MASTERTHESIS

Basic Psychological Needs: Determinants or Correlates of subjective Vitality and Fatigue?

A systematic review of the literature.

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10 EC M.Sc. Thesis
07-04-2017
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Abstract

Background: Self-determination theory (SDT) claims to be an empirically validated theory. This systematic review wanted to contribute to the empirical soundness of SDT by examining whether causal evidence supports SDT's central assumptions that the basic psychological needs for autonomy, competence and relatedness are determinants of subjective vitality and related but distinct necessary psychological nutriments for subjective vitality. This review also examined whether current causal evidence supports both assumptions in relation to subjective fatigue, that is, a construct which is not part of SDT:

Method: A systematic PRISMA review was conducted. The internet-based reference databases *Scopus* and *PsycInfo* were searched to access high evidence studies that examined the relationships under investigation. Through a narrative synthesis an indication about the variation in study characteristics was given and cumulative evidence from the findings about the relationships of interest was obtained to provide answers to the research questions.

Results: 8 eligible studies were identified. Main findings were that cumulative evidence supported a positive causal relationship between each basic need and subjective vitality. Also, evidence for a negative causal relationship between relatedness satisfaction and emotional fatigue was found. Moreover, causal evidence supported the aggregated positive effect of basic need satisfactions on subjective vitality under the condition that each basic need is satisfied, but contrary to expectation only autonomy and competence satisfaction were found to have a significant independent impact.

Conclusion: This systematic review contributes to the empirical soundness of SDT since best available research supports SDT's central assumption that the basic psychological needs are determinants of subjective vitality. In addition, the found evidence emphasizes that the explanatory and predictive power of SDT might be improved by incorporating subjective fatigue as an outcome of basic need satisfaction. Causal evidence also supports SDT's conceptualization of the basic psychological needs as theoretical related constructs and requirements for subjective vitality, whether they are three distinct constructs still needs to be explored. Causal evidence for the assumptions examined in this review is still insufficient but vital because evidence-based need-supportive interventions seem to provide a way to improve subjective vitality and subjective fatigue. Researchers are encouraged to continue and expand the research of this systematic review.

Introduction

In 2000 Richard M. Ryan and Ed Deci introduced the *self-determination theory* (SDT), a macro-theory of human motivation, personality development, health and well-being. Since the release of this paper, SDT has spawned research and had been used to generate numerous interventions in various areas (Ryan, 2009). Given the profound impact of this scientific theory, it is important to determine whether SDT's assumptions are supported by the best available evidence. SDT claims to be an empirically validated theory and assumes causal relationships among its constructs (Ryan & Deci, 2000).

One of these constructs are the basic psychological needs. These include the basic psychological need for *autonomy* which is described as the striving to be agentic and to feel like the origin of one's actions (Deci & Ryan, 1991), the basic psychological need for *competence* which is described as the need to control outcomes and experience effectance in one's pursuits (White, 1959) and the basic psychological need for *relatedness* which is described as the need for belongingness and refers to the desire to relate as well as genuinely feel connected to others, to love and care and to be loved and cared for (Deci & Ryan, 1991). The basic needs are conceptualized as necessary psychological nutriments for well-being and health, which implies that each need must be satisfied to feel well and healthy (Deci & Ryan, 2000).

One central assumption of SDT is that the basic psychological needs are determinants of subjective vitality. Subjective vitality refers to a positively toned state and has been defined as the state of organismic well-being in which individuals feel energetic, alert and fully alive (Lopez, 2011). In SDT research the presence of subjective vitality is considered a main indicator of well-being and health (e.g. Niemiec, Ryan, Patrick, Deci & Williams, 2010, Salama-Younes, 2011; Niemiec et al., 2006; Penninx et al., 2000). The maintenance, enhancement, and depletion of subjective vitality is determined by the extent to which the basic psychological needs are satisfied (Deci & Ryan, 2000).

Correlational evidence is consistent with SDT's assumption of a positive causal relationship between satisfaction of the basic psychological need for autonomy, competence and relatedness and subjective vitality. On a within- and a between-person level of analysis higher levels of autonomy, competence and relatedness satisfaction were significantly correlated with an increase in or maintenance of subjective vitality, whereas lower levels of

need satisfaction were significantly correlated with a decrease in or depletion of subjective vitality (Sheldon, Ryan & Reis, 1996; Reis, Sheldon, Gable, Roscoe & Ryan, 2000). Considering that the correlation between the satisfaction of the basic psychological needs and subjective vitality does not imply causation and SDT assumes causal relationships between its constructs it is important to examine whether causal evidence supports this central assumption of SDT.

Another central assumption of SDT is that the three basic psychological needs are *related* but yet *distinct necessary* psychological nutriments for subjective vitality, since they are related but yet theoretically distinct constructs (Vlachopoulos & Michailidou, 2006). Supporting this assumption, correlational studies found a significant aggregated effect of basic need satisfactions as well as a significant independent positive effect of satisfaction of each basic need on subjective vitality (Reis et al., 2000; Martela & Ryan, 2015; Sheldon, Ryan & Reis, 1996, Weinstein & Ryan, 2010; Gebauer, Riketta, Broemer & Maio, 2008; Aknin, Dunn, Whillans, et al., 2013; Aknin, Dunn, Sandstrom, & Norton, 2013; Aknin, Sandstrom, Dunn, & Norton, 2011). Consistent with the basic needs being necessary psychological nutriments, these positive effects on subjective vitality were found on condition that each basic psychological need was satisfied. It is important to examine whether causal evidence supports these assumptions.

Correlational evidence also points to a negative causal relationship between satisfaction of the basic psychological needs and subjective fatigue. Subjective fatigue has been defined as an *overwhelming sense of tiredness, lack of energy and a feeling of exhaustion, associated with impaired physical and/or cognitive functioning […]"* (Shen, Barbera & Shapiro, 2006, p.8). Although subjective fatigue is not part of SDT, significant negative correlations were found between satisfaction of the basic needs and the mental as well as physical components of subjective fatigue (Lonsdale, Hodge & Rose, 2009; Saksvik-Lehouillier & Hetland, 2016). Exploring this relationship is important due to the new possible insights for SDT research and for research on subjective fatigue.

Lastly, theoretical considerations suggest that basic psychological needs are related but yet distinct necessary psychological nutriments for subjective fatigue, in the sense that basic need satisfaction leads to lower levels of subjective fatigue. The absence of subjective fatigue is used as an indicator of well-being and health, for example, in RA research

(Treharne, Kitas, Lyons & Booth, 2005; Gettings, 2010; Nikolaus, Bode, Taal & van de Laar, 2013). Considering that the basic psychological needs are requirements for health and well-being in general SDT's assumptions should also apply to subjective fatigue. Albeit no scientific literature researching this relationship exists, exploring whether causal evidence supports the basic psychological needs being related but yet distinct necessary psychological nutriments for subjective fatigue might be an interesting addition.

