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Published: 01/03/2020

Document Version
Publisher's PDF, also known as Version of record

[Link to publication](#)

The Human Energy and Fatigue Constructs in Relation to Information and Communication Technologies: A Conceptual Framework

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ABSTRACT

Information and communication technologies (ICTs) are generally assumed to save time and energy, yet user fatigue due to ICT use is assumed to be on the rise. The question about the effects of ICT use on human energy has sparked increased research interest in recent years, however, the course is complicated by the fact that the conceptualization of human energy is extremely diverse. The aim of this paper is therefore to provide a conceptual framework and classification of the subjective energy and fatigue concepts and reflect on the theoretical embedding of technology within the theories on subjective energy. We also reflect on the new phenomena of social networking sites (SNS) exhaustion and SNS fatigue. With this, we aim to provide a conceptual baseline for future research on the relationship between ICT use and subjective energy of ICT users.

Keywords: Human energy, fatigue, exhaustion, vigor, vitality, depletion, ICTs, ICT use

1. INTRODUCTION

As we approach the third decade of the 21st century, our lives appear more and more like the wildest sci-fi dreams of the previous millennium: we own pocket-sized devices and wearables that are connected not only to our friends, family and colleagues, but also to our refrigerators, radiators and home cameras. At our fingertips or voice commands we have access to a library of infinite human knowledge and even at the remotest locations we can accomplish most of our tasks. The new information and communication technologies (ICTs) that help us achieve this were invented to make humanity more efficient and productive, save us time and energy, and improve our quality of life and well-being.

Yet at the same time, lack of time and energy is the number one complaint of modern society, and digital technology is often seen as a cause. The number of employees who suffer from fatigue and emotional exhaustion seems to be rising and often tips over 25% of the general working population, depending on country and assessment method (Aumayr-Pintar, Cerf, & Parent-Thirion, 2018; Bültmann, Kant, Kasl, Beurskens, & van den Brandt, 2002; Shanafelt et al., 2015; Shanafelt et al., 2019). The costs of burned-out employees is estimated to be up to 190 billion dollars per year in health-care spending in the US alone, and additional 5 billion US dollars in turnover and

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productivity loss among physicians only (Garton, 2017; Han et al., 2019; Waldman, Kelly, Aurora, & Smith, 2004).

Digitalization of the work place has been cited as a common reason for this decrease in employees' energy levels, and terms such as "techno-stress", "tech-invasion" and "digital fatigue" have entered the vocabulary (Ayyagari, Grover, & Purvis, 2011; Ragu-Nathan, Tarafdar, Ragu-Nathan, & Tu, 2008; Shin & Shin, 2016). Additional technology-related phenomena such as Internet addiction and addiction to Social Networking Sites (SNS) have also been associated to fatigue, which extends the problem beyond work environments to the general population, especially the younger generations (Bener et al., 2018; Lin, Tsai, Chen, & Koo, 2013). So the question arises, are ICTs saving or are they costing us energy?

Considering the trends, it is not surprising that research on this topic has started to proliferate in the last couple of years. As of 2019, 83% of the articles published on the topic in the leading Human Computer Interaction (HCI) and Information Systems (IS) journals date no earlier than 2014 and 69% as recently as 2016. However, if one attempts to review the results, it quickly becomes evident that human energy, especially the subjective experience thereof, is an extremely elusive and complicated construct. Different disciplines use different terms, different definitions and different theories to describe and explain subjective energy. For example, organizational scholars mostly refer to employees' feelings of "emotional exhaustion" and "vigor" (Bakker, Schaufeli, Leiter, & Taris, 2008; Cropanzano, Rupp, & Byrne, 2003). Personality and social psychologists on the other hand focus on "depletion" and "vitality" (Deci & Ryan, 2011; Muraven, Tice, & Baumeister, 1998). All these terms come with their own measurement instruments, sometimes multiple per term. Other terms such as mental or psychic energy, fatigue, tiredness, activity, (positive) arousal, inertia, etc., are frequently used to describe the subjective experience of having energy as well.

The consistent use of singular term as opposed to almost arbitrary use of multiple terms reflects the level of established agreement and existence of dominant theory within a discipline. For instance, the theories of job burnout and work engagement within organizational science are almost undisputed, but there is still an ongoing debate about the nature of self-regulation in social and motivation science or the nature and type of affect. Little consensus seems to exist on terminology and measurement, sometimes even within a single discipline like psychophysiology, cognitive and affective sciences, etc. When HCI and IS scholars now enter the field and borrow from all these disciplines, they risk using the terms arbitrarily and interchangeably

The broadness of terms and conceptualizations makes it also difficult (if not impossible) to systematically study the effects of IT use on human energy. Empirical studies are not comparable if they all use different definitions and measure different impacts in different ways. Thus, there is an urgent need for a systematic structure of all the different terms, their definitions, dominant theories, and the way that they have been operationalized, i.e., measured, and used.

In this paper, we therefore provide a conceptual framework for the subjective energy and fatigue constructs. Specifically, we investigate how the different terms are defined and how they are operationalized in papers published in the 30 top-ranked journals in the fields of Human-Computer Interaction and Information Systems, but also the leading journals in Applied Psychology, Organizational Behavior and Consumer Research. After identifying 53 relevant studies, we analyze what theories (if any) were used in the papers. We then delve into the prominent theories about the specific energy-concepts and reflect how technology can be fitted in these theories.

In sum, the paper provides a detailed conceptual framework about subjective energy, fatigue and technology and classifies the different energy-related terms. With this, we provide clarity and classification of the subjective energy constructs and their theories, which are otherwise scattered and sometimes ill-conceived. This aim is to help HCI and IS researchers who are interested in human energy and fatigue get an overview of the constructs and theories and choose the one (or several) construct(s) that are most suitable and relevant for their studies (See for e.g. Table 1 in Section 2 or Figure 1 in the Section 4).

2. THE DIFFERENT FACES OF SUBJECTIVE ENERGY AND FATIGUE: CONCEPTUAL FRAMEWORK AND CLASSIFICATION OF THE TERMS

When scholars study subjective energy or subjective fatigue, the scope of the analyzed construct varies: Some study short-term, momentary experiences of energy or tiredness, while others look into longer lasting states thereof (*duration*). Some focus very narrowly on the experience of subjective energy and fatigue, while others combine it in broader concepts that entail attitudes or motivation (*range*). Again others emphasize the *cause* of energy loss or gain, for example *work*-stress as a cause of emotional exhaustion, while others postulate no specific cause for the experience of subjective energy. Last but not least, scholars embrace different *conceptualizations* of subjective energy: Some base their work on a bipolar (univariate) view, which sees subjective energy and subjective fatigue as two opposite ends on one energy dimension that ranges from tired to energetic. On the contrary, others embrace the more timely bivariate (unipolar) view, which postulates that subjective energy and subjective fatigue are separate feelings or mental states that are based on different energy dimensions and processes (Bakker & Demerouti, 2007; Shirom, 2011). This view thus recognizes that, somewhat contraintuitively, mixed feelings of energy and fatigue are possible. In sum, according to the bipolar view, if someone is feeling energetic and vigorous, they by definition cannot feel tired and fatigued at the same time. However, recent evidence, including neurological studies, have shown that subjective energy and subjective fatigue are based on two different brain networks, have different antecedents and behavioral consequences and can therefore be experienced at the same time (Mäkikangas et al., 2014).

In the following, we present all the relevant terms related to subjective energy, their underlying theories as well as their operationalization. Within the sections, we reflect on the place ICTs can have within these theories. Finally, we classify the concepts based on their duration, range, cause and conceptualization. We start, in Section 2.1., with emotional exhaustion and vigor, which come from the organizational sciences and are exclusively concerned with employees' energy. In Section 2.2., we present depletion and vitality, two prominent terms in personality and social psychology. In section 2.3., we discuss subjective energy and fatigue from the viewpoint of affect theories. The terms from these two sections apply to the general population. In Section 2.4., we conclude by introducing the new concepts of SNS exhaustion and SNS fatigue which is restricted to SNS users. An overview of the classification is presented in Table 1.

Table 1. Summary and classification of subjective energy and fatigue constructs

Construct	Terms used for: Subjective energy	Subjective fatigue	Main definition	Main measures	Duration	Range/Scope	Specific cause	Field/Context
Emotional Exhaustion	Rarely, when reverse scored	Yes	Feeling exhausted and drained by work	Emotional exhaustion subscale of the MBI	Long lasting, chronic	Narrow to broad: work strain is also part of the experience	Work, work demands	Organizational science Occupational psychology ———————
Vigor	Yes	No	Feeling high levels of energy and mental resilience while working	*Vigor subscale of the UWES*	Long lasting	Broad: resilience and willingness to invest energy are also part of the experience	Work resources	Applied to employees
Depletion	No	Yes	Temporary reduction in the available energy for self-control	Dual-task paradigm. Performance measure on self-depleting tasks	Temporary, fluctuates daily	Broad: inability and unwillingness to invest energy are also part of the experience	Prior voluntary and self-controlling activities	Personality psychology Social psychology ———————
Vitality	Yes	No	Experience of possessing energy and aliveness that comes from the self	Subjective Vitality Scale	Long lasting	Broad: optimism, feeling alive, awake and alert are also part of the experience	Satisfaction of basic psychological needs, especially the need for self-determination (autonomy)	Applied to the general population
Vitality	Yes	Yes		Vitality-fatigue subscale of SF-36	1 month	Narrow, only feeling of energy or fatigue	No specific cause	Psychophysiology
Vigor, energy	Yes	No	Feeling energetic, vigorous, vital, full of pep	Vigor-energy subscale of POMS	1 week	Narrow, only feeling of energy	No specific cause	Cognitive and Affective science ———————
General a activation, energy	Yes	No		General activation subscale of AD ACL	Momentary feeling	Narrow, only feeling of energy	No specific cause	Applied to the general population

Construct	Term used for:		Main definition	Main measures	Duration	Range/Scope	Specific cause	Field/Context
	Subjective energy	Subjective fatigue						
Fatigue	Yes	Yes	Feeling tired, worn out	Vitality-fatigue subscale of SF-36	1 month	Narrow, only feeling of energy and fatigue	No specific cause	Psychophysiology
	No	Yes	Feeling fatigued, exhausted	Fatigue subscale of POMS	1 week	Narrow, only feeling of fatigue, exhaustion	No specific cause	Cognitive and Affective science
Deactivation	No	Yes	Feeling tired, sleepy	Deactivation subscale of AD ACL	Momentary feeling	Narrow, only feeling of tiredness, sleepiness	No specific cause	Applied to the general population
SNS Exhaustion	No	Yes	Feeling exhausted and drained by SNS	SNS exhaustion (adopted from the MBI)	Long lasting	Narrow to broad: strain is also part of the experience	SNS use	Human Computer Interaction Science
SNS Fatigue	No	Yes	Feeling exhausted and drained by SNS. Feeling bored disinterested and indifferent	Adopted Mental Fatigue scales. Various self-constructed scales	Long lasting	Broad: indifference, boredom and disinterest are also part of the experience	SNS use	Information Systems Applied to SNS users

2.1. Work-related Emotional Exhaustion and Vigor

The most researched concepts related to subjective energy in the HCI and IS communities are work-related emotional exhaustion (*n=17)* and work-related vigor (*n=9)*. The two concepts are primarily used in the fields of organizational sciences as well as education and are the focus of almost half (49%) of the studies we identified. There is a great agreement in these two disciplines about the definition of the two constructs, including their underlying theories. Consequently, the studies presented hereafter use the definitions, measures and theories relatively consistently

Emotional exhaustion

Emotional exhaustion is defined as a feeling of chronic fatigue and being drained of emotional energy by one's work (Maslach & Jackson, 1981; Maslach, Schaufeli, & Leiter, 2001; Moore, 2000; W. Schaufeli, Leiter, Maslach, & Jackson, 1996). It is considered to be the most important and energetic aspect of work-related, chronic ill-being (Maslach et al., 2001). Together with cynicism and inefficacy, it is a core symptom of job burnout. It is measured with a subscale from the Maslach Burnout Inventories (MBI), which contain items such as "I feel emotionally drained from my work" or "I feel fatigued when I get up in the morning and have to face another day on the job". Five different versions of the MBI tailor the measurements to different target populations, including workers in human services, medical personnel, educators, the general worker's population or students, where for e.g. emotional exhaustion is postulated to be caused by school work (Hietajärvi, Salmela-Aro, Tuominen, Hakkarainen, & Lonka, 2019).

Emotional exhaustion is a key construct for the two most prominent work related stress theories: the Job Demands-Resource Model (J-DR) and the Person-Environment (P-E) fit model (Ayyagari et al., 2011; Bakker & Demerouti, 2007; Demerouti, Bakker, Nachreiner, & Schaufeli, 2001; Edwards, 1991; French, Rodgers, & Cobb, 1974; Maslach et al., 2001). Both theories consider emotional exhaustion to be a consequence of work stressors. According to the JD-R, prolonged work demands cause exhaustion when the work resources are low (Bakker & Demerouti, 2007). Work demands are those "aspects of a job that require sustained physical or mental effort and are therefore associated with physiological or psychological costs" (Demerouti et al., 2001, p.501). Workload and time pressure are common examples for job demands. Job resources, on the other hand, are those aspects of a job that reduce the job demands, stimulate personal growth, or facilitate achieving work goals (Demerouti et al., 2001). Social support, autonomy and feedback are leading examples for job resources.

Technology can be both a demand and a resource or it can indirectly increase or decrease the demands and the resources (Sardeshmukh, Sharma, & Golden, 2012). For example, too many e-mails can increase the information load or frequent updates can require permanent learning effort (Ayyagari et al., 2011). However, technology can also decrease the work demands or increase the resources, for example when it enables an employee to finish a task while at home or during commuting (Chen & Karahanna, 2018). Technology is therefore hypothesized as both: a cause of as well as a buffer against emotional exhaustion.

Unlike the J-DR, the P-E Fit Model does not weigh causes and buffers of emotional exhaustion, but rather emphasizes the *fit* between environmental demands (stressors) on one side and the needs or expectations of the person on the other (Ayyagari et al., 2011; Edwards, 1991; Maslach et al., 2001). The P-E Fit Model postulates that it is a misfit between a person's individual needs and their environment that causes emotional exhaustion. In this respect, the same number of incoming e-mails can be perceived as e-mail overload that cause emotional exhaustion to some employees, but not to others (Reinke & Chamorro-Premuzic, 2014).

Emotional exhaustion is a long lasting, *chronic* feeling of low energy (*duration*). People are unable to recover and re-energize in their free time, thus permanently experiencing exhaustion. The construct is relatively narrow (*range*), but it does embrace related experiences like stress, because the MBI scales include the item "Working all day is a strain for me". Emotional exhaustion has a specific *cause* in the work of the employee. The demands, job characteristics, or the act of working itself are the direct causes of the feeling of exhaustion and hence the cause is part of the experience (e.g. "I feel emotionally drained *from my work*"). Originally, emotional exhaustion was *conceptualized* as low vigor, i.e., as the low end on one bipolar energy scale, however the authors now accept that vigor is a separate energy dimension (Maslach, Jackson, & Leiter, 1996; Maslach, Jackson, Leiter, Schaufeli, & Schwab, 1986; Maslach et al., 2001).

Vigor at Work and School

Vigor is defined as "high levels of energy and mental resilience while working, willingness to invest effort in work, and persistence in the face of difficulties" (p. 74W. Schaufeli, Salanova, González-Romá, & Bakker, 2002). It is the ability not to be easily fatigued at work (Llorens, Schaufeli, Bakker, & Salanova, 2007). Similarly to emotional exhaustion, vigor is defined as a core and energetic dimension of work-related well-being (Bakker et al., 2008). Work-related vigor is a broad concept (*range*), which embraces a motivational side mirrored in the mental resilience of employees and their sustained willingness to invest effort. Together with dedication and absorption, it is one core aspect of the broader mental state of work engagement. The most used instrument to measure work-related vigor is the vigor subscale from the Utrecht Work Engagement Scale (UWES) (Schaufeli, Bakker, & Salanova, 2006). Example items are "At my work, I feel bursting with energy", "At my job, I am very resilient, mentally", and "When I get up in the morning, I feel like going to work". The focus on work-related vigor" is part of the 'positive psychology movement' (Seligman & Csikszentmihalyi, 2014). The construct of vigor has been used to student population as well (Hietajärvi et al., 2019).

Vigor is a relatively long-lasting feeling of high energy levels (*duration*). Vigorous people feel energized during the workday and are re-energized by the thought of work in the morning. However, vigor is not specifically *caused* by work but it is rather the felt energy *at* work and *while* working. According to the JD-R model, it is the job resources that lead to work-related vigor especially when the demands are also high, resembling a state of "flow" which requires optimal challenge (Csikszentmihalyi, 1991; Csikszentmihalyi, Abuhamdeh, & Nakamura, 2014). This motivational process that leads to high energy

while working is *conceptualized* as a separate to the energy draining one that causes emotional exhaustion (Bakker et al., 2008; Mäkikangas et al., 2014; Shirom, 2011).

Any technology that can serve as a job resource can potentially energize and invigorate, for instance technology that supports autonomy and personal growth through learning or supportive technology that facilitates achieving work goals (Llorens et al., 2007; Sardeshmukh et al., 2012; van Zoonen & Rice, 2017).

2.2. Depletion and Vitality: Energy as a Fuel for Self-regulation and a Result of Self-determination

The next most prominent terms related to subjective energy are depletion (*n=6*) and vitality (*n=4*). Together they represent 19% of the considered studies. Both terms come from personality and social psychology and are theories about self-control or self-regulation. Depletion is rooted in the Strength Model of Self-Control (Baumeister, Vohs, & Tice, 2007). Vitality in contrasts stems from Self-determination Theory, which expands the Strength Model of Self-Control and shows why and when self-regulation is *not* depleting (Deci & Ryan, 2008; Ryan & Deci, 2000). Both theories are well established and so a rather consistent use of their definitions and methods is evident across the considered studies that focused on depletion and vitality.

Depletion

Depletion, also termed ego-depletion, is a temporary lack of capacity for volitional action and self-control caused by previous exertions of self-control (Baumeister et al., 2007; Muraven & Baumeister, 2000; Muraven et al., 1998). Depletion demonstrates itself in feelings of low energy and unwillingness to engage in further self-control. It is often accompanied with self-regulatory failures ranging from inability to regulate emotion, impulses, cravings and temptations to inability to control attention (Baumeister et al., 2007; Hagger, Wood, Stiff, & Chatzisarantis, 2010). Thus, depletion is broad in *range* in that it is not only a feeling of low energy, but also encompasses lack of motivation mirrored in the unwillingness to engage in many different tasks that require effort and self-control. Unlike emotional exhaustion or work-related vigor, it is not a lasting state but it is a relatively shorter reaction to exertion of self-control (*duration*).

Typically, depletion is measured with performance on tasks that are known to require self-control (Baumeister et al., 2007; Hagger et al., 2010). Characteristic examples are persistence on unsolvable anagrams, snack choice when presented with healthy vs. unhealthy options or performance on attention and cognitive-control tasks such as the Stroop task, which is a famous color-naming task that requires inhibition of the automatic response to read the text rather than name the color. Prior to the depleting task, participants are required to do an initial task that varies in its degree of required self-regulation. Drop in performance on the second task is then interpreted as evidence for energy depletion in the first one.

According to the Strength Model of Self-Control, people possess "psychic energy" in order to self-regulate. This resource is limited and can be drained by any deliberate control of

cognition, emotion or behavior. Once depleted, people are no longer able or willing to exert self-control until rested or restored (for instance by sugar intake). Energy reservoirs are considered to be domain-independent (Baumeister et al., 2007), which means that prolonged self-regulation in any form will have hindering effects on any subsequent self-control tasks, even if these are unrelated. For example, prolonged cognitive effort will drain the energy for subsequent emotional impulse-control or decision making. Resisting unhealthy temptations will drain the energy for subsequent focused attention. The depleted energy can be restored quite easily however, by rest or engaging in activities that do not require self-regulation (Hagger et al., 2010). Self-control can also be trained so that frequent self-control in any domain will lead to slower depleting effects overall (Muraven & Baumeister, 2000). The *cause* for depletion is not as specific as job demands, however it is still specific enough to exclude tasks that do not require any effort.

Seen from this lens, any technology that requires self-restraint can deplete its users of their energy. For instance trying to abstain from mobile phone or social network use can be depleting (Du, van Koningsbruggen, & Kerkhof, 2018). On the contrary, if technology is created to decrease mental effort, reduce the need for self-regulation or even train self-control it can also nourish this valuable energy resource (Cranwell et al., 2014; Engin & Vetschera, 2017).

Vitality

The term "vitality" stems from Self-Determination Theory and is defined as a feeling of aliveness and vigor, a state of experiencing calm energy (Ryan & Deci, 2008). It is a eudemonic well-being related to self-realization and growth. This is in contrast to hedonic well-being, which is happiness that arises from immediate pleasures (Ryan & Deci, 2001; Ryan, Huta, & Deci, 2008). Vitality is felt as coming from within the self and is not related to any immediate external *cause*. It is often measured with Ryan and Frederick's seven-item subjective vitality scale (SVS), with items like "I feel alive and vital", " "I look forward to each new day" or (reverse scored) "I don't feel very energetic" (Ryan & Frederick, 1997).

Self-Determination Theory (SDT) describes vitality as the optimal end of a favorable interaction between people and their environment. The theory postulates three basic human psychological needs: autonomy, efficacy and relatedness (Deci & Ryan, 2000, 2011; Ryan & Deci, 2000). When these needs are thwarted, the person cannot grow and achieve vitality. In contrast, when these needs are continuously satisfied, people are energized and experience vitality. Thus, autonomous (self-determined) activities, as well as activities that develop competences and belonging can all enhance vitality even if they imply invested effort. This is in direct contrast to the Strength Model of Self-Control, which postulates that any self-regulating activities deplete people of energy. However, according to SDT, autonomous activities and activities that promote competence and belongingness are intrinsically motivating and energizing. In sum, SDT is a theory that postulates the process of creating vitality as a function of (not always conscious) need satisfaction throughout life.

In our classification, vitality is a long lasting state of energy and "aliveness" (*duration*) that is felt at the present moment and that gives optimism to the future ("I look forward to each

new day"). Thus, vitality's *range* is broad in that it encompasses optimism, but also aliveness, awakeness and alertness. According to SDT, technologies that support the autonomy, competence and belongingness of their users can increase their vitality (James, Wallace, & Deane, 2019), those that thwart those needs deplete it (Akın, 2012; Jang, Bucy, & Cho, 2018; Satici & Uysal, 2015).

2.3. Subjective Energy and Fatigue as Positive and Negative Affect

At the core, the experience of energy or fatigue is an affective state, i.e. an affect. In psychology, an affective state is the subjective experience of a feeling. Affective states are commonly divided into emotions and moods. Emotions are usually shorter, more intense affective states with a known object, for example being angry with someone (the object of anger). Moods on the other hand are generalized affective states that are typically longer, fluctuating, and less intense. They are usually not related to specific objects, for example feeling blue (O'Connor, 2006; Shirom, 2011; Thayer, 1990). Subjective energy and fatigue are more often described as moods because feeling energetic or tired does not necessarily need a specific object and is experienced for longer time frames than typical emotions. From the concepts that we described so far, vigor can be defined as broader mental state that encompasses the energetic mood whereas emotional exhaustion is the chronic experience of the fatigue mood (O'Connor, 2006).

Theoretically, the nature and structure of affective states have been disputed since the birth of psychology. Especially contested are the number and the labeling of the core dimensions of affect, i.e., what constitutes the fundamental underlying characteristic of affective experience (Kuppens, Tuerlinckx, Russell, & Barrett, 2013). In the different theories of affect, the energy and fatigue have different prominence, from being a core underlying dimension to being just part of a broader positive or negative affect. They also appear under very different names, such as activation, arousal[2], vigor, fatigue, energy, tiredness, inertia, vitality, depletion, etc. In spite of these differences, the measures used to assess the feelings of energy and fatigue are remarkably similar.

If we combine all the studies that have used simple affect scales to measure subjective energy or fatigue they make a little more than one fifth (22%, *n=12*) of all the considered studies, with half of them considering both positive and negative affect. In the following, we present the most common measures of subjective energy and fatigue and the theories of affect that have included them.

Subjective Energy as Positive Affect

Vigor, energy, activity, activation, arousal and vitality are amongst the many terms used to describe the experience of subjective energy as affective state. Subjective energy as affect can therefore be defined as the feeling of being vigorous, energetic, active, and vital. Subjective energy as affect is thus very narrow in *range* with a focus only on the affective experience of energy and excluding other mental states or motivation, and without any focus on a specific *cause* of the experience. The most common way to measure it is with

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[2] Arousal and activation have mostly the same meaning within psychophysiology, but modern psychologists prefer the term activation. The neuropsychological literature sometimes distinguishes between the two.

adjective scales that describe the exact feelings studied, such as to feel vigorous, energetic, active, wakeful, alert, lively, full of pep, etc. The three most widely used instruments across disciplines to measure subjective energy are the vitality-fatigue subscale of the MOS 36-Item Short-Form Health Survey (SF-36; Ware Jr & Sherbourne, 1992); the vigor-energy subscale of the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971; Shacham, 1983) and the general activation subscale of the Activation Deactivation Adjective Checklist (AD ACL; Thayer, 1986). The vitality-fatigue scale of the SF-36 is a bipolar scale that measures subjective energy and subjective fatigue simultaneously (bipolar *conceptualization*), whereas the POMS and AD ACL are bivariate scales that have additional, separate fatigue scales (bivariate *conceptualization*). The adjectives among all scales overlap greatly; in fact, the POMS and the AD ACL are almost identical. The only notable differences between the scales are their time frames and their answering formats: Whereas the SF-36 inquires how one felt in the past month and the POMS in the past week, the AD ACL inquires how one feels right now. Depending on measure, the *duration* of the affect can consequently range from momentary feeling (if assessed with the AD ACL) to a month-long feeling (if assessed with the SF-36).

There is no clear place for technology within the affect theories, since the theories themselves do not postulate the specific causes for affect (other than some physiological or neurological correlates). However, technologies can induce mood either by design (Herrero, Garcia-Palacios, Castilla, Molinari, & Botella, 2014; Serrano, Baños, & Botella, 2016) or as a byproduct and thus the cited measurement instruments have been frequently utilized for the study of the relationship between technology and subjective energy (Botella, Baños, Etchemendy, García-Palacios, & Alcañiz, 2016; Du et al., 2018; Huang, Wong, Yang, Chiu, & Teng, 2017; Kelley & Gruber, 2010; J. E. Lee, Xiang, & Gao, 2017).

Subjective Fatigue as Negative Affect

Subjective fatigue as affect can be defined as the feeling of being fatigued, tired, worn-out, exhausted and weary. It is often seen as a symptom of ill-being. The variety of terms used to describe fatigue is much smaller than that for energy with a clear preference for the term "fatigue". Conceptually, subjective fatigue is the negative opposite of subjective energy, just as narrow in its conceptual *range,* measured with precise adjectives and rather short-termed in *duration* especially when compared to emotional exhaustion. Subjective fatigue is often studied separately from subjective energy and has its own subscales within the measurement instruments mentioned above. Most often it is measured with the vitality-fatigue scale of the SF-36 (e.g. items "tired", "worn-out") and the fatigue-inertia scale of the POMS (e.g. items "fatigued", "exhausted").

2.4. Social Media Exhaustion and Fatigue

The last energy related concepts that we introduce are "SNS exhaustion" and "SNS fatigue". They are new energy related phenomena introduced by HCI and IS researchers due to the establishment of SNS as main portals to the Internet in recent years. We consider SNS exhaustion and fatigue specifically because they represent 21% of the identified studies (*n=11*). Next to SNS exhaustion and fatigue, constructs such as cellphone messenger fatigue, privacy fatigue, general digital fatigue as well as user fatigue have also

been introduced in the literature. However, these aspects of technology fatigue are still not very well established, which is why we do not discuss them here.

Social Media Exhaustion

SNS exhaustion is defined as an "aversive, potentially harmful, and unconscious psychological reaction" caused by SNS-use (Maier, Laumer, Eckhardt, & Weitzel, 2015) or excessive SNS use (Cao, Masood, Luqman, & Ali, 2018). It is mostly a user reaction caused by perceived social overload (Cao & Sun, 2018; Maier et al., 2015). SNS exhaustion demonstrates itself in feelings of tiredness from SNS use (Luqman, Cao, Ali, Masood, & Yu, 2017). It is often measured with a 4-item scale created by Maier and colleagues (Maier et al., 2015). The scale is an adaptation of the Maslach Burnout Inventory (MBI) where "work" and "my job" are replaced by "SNS activities" or "Facebook". Notably, the item "I feel fatigued when I get up in the morning and have to face another day on the job" was omitted from the new scale. Example items of the SNS exhaustion scale are "I feel drained from activities that require me to use SNS" or "I feel tired from my SNS activities". The instruments sometimes specify the concrete social network (e.g. "I feel tired from my Facebook activities") or the device ("I feel tired from my mobile SNS activities").

SNS exhaustion is based on the work by Ayyagari et al. (2011) and is explained with the PE-fit model as well as job burnout theory. Ayyagari et al. (2011) investigated how new technologies and their features can cause "technostress" and were the first to explicitly specify ICTs as cause of emotional exhaustion with work. Even though they stayed within the borders of job burnout theory, this work inspired other HCI and IS researchers to investigate the role of ICTs beyond work-related exhaustion. The basic premise is that some technology features, such as being always reachable and non-anonymous, create stress and lead to emotional exhaustion.

Based on its operationalization, we would argue that social media exhaustion is a longer lasting state (*duration*). However, the chronic aspect evident in work-related emotional exhaustion is not apparent in SNS exhaustion. Neither the definition nor the instruments (because of the omitted item) imply that one cannot recover from SNS exhaustion or that the permanence of these feelings of tiredness persist throughout the day and reoccur in the morning. The *range* of the term is narrower similarly to emotional exhaustion. Finally, SNS exhaustion has a very specific *cause* that is the prolonged or excessive use of SNS. Unlike job demands and work stressors that can vary greatly, social media exhaustion has only this one proposed stressor. Thus, SNS exhaustion seems more specific and less chronic than work-related exhaustion.

Social Media Fatigue

SNS fatigue has been defined as the subjective feeling of tiredness caused by SNS stress, overwhelming amounts of information, and too many SNS friends (Bright, Kleiser, & Grau, 2015; A. R. Lee, Son, & Kim, 2016). It is also seen as a tendency for SNS users to "back away" from social media (Bright et al., 2015). In this sense it is similar to SNS exhaustion. However, unlike SNS exhaustion, it is also characterized by feelings of boredom, indifference, and lower interest, as well as inability to relax and focus (Zhang,

Zhao, Lu, & Yang, 2016). SNS fatigue has been measured with adopted subjective fatigue items such as ("After a session of using SNSs, I feel really…"fatigued", "tired", "worn out"). However, other self-constructed items include the most diverse statements and feelings like "After a session of using SNSs, I feel really bored", "I find it difficult to relax after continually using SNSs" or "After using SNSs, it takes effort to concentrate in my spare time". In this sense SNS fatigue is a very broad (*range*) negative emotional reaction to SNS use. It also has a shorter duration than SNS exhaustion, mostly describing the immediate feeling post SNS use. Because of the specific focus on negative affect, there is no place for a univariate vs. bivariate distinction within the concepts of both SNS exhaustion and SNS fatigue. Being energized by SNS or having energy because of SNS use is not discussed as a potential process.

4. CONCLUSION

The different subjective energy and fatigue constructs vary in their conceptualizations of three main dimension: the duration of the feeling of energy or fatigue, the scope of the definition and the specificity of the cause for the feeling of energy or fatigue. For example, emotional exhaustion, work vigor, vitality and SNS fatigue are defined as long lasting, almost chronic states of fatigued or energized states. Depletion and the affect conceptualizations of subjective energy and fatigue on the other hand, are defined as much shorter states, sometimes only momentary experiences. SNS exhaustion falls between the two extremes.

Similarly, all conceptualizations but the subjective energy and fatigue as affect constructs, have broader scopes in their definitions, which means that they go beyond the mere experience of energy or fatigue and include additional states and experiences. The additions include the experiences of stress, resilience and willingness (or unwillingness) to invest energy, motivation or lack of motivation, optimism, aliveness, alertness and awakeness, boredom, indifference and lack of interest. However, all conceptualizations include the experience of energy or fatigue, which means that all constructs overlap with one of the two affect constructs.

Finally, most constructs postulate a specific cause for the feelings of energy and fatigue, at least implicitly. For emotional exhaustion, it is the work or work demands; for depletion, the exertion of self-control; for vitality, the fulfilment of the three psychological needs of autonomy, competence and relatedness; and for the SNS exhaustion and fatigue constructs, the use of social networking sites. Work vigor only postulates energized feelings during work activities without postulating that the activities are per se energizing, whereas the affect constructs simply describe the experiences of energy and fatigue while the causes of such experience are out of the scope of their definitions.

The differentiations of the constructs makes clear their applicability for different domains, populations and research questions. For example, emotional exhaustion and work vigor are obviously suitable for the study of the working population in organizational contexts, but also the student population. They are also excellent indicators of long-term organizational ill- or well-being, respectively. The study of non-working and general populations on the

other hand is better suited with the two affect constructs, as well as depletion and vitality. An exception are studies on work-life balance and boundaries.

It is also important to note that emotional exhaustion, work vigor, and vitality only capture the chronic states of energy and fatigue and are not suitable if one is interested in the immediate effects of ICTs use. In those cases, using depletion, and the affect constructs would be more appropriate. Finally, the SNS exhaustion and SNS fatigue constructs are only suitable for studying SNS users. Figure 1 presents a decision three for researchers based on the research question.
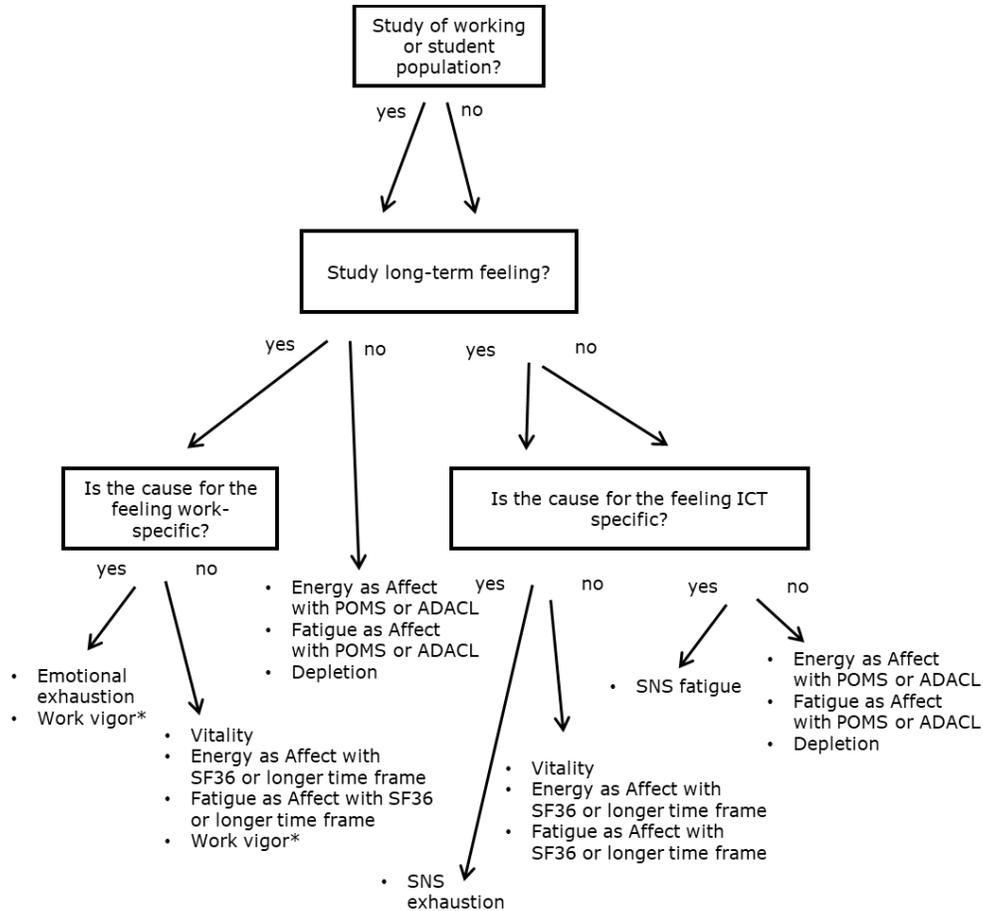

Figure 1. Decision tree for appropriate construct use based on research question

Finally, this paper points to the existence of two different conceptualizations of human energy, namely the bipolar and bivariate view on human energy. Even though the majority of studies subscribe to the bipolar view, we advise researchers to threat and measure the experiences of energy and fatigue as two related but separate dimensions and outcomes. Otherwise, a lot of valuable information on the effects of ICT use on energy and fatigue is being lost.

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