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From Recovery to Regulation: An Attempt to Reconceptualize 'Recovery from Work'

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Abstract

The concept of 'recovery' (from work) has quickly gained in importance in the occupational health literature. However, we think that the conceptualization of 'recovery' needs some more attention. Although many authors acknowledge that 'recovery' refers to a 'process', the concept is often treated as a static construct. In this paper, we argue that recovery should be conceptualized as a dynamic construct related to changes in psychophysiological state of the person. We refer to two main theories that have provided a theoretical framework for research in this area: Meijman & Mulder's Effort-Recovery (E-R) model and Hobfoll's Conservation of Resources theory.

In particular, the E-R model has been seminal in this area and stresses the element of changing psychophysiological states that has been used for reconceptualising 'recovery'. Various biological rhythms influence these changing psychophysiological states, and thus the level of energy (or effort) a person can mobilize or wants to mobilize. A distinction is made between 'physical fatigue' and 'mental fatigue' and its consequences for recovery. The discrepancy between 'actual state' and 'required state' has been suggested as the basis for 'recovery'. This emphasises that recovery is a dynamic and ongoing process, which also included motivational aspects, in particular as far as mental work is concerned.

The capacity to maintain self-regulation of one's psychophysiological state is important in this respect. Thus, we propose that 'recovery' is the continuous process of harmonizing the 'actual state' with the state that is 'required' at that moment. Copyright © 2014 John Wiley & Sons, Ltd.

Keywords

recovery; effort; self-regulation; energy; definition

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Introduction

Although the term 'recovery' originally refers to the process of changing from being ill to being healthy, recovery (from work) can best be understood as the process that restores the individual's energetic and mental resources (Zijlstra & Sonnentag, 2006). Linden, Earle, Gerin, and Christenfeld (1997) conceptualized recovery by contrasting it to reactivity, which they defined as the change in a parameter from its baseline value after exposure to a stressor. Recovery was, by the same authors, defined by as 'the post-stress rest period that provides information about the degree to which the reactivity in the physiological and psychological parameters measured persists after the stressor has ended' (Linden et al., 1997; p. 117). It has been argued that the speed of recovering to baseline after stress exposure may be as important in the aetiology of disease

and illness as the acute reactivity in response to the stress exposure (Linden et al., 1997; Lundberg, 2003; Pavlides, Nivon, & McEwen, 2002). From the preceding text, it becomes clear that the concept of recovery is still under discussion and may not be fully understood yet.

The aim of this paper is to contribute to this discussion by offering a new conceptualization of recovery whilst stressing that it is a process. It is not possible due to limited space, nor is it the aim of this paper to discuss all the literature on recovery; however, we have included a brief summary of the two most widely cited theoretical models underpinning recovery research. We then discuss and redefine the notion of recovery and offer the idea of recovery being a dynamic process that needs to be understood in terms of 'self-regulation'. Finally, we offer a number of suggestions for future research.

Theoretical models of recovery

Many of the studies in the domain of 'recovery research' (sometimes also indicated as 'respites or breaks' research) have taken the Conservation of Resources (COR) theory (Hobfoll, 1989) or the effort-recovery (E-R) model (Meijman & Mulder, 1998) as a starting point for their theoretical elaborations on 'recovery'. However, neither of these two models indicates what 'recovery' actually is. The E-R model just states that 'lack of recovery' or insufficient recovery may lead to health problems. The COR approach does not refer to 'recovery' but only states that people aim to preserve their resources, prevent the loss of resources and/or acquire new resources. The topic of 'recovery', or the 'replenishing of resources', has nonetheless evolved into an important theme in the domain of occupational health research. As a result, this calls for a closer look at both concepts 'recovery' and 'resources', and in particular at the definitions of both concepts. We will address both in this paper.

The model on effort and recovery that Meijman and Mulder (1998) presented primarily focuses on the consequences of workload. According to their model, the consequence of high work demands, and subsequently high workload, is fatigue. In their view, fatigue implies a reduced capacity to work, or, to be more specific, it makes people avoid taking on new demands or challenges. In Meijman's (1991) view, 'fatigue' is a *psychophysiological state* that is characterized by a low level of energy, high level of irritability and a lack of motivation to exert any further effort. The energetic aspect is therefore probably the most relevant dimension in the fatigue concept; it determines whether people are willing to exert any further effort (cf. Meijman & Zijlstra, 1986; Zijlstra, Cavalini, Wiethoff, & Meijman, 1990). This forms the background for introducing the concept of 'recovery' in the E-R model. The notion of 'recovery' according to the E-R model primarily refers to the reduction or elimination of the fatigue symptoms, and restoring the energy levels. Therefore, Meijman and Mulder referred to 'reversible consequences' of workload. Restoring the energy level will allow the person to accept new demands and challenges (i.e. tasks) again. If the energy level is not restored, or in E-R terms 'recovery' is 'insufficient', this can lead to 'irreversible consequences' or, as Meijman and Mulder (Meijman, 1991; Meijman & Mulder, 1998) indicated, health problems (what they saw as accumulation of fatigue, and the accompanying consequences of sustained activation).

Fatigue itself is a rather difficult concept to define. Various types of distinctions have been made, such as 'acute' (short lived) and more 'chronic' fatigue (closely related to exhaustion/burnout). But the more interesting distinction probably is the distinction between 'physical' and 'mental' fatigue. Whereas physical fatigue is associated with muscular fatigue after hard physical labour, mental fatigue seems to be connected to (intense) cognitive activity. Whereas for physical

fatigue a period of rest is an appropriate remedy, this still remains to be seen as far as mental fatigue is concerned. Meijman (1991) has defined (mental) fatigue as a 'state that is primarily characterized by *resistance to further activity*' (see also Hockey, 2013). It has some similarity with 'boredom', defined as a unique psychophysiological state possessing interrelated and inseparable emotional, motivational, perceptual and cognitive concomitants (O'Hanlon, 1981). This implies a strong motivational component on behalf of the individual and also suggests that 'rest' may not be an appropriate solution or remedy for 'mental fatigue'. In any case, the concept of 'recovery' is most often associated with 'rest', and the preceding text suggests that this may not be entirely adequate. Another aspect is that the aforementioned conceptualizations refer to (psychophysiological) 'states' that change, which implies that a 'process' is involved. So, recovery refers to a 'process'; whereas in most research, 'recovery' is treated as a static construct. This is our first proposition in this paper: 'Recovery is a dynamic process, and not a static construct'. However, how this process should be conceptualized is not specified in the E-R model. In the following, we will try to model this process and indicate some directions for future research in this area.

The recovery process

As further elaborated in our thesis, the crucial characteristics of the dynamics of the recovery process have not yet been fully addressed in the literature. Recovery is thus to be understood as a dynamic process where the mental and physiological resources that an individual spends to deal with external demands are replenished (Hobfoll, 1989; Zijlstra & Sonnentag, 2006). Fatigue, which often has been used as a 'proxy' for recovery, refers to a particular state, whereas recovery refers to the process when the psychophysiological state of the organism is returned to a preferred baseline (Sonnentag & Zijlstra, 2006). In self-report studies, recovery is also mainly conceptualized in 'negative terms', as 'lack of recovery' or 'need for recovery' (from work).

There has been an attempt in the literature to distinguish between 'internal' and 'external' recovery. Internal recovery refers to the shorter periods of relaxation that take place within the frames of the workday or the work setting (Geurts & Sonnentag, 2006; Veldhoven & Sluiter, 2010) in the form of short scheduled or unscheduled breaks, by shifting attention or changing to other work tasks when the mental or physical resources required for the initial task are temporarily depleted or exhausted. External recovery refers to recovery promoting actions that take place off work—e.g. in the free time between the work days, and during weekends, public holidays or vacations (Sonnentag & Fritz, 2007). The notion of internal recovery is difficult to quantify in practice and is perhaps easier to apply to situations that involve physical/manual work, i.e. blue-collar workers, than

to situations that involve mental/office work. Interruptions or very short breaks may halt or delay the accumulation of fatigue, but these are not really adequate to allow actual recovery to occur, particularly not for mental work (Zijlstra, Roe, Leonova, & Krediet, 1999).

With respect to external recovery, it is also difficult to say with any conviction when recovery starts. The recovery process is assumed to begin when external stress exposure has ended, i.e. when the worker stops working. Yet, it has been convincingly demonstrated that mental representation of stressors or stressful scenarios often interferes with the recovery process even when the exposure to the stressors is no longer present (Brosschot, Gerin, & Thayer, 2006). This process of perseverative thinking or work-related rumination has been shown to be associated with disturbed recovery and reduced well-being (Berset, Elfering, Lüthy, Lüthi, & Semmer, 2011; Cropley, Rydstedt, Devereux, & Middleton, 2013; Querstret & Cropley, 2012; Vahle-Hinz, Bamberg, Dettmers, Friedrich, & Keller, 2014). Furthermore, in addition, Brosschot et al. (2014) have convincingly argued that perseverative cognition may even prevail unconsciously and interfere with the recovery process without the awareness of the individual.

Recovery includes cognitive as well as psychophysiological processes that most often run in parallel. In a number of studies, Sonnentag, Kuttler, and Fritz (2010) have argued that psychological detachment, that is, 'switching-off' from work, is a necessary prerequisite for recovering from work during off-work time. Perhaps not all forms of thinking about work should be seen in negative terms. For instance, Cropley and Zijlstra (2012) have made a distinction between, on the one hand, affective work-related rumination, referring to the often involuntary, perseverative, negative emotional dimension of rumination, and, on the other hand, 'problem solving pondering', which denotes a more distanced cognitive reflection over solving actual (non-emotional) work-related issues. The third aspect of recovery in this taxonomy is psychological detachment from work, a non-ruminating state where the individual is capable of relaxing from all thoughts of work. A study by Querstret and Cropley (2012) found that whereas affective rumination significantly predicted increased chronic and acute work-related fatigue, problem-solving pondering and detachment was associated with reduced fatigue. Thus, recovery from work does not necessarily mean a complete absence of work-related thinking, and reflection about the positive aspects of one's day may actually be beneficial for health.

Incomplete recovery: precursors and consequences

A number of studies (e.g. Rydstedt & Devereux, 2013; Sluiter, Frings-Dresen, Meijman, & van der Beek, 2000; Sluiter, Frings-Dresen, van der Beek, & Meijman, 2001;

Cropley & Joeke, 1999) have demonstrated high job demands or high job strain (high demands in combination with low control) to be related to increased need for recovery. Research has shown that inadequate recovery outside of work is associated with a number of poor health outcomes including increased risk of cardiovascular disease (Kivimaki et al., 2006), sleep problems and fatigue (Akerstedt, Fredlund, Gillberg, & Jansson, 2002; Cropley, Dijk, & Stanley, 2006; Nylen, Melin, & Laflamme, 2007). On the positive side, Rau and Triemer (2004) claimed that complete recovery between two work shifts is a valid indicator of good health.

Sonnentag and colleagues (Kinnunen, Feldt, Siltaloppi, & Sonnentag, 2011) have also demonstrated that activities that contrast to the content of the work tasks are particularly beneficial for recovering from work, which may be explained by the fact that they involve different systems and resources of the person. When classifying the content of different types of off-work activities, it has been firmly established that sport and physical activities keenly promote recovery (Rook & Zijlstra, 2006). Several, but not all (e.g. Sonnentag & Bayer, 2005; Sonnentag & Natter, 2004), studies have also found social as well as low-effort off-work activities to be positively related to recovery (Sonnentag & Zijlstra, 2006; Kinnunen et al., 2011). With regard to household activities and child care, the results are more mixed. Whereas some studies (e.g. Rook & Zijlstra, 2006) found a positive impact from them on recovery, which could be because that they shift attention away from work-related issues, other studies (i.e. Volmana, Bakker & Xanthopoulos, 2013) found household and child care unrelated to the recovery process.

Some of the inconsistencies within the literature regarding the association between leisure activities, recovery and well-being can be quite readily explained by differences in study designs, measures used, samples sizes, different occupational groups and so on, but perhaps the underlying factor is that most studies treat the notion of recovery as a binary process: workers are either working or not working (and therefore recovering from work), and as we argue, the process of recovery is not that straightforward. Even when people are sleeping, they may not be fully recovering as their sleep could be fragmented because of thinking or even dreaming about work issues.

Recovery and restoration: similarities and distinctions

The concept of recovery has also been examined from different perspectives (Hartig, Mang, & Evans, 1991). The two most prominent theories from the environmental perspective being Kaplan's attention restoration theory (Kaplan, 1995; Kaplan & Kaplan, 1989) and Ulrich's (1983) stress recovery theory. The environmental perspective characterizes the sociophysical

aspects of environments that promote (and do not merely permit) restoration, which include particular patterns of change in physiology as well as in affect and cognition, the assumption being that the 'need for restoration' can arise in many circumstances, including work circumstances. Although both are concerned with handling human stress reactivity or mental overload, one obvious distinction between the two traditions is that a main focus of interest in the environmental restoration tradition is placed on the potential health-promoting or restorative qualities of the particular environments or places (e.g. Hansmann, Hug, & Seeland, 2007; Johnsen, 2011; Kaplan, 1995; Ulrich et al., 1991). On the other hand, occupational stress/health research on recovery has mainly focused on the energetic dynamics of the recovery process and the potential health impairments associated with failed recovery (e.g. Meijman & Mulder, 1998; Sluiter et al., 2000; Zijlstra & Sonnentag, 2006). The occupational tradition has also been more concerned with activities or processes that either create fatigue and need for recovery (Kahn & Byosiere, 1992) or promote post-work recovery (Sonnentag and colleagues), rather than the properties of the environment *per se*. Despite this conceptual distinction, there is a good deal of overlap, and it should be portrayed as a matter of different researchers looking at a set of closely related phenomena from different perspectives, using similar concepts and often similar methods.

Resources

According to Hobfoll's (1989) COR model, individuals have an innate drive that motivates them to 'create, foster, and conserve' personal resources. Resources can be many, but according to the COR theory, key resources are those that help to maintain survival, self-esteem and well-being. Resources can be depleted in a variety of ways, but demanding environments such as those experienced during work are thought to be particularly resource intensive (Gorgievski & Hobfoll, 2008). In line with the assumption of the central role of resources, work-related stress may also occur when resources are threatened, lost or taxed—and the worker feels unable or unsure that they can replace what resources have been used up (Bakker & Demerouti, 2007; Hobfoll, 1989). Performing daily work activities always require mental and physical energy investment that may tax the limited resources of the individual (Meijman & Mulder, 1998).

When applying the resource perspective from the theory of COR to work life, Bakker and Demerouti (2007) proposed the job demand–resource (JDR) model. A basic assumption behind the JDR model is that each type of work is associated with different types of job demands. The JDR model builds upon Peter Warr's (1994) notion that some work characteristics, e.g. control, or work-related social support, facilitate the worker to meet the requirements and demands of

work, whereas other characteristics, e.g. responsibility, constitute the demands. The former are considered to be 'resources', along with the characteristics of the person in terms of skills, physical condition, social competence and so on. A central idea here is that these potential resources, being characteristics either of the person or of the work settings, become valuable to the degree that they enable the job incumbent to meet the job demands. Thus, physical strength, for example, may be crucial for a work role of a farmer but is generally of little use in office work. The most relevant 'resource' in the perspective of recovery is 'energy'.

Human energetics as a motivational process

The energetics of humans refers to the level of activation or 'arousal' of an individual, which is (for healthy persons) largely determined by the circadian rhythm of our biological system (cf. Kahneman, 1973). Our biological circadian rhythm relates to several underlying cycles, such as the temperature cycle and hormonal cycle, and evidently also determines the sleep–wakefulness cycle. There are also several biological processes that follow a circaseptum cycle, and the work of Larsen and Kasimatis (1990), for example, demonstrated in students how mood and emotions clearly follow a weekly cycle. Another important biological mechanism is the production of insulin and glucose. Glucose is the primary source of energy for our body cells. Glucose levels are usually at their lowest in the morning, typically before the first meal of the day, and rise up to 2 h after a meal. Blood glucose levels are constantly changing throughout the day, and they tend to be lower just before a meal. When we eat, we increase our blood glucose levels. Thus, energy levels fluctuate and decline over time. The brain is particularly sensitive to changes in glucose levels. For example, pre-frontal cortex operations (e.g. decision making) are thought to be associated with the metabolism of glucose (Gailliot et al., 2007).

The circadian 'arousal cycle' is a composite of the various underlying biological cycles, and evidently, this circadian rhythm determines when people are best equipped to perform physically and psychological activities, including work. For instance, when we have to be very active or alert, it is best that our energy level is at the highest. However, our working life does not always follow the pattern of our circadian rhythm, and from time to time, the demands of work require us to work hard (be active) and put in more energy than the natural periodicity of our rhythm permits. An extreme example of this is shift work, but the basic notion can be applied to all types of work. This in fact means that we will have to concentrate our energy, attention and effort, in order to get the work done. This refers to a situation in which the 'required state' of the person deviates from the 'actual state' of that person. The person needs to invest or mobilize more energy

than is actually available at that moment (i.e. sometimes, we need to walk faster, or think harder, or stay more alert, or pay more attention, depending on what is required). McEwen (1998) introduced the concepts 'homeostasis' and 'allostatic load' to describe such a situation in which a person is faced with demanding situations that exceed the regular capacity to deal with these demands and therefore disturb the situation of homeostasis.

So far, we have not made a distinction between physical and mental demands, fatigue or energy. Work activities generally require both physical and mental activities, as each conscious activity generally requires a physical component (muscle activity) and mental components (planning, coordination and monitoring of activities). These are difficult to separate from each other. Only for highly routine activities (or reflexes) may one assume that they are almost without mental effort. The effort that is required to execute both physical and mental activities is dependent on the same underlying biological system that determines the periodicity and amplitude of the circadian rhythm, and thus the available energy. According to the E-R model, mobilizing one's capacities is a personal decision, which means that the employee has accepted the task and wants to comply with the requirements of the task at that moment (cf. Hacker, 1978; 2003; Hackman, 1969; Meijman & Mulder, 1998). The employee is therefore willing to invest the effort (or energy) to work on that particular task. This means that it is not the task demands that automatically trigger the expenditure of energy, but it is the *individual* that makes that decision (more or less explicit). The person might also decide *not* to go to work, or *not* to work on that task at that moment or just do it in a 'sloppy' way. This refers to the strategy a person wants to follow in that particular situation (Hockey, 1997; Meijman, 1991; Zijlstra, 1996). Note that investing effort is not identical to autonomous responses to stressors (such as reflexes), for instance, when confronted with threats.

The implication of this perspective is that a person actively needs to regulate his or her energy level throughout the working day (cf. Teiger, 1978), just like a marathon runner needs to regulate his or her energy investment during the race. This means that when the level of arousal or activation is not sufficiently high to deal with the requirements or demands of the task, the person needs to muster extra energy to compensate for the energetic deficiency (cf. Hockey, 1996; Zijlstra, 1996). The person needs to adjust his or her state from an actual state to a required state. From a biological perspective, the biological system determines the energy level, which is reflected in various physiological parameters, such as the hypothalamic-pituitary-adrenal axis, of which the corticotropin-releasing hormone is an important parameter. Under demanding circumstances and when the individual assesses and interprets the situation such as that action is required,

the implication is that energy needs to be mobilized, which may be more than according to the regular circadian pattern might be available. In this case, the person needs to compensate for his or her current state and needs to muster *extra* effort (i.e. compensatory effort; Zijlstra, 1993). This adjustment of his or her state may then lead to a deviation from the regular circadian pattern (Figure 1).

The psychological perspective is that, although the biological system determines the basic level of energy that a person has, it is the psychological appraisal of the situation that determines whether extra energy or effort needs to be mobilized (cf. Lazarus & Folkman, 1984). This way, the person influences (regulates) his or her own level of energy, up to a maximum, of course. This, in fact, is a motivational process. Consequently, the amount of energy, or effort, a person can muster is limited, but there are individual differences.

From time to time, more energy (effort) is required than the person has available. As indicated before, the availability of energetic resources is dependent on the circadian rhythm, and on how much energy has been consumed thus far during the day. In these situations, the person has to 'up regulate' his or her arousal level and thus to adjust his or her psychophysiological state, which allows to exert more effort (Cavalini, Meijman, Mulder, Westerink, Wiethoff, & Zijlstra, 1988). Similarly, there can be moments that he or she may want to 'down-regulate' the arousal level. For instance, at moments when the individual is highly aroused and the situation or task requires being quiet and relaxed, the individual may try to actively regulate the level of arousal downwards (for instance, through yoga or meditation techniques, and sometimes with alcoholic consumption). A typical situation that may require 'down-regulation' is the period of the evening before going to sleep. When the individual has been very active (either by working late or sports), this causes being very 'aroused'. If the person wants to go to sleep, the arousal level has to be low, which means that the person needs to (mentally and physiologically) 'unwind', i.e. to adjust the level of arousal. So, the regulation of the arousal level seems to be a crucial aspect. A person either needs to exert effort to compensate for a lack of arousal and activation or needs to bring down the level of arousal and activation when it is too high. The energetic regulation can be seen as being primarily concerned with 'reducing the deviation' from

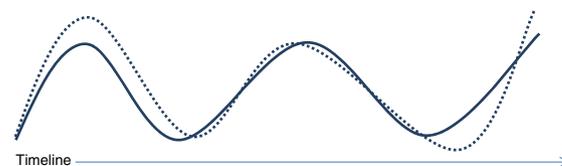


Figure 1. Circadian rhythm of arousal level (i.e. available energy). The fixed line represents the regular circadian pattern, and the dotted line represents the 'actual pattern'

the regular biological pattern and adjusting the actual pattern to the required pattern (Figure 1).

Downregulation of the level of arousal is particularly relevant in the evening. At some point, the person needs to go to sleep, as sleep is very important in the process of restoring the human functions, and also the level of energy. The exact role of sleep in the process of restoring the functions is not yet understood, but from a biological perspective, it may have to do with harmonizing the various internal rhythms again with the overall circadian rhythm.

Redefining 'recovery'

This brings us to a somewhat different perspective on recovery. In many studies, 'recovery' has been conceived as the (temporary) relief of demands (Sonnetag & Zijlstra, 2006). This assumes that when demands are no longer imposed upon people, they would more or less automatically recover from work. This is a rather mechanistic viewpoint with a passive role of the individual and may, to some extent, apply to physical types of work, where people work primarily with their muscles. When muscles are given rest, they can recuperate somewhat from earlier labour. However, this perspective does not necessarily apply to cognitively or emotionally demanding (i.e. mental) work. We believe that for cognitive types of work, an active regulation perspective on recovery is required. A short break does not necessarily imply a (temporary) relief of the demands. People may still think about the activity they are engaged in, even if they are involved in other activities for a while, or go for a coffee. Also, when they think about another problem, this still would require involvement of their mental capacities. A change of activity may imply a change of focus of attention, but it generally does not lead to a change of level of arousal that is required; this will remain more or less at the same level during that period. Therefore, in this case, short breaks during the day can be seen as *interruptions* during work but are not really moments for recovery since a certain level of arousal needs to be sustained. Even during the evening, the demands may still be relevant, hence the introduction of the concept of 'rumination' and 'worrying' in the recovery literature (cf. Cropley & Zijlstra, 2011), or 'perseverative cognition' (Brosschot et al., 2006). And as we know from that literature, thinking about work (either positively in the sense of 'problem solving pondering' or negatively, such as 'affective ruminating') may keep arousal at a high level (cf. Brosschot et al., 2006; Walkowiak, Hülshager, & Zijlstra, 2010).

Hence, we should reorient ourselves towards the concept of recovery and maybe even redefine the concept of 'recovery'. First of all, we should take into account that in the original sense, when Meijman and Mulder (1998) introduced the concept 'lack of recovery', this referred to recuperating from having become tired and fatigued because of the investment

of effort, or energy. Fatigue is a suboptimal state in which people resist spending additional effort on a particular task. This means that people are no longer willing to upregulate their energy-level in order to meet the demands of the task. This can be seen as that they do not want to invest any more effort in order to adjust their actual arousal pattern to a level that is required for the task.

From a conceptual point of view, there is a difference between physical and mental fatigue. Physical fatigue is the result of muscle activities, and rest might help the physiological process that helps to recuperate (i.e. removing lactic acids). However, for mental fatigue, there is not a physiological equivalent. Mental fatigue should therefore primarily be understood as the feeling of 'not wanting to continue' (i.e. resistance to continue the current activity—Meijman, 1991; Hockey, 2013). It is like a point of 'saturation' has been reached, and performance level at that particular activity (i.e. task) cannot be guaranteed anymore. This implies that changing the activity might be an option. However, this 'new' activity also requires effort (energy).

Therefore, we suggest that 'recovery' is not just the 'absence of demands', or 'rest' (cf. Zijlstra & Sonnetag, 2006). Such a conceptualization suggests that recovery occurs *automatically* when demands are (temporarily) removed. And it does not sufficiently acknowledge that recovery should preferably be seen as a *dynamic process* that aims at restoring the energetic resources. Restoring *and* expending the energetic resources is a process that takes place continuously throughout the day and is actively controlled or *regulated* by the individual. 'Recovery' means trying to restore the energy resources, which should generally happen through regulating the psychophysiological state. For the recovery process, 'down regulating' the actual arousal level (i.e. psychophysiological state) seems to be the appropriate strategy. When the individual's psychophysiological state is not down-regulated for some time, this implies that the level of arousal is sustained for a longer time. A sustained level of arousal leads to allostatic load problems (McEwen, 2000).

The concept of 'self-regulation' (Carver & Scheier, 1998; Muraven & Baumeister, 2000) can be helpful here, although this framework is primarily geared towards obtaining 'behavioural goals'. In fact, one might see 'regulating one's state' also as a goal in which a person needs to exert some kind of control over his or her psychophysiological state. 'Recovery' has some resemblance with 'coping with stress' and may require altering emotions and arousal level (Hockey, 1984; Schönplflug, 1983); it may include overriding thoughts (rumination) and stopping emotions, and regulate attention. This regulation effort draws upon an *unspecified but limited resource*, according to Muraven and Baumeister (2000). There may be individual

differences in the size of the reservoir: some people have a larger reservoir than others, and it may be possible to increase the size of the reservoir over time. They make the analogy with a 'muscle': practising makes the muscle stronger (and thus expands the reservoir). The concept of 'resource' has become very popular in psychological research and yet, again, not very well defined, whilst it relates to the notion of 'reservoir'. According to the dictionary, a 'resource' is 'a useful or valuable possession or quality of a country, organization, or person' (Cambridge online dictionary). This means that a resource is 'owned' by the person, and it should be a capacity or entity that the person can freely use for his or her own benefits. For example, money is a financial resource, and intelligence and energy can be seen as personal resources. Elements that are not in 'possession' of the person, but are features or characteristics of the situation or task, should not be considered a resource. Examples of the latter are the level of autonomy or control that a task allows or the social support that is primarily a characteristic of the environment and may (or may not) be available.

Muraven and Baumeister (2000) made no suggestions as to what 'the resource' in their model might be. Apparently, *the* resource is related to the energetics of a person, which is dependent on the arousal level. We suggest that the capability to invest mental effort is the crucial resource here, and this is a cognitively controlled process (Zijlstra, 1993), and this is also related to the energy that is available (i.e. arousal level). Exerting control over the psychophysiological state does make a demand on this energetic resource: i.e. costs energy. Continuous self-control will deplete the energy resource and may eventually result in a loss of self-control (Muraven & Baumeister, 2000), and the loss of self-control here means losing the capacity to adjust one's state. A recent study of the functionality of the brain indicates that the connectivity of the 'fronto-parietal network' is related to exerting effort (Otto, 2013; Otto, Zijlstra, & Goebel, 2013). During exertion of effort, the various brain areas were well connected and organized. The depletion of mental resources by sustained effort investment had measurable effects on the functional connectivity of these brain areas, in the sense that the fronto-parietal network was less organized after a period of sustained attention. This supports the underlying notion of various processes being in synchronicity. The level of connectivity in the brain can thus be seen as a physiological indicator of exerting mental effort, and the degree to which this network is capable of organizing itself reflects the capability of investing effort, i.e. focusing and concentrating. Apparently, the brain is involved in regulating our energy level and thus our capacity to exert mental effort.

Restoring the energy resources is an essential aspect of recovery. In particular, for the cognitive aspects of restoration, the process of sleep is thought to be very

important. The role of sleep in the restoration process is not yet completely understood. Sleep is a process that is largely beyond voluntary control. However, in order to be able to fall asleep, our arousal level needs to be low, and here, self-regulation may be required. The circadian rhythm of the biological arousal pattern indicates that arousal level should be low during the night, and in order to prepare the organism for sleep, the system needs to 'wind down' in the evening. In case the arousal level is (too) high (because of intense and hard work during the day, or working late in the evening), the person will have to adjust his or her actual state to the required state, which means he or she has to downregulate his or her arousal level. The period 'before going to bed' (i.e. preparation for sleep) is therefore a relevant period in research into recovery. The important question then is to what extent is regulation of state necessary? If the state pattern is following the regular circadian pattern, then no adjustment is required, but if there is a discrepancy, then regulatory efforts are required, and we should try to find out how much effort is required to regulate the state, and what activities contribute to regulating the state. For example, mindfulness exercises, or yoga, might help to downregulate the state and adjust the arousal level with the (for sleep) required state Hülshager, Lang, Depenbrock, Fehrmann, Zijlstra, & Alberts (in press). In sum, we can conclude that 'recovery' is *the continuous process of harmonizing the 'actual state' with the 'required state'*.

Consequences for research

Although studies may implicitly assume that recovery is a dynamic process, most studies treat recovery as a set point: one is either recovered or not. Recovery is a dynamic and complex process and depends on many contributing factors. As we have argued earlier, recovery is perhaps not the correct word, as in our minds, recovery is never and can never be fully achieved. The main issue is thus to focus on discrepancies in arousal patterns: What is the deviation of the actual arousal pattern from the required or desired arousal pattern? And this implies that we should try to figure out whether there is a large deviation or not. This determines how much effort the individual needs to exert to regulate his or her arousal level (and how long it will take before it has been regulated to its target level). In the evening, the target level is more or less similar to the regular circadian rhythm, but during daytime, the target level is determined by the demands of the task.

So, the focus of research should be on the regulation of the energy (or arousal) level. This regulation of the arousal level actually means that people are continuously trying to adjust their psychophysiological state. The distance between the two lines in Figure 1 actually determines how much regulation is needed at certain points in time. Various psychological processes have an effect on the circadian pattern, and indeed the circaseptan pattern, which can be represented as

'forces' that affect the underlying rhythm. Whereas 'recovery', in the traditional sense, involves those situations in which the individual needs to 'downregulate' his or her pattern, situations where an 'upregulation' is required refer to mobilizing extra 'resources'. This means that instead of focusing on 'recovery' as a concept, research should focus on the *regulation process* and determine how this process takes place and how psychological processes (can) affect this process. The framework of self-regulation can provide a conceptual framework to guide this type of research. The next challenge is to design studies that test this assumption. To this end, researchers will need to develop or utilize more time-series techniques, such as spectral analysis. Sine-cosine waves could be used to describe dynamic patterns (e.g. length, amplitude and phase) of the

regulation of different work-recovery parameters. Given that our daily and weekly cycles and underlying rhythms regulate much of our work, recreational activities and mood, it seems a logical step forward to understand and map these rhythms if we are going to fully understand the work-recovery process.

Paraphrasing Hans Selye (1976), we conclude that 'The fatigue of work well accomplished gets you ready for sleep, but during the evening and night, you must protect yourself against stressors that haunt the mind' (p. 423).

Conflict of interest

The authors have declared that they have no conflict of interest.

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