The *objective* of this systematic review was to contribute to the empirical soundness of SDT by examining whether the current causal evidence support its assumptions that (1) the basic psychological needs are determinants of subjective vitality and subjective fatigue and that (2) the basic psychological needs are related but yet distinct necessary psychological nutriments for subjective vitality and subjective fatigue.

To my best knowledge, this is the first review that systematically examined whether these assumptions are supported by causal evidence. To consider the possibility that some basic needs are determinants of subjective vitality or fatigue whereas others are not, the effects of autonomy, competence and relatedness satisfaction were examined independently. In line with the objective of this systematic review the following research questions have been chosen:

1. What is the current scientific evidence for a positive causal relationship between the satisfaction of the basic psychological need for autonomy, competence and relatedness and subjective vitality?
2. What is the current scientific evidence for a negative causal relationship between the satisfaction of the basic psychological need for autonomy, competence and relatedness and subjective fatigue?
3. Regarding subjective vitality, what is the current causal evidence for the assumption that the three basic psychological needs are related but and yet distinct necessary psychological nutriments?
4. Regarding subjective fatigue what is the current causal evidence for the assumption that the three basic psychological needs are related but and yet distinct necessary psychological nutriments?

1.1 Basic psychological needs

According to SDT, the basic psychological needs are *innate* and *universal* necessary psychological nutriments for health and well-being. They are innate requirements in the sense that they are endowed by nature and cannot be learned or developed in different strengths (Deci, & Ryan, 2008). In addition, SDT's universal hypothesis states that all humans are endowed with a natural tendency to seek out these necessary psychological nutriments for well-being and health, regardless of individual differences such as gender, age, culture or contexts (Deci & Ryan, 2000). Nonetheless, intra- and inter-individual differences in the satisfaction of basic psychological needs exist because their presence alone does not guarantee their support and subsequent satisfaction (Deci, & Ryan, 2002). As SDT claims, that the basic psychological needs are universal the proposed relationships are expected to be examined in a great variety of samples and contexts.

The basic psychological needs for autonomy, competence and relatedness are *conceptually related to other constructs*. Commonly it is wrongly considered that the basic psychological need for autonomy concerns the experience of acting totally independent of external influences. However, in view of Ryan and Deci (2000) it refers to the innate need to have a voice or input in determining one's behavior and to perceive the forces that influence it as valuable, helpful, and congruent sources of information that support one's initiative. In order to experience a sense of freedom with regard to one's actions, the behavior must be *integrated into the self*, in the sense that it is perceived as coherent with one's values and interests (Ryan, Patrick, Deci & Williams, 2008). This experience has been referred to by deCharms (1968) as an *internal perceived locus of causality*, that is, the experience of one's actions as emanating from the self. In contrast, an *external perceived locus of causality* involves feeling controlled through externally enforced or self-imposed pressures (Deci & Ryan 1985). As integration is the means through which the self develops, the basic psychological need for autonomy is viewed as the basis of self-determination (Ryan & Deci, 2000).

The *basic psychological need for competence* is the need to control outcomes and to experience effectance in one's pursuits (White, 1959). Feeling effective and capable of mastering the environment necessitates an understanding of the instrumentalities that lead to desired outcomes and an ability to reliable effect those instrumentalities (Deci & Ryan,

1991). If the basic psychological need for competence is not satisfied, feelings of failure and doubts about one's efficacy arise (Deci, 1975; Ryan 1995).

The *basic psychological need for relatedness* – or alternatively the need for belongingness – refers to the desire to relate to feel genuinely connected to other, to love and care, and to be loved and cared for (Deci & Ryan, 1991). It also concerns the need to feel a satisfying and coherent involvement with the social world more generally and shares similarities with the construct *of perceived social support* is the feeling of being connected to significant others in one's social environment (Barrera, 1986). If the basic psychological need for relatedness is not satisfied, individuals are assumed to experience relational exclusion and loneliness (Deci, 1975; Ryan 1995).

1.2 Subjective vitality and subjective fatigue

Subjective vitality refers to a *positive state of energy*. Correspondingly, subjective vitality is associated with feelings of vigor (McNair, Lorr, & Droppleman, 1971), joy, interest, enthusiasm (Watson & Tellegen, 1985) and Thayer's concept of calm energy, which refers to a pleasant productive state of high energy and low tension (Thayer, 2003; Ryan & Bernstein, 2004). It only concerns energy experienced as positive, when in the state of subjective vitality one is relatively free from negative states of energy or arousal such as feelings of tenseness, anxiety, pressure, jitteriness, anger or fatigue (Ryan & Frederick, 1997).

SDT views subjective fatigue as a *negative state of energy* that must be distinguished from subjective vitality. The lack of energy and negative consequences that characterize subjective fatigue support its conceptualization as a negative state of energy (Shen, Barbera & Shapiro, 2006). In addition, subjective fatigue is considered a physical factor that hampers one's activation and dimish subjective vitality (Ryan & Frederick, 1997), for example, RA patients who felt more vital also experience less fatigue (Cella et al., 2005; Rouse et al., 2015; Rupp et al., 2004). At first sight evidence pointing to a reverse relationship between subjective vitality and subjective fatigue might support SDT's view of them as different constructs that must be distinguished from each other, but it might just as well support the assumption that they are related constructs, in the sense that subjective fatigue is the state of lacking subjective vitality and subjective vitality is the absence of subjective fatigue. In any

case, evidence for a reverse relationship between these constructs supports the assumption of a positive causal relationship between basic need satisfaction and subjective vitality and a negative causal relationship between basic need satisfaction and subjective fatigue.

Conceptual considerations about *ego depletion* support the assumption that subjective fatigue refers to the subjective state when vitality becomes depleted. SDT is interested in how energy could be *maintained* or *enhanced*. According to this theory subjective vitality is an inner resource which grows when developed and could be rekindled when depleted (Ryan & Deci, 2008). On the contrary, models of energy and depletion costs conceptualize subjective vitality as a limited resource. For example, the ego depletion model of Baumeister, Bratslavsky, Muraven, and Tice (1998). Ryan and Deci (2008) argued that ego depletion and subjective vitality both concern energy available to the self since *ego depletion* particularly refers to a subjective state when this energy becomes depleted. Considering the reverse relationship with subjective vitality, this argument might also apply to subjective fatigue.

In case subjective vitality is more than the absence of subjective fatigue, this might be related to subjective vitality's close conceptual relationship with the *basic psychological need for autonomy*. According to Ryan and Frederick (1997, p. 535) subjective vitality being "*the energy that is perceived to emanate from the self*" means that one feels *most vital* when one has an internal perceived locus of causality, whereas it is rather *untypical* that one feels vital if one has an external perceived locus of causality. This implies, that the increase, maintenance or depletion of subjective vitality *mainly* depends on the extent to which the basic psychological need for autonomy is satisfied. Contrary to SDT's assumption that all basic needs must be satisfied to achieve a positive effect on subjective vitality, just as well a satisfied need for autonomy might be sufficient for subjective vitality to increase (or at least to be maintained) and necessary to prevent its depletion.

In contrast with subjective fatigue, subjective vitality's relationship with the basic psychological needs is part of the conceptualization of this construct. Basic need satisfaction is assumed to make energy more available to the self, in a sense that when vital one is in control of energy for purposive actions (Ryan & Deci, 2008). Subjective vitality has therefore been defined as the conscious experience of possessing energy available to the self, energy that empowers an individual to express all aspects of his or her functioning and become self-

realized (Ryan & Frederick, 1997). Given the lack of conceptual connection, likely fewer studies examine the causal relationship between basic need satisfaction and subjective fatigue.

Supporting the assumption of subjective vitality and subjective fatigue being related constructs, both are conceptualized as *psychophysical* constructs. Phillips (2015) states that subjective fatigue is a summative result of an interplay between different physiological and psychological factors. Also, subjective vitality is affected by physical and psychological factors. Particular emphasis on the psychophysiological quality of that construct was placed in the classical definition of subjective vitality, that is, "*having physical and mental energy*" (Ryan & Deci, 2008).

Lastly, subjective fatigue has been operationalized as a *multidimensional* construct. Subjective fatigue can find expression on a physical, cognitive or emotional level (Arnold, 2008). Physical symptoms of subjective fatigue include for example reduced activity, decreased physical endurance and increased effort with physical tasks. Examples of cognitive symptoms are decreased concentration and a slowing of thinking processes. The emotional dimension of subjective fatigue can be described as a lack of motivation, initiative and interest, and feelings of boredom. In contrast, subjective vitality has been operationalized as a *unidimensional* construct. As it has been defined as possessing mental and physical energy, it might still be expected that in particular the mental and physical dimensions of subjective fatigue are conceptually related to subjective vitality.

Method

Answers to the research questions have been given through the conduction of a PRISMA-P systematic review (Moher et al., 2015).

2.1 Inclusion and exclusion criteria

Inclusion and exclusion criteria were formulated to assess which articles are eligible. An overview of the criteria can be found in Appendix A.

Systematic reviews, meta-analysis, interventional, quasi- and experimental studies were included due to their strong ability to prove causation (Bonita, Beaglehole & Kjellström, 2006; Moher, Liberati, Tetzlaff & Altman, 2009). Observational studies were excluded from the systematic review. This eligibility criterion was used because observational studies'

ability to prove causation is moderate (for cohort and case-control studies) to weak (e.g. cross-sectional studies) (Bonita, Beaglehole & Kjellström, 2006). Qualitative studies were excluded from the systematic review because outcome measures of qualitative studies are less standardized and results are less comparable. Search results that have been text parts of a book and survey validating studies were excluded as well.

Studies that examined and analyzed causal relationships between basic need satisfaction (or related constructs such as perceived social support) and subjective vitality (or related constructs such as ego depletion) or causal relationships between basic need satisfaction and subjective fatigue (or related constructs such as exhaustion) were included. Studies that did not examine or analyze the relationships of interest were excluded. From the studies that examined causal relationships between autonomy, competence and relatedness satisfaction and subjective vitality or subjective fatigue, only those were included that analyzed the aggregated as well as the independent effect of each basic psychological need.

Furthermore, eligibility criteria were applied for practical reasons. Studies written in English, German or Dutch were included in this systematic review, whereas studies written in other languages were excluded. To limit the number of studies about different topics, research from areas of biochemistry, genetics and molecular biology, agricultural and biological sciences as well as business, management and accounting were excluded. There were no author or year of publication restrictions. Also, no exclusions were set on populations, measurement instruments, interventions or experimental manipulations.

2.2 Information sources and search strategy

The reference databases *Scopus* and *PsycInfo* were used in the search for eligible studies. Both databases only contain published research. The two reference databases were searched for articles that have been catalogued until November 21, 2016. Proper and exhaustive terms to search for articles were chosen. In addition to the terms described in the introduction of this review (e.g. basic psychological need for relatedness or perceived social support), examples of literature were scanned for terms they used to refer to subjective vitality, subjective fatigue or the basic psychological needs. Terms that did not produce results during literature search were removed from the list of search terms. These were the terms:

revitalized, calm energy, tired and internal locus of causality. Table 1 provides an overview of the final list of search terms and how they were combined.

Table 1. *Final list of search terms*

Terms for (satisfaction of) basic psychological needs			
Basic needs	Autonomy	Competence	Relatedness
'basic psychological need satisfaction' OR 'basic need satisfaction' OR 'basic need fulfilment' OR 'basic psychological need' OR 'basic psychological need' OR 'basic needs' OR 'basic need'	'basic psychological need for autonomy' OR 'basic need for autonomy' OR 'perceived autonomy' OR 'internal locus of control'	'basic psychological need for competence' OR 'basic need for competence' OR 'need for competence' OR 'perceived competence' OR 'environmental mastery'	'basic psychological need for relatedness' OR 'basic need for relatedness' OR 'need for relatedness' OR 'perceived relatedness' OR 'basic psychological need for belongingness' OR 'basic need for belongingness' OR 'need for belongingness' OR 'perceived belongingness' OR 'perceived social support'
AND ↓	AND ↓	AND ↓	AND ↓
Terms for subjective vitality or subjective fatigue			
Vitality		Fatigue	
'subjective vitality' OR 'vitality' OR 'energy' OR 'vigor' OR 'vital' OR 'energetic' OR 'energized' OR 'vigorous'		'fatigue' OR 'tiredness' OR 'exhaustion' OR 'fatigued' OR 'exhausted'	

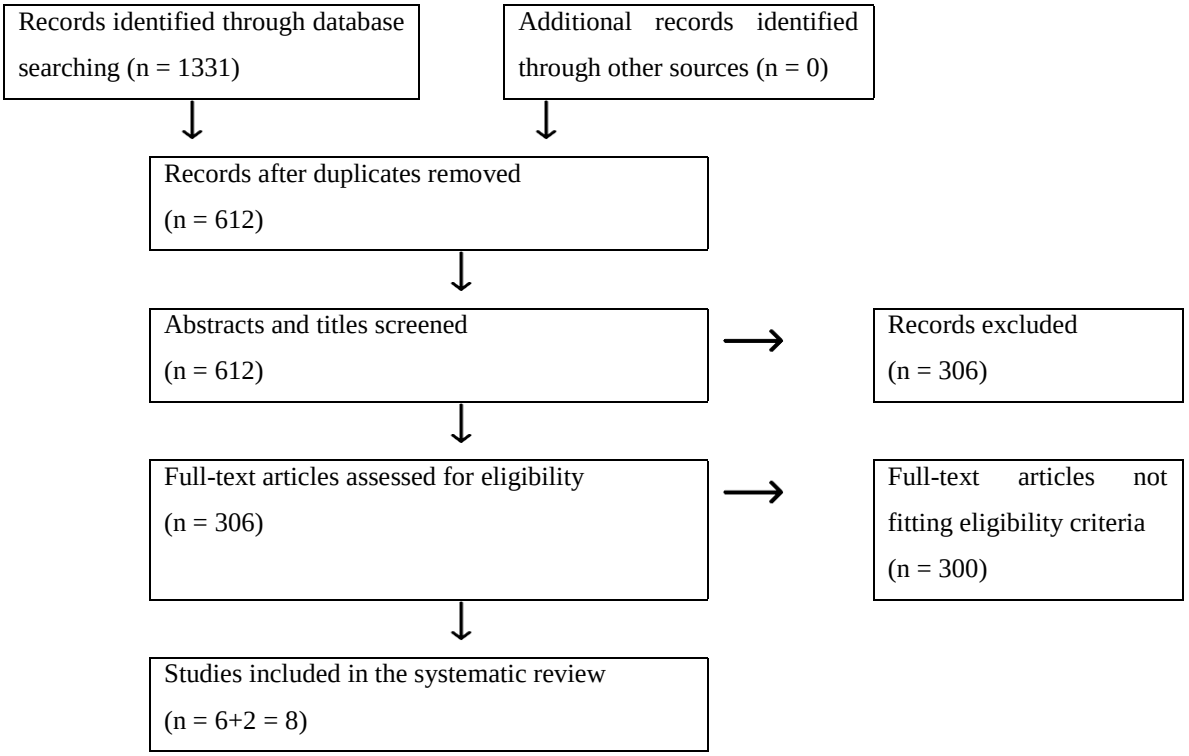
2.3 Selection of eligible studies

After exclusion of duplicate citations records 612 records remained (see flowchart Figure 1). Screening of titles, abstracts and most of the full-texts led to the exclusion of 306 documents from this systematic review. The full-texts of 51 documents were not retrievable and 10 studies were written in a Spanish or Portuguese. In addition, 245 out of the 306 excluded documents concerned different topics. For example, the term *vital* in the sense of importance was used.

The remaining 306 full-texts of potentially eligible studies were reviewed against the pre-defined exclusion and inclusion criteria. The excluded documents included 227 observational studies, 4 survey validating studies, 9 qualitative studies, 13 book chapters and 3 systematic reviews of observational studies. Furthermore, 41 studies did not examine or analyze the relationships of interest.

From the studies that did examine the relationships of interest, 2 studies only analyzed the aggregated effect of basic need satisfactions on subjective vitality. From the remaining studies one was excluded because it employed probabilistic magnitude-based inferences. Due to the different statistical analysis method, the results of this study were not comparable with the results of the remaining studies which employed statistical significance testing. Finally, 6 studies were included in the systematic review. One article compromised three studies, therefore the number of included eligible studies totals 8.

Figure 1. *Literature review flowchart*



2.4 Data collection

Relevant information was extracted by use of an extraction form. The extraction form can be found in Appendix B. The extraction form is structured according to seven key points: 1) general information about the study (e.g. author), 2) characteristics of the study (e.g. aim of the study), 3) sample characteristics and setting (e.g. sample size), 4) manipulations procedures or interventions (e.g. results of manipulation check), 5) definitions and measurements tools used, 6) examined relationships (e.g. relationship between autonomy satisfaction and subjective vitality) and 7) related results (e.g. p-value).

2.5 Quality assessment

Information about study design and results of the manipulation check were used to assess the quality of the included studies. Quality assessment revealed that most studies successfully manipulated the dependent variable. In the study of Klassen, Perry and Frenzel (2012) the manipulation of two components of perceived relatedness satisfaction was only partially successful. Therefore, only the results on the dependent variable *perceived student relatedness satisfaction* were included in this systematic review.

Although only studies with a strong ability to prove causation were included, study designs enabled more or less precise causal inferences (see table 2). Studies of Martela and Ryan (2016) and Solberg, Halvari and Ommundsen (2013) were assumed to enable *most precise* causal inferences because they employed RCTs. Compared to RCTs, the completely randomized trials of Nix, Ryan and Deci (1999) and Howell and Hill (2009) only enable *precise* causal inferences (Imbens & Rubin, 2015). Quasi-experimental studies enable *less precise* causal inferences than experimental studies because no randomization takes place (Chambliss & Schutt, 2015). In the quasi-experimental study of Klassen, Perry and Frenzel (2012) a counterbalanced design was used, which reduces the chances of order or treatment effects influencing the results (Fraenkel, Wallen & Hyun, 1993; Charness, Gneezy & Kuhn, 2012). In contrast, in the quasi-experimental study of Vazou-Ekkekakis and Ekkekakis (2009) the issue of order effects arises (Charness, Gneezy & Kuhn, 2012). Due to this, the study of Vazou-Ekkekakis and Ekkekakis (2009) enables the *least precise* causal inferences of the all included studies. To prevent redundancy the information about differences in the

studies' ability to enable accurate causal inferences based on their study design is given in table 2 (see section 2.6).

2.6 Data analysis

A narrative synthesis was conducted (Popay et al., 2006). To give an indication about the variation in the sample, the studies were compared for study design, aim, sample, setting, experimental manipulations or interventions, definitions and measurement tools used. The results were tabulated and described.

Thereafter, the studies were grouped based on their findings about the relationships of interest. As can be seen from Table 2, Martela and Ryan (2016) belong to the *Autonomy-Vitality group* because both examined the relationship between satisfaction of the basic psychological need for autonomy and subjective vitality. Studies that assessed satisfaction of all basic psychological needs belonged to more than one group. Within each group the findings were compared to examine if the multiple pieces of evidence come to the same or to different conclusions about the examined relationship(s). During analysis, greater credence was given to the findings of studies that enabled more precise causal inferences and less credence was given to the findings of studies that enabled less precise causal inferences. The resulting cumulative evidence, whether conflicting or consistent, was used to provide answers to the four research questions. The results were tabulated and described.

Table 2. *Examined relationships and differences in studies'' ability to enable accurate causal inferences based on their study design*

		Groups							
		A		C		R		ACR	
Study	Accuracy of causal inferences	V	F	V	F	V	F	V	F
Martela & Ryan (2016)	Most precise	x		x		x		x	
Solberg, Halvari & Ommundsen (2013)	Most precise			x					
Howell & Hill (2009)	Precise	x		x		x		x	
Nix, Ryan & Deci (1999) I	Precise	x							
Nix, Ryan & Deci (1999) II	Precise	x							
Nix, Ryan & Deci (1999) III	Precise	x							

Klassen, Perry & Frenzel (2012)	Precise			x
Vazou-Ekkekakis & Ekkekakis (2009)	Least precise	x		

Note. Examined constructs: A = basic need for autonomy, C = basic need for competence, R = basic need for relatedness, ACR = all needs, V = subjective vitality, F = subjective fatigue

2.7 Data management

The recorded results of the selection, data collection and data analysis process were made accessible. They can be retrieved via the following link: https://www.dropbox.com/sh/a9hqc01iaf99sr7/AACDXmmywTQf3yBoEDUdbePQa?dl=0.

Results

3.1 Aims, settings, samples, examined relationships and manipulation procedures

The examination of the relationship between satisfaction of the basic psychological needs and subjective vitality or subjective fatigue was an explicit aim of all included studies. Martela and Ryan (2016) examined whether the positive effect of perceived prosocial impact on subjective vitality is mediated by satisfaction of the basic needs. Howell and Hill (2009) tested whether the positive effect of experiential purchases (= money invested in an experience) on subjective vitality was due to increased satisfaction of psychological needs. Solberg, Halvari and Ommundsen (2013) examined whether perceived competence is a mediator of the positive relationship between physical exercise and subjective vitality. Nix, Ryan and Deci (1999) and Vazou-Ekkekakis and Ekkekakis (2009) tested whether conditions designed to support autonomy satisfaction would result in greater maintenance or enhancement of subjective vitality relative to conditions that do not support autonomy satisfaction. Klassen, Perry & Frenzel (2012) examined whether satisfaction of the need for two components of relatedness — relatedness with colleagues and relatedness with students — influences teachers' emotional fatigue.

Most frequently, studies took place in a laboratory setting and samples were university students living in Western cultures. Exceptions formed the studies of Solberg, Halvari and Ommundsen (2013), which took place in an exercise setting and used a sample consisting of older adults (M = 74,2 years) and the study of Klassen, Perry and Frenzel (2012), which was conducted in a school setting and used a sample of practicing teachers of

moderate age. Sample size of the included studies varied greatly, ranging from 24 participants to 185 participants.

Seven out of the eight included studies examined causal relationships between basic need satisfaction and subjective vitality. The experimental studies of Martela and Ryan (2016) and Howell and Hill (2009) examined the positive causal relationship between satisfaction of the basic psychological need for autonomy, competence and relatedness and subjective vitality. The three experimental studies of Nix, Ryan and Deci (1999) and the quasi-experimental study of Vazou-Ekkekakis and Ekkekakis (2009) examined the positive causal relationship between autonomy satisfaction and subjective vitality. The interventional study of Solberg, Halvari and Ommundsen (2013) examined the positive causal relationship between competence satisfaction and subjective vitality.

The remaining quasi-experimental study of Klassen, Perry and Frenzel (2012) concerned the negative causal relationship between relatedness satisfaction and the emotional component of subjective fatigue. The search of the literature revealed no eligible studies on the relationship between satisfaction of the basic psychological need for autonomy or competence and subjective fatigue. Also, no eligible studies were found that analyzed the relationship between satisfaction of all basic psychological needs and subjective fatigue. Consequently, it could not be examined whether current causal evidence supports a negative causal relationship between autonomy or competence satisfaction and subjective fatigue, neither was it possible to examine whether current causal evidence supports the assumption that three basic psychological needs are related but and yet distinct necessary psychological nutriments for subjective fatigue.

In four studies autonomy satisfaction and in one study relatedness satisfaction was manipulated. In the study of Vazou-Ekkekakis and Ekkekakis (2009) and the three studies of Nix, Ryan and Deci (1999) differences in autonomy satisfaction were brought about by a manipulation of the context. For example, by allowing or not allowing the participants free choice in the execution of a task (e.g. freedom to self-organize one's behavior or freedom to set one's own exercise pace), or by letting them imagine that they freely chose for a particular activity (e.g. reading a vignette that asked them to think about taking a course for autonomous reasons). A scenario approach was used by Klassen, Perry and Frenzel (2012) to manipulate the two components of satisfaction of the basic need for relatedness: student relatedness

satisfaction and colleague relatedness satisfaction. The detailed results can be found in Appendix C.

3.2 Definitions and measurement tools

Definitions for basic need constructs were in line with SDT's definition of the basic psychological needs for autonomy, competence and relatedness. In the studies of Martela and Ryan (2016), Howell and Hill (2009) and Klassen, Perry and Frenzel (2012) the terms *basic need for autonomy*, *competence* and *relatedness* were used. Four studies employed different terms for the basic need for autonomy. Vazou-Ekkekakis and Ekkekakis (2009) referred to it as *perceived autonomy* or *perceived self-determination* and in the studies of Nix, Ryan and Deci (1999) it was called *perceived locus of causality*. Regarding the basic need for competence, by Solberg, Halvari and Ommundsen (2013) the term *perceived competence* was used.

Contrary to the other studies, Vazou-Ekkekakis and Ekkekakis (2009) operationalized perceived autonomy as multidimensional. In their operationalization, an inner endorsement of one's actions or an internal perceived locus of causality was only one of three qualities of perceived autonomy or self-determination.

Mostly self-assessment tools were used to measure satisfaction of the basic psychological need for autonomy, competence and relatedness. Two self-assessment tools were employed in more than one study. The perceived choice subscale taken from the *Intrinsic Motivation Inventory* was used in the studies of Nix, Ryan and Deci (1999) to assess perceived locus of causality. In two studies the self-assessment tool developed by Reeve (2002) was employed. Items selected from this measurement tool were used in the study of Vazou-Ekkekakis and Ekkekakis (2009) to assess perceived autonomy and by Solberg, Halvari and Ommundsen (2013) to measure perceived competence. Martela and Ryan (2016) used the *Basic Need Satisfaction and Frustration Scale* to assess satisfaction of the basic psychological needs for autonomy, competence and relatedness. Howell and Hill (2009) developed a self-assessment tool by themselves to assess satisfaction of the basic psychological needs. Perceived satisfaction of the need for relatedness was assessed qualitatively in the study of Klassen, Perry and Frenzel (2012).

Definitions for subjective vitality were in line with the definitions from SDT. In all studies that examine the effects of need satisfaction on subjective vitality the term *subjective vitality* was used. Martela and Ryan (2016) also assessed *ego depletion*, defined as the experience of possessing energy available to the self.

Most frequently self-assessment tools were used to measure subjective vitality. Two self-assessment tools were employed in more than one study. The *Subjective Vitality Scale* (SVS) was used by Solberg, Halvari and Ommundsen (2013), in the first study of Nix, Ryan and Deci (1999) and Martela and Ryan (2016). In the study of Vazou-Ekkekakis and Ekkekakis (2009) and the third study of Nix, Ryan and Deci (1999) the *Activation Deactivation Adjective Check List* was employed. In the study of Howell and Hill (2009) a self-assessment measure and in the second experiment of Nix, Ryan and Deci (1999) the implicit measure *Disguised Measure of Affect* was developed for the particular purpose of the study. Simultaneously to assessing subjective vitality with the SVS, Martela and Ryan (2016) used a *Stroop Task* as a behavioral measure for ego depletion.

The emotional component of subjective fatigue was measured with a self-assessment tool. In the study of Klassen, Perry and Frenzel (2012) *emotional exhaustion*, defined as feelings of being emotionally overextended and exhausted by one's work (Maslach et al., 1996), was assessed with the *Maslach Burnout Inventory*. The detailed results can be found in Appendix C.

3.3 What is the current causal evidence for a positive relationship between satisfaction of the basic psychological need for autonomy, competence and relatedness and subjective vitality?

As can be seen from table 3, significant and non-significant relationships were found between basic need satisfaction and subjective vitality. The cumulative causal evidence was solely based on statistical significant findings.

Regarding the basic psychological need for autonomy, cumulative evidence from the included studies consistently supported a positive causal relationship between autonomy satisfaction and subjective vitality. Amongst them were two studies of Nix, Ryan and Deci (1999) and the study of Vazou-Ekkekakis and Ekkekakis (2009). They found that conditions designed to foster autonomy satisfaction resulted in greater maintenance or enhancement of subjective vitality relative to conditions designed to thwart satisfaction of the basic

psychological need for autonomy. As can be seen from table 3, in the third study of Nix, Ryan and Deci (1999) the found positive relationship was not significant.

Findings of Martela and Ryan (2016) also supported a beneficial causal relationship between autonomy satisfaction and subjective vitality as well as a positive causal relationship with competence satisfaction. They found that satisfaction of the basic psychological needs for autonomy and competence were significant partial mediators of the positive causal relationship between experimental condition and subjective vitality as well as of the significant negative relationship between experimental condition and performance on a Stroop Task, indicating depletion of energy available to the self.

Solberg, Halvari and Ommundsen (2013)'s findings about competence satisfaction did not reach statistical significance but were consistent with the findings of Martela and Ryan (2016). They found that exercise intervention was indirectly linked to positive change in vitality over the trial through an increase in perceived competence. As table 3 shows, the mediating effect of change in perceived competence was not significant.

Findings of Howell and Hill (2009) supported a positive causal relationship between the basic psychological need for relatedness and subjective vitality. They found that the positive causal relationship between experiential purchases and subjective vitality was fully mediated by satisfaction of the basic need for relatedness. Although, in the study of Martela and Ryan (2016) the indirect effect through relatedness did not reach statistical significance, they pointed in the same direction.

Table 3. *Findings of the seven studies on the relationship between basic need satisfaction and subjective vitality*

	Did they find a positive (+) or negative (-) causal relationship between the basic need for ____ and subjective vitality?					
	A		C		R	
Studies	+	-	+	-	+	-
Martela & Ryan (2016)	x*	x*	x*	x*	$x^{n.s.}$	$x^{n.s.}$
Solberg, Halvari & Ommundsen (2013)			$x^{n.s.}$			
Howell & Hill (2009)					x*	
Nix, Ryan & Deci (1999) Study I	x*					
Nix, Ryan & Deci (1999) Study II	x*					
Nix, Ryan & Deci (1999) Study III	$x^{n.s.}$					

Vazou-Ekkekakis & Ekkekakis (2009)	x*

Note. Statistical significance: x* = $p \leq 0.05$, $x^{n.s.}$ = $p > 0.05$. Examined constructs: A = basic need for autonomy, C = basic need for competence, R = basic need for relatedness, ACR = all needs, V = subjective vitality, F = subjective fatigue

3.4 What is the current causal evidence for a negative relationship between satisfaction of the basic psychological need for relatedness and subjective fatigue?

As can be seen from table 4 in the study of Klassen, Perry and Frenzel (2012) significant relationships were found between relatedness satisfaction and the emotional component of subjective fatigue. This finding supports the assumption that basic psychological need for relatedness is a determinant of emotional fatigue.

Table 4. *Findings of the study on the relationship between relatedness satisfaction and subjective fatigue*

	Did they find a positive (+) or negative (-) causal relationship between the basic need for ____ and subjective fatigue?					
	A		C		R	
Studies	+	-	+	-	+	-
Klassen, Perry & Frenzel (2012)						x*

Note. Statistical significance: x* = $p \leq 0.05$, $x^{n.s.}$ = $p > 0.05$. Examined constructs: A = basic need for autonomy, C = basic need for competence, R = basic need for relatedness, ACR = all needs, V = subjective vitality, F = subjective fatigue

3.5 Regarding subjective vitality, what is the current causal evidence for the assumption that the three basic psychological needs are related but and yet distinct necessary psychological nutriments?

Martela and Ryan (2016)'s findings supported the assumption that the basic psychological needs are *related necessary* psychological nutriments for subjective vitality. Aggregated basic need satisfactions fully mediated the positive causal relationship between perceived prosocial impact and subjective vitality as well as the negative causal relationship between perceived prosocial impact and ego depletion. As can be seen from table 5, findings also support the assumption that all basic psychological needs must be satisfied to achieve a positive effect on subjective vitality. The group that had significant higher scores on perceived prosocial impact also reported significant higher satisfaction of the basic psychological need for autonomy, competence and relatedness.

Findings of Martela and Ryan (2016) did not support the assumption that the basic psychological needs are *distinct* necessary psychological nutriments. As can be seen from table 5, only autonomy and competence satisfaction were significant partial mediators of the positive causal relationship between perceived prosocial impact and subjective vitality and the negative causal relationship between perceived prosocial impact and ego depletion, whereas the indirect effect through relatedness satisfaction was not significant. In other words, only autonomy and competence satisfaction had a significant independent effect on energy available to the self.

Table 5. *Findings on the research question "Regarding subjective vitality, what is the current causal evidence for the assumption that the three basic psychological needs are related but and yet distinct necessary psychological nutriments?"*

Study	Did they find a significant aggregated effect of basic need satisfactions on subjective vitality?		Did they find a significant indirect effect of ____ satisfaction on subjective vitality?						Did the findings indicate that all basic psychological needs are satisfied?	
			A		C		R			
	Yes	No	+	-	+	-	+	-	Yes	No
Martela & Ryan (2016)	x		x*	x*	x*	x*	$x^{n.s.}$	$x^{n.s.}$	x	

Note. Statistical significance: x* = $p \leq 0.05$, $x^{n.s.}$ = $p > 0.05$. Examined constructs: A = basic need for autonomy, C = basic need for competence, R = basic need for relatedness, ACR = all needs, V = subjective vitality, F = subjective fatigue

Discussion

The *objective* of this systematic review was to examine whether current causal evidence supports the assumptions that (1) the basic psychological needs are determinants of subjective vitality and subjective fatigue and that (2) the basic psychological needs are related but yet distinct necessary psychological nutriments for subjective vitality and subjective fatigue.

The *main findings* of this review are that cumulative evidence supports a positive causal relationship between satisfaction of each basic need and subjective vitality. Also, evidence for a negative causal relationship between relatedness satisfaction and emotional fatigue was found. Moreover, causal evidence supports the aggregated positive effect of basic

need satisfactions on subjective vitality under the condition that each basic need is satisfied, but contrary to expectation only autonomy and competence satisfaction were found to have a significant independent impact.

However, the objective was only *partially reached.* The search of the literature revealed no eligible studies on the relationship between satisfaction of the basic psychological need for autonomy or competence and subjective fatigue. Also, no eligible studies were found that analyzed the relationship between satisfaction of all basic psychological needs and subjective fatigue. Consequently, it could not be examined whether current causal evidence supports a negative causal relationship between autonomy or competence satisfaction and subjective fatigue, neither was it possible to examine whether current causal evidence supports the assumption that three basic psychological needs are related but and yet distinct necessary psychological nutriments for subjective fatigue. It could only be examined whether relatedness satisfaction is a determinant of emotional fatigue.

4.1 Basic psychological needs: determinants or only correlates of subjective vitality and subjective fatigue?

Findings of this systematic review support SDT's assumption that the basic psychological needs for autonomy, competence and relatedness are determinants of subjective vitality. In most of the included studies the maintenance, enhancement, and depletion of subjective vitality significantly depended on the extent to which the basic psychological need for autonomy, competence and relatedness was satisfied. Causal evidence was in line with correlational findings on this assumption (Sheldon, Ryan & Reis, 1996; Reis, Sheldon, Gable, Roscoe & Ryan, 2000).

Given SDT's popularity and its status as sound empirical theory it has been expected that a search on *SCOPUS* and *PsycInfo* would reveal a greater number of high evidence studies on the relationship between basic need satisfaction and subjective vitality. Contrary to expectation, the search of the literature revealed, for example, only one eligible study on the causal relationship between competence satisfaction and subjective vitality.

Causal evidence for the assumption that the basic psychological needs are determinants of subjective vitality and subjective fatigue is still insufficient. In some studies,

the positive effects of autonomy, competence and relatedness satisfaction on subjective vitality did non-reach statistical significance.

This systematic review also supports the assumption that the basic psychological need for relatedness is a determinant of the emotional component of subjective fatigue. The negative causal relationship between relatedness satisfaction and emotional fatigue is consistent with correlational evidence (Lonsdale, Hodge & Rose, 2009). The causal relationship with one component of subjective fatigue strengthens the assumption that relatedness satisfaction might also be a determinant of other components of subjective fatigue, which would be consistent with previous correlational findings (Lonsdale, Hodge & Rose, 2009; Saksvik-Lehouillier, & Hetland, 2016).

As expected, a search of the literature revealed few high evidence studies on the relationship between basic need satisfaction and subjective fatigue. The fact that only one eligible study was found on that topic reinforces the impression that subjective fatigue has not yet been thought of as an outcome of basic need satisfaction that SDT is lacking. Another reason for the seemingly low interest in subjective fatigue might be that fatigue often is perceived as a normal experience. For example, fatigue is often neglected by medical doctors in the severity and treatment of RA although the experience of extreme and persistent tiredness has disadvantages for patient's health and well-being (Nikolaus, 2012; Gettings, 2010; Treharne, Kitas, Lyons & Booth, 2005; Nikolaus, Bode, Taal & van de Laar, 2013). Also, the fact that it concerns a subjective experience, which is difficult to measure and difficult to treat, might play a role (Johnson, 2008).

That the only eligible study on subjective fatigue concerned the relationship between relatedness satisfaction and emotional consequences of subjective fatigue is not surprising. The relationship between perceived social support and the emotional consequences of fatigue is a popular topic in research about burn-out and depression. For example, perceived social support has been shown to have an inverse relationship with symptoms of depression (Gurung, Sarason & Sarason, 1997) and a perceived lack of social support is a predictor of emotional exhaustion, which is a core symptom of burn-out (Cordes & Dougherty, 1993).

4.2 Does current causal evidence support the assumption that the basic psychological needs are related but yet distinct necessary psychological nutriments for subjective vitality?

This systematic review partially supported the assumption that the basic psychological needs are related but yet distinct necessary psychological nutriments for subjective vitality. The finding of a significant *aggregated* positive effect of basic need satisfactions on subjective vitality *under the condition* that all basic psychological needs are satisfied is in line with previous correlational research (Reis et al., 2000; Martela & Ryan, 2015; Sheldon, Ryan & Reis, 1996, Weinstein & Ryan, 2010; Gebauer, Riketta, Broemer & Maio, 2008; Aknin, Dunn, Whillans, et al., 2013; Aknin, Dunn, Sandstrom, & Norton, 2013; Aknin, Sandstrom, Dunn, & Norton, 2011). Concluding, the found evidence supports SDTs assumption that the basic psychological needs are *related* constructs and that all of them *must* be satisfied to achieve a positive effect on subjective vitality.

Contrary to SDT's assumption and correlational evidence, only autonomy and competence satisfaction had an *independent* significant effect on subjective vitality. This finding should be interpreted with caution because it was based on one study. Therefore, this systematic review suggests that although the basic needs are related necessary psychological nutriments for subjective vitality, whether they also are three *distinct* constructs is unclear.

However, the found causal evidence shows that the satisfaction of the basic needs for autonomy and competence is of vital importance for the energy available to the self. The found significant independent effect of autonomy satisfaction is consistent with Ryan and Frederick (1997)'s statement that it is rather untypical that one feels vital if one’s need for autonomy is not satisfied. Indeed, this finding suggests that a satisfied need for autonomy is *necessary* for subjective vitality to increase, although it does not allow a statement to whether a satisfied need for autonomy is *sufficient* to achieve a positive effect on subjective vitality since also a significant effect of competence satisfaction was found. In the study of Neubauer, Schilling, and Wahl (2015) correlational evidence against the necessity of a satisfied need for autonomy was found: competence satisfaction had a significant impact on subjective vitality, whereas autonomy satisfaction did not. However, it concerned a correlational finding therefore effects might just as well be due to chance or a confounding variable.

4.3 Variety in samples and contexts

As SDT claims, that the basic psychological needs are *universal*, it has been expected that experimental studies would examine the relationship between basic need satisfaction and subjective vitality in a *great variety* of samples and contexts. Contrary to this expectation, this systematic review found that experimental studies on the relationship between basic need satisfaction and subjective vitality are manly conducted in laboratories with a sample of university students living in Western cultures.

4.4 Operationalization of the basic psychological needs and subjective vitality

This systematic review suggests that researchers agree upon SDT's definition and unidimensional operationalization of each basic psychological need and subjective vitality. Since alternative terms for the three basic psychological needs and subjective vitality were used to search for articles just as well inconsistencies in the definition and operationalization of the constructs could have been found. For example, multidimensional operationalizations could have been revealed by the search terms *perceived social support,* which was used for the basic psychological need for relatedness, or e*nergetic*, which was used for subjective vitality and could have led to articles on energetic arousal (Murrell, Norris & Chipley, 1992; Thayer, 1989). Therefore, findings of this systematic review point to a prevailing influence of SDT in the definition and operationalization of the basic psychological needs and subjective vitality and also suggest that other definitions and operationalizations of these constructs are lacking. Concluding, the possibility that the prevailing definitions and operationalizations of these constructs will be questioned or refined is relative low.

4.5 Psychometric quality of the measurement tools

Findings of this systematic review suggest a trend towards using measurement devices for basic need satisfaction and subjective vitality of which validity and reliability is unclear. For example, the *Disguised Measure of Affect* (DMA), which enables a rapid assessment of momentary activation or arousal states, was developed by Nix, Ryan and Deci (1999) themselves for the particular purpose of one study. The psychometric quality of the DMA has not been examined yet. Also, the psychometric properties of the measure of Reeve (2002) and the *Perceived Choice* subscale (Markland & Hardy, 1997) is just as unclear as the

psychometric quality of the *Perceived Competence scale* (Williams & Deci, 1996) in the context of physical exercise. Concluding, it cannot be ruled out that the findings of this review are based on data that has been collected by invalid or unreliable measures.

Only a few devices used to assess basic need satisfaction and subjective vitality possessed *sufficient psychometric properties*, which should caution us about the use and interpretation of research findings. Among them the *Basic Need Satisfaction and Frustration Scale*, used by Martela and Ryan (2016), that has been proven to be a valid and reliable measure of aggregated basic need satisfaction and also enables an examination of the independent effect of each basic need (Chen et al., 2015). Furthermore, recommendable measurement devices to assess subjective vitality are the 7-item *Subjective Vitality Scale* (SVS) (Bostic, Rubio & Hood, 2000) and the *Activation Deactivation Adjective Check List* (ADACL) (Thayer, 1986; Ryan & Deci, 2008). Concluding, if researchers want to assess basic need satisfaction or subjective vitality, then they should use the listed instruments with sufficient psychometric properties.

However, self-assessment tools are particularly subject to problems with social desirability biases and therefore may affect the accuracy of data collected (Kimberlin & Winterstein, 2008). Findings of this systematic review suggest that performance on a *Stroop task* is a valid objective measure for energy available to the self. The fact that this behavioral measure yielded the same results as the SVS also adds to the construct validity of this self-assessment tool. Concluding, by combining self-assessment instruments (SVS or ADACL) with behavioral measures (Stroop Task) the assessment of subjective vitality can be improved.

This systematic review suggests that other measurement tools will be needed to examine the overall experience of fatigue and its different dimensions. Albeit the *Maslach Burnout Inventory* has acceptable validity and reliability, this self-assessment tool is limited to the component of emotional fatigue (Aluja, Blanch & Garcia, 2005). Measures that enable the examination of the overall experience of fatigue and its different dimensions exist. For example, the BRAF-MDQ, which is used as a self-assessment tool in research on fatigue in RA patients could be adapted to and validated for other populations (Hewlett, Dures & Almeida, 2011).

4.6 Ways to manipulate satisfaction of the basic psychological needs

Manipulation of autonomy satisfaction had in common that differences in the satisfaction of the basic psychological need for autonomy were brought about by a manipulation of the context. This approach is in line with SDT's assumption that the social context can support (rather than thwart) satisfaction of the basic needs (Deci & Ryan, 2000), for example, by allowing or not allowing the participants free choice in the execution of a task (e.g. freedom to self-organize one's behavior or freedom to set one's own exercise pace), or by letting them imagine that they freely chose for a particular activity (e.g. reading a vignette that asked them to think about taking a course for autonomous reasons). The advantage of these manipulation procedures is that they can be easily adapted to other contexts and populations. However, they did not control the potential confounding effect of aggregated basic need satisfactions, autonomy or competence satisfaction. Since the three basic needs are conceptualized as related but yet distinct theoretical constructs the results might also be due to changes in these variables. Concluding, if autonomy satisfaction is manipulated, then aggregated basic need satisfactions as well as the independent effect of *each* basic need should be assessed.

The scenario approach of Klassen, Perry and Frenzel (2012) provides a way to manipulate relatedness satisfaction. The main advantages of this approach are that it is easy to administer, adaptable to different populations and contexts (e.g. replacing the teacher in the vignette by an athlete) and also to other basic needs. The main disadvantage of this approach is that the significant effects on emotional fatigue were biased by a priori existing individual differences in the perceived importance of components of relatedness satisfaction.

Actually, there are good reasons to assume that the results about emotional exhaustion mainly depend on whether the need for student's relatedness was perceived to be satisfied or not. Klassen, Perry and Frenzel (2012) found that participants rated a scenario in which a hypothetical teacher's need for colleague relatedness is satisfied *but not* his need for student relatedness causing significantly greater emotional exhaustion than a scenario in which a teacher's need for student relatedness is satisfied *although* his need for colleague relatedness is not. Therefore, it can be assumed that the results about emotional exhaustion mainly depend on whether the need for student's relatedness is perceived to be satisfied or not. Indeed, participants who were teachers themselves perceived relatedness with students also

as significantly more important than relatedness with colleagues. It follows that only a successful manipulation of student relatedness satisfaction can be assumed, as the results about emotional fatigue seemed to depend on the component, which participants perceived important for their own relatedness satisfaction, that is, student relatedness satisfaction. Concluding, if researchers want to manipulate different components of autonomy, competence or relatedness satisfaction, then they should take measures to ensure that these components are perceived as important and as evenly important.

4.7 Strengths and limitations

The major strengths of this systematic review are that the found causal evidence is based on high evidence studies and its adherence to the PRISMA-P guidelines for systematic reