two constructs.

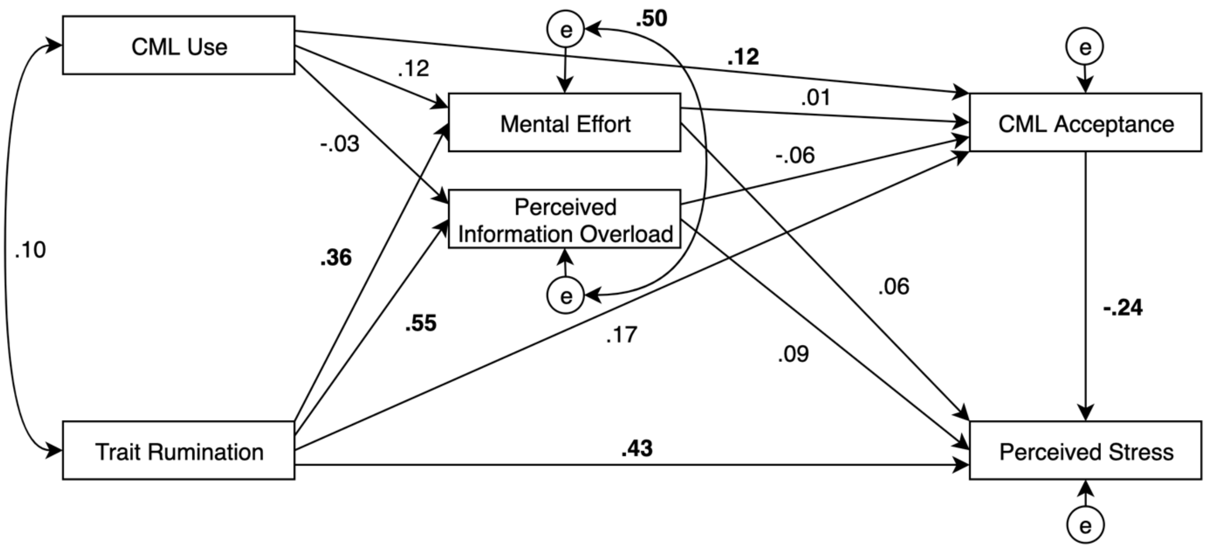

Figure 14: Modified research model: $\chi 2(1)$=0.02, p=0.97, $\chi 2/df$=0.02, CFI=1.0, RMSEA=0.00, PCLOSE=.99, SRMR=.001

In the modified research model, a radical change in the fit indices with $\chi 2(1)$=0.02, *p*=0.97, $\chi 2/df$=0.02, *CFI*=1.0, *RMSEA*=0.00, *PCLOSE*=.99 and *SRMR*=.001 is observed. This model seems to fit the data well. Also, a statistical comparison between the original research model and the modified research model was computed by using a *chi-square difference test for Satorra-Bentler scaled chi-square* (also for *Yuan-Bentler chi-square*) robust estimators (Bryant & Satorra, 2012). This is legitimate, as both models are incorporated as nested models, which means that one of the models can be transformed in the other simply by eliminating (or fixing) parameter(s) from the other model, which is in this case the additional parameter of the freely estimated error covariance of Mental Effort and PIO. As anticipated due to the big differences in the significance-tests of the $\chi 2$ and fit indices of each model, the $\chi 2$-difference test is highly significant with $\chi 2(1)$=11.486, *p*<.001, which indicates a substantial change in the fit. Furthermore, with this model, the modification indices do not indicate a further change. With the given result, the hypothesis that Mental Effort and PIO may have a problem in their distinction is given evidence, at least statistically, by improving the model fit by letting their residuals co-vary (*cov*=.50, *p*=.001). With this modification, the path coefficient can be interpreted concerning the hypothesis. CML Use is positively associated with CML Acceptance (β=.12, *p*<.01), as hypohesized in H1. No significant effects are observed from CML Use on Mental Effort and PIO, as it was assumed in hypotheses 2 and 3. Also contrary to hypotheses 4, 5, 10 and 11, Mental Effort and PIO show no effects on CML Acceptance (H4 & H5) and Perceived Stress (PS; H10 & H11). Only the path coefficient of PIO on PS shows at least an effect tendency (β=.09, *p*=0.053). As predicted by hypothesis 9, CML Acceptance has a negative association with PS (β=-.24, *p*=.005). Also as assumed, in hypothesis 12, Trait Rumination and PS are positively related (β=.43, *p*<.001). Furthermore, and also as predicted, Trait Rumination has a positive relation to Mental Effort (β=.36, *p*<.05) and PIO (β=.55, *p*<.05), but this has to be interpreted in the light of the covariance, as described above. Also, the poor internal consistency of the Trait Rumination measure must be taken into account when interpreting the results (see discussion/limitation section).

Study 2

The correlation matrix of study 2 is shown below (Table 7), without the constructs of CML Acceptance and Trait Rumination, as the model is reduced compared to the main study and the focus is set on the role of Mental Effort and PIO on PS, while CML Use was also co-raised. Again, correlations of the constructs with demographic variables are in focus here.

	M	SD	1	2	3	4	5	6
1. Age	27.0	11.2	-					
2. Gender	.75	.44	- .10	-				
3. Education	2.91	1.39	.49***	-.19	-			
4. CML Use	3.05	1.31	- .25*	.11	- .09	-		
5. Mental Effort	5.78	1.51	.53***	.06	.21*	.02	-	
6. Perceived IO	4.65	1.89	.21	- .01	- .03	.14	.47***	-
7. Perceived Stress	3.30	1.26	.21*	.11	.07	.05	.34***	.36***

*p<.05; **p<.01; ***p<.001

Table 7: Mean values, standard deviations and correlations. Gender: 0=Male, 1=Female; Education (Highest qualification): 1=Regular School, 2=Matura/Abitur, 3=Apprenticeship/Vocational School, 4=Professional School, 5=University/College, 6=Teachers seminary

In the following, the path model of study 2 is presented. As multivariate normality is given according to the R MVN function in the data of study 2, estimators based on Maximum Likelihood (instead of Robust Maximum Likelihood as displayed in the results of the main study) are used here.

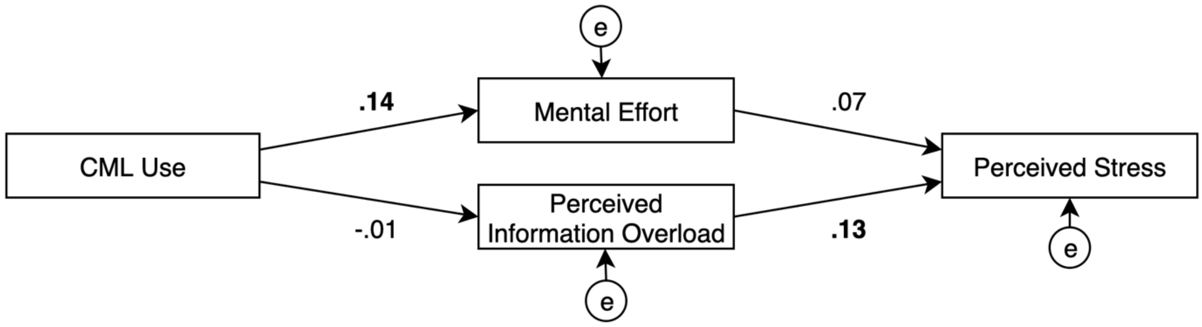

Figure 15: Research model 2. $\chi 2(2)=12.6$, p=.002, $\chi 2/df=6.3$, CFI=.55, RMSEA=.17, PCLOSE=.01, SRMR=.09

The original research model of study 2 (as derived from the main study) did not show a sufficient fit with $\chi2(2)$=12.6, *p*=.002, $\chi2/df$=6.3, *CFI*=.55, *RMSEA*=.17, *PCLOSE*=.01 and *SRMR*=.09. This confirms the impression of the corresponding results of the main study.

Analogous with the modified research model of the main study and also indicated by the modification indices value (12.11), Mental Effort and PIO residuals have been allowed to co-vary (see Figure 16).

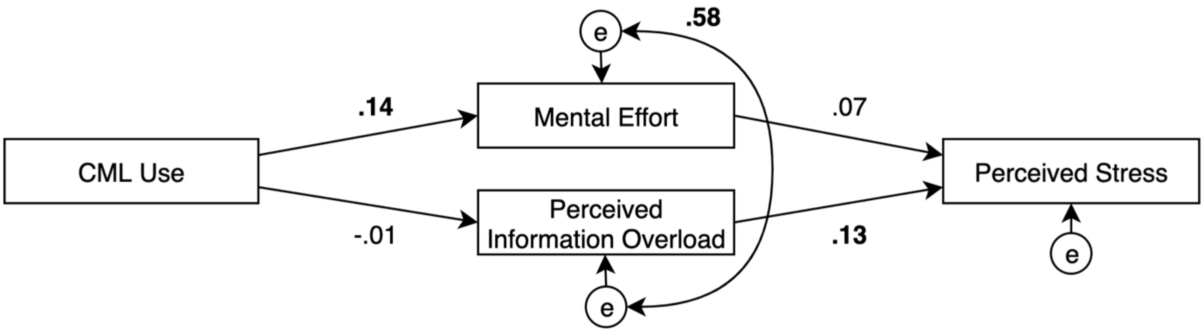

Figure 16: Modified research model 2. χ2(1)=0.07, p=.796, χ2/df=0.07, CFI=1.0, RMSEA=.00, PCLOSE=.84, SRMR=.006

In accordance with the observation from the main study, the fit substantially increases with $\chi2(1)$=0.07, *p*=.796, $\chi2/df$=0.07, *CFI*=1.0, *RMSEA*=.00, *PCLOSE*=.84 and *SRMR*=.006, leading further to the assumption, that Mental Effort and PIO are not sharply distinguishable (*cov*=.58, *p*=.001). Model comparison confirm the increase in fit characteristics with $\chi2(1)$=13.064, *p*<.001. Rather small significant path coefficients are observed between CML Use and Mental Effort (β=.14, *p*<.05), as hypothesized in H2, and between PIO and PS, as assumed in H11 (β=.13, *p*=<.01). Contrary to hypothesis 3 and 10, CML Use did not show a relation to PIO (H3) and PIO also not on PS (10). Like in the main study, these results should be interpreted with caution because of the residual covariance of mental effort and PIO.

Discussion

The aim of this research was the investigation of potential antecedents of Perceived Stress (PS) occurring from the use of Computer-Mediated Learning (CML use, as a highly relevant form of Information and Communication Technology (ICT) use). For this purpose, a research model (represented as a path model) was formulated with corresponding hypotheses for direct effects of the assumed antecedent constructs, namely CML Acceptance, Mental Effort, Perceived Information Overload (PIO) and Trait Rumination. First, the fit of the path model is discussed, and afterward, implications coming from the individual path hypotheses.

The results of the original research model of the main study (see Figure 13), without modification, has not shown a sufficient fit. Thus, the individual path coefficients were not interpretable. Thru theoretical deliberation and the observations of the modification indices, an improvement of the model fit was successful, leading to the modified research model displayed in Figure 14. More precisely, this was done by allowing the residuals of the constructs Mental Effort and Perceived Information Overload (PIO) to covary, with a subsequent significant result. The fit indices improved strongly with a resulting good fit. This led to the assumption, that those constructs were not sharply separable and may explain a similar concept. This is in line with the notion of both Mental Effort and Information Overload to their theoretical underpinnings of the crucial involvement of working memory strain (Chen et al., 2011; compare with Figure 9). The same observation was also made in Study 2, where the same changes occur from the research model (insufficient fit) to the modified research model (good fit), when Mental Effort and PIO residuals were allowed to covary. As Mental Effort was only represented through the item "*Please rate your amount of mental effort you deal with when you are using computer-mediated learning"* (adapted from the Mental Effort Rating Scale; Paas et al. (1992)), it was possibly mainly associated with the perception of too much information (PIO), instead of the theoretically distinct origins of Mental Effort from the interaction between working memory and long-term memory (Figure 9). Consequently, a substantial conceptual overlap in the constructs of Mental Effort and PIO resulted. However, due to their theoretical distinctness, Mental Effort and PIO paths will be discussed also independently.

A major problem in the research model of study 1 remains and is coming from the low internal consistency of the Scott-McIntosh Rumination Inventory (Scott & McIntosh, 1999), the measurement for Trait Rumination in the main study. Thus, the good fit of the modified research model is questionable (see limitations). This could be due the composition of the Scale, as it regards to three aspects of thoughts about goal progression: Emotion, motivation and distraction (Scott & McIntosh, 1999).

With these possible restrictions about the research models in mind, the individual results of the paths with corresponding hypotheses follows. We start with the perspective from CML Use. As predicted in hypothesis 1, the level of CML Use is positively related to CML Acceptance, although the effect is small. This is consistent with research on the occurrence of the Mere Exposure Effect (Zajonc, 1968) and attitude/acceptance models, determining previous experience as an influence of Attitude Toward a Behavior (ATB; which is synonymous with acceptance in this research; Zhang et al., 2008).

In hypothesis 2, the influence of CML Use on Mental Effort was tested. While the main study does not show a significant effect, Study 2 does. Hypothesis 2 was formulated as that more CML Use should decrease Mental Effort, but the effect, although small, is inversely. The hypothesis assumed that when individuals have more experience with CML, they should have more schemata present to better cope to new CML interactions, which, however, could not be confirmed here. It is possible that this is a chance finding in study 2, but the effect in the main study tends in the same direction, even though it is not significant. There are two different deliberations of this effects depending on the respective study. Concerning the main study, CML referred to a very broad field, where users had the possibility to define CML in a wide variety of applications. For example, one user indicated CML use as *"Reading on Laptop, writing scripts, researching in the Internet"*, another as *"Watching YouTube-Videos that explain some subjects or using online dictionary."* Often, participants indicated a multitude of different ways to learn. Thus, it becomes apparent, that people practice *Media Multitasking*, defined as the simultaneously use of two or more different media stimuli (Ophir, Nass, & Wagner, 2009) or media stimuli in combination with further non-media activities (Jeong & Fishbein, 2007). It seems obvious, that many CLM users use media in a multitasking way, which however is known to challenge cognition (Ophir et al., 2009). To conclude, users with more CML Use may participate more in multitasking and consequently tend to have a higher Mental Effort. The following examples given by participants, describing their most common problems they experienced while using CML, further underpin this notion: *"Getting distracted by social media."; "Switching to non-learning related websites."; "Distractions - easy to click on another page and get distracted"; "High distractions from internet opportunities, necessity to think to more things at the same time and faster. More nervous than studying from books".* As this possible explanation fits to the main study, the positive relation of CML Use and Mental Effort in study 2 seems harder to comprehend. As the CML software that was used in this study was very specific, experience with CML use in general may not have helped to reduce Mental Effort through prior knowledge/pre-existing schemata, or were even a burden since they are not fitting to the specific software design (Frametrail) used in the present study. There is also another possible effect that potentially could play a role, originating from the above-mentioned Media Multitasking activities. Participants that already use more CML (and perhaps ICT in general), are more at risk to develop a deficit in cognitive processes, arising from more engagement in Media Multitasking. For example, Ophir et al. (2009) concluded: *"(…) heavy media multitaskers are more susceptible to interference from irrelevant environmental stimuli and from irrelevant representations in memory."* (p. 15583). Thus, Mental Effort is possibly elevated through these interferences even when prior knowledge/pre-existing schemata are present.

Interestingly and again contrary to the formulated hypothesis 3, the level of CML use does not have an effect on PIO in both studies. This result also does make sense, since sensory and working memory (where Information Overload takes place) are of limited capacity (see e.g., Baddeley, 2006) and therefore the amount of experience in CML use probably has no diminishing influence on the perception of too much incoming information. The notion that schemata (stored in long-term memory) are functioning as organizers that support the interpretation of new sensory input and link it to already existing schemata (Vonderwell & Zachariah, 2005) may not be given or do not play a role in the context of both of the conducted studies in reducing PIO. In the main study, the lack of an effect to PIO could also be a consequence of the broad definition of CML. In study 2 on the other hand, there may be just no fitting pre-existing schemata from previous CML use to reduce PIO in the interaction with the specific used CML software. The difference in path coefficients of Mental Effort and PIO, beside the fact that they have common causes outside the investigated models (residual covariance), point in the direction, that they perhaps are similar in their conception, but not identical.

In hypotheses 4 and 5, the influence of Mental Effort and PIO on CML Acceptance, were only tested in the main study. A negative influence was expected for both paths, but no relations were shown. The fact that neither Mental Effort, nor PIO have an impact on CML Acceptance is surprising at the first glance, as the hypotheses anticipated that one important antecedent of ATB (CML Acceptance respectively), Perceived Ease of Use (accroding to the Technology Acceptance Model (TAM; Davis, 1985), compare with Figure 4), is reduced when Mental Effort and PIO increase, hence also ATB. One possible explanation that this is not the case could be, that Perceived Usefulness (the second direct antecedent of ATB, according to TAM) would play a more important role for ATB in this context (CML

Acceptance). This is in line with results of studies conducted by Davis (1989), where Perceived Usefulness and Perceived Ease of Use were compared in their influences on ATB: *"(…) usefulness was significantly more strongly linked to usage than was ease of use."* (p. 333). The following conclusion was that *"(…) the prominence of perceived usefulness makes sense conceptually: users are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform those function."* (p. 333).

Hypotheses 6, 7 and 8 covered the influences of Trait Rumination of ICT Acceptance, Mental Effort and PIO. Again, those hypotheses were only tested in the main study, as Trait Rumination only was included in the model there. These results must be interpreted with caution, due to the low internal consistency in the measurement of Trait Rumination, as mentioned before. Contrary to the prediction in hypothesis 6, Trait Rumination does not show a significant effect on CML Acceptance. Following the deliberations about the absence of an effect of Mental Effort and PIO on CML Acceptance, similar inferences are possible about the observed absence of an effect by Trait Rumination as well, by acknowledging other determinants to be more crucial in the formation of ATB. The possible importance of Perceived Usefulness as emphasised before, is probably not influenced by a personal precondition as Trait Rumination. In stark contrast to, and in line with the notion that Trait Rumination elevates the occurrence of Rumination about information related to incomplete goals (Martin et al., 1993), the derived hypotheses that this will increase Mental Effort (H7) and PIO (H8) are supported by the resulted path coefficients in the models.

The four remaining hypotheses were formulated in regard to the influences on PS. As investigated in the main study and predicted in hypothesis 9, CML Acceptance diminishes PS in CML use. This could be in accordance with the Transactional Model of Stress and Coping (TMSC; Folkman & Lazarus, 1984) and its notion that PS accrues from a unfavorable person-environment relationship (Lazarus, 1993). Accordingly, CML use can be seen as an environmental demand and CML Acceptance as a characteristic of the person. The evaluation about the CML use as an environment demand (Primary Appraisal) could result in the perception of it as less harmful when there is a favorable attitude/acceptance (as a characteristic of a person) of it. Also, this should lead to more favorable person-environment relationship and thus, to the observed lowered PS.

Hypotheses 10 and 11 proposed positive influences of Mental Effort and PIO to PS, which were not confirmed in the main study. In Study 2, a small effect of PIO on PS was observed. As highly significant correlations between Mental Effort and PS and also between PIO and PS could be shown in both studies (see Table 6 and Table 7), the results of the path coefficient are leading to a hypothetical conclusion, that the direction of the effect, as proposed by the research model, is false. Instead, PS may have a positive influence on Mental Effort and PIO in the casual flow, and not the other way around. When taking the result of the small relation in direction from PIO to PS in study 2 into account, also a bidirectional effect is imaginable. This gives rise to test additional models concerning the interplay of mental effort, PIO and PS. Taking these deliberations aside, Mental Effort and PIO do not emerge as antecedents of PS in the main study and only PIO to a small degree in Study 2.

Finally, as predicted in hypothesis 12 and tested in the main study, Trait Rumination has a positive effect to PS. Together with the effects on Mental Effort and PIO shown above, Trait Rumination plays an important role in the research model. But again, the Internal consistency problem of Trait Rumination leaves open questions regarding these effects.

To summarize and with the addressed limitations in mind, constructs of cognitive demands (Mental Effort and PIO) do not or only very little manifest themselves as antecedents of PS. On the contrary, the aspects of acceptance and a trait characteristic (Trait Rumination) are seemingly clear antecedents of PS in CML use. Additionally, the level of CML Use has an elevating effect on CML acceptance.

Limitations

There are critical limitations in this research that need to be taken into account.

First, the research model was not derived from pure structural equation modeling (SEM), in which every construct included in the model is treated as a latent variable. Latent variables are not directly observable but are inferred from other directly observed variables. Instead of using latent variables, the constructs represent the means across all corresponding items of the respective scales and are being treated as directly observed variables. On the basis of these directly observed variables, a path model was tested. While this procedure is legitimate, it has disadvantages in comparison to using SEM with latent variables. Path analysis implicitly assumes that the variables are free of measurement errors and it remains unclear if the used measured items of the constructs are reflective measures of a single latent variable and not facets of multidimensional constructs. The research models used in this work, assumes that this is the case primary based on theoretical underpinnings and tests of internal consistency. In the case of Trait Rumination, even internal consistency was poor and thus, its effects and also the fit of the research model of the main study (but not of study 2) is questionable.

Second, due to the match with the German speaking participants sample of study 2, the questionnaires used in the research model (CML Use, Mental Effort, PIO and PS) were directly translated to German without validation. It is possible, that this may have distorted the representation of the corresponding construct.

A further limitation lies in the definition of CML in the main study, which was defined in a very wide sense and may contributed for a dispersion of different meanings to the participants in the main study and undermine validity. This is specially the case in CML Acceptance, ATB respectively, where the specifity of the behavior in question plays an important role (Petty & Krosnick, 1995).

Also, the questionnaires in the main study are aimed to past experiences and hence, a *recall bias* in the answers of the participants is possible. The term recall bias is described as *"(..) the type of bias, that often occurs when an individual reports a past behavior or event. Although such retrospective reporting may have accurate features, it also tends to include inaccurate aspects, such as systematic undercount or overcount of the frequency with which a certain behavior occurred. This type of distortion has ramifications in survey methodology (…)."* (VandenBos, 2007). This is mostly relevant to the reports on the amount of previous CML use and the occurrences of Mental Effort and PIO.

Future Research

The present work gives rise for a multitude of implications for future research. One interesting finding is that previous CML use does not negatively affect Mental Effort in the tasks of study 2, but even account for a small significant increase. It would be interesting to see, if in other CML contexts, similar effects can be shown or if this effect is only occurring in this specific CML software that was used. This could have implications to the assessment of an CML software about its utilization of previous experiences of its users with CML in general, for example if the design fails to adapt to these experiences.

As the research question was to find antecedents for PS in CML use, the proposed path model mainly failed to confirm Mental Effort and PIO as two of these possible antecedents. But there are other constructs that can be tested in this context. For example, the concept of Technology Overload (Karr-Wisniewski & Lu, 2010), that include Information Overload, but also the aspects of Communication Overload and System Feature Overload. Communication Overload refers to *“the phenomenon or experience of feeling overwhelmed by communication technologies”* (Burns & Bossaller, 2012, p. 598) and System Feature Overload occurs *“when the given technology is too complex for a given task”* (Karr-Wisniewski & Lu, 2010, p. 2). Or more generally speaking, the influence on PS by load/overload and related concepts is indicated and should be addressed in future research.

Further, the seemingly importance of Trait Rumination in the perception of stress (PS) in CML use indicates that the research in traits in general is worth to consider more, as with its consequent adaption in the design of CML software or work environments, the benefits of CML could be extended to users with difficulties is certain areas (such as goal attainment and Rumination). However, this finding cannot be conclusively clarified, as the used measurement of Trait Rumination lacks internal consistency. There is need to find other ways to measure Trait Rumination from the perspective of goal attainment or in related forms in future research.

Also, as concluded before, the hypothesized direction of the effect of Mental Effort and PIO on PS, as tested in the research model, could be a misconception. This is in line with deliberations by Reinecke et al. (2017), where (beside Internet Multitasking) the influence of Communication Load on PS was tested: *“Whereas communication load and Internet multitasking are treated as sources of perceived stress in the present study, the direction of effects could also be reversed” (p. 18).* Thus, a model with different effect directions (reversed or bidirectional) could be considered and tested.

Conclusion

In this work, a model to investigate in finding important antecedents of PS in technology use, more precisely in CML, was constructed and tested in a path analysis. The included constructs did account for four aspects that were considered crucial for the potential occurrence of PS in the context of CML: The amount of engagement in CML in general (CML Use), the attitude about using CML (CML Acceptance), cognitive processing demands (Mental Effort and PIO) and trait characteristics (Trait Rumination). Two studies were conducted, while the full model was used in the main study. The main study was conducted with an online survey, where participants provided information about their general CML use experiences with the corresponding construct questionnaires. There are no effects of the constructs regarding cognitive processing demands (Mental Effort and PIO) on PS. A cushioning effect is observed by the attitude in favor of using CML (CML Acceptance) on PS. Also, CML acceptance is a little improved through the amount of engagement in CML in general (CML Use). The trait characteristics of rumination (Trait Rumination) of the participants show a profound effect on PS, and also on Mental Effort and PIO, emphasize its potential importance in the whole model. In the additional study 2 with an experimental design and a specific CML software, CML Use and the cognitive processes of Mental Effort and PIO were tested to its influence of PS. Only a small effect of PIO on PS was observed.

It is concluded, that acceptance and traits are potentially more important to the formation of stress perception in CML activities than constructs regarding cognitive demands. This notion implies that it is crucial to design CML software or whole CML working environments that improve the attitude for using them. Also, considerations about the optimization of software or working environments in view of trait characteristics of users, concretely of rumination, should be taken into account, for example in keeping distractions apart and improving goal progression properties. However, the role of Trait Rumination needs further confirmation with other measurements with sufficient internal consistency. At last, it is also important to mention that cognitive processing aspects (Mental Effort and PIO) may not influence PS but it could be the other way around. If that would be the case, improving attitude and reducing effects of Rumination would have even a bigger impact. Further research can be focused on such deliberations and test corresponding models.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action control* (pp. 11-39). doi:10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Ajzen, I., & Fishbein, M. (1973). Attitudinal and normative variables as predictors of specific behavior. *Journal of Personality and Social Psychology, 27*(1), 41-57. doi:10.1037/h0034440

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior.* New Jersey, USA: Prentice-Hall.

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British journal of social psychology, 40*(4), 471-499. doi:10.1348/014466601164939

Baddeley, A. (1992). Working memory. *Science, 255*(5044), 556-559. doi:10.1126/science.1736359

Baddeley, A. (2006). Working memory: An overview. In S. J. Pickering (Eds.), *Working memory and education* (pp. 1-31): doi:10.1016/B978-0-12-554465-8.X5000-5

Basilaia, G., & Kvavadze, D. (2020). Transition to Online Education in Schools during a SARS-CoV-2 Coronavirus (COVID-19) Pandemic in Georgia. *Pedagogical Research, 5*(4), 1-9. doi:10.29333/pr/7937

Borg, G., Bratfisch, O., & Dorni'c, S. (1971). On the problems of perceived difficulty. *Scandinavian journal of psychology, 12*(1), 249-260. doi:10.1111/j.1467-9450.1971.tb00628.x

Bryant, F. B., & Satorra, A. (2012). Principles and practice of scaled difference chi-square testing. *Structural equation modeling: a multidisciplinary journal, 19*(3), 372-398. doi: 10.1080/10705511.2012.687671

Burns, C. S., & Bossaller, J. (2012). Communication overload: a phenomenological inquiry into academic reference librarianship. *Journal of Documentation*, *68*(5), 597-617. doi:10.1108/00220411211255996

Chen, C.-Y., Pedersen, S., & Murphy, K. L. (2011). Learners' perceived information overload in online learning via computer-mediated communication. *Research in Learning Technology, 19*(2), 101-116. doi:10.1080/21567069.2011.586678

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of health and social behavior*, 24(4), 385-396. doi:10.2307/2136404

Crites Jr, S. L., Fabrigar, L. R., & Petty, R. E. (1994). Measuring the affective and cognitive properties of attitudes: Conceptual and methodological issues. *Personality and social psychology bulletin, 20*(6), 619-634. doi:10.1177/0146167294206001

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334. doi:10.1007/BF02310555

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results.* (Doctoral dissertation, Massachusetts Institute of Technology). Retrieved from https://dspace.mit.edu/handle/1721.1/15192/

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, *13*(3), 319-340. doi:10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management science, 35*(8), 982-1003. doi:10.1287/mnsc.35.8.982

de Quervain, D. J., Roozendaal, B., & McGaugh, J. L. (1998). Stress and glucocorticoids impair retrieval of long-term spatial memory. *Nature, 394*(6695), 787-790. doi:10.1038/29542

de Sousa, A. E. C. (2019). *Students' perceptions regarding the use of ICT in learning. Proceedings of the International Conference on Education*, *5*(1), 1-7. doi:10.17501/24246700.2019.5101

Denis, D., & Legerski, J. (2006). Causal modeling and the origins of path analysis. *Theory & Science, 7*(1). Retrieved from http://theoryandscience.icaap.org/content/vol7.1/denis.html

DeStefano, D., & LeFevre, J.-A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior, 23*(3), 1616-1641. doi:10.1016/j.chb.2005.08.012

Edwards, E. J., Edwards, M. S., & Lyvers, M. (2015). Cognitive trait anxiety, situational stress, and mental effort predict shifting efficiency: Implications for attentional control theory. *Emotion, 15*(3), 350-359. doi:10.1037/emo0000051

Edwards, M. S., Burt, J. S., & Lipp, O. V. (2006). Selective processing of masked and unmasked verbal threat material in anxiety: Influence of an immediate acute stressor. *Cognition and Emotion, 20*(6), 812-835. doi:10.1080/02699930500375761

Ellison, N. B., Vitak, J., Gray, R., & Lampe, C. (2014). Cultivating social resources on social network sites: Facebook relationship maintenance behaviors and their role in social capital processes. *Journal of Computer-Mediated Communication*, *19*(4), 855-870. doi:10.1111/jcc4.12078

Eppler, M. J., & Mengis, J. (2004). The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines. *The information society, 20*(5), 325-344. doi:10.1080/01972240490507974

Finney, S. J., & DiStefano, C. (2006). Non-normal and categorical data in structural equation modeling. *Structural equation modeling: A second course, 10*(6), 269-314.

Fishbein, M. (1967). Attitude and the prediction of behavior. in A. W. Kruglanski & J. P. Forgas (Eds.), *Attitudes and attitude change* (pp. 289-311). New York, USA: Psychology Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Massachusetts: Addison-Wesley.

Folkman, S., & Lazarus, R. S. (1984). *Stress, appraisal, and coping*. New York: Springer Publishing Company.

Gianferante, D., Thoma, M. V., Hanlin, L., Chen, X., Breines, J. G., Zoccola, P. M., & Rohleder, N. (2014). Post-stress rumination predicts HPA axis responses to repeated acute stress. *Psychoneuroendocrinology*, *49*, 244-252. doi:10.1016/j.psyneuen.2014.07.021

Harris, C., & Straker, L. (2000). Survey of physical ergonomics issues associated with school childrens' use of laptop computers. *International Journal of Industrial Ergonomics, 26*(3), 337-346. doi:10.1016/S0169-8141(00)00009-3

Helsper, E. J., & Eynon, R. (2010). Digital natives: where is the evidence? *British educational research journal, 36*(3), 503-520. doi:10.1080/01411920902989227

Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal, 6*(1), 1-55. doi:10.1080/10705519909540118

Hunt, R. E., & Newman, R. G. (1997). Medical knowledge overload: a disturbing trend for physicians. *Health care management review, 22*(1), 70-75.

Jeong, S.-H., & Fishbein, M. (2007). Predictors of multitasking with media: Media factors and audience factors. *Media Psychology, 10*(3), 364-384. doi:10.1080/15213260701532948

Kalyuga, S. (2009). Knowledge elaboration: A cognitive load perspective. *Learning and instruction, 19*(5), 402-410. doi:10.1016/j.learninstruc.2009.02.003

Kan, M. P. H., & Fabrigar, L. R. (2017). Theory of Planned Behavior. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of Personality and Individual Differences* (pp. 1-8). Oakland, USA: Springer Nature.

Karr-Wisniewski, P., & Lu, Y. (2010). When more is too much: Operationalizing technology overload and exploring its impact on knowledge worker productivity. *Computers in Human Behavior, 26*(5), 1061-1072. doi:10.1016/j.chb.2010.03.008

Koolhaas, J. M., Bartolomucci, A., Buwalda, B., de Boer, S. F., Flügge, G., Korte, S. M., ... Palanza, P. (2011). Stress revisited: a critical evaluation of the stress concept. *Neuroscience & Biobehavioral Reviews, 35*(5), 1291-1301. doi:10.1016/j.neubiorev.2011.02.003

Lazarus, R. S. (1993). From psychological stress to the emotions: A history of changing outlooks. *Annual review of psychology, 44*(1), 1-22. doi:10.1146/annurev.ps.44.020193.000245

Lazarus, R. S., & Folkman, S. (1987). Transactional theory and research on emotions and coping. *European Journal of personality, 1*(3), 141-169. doi:10.1002/per.2410010304

Lipowski, Z. (1975). Sensory and information inputs overload: behavioral effects. *Comprehensive Psychiatry*, *16*(3), 199–221. doi:10.1016/0010-440X(75)90047-4

Lok, C.-F., & Bishop, G. D. (1999). Emotion control, stress, and health. *Psychology and health, 14*(5), 813-827. doi:10.1080/08870449908407349

Lu, Y., Zhou, T., & Wang, B. (2009). Exploring Chinese users' acceptance of instant messaging using the theory of planned behavior, the technology acceptance model, and the flow theory. *Computers in human behavior*, *25*(1), 29-39. doi:10.1016/j.chb.2008.06.002

MacIntyre, P. D., & Blackie, R. A. (2012). Action control, motivated strategies, and integrative motivation as predictors of language learning affect and the intention to continue learning French. *System, 40*(4), 533-543. doi:10.1016/j.system.2012.10.014

Martin, L. L., & Tesser, A. (1996). Some ruminative thoughts. In R. S. Wyler (Series Ed.), *Advances in Social Cognition: Vol. 9. Ruminative Thoughts* (pp. 1-47).

Martin, L. L., Tesser, A., & McIntosh, W. D. (1993). Wanting but not having: The effects of unattained goals on thoughts and feelings. In D. M. Wegner & J. W. Pennebaker (Eds.), *Century psychology series: Handbook of mental control* (pp. 552–572). New York, USA: Prentice-Hall.

Masrom, M. (2007). Technology acceptance model and e-learning. *Technology, 21*(24), 1-10.

Mathieson, K. (1991). Predicting user intentions: comparing the technology acceptance model with the theory of planned behavior. *Information systems research, 2*(3), 173-191. doi: 10.1287/isre.2.3.173

Matthes, J., Karsay, K., Schmuck, D., & Stevic, A. (2020). "Too much to handle": Impact of mobile social networking sites on information overload, depressive symptoms, and well-being. *Computers in Human Behavior, 105*, 1-10. doi:10.1016/j.chb.2019.106217

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England journal of medicine, 338*(3), 171-179. doi:10.1056/NEJM199801153380307

McEwen, B. S., Nasca, C., & Gray, J. D. (2016). Stress Effects on Neuronal Structure: Hippocampus, Amygdala, and Prefrontal Cortex. *Neuropsychopharmacology, 41*(1), 3-23. doi:10.1038/npp.2015.171

McEwen, B. S., & Wingfield, J. C. (2003). The concept of allostasis in biology and biomedicine. *Hormones and behavior, 43*(1), 2-15. doi:10.1016/S0018-506X(02)00024-7

Meade, A. W., & Craig, S. B. (2012). Identifying careless responses in survey data. *Psychological Methods, 17*(3), 437-455. doi:10.1037/a0028085

Meier, R. L. (1963). Communications overload: Proposals from the study of a university library. *Administrative Science Quarterly*, 7(4), 521-544. doi:10.2307/2390963

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97. doi:10.1037/h0043158

Misra, S., & Stokols, D. (2012). Psychological and health outcomes of perceived information overload. *Environment and behavior, 44*(6), 737-759. doi:10.1177/0013916511404408

Moreland, R. L., & Topolinski, S. (2010). The mere exposure phenomenon: A lingering melody by Robert Zajonc. *Emotion Review, 2*(4), 329-339. doi:10.1177/1754073910375479

Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology, 100*(4), 569-582. doi:10.1037/0021-843X.100.4.569

Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: the 1989 Loma Prieta Earthquake. *Journal of Personality and Social Psychology, 61*(1), 115. doi:10.1037/0022-3514.61.1.115

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on psychological science, 3*(5), 400-424. doi:10.1111/j.1745-6924.2008.00088.x

Oettingen, G., Hönig, G., & Gollwitzer, P. M. (2000). Effective self-regulation of goal attainment. *International journal of educational research, 33*(7-8), 705-732. doi:10.1016/S0883-0355(00)00046-X

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences, 106*(37), 15583-15587. doi:10.1073/pnas.0903620106

World Health Organization (2020). Coronavirus disease 2019 (COVID-19): situation report - 72. Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological bulletin, 124*(1), 54-74. doi:10.1037/0033-2909.124.1.54

Paas, F. G., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist, 38*(1), 63-71. doi:10.1207/S15326985EP3801_8

Paas, F. G. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of educational psychology, 84*(4), 429-434. doi:10.1037/0022-0663.84.4.429

Paas, F. G., & Van Merriënboer, J. J. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performance measures. *Human factors, 35*(4), 737-743. doi:10.1177/001872089303500412

Paas, F. G., & Van Merriënboer, J. J. (1994). Instructional control of cognitive load in the training of complex cognitive tasks. *Educational psychology review, 6*(4), 351-371. doi:10.1007/BF02213420

Papageorgiou, C., & Wells, A. (2003). An empirical test of a clinical metacognitive model of rumination and depression. *Cognitive therapy and research, 27*(3), 261-273. doi:10.1023/A:1023962332399

Paulo, H. F. (1999). *Information overload in computer-mediated communication and education: is there really too much information? Implications for distance education.* (Doctoral dissertation, University of Toronto). Retrieved from https://tspace.library.utoronto.ca/handle/1807/13110

Pearson, K. (1895). Notes on Regression and Inheritance in the Case of Two Parents. *Proceedings of the Royal Society of London*, *58*, 240-242. doi: 10.1098/rspl.1895.0041

Petty, R. E., & Krosnick, J. A. (1995). *Attitude strength: Antecedents and consequences*: New York, USA: Psychology Press.

Przybylski, A. K., Murayama, K., DeHaan, C. R., & Gladwell, V. (2013). Motivational, emotional, and behavioral correlates of fear of missing out. *Computers in Human Behavior*, *29*(4), 1841-1848. doi:10.1016/j.chb.2013.02.014

Reinecke, L., Aufenanger, S., Beutel, M. E., Dreier, M., Quiring, O., Stark, B., ... Müller, K. W. (2017). Digital stress over the life span: The effects of communication load and internet multitasking on perceived stress and psychological health impairments in a German probability sample. *Media Psychology, 20*(1), 90-115. doi:10.1080/15213269.2015.1121832

Reinecke, L., Meier, A., Aufenanger, S., Beutel, M. E., Dreier, M., Quiring, O., ... Müller, K. W. (2018). Permanently online and permanently procrastinating? The mediating role of Internet use for the effects of trait procrastination on psychological health and well-being. *New Media & Society, 20*(3), 862-880. doi:10.1177/1461444816675437

Reinecke, L., Vorderer, P., & Knop, K. (2014). Entertainment 2.0? The role of intrinsic and extrinsic need satisfaction for the enjoyment of Facebook use. *Journal of communication, 64*(3), 417-438. doi:10.1111/jcom.12099

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of statistical software, 48*(2), 1-36.

Ryan, R. M., & Deci, E. L. J. A. p. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist, 55*(1), 68-78. doi:10.1037/0003-066X.55.1.68

Schmeck, A., Opfermann, M., van Gog, T., Paas, F., & Leutner, D. (2015). Measuring cognitive load with subjective rating scales during problem solving: differences between immediate and delayed ratings. *Instructional Science, 43*(1), 93-114. doi:10.1007/s11251-014-9328-3

Schroder, H. M., Driver, M. J., & Streufert, S. (1967). *Human information processing: Individuals and groups functioning in complex social situations*. New York, USA: Holt, Rinehart and Winston.

Scott, V., & McIntosh, W. D. (1999). The development of a trait measure of ruminative thought. *Personality and Individual Differences, 26*(6), 1045-1056. doi:10.1016/S0191-8869(98)00208-6

Selwyn, N., Gorard, S., & Furlong, J. (2006). *Adult learning in the digital age: Information technology and the learning society*. New York, USA: Routledge.

Selye, H. (1976). Stress without distress. In G. Serban (Ed.), *Psychopathology of human adaptation* (pp. 137-146). doi:10.1007/978-1-4684-2238-2

Seppmann, W. (2017). *Kritik des Computers. Der Kapitalismus und die Digitalisierung des Sozialen.* Kassel, Germany: Mangroven Verlag.

Smith, J. M., & Alloy, L. B. (2009). A roadmap to rumination: A review of the definition, assessment, and conceptualization of this multifaceted construct. *Clinical psychology review, 29*(2), 116-128. doi:10.1016/j.cpr.2008.10.003

Steinmetz, H. (2015). *Lineare Strukturgleichungsmodelle: Eine Einführung mit R*. Mering, Germany: Rainer Hampp Verlag.

Steptoe, A. (1991). Invited review: The links between stress and illness. *Journal of Psychosomatic Research, 35*(6), 633-644. doi:10.1016/0022-3999(91)90113-3

Sun, H., & Zhang, P. (2006). The role of moderating factors in user technology acceptance. *International journal of human-computer studies, 64*(2), 53-78. doi:10.1016/j.ijhcs.2005.04.013

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive science, 12*(2), 257-285. doi:10.1016/0364-0213(88)90023-7

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction, 4*(4), 295-312. doi:10.1016/0959-4752(94)90003-5

Sweller, J. (2011). Cognitive load theory. In J. P. Mestre & B. H. Ross (Eds.) *Psychology of learning and motivation - Vol. 55* (pp. 37-76). doi:10.1016/B978-0-12-387691-1.00002-8

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational psychology review, 10*(3), 251-296. doi:10.1023/A:1022193728205

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia manufacturing, 22*, 960-967. doi:10.1016/j.promfg.2018.03.137

Tarafdar, M., Tu, Q., & Ragu-Nathan, T. S. (2010). Impact of technostress on end-user satisfaction and performance. *Journal of management information systems, 27*(3), 303-334. doi:10.2753/mis0742-1222270311

Thomée, S., Eklöf, M., Gustafsson, E., Nilsson, R., & Hagberg, M. (2007). Prevalence of perceived stress, symptoms of depression and sleep disturbances in relation to information and communication technology (ICT) use among young adults – an explorative prospective study. *Computers in Human Behavior, 23*(3), 1300-1321. doi:10.1016/j.chb.2004.12.007

Tiernan, P. (2015). An inquiry into the current and future uses of digital video in University teaching. *Education and Information Technologies, 20*(1), 75-90. doi:10.1007/s10639-013-9266-8

VandenBos, G. R. (Ed.). (2007). *APA dictionary of psychology*. Washington, DC, USA: American Psychological Association.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science, 46*(2), 186-204. doi:10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly,* 27(3), 425-478. doi:10.2307/30036540

Vonderwell, S., & Zachariah, S. (2005). Factors that influence participation in online learning. *Journal of Research on Technology in education, 38*(2), 213-230. doi:10.1080/15391523.2005.10782457

Vorderer, P., & Kohring, M. (2013). Permanently online: A challenge for media and communication research. *International Journal of Communication, 7*(1), 188-196.

Wang, E. S.-T., & Chen, L. S.-L. (2012). Forming relationship commitments to online communities: The role of social motivations. *Computers in Human Behavior, 28*(2), 570-575. doi:10.1016/j.chb.2011.11.002

Whiteman, J. A. M. (2002). Interpersonal Communication in Computer Mediated Learning. Retrieved from https://www.academia.edu/2156381/

Wong, E. T. (2004). Impact of E-Learning During SARS Outbreak in Hong Kong. In M. Khosrow-Pour (Ed.), *The Social and Cognitive Impacts of E-commerce on Modern Organizations* (pp. 185-203). doi:10.4018/978-1-59140-249-7.ch009

Yehuda, R. (2002). Post-traumatic stress disorder. *New England journal of medicine, 346*(2), 108-114. doi:10.1056/NEJMra012941

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9*(2, Pt.2), 1-27. doi:10.1037/h0025848

Zhang, P., Aikman, S. N., & Sun, H. (2008). Two types of attitudes in ICT acceptance and use. *International Journal of Human–Computer Interaction, 24*(7), 628-648. doi:10.1080/10447310802335482

Zuppo, C. M. (2012). Defining ICT in a boundaryless world: The development of a working hierarchy. *International journal of managing information technology, 4*(3), 13-22. doi:10.5121/ijmit.2012.4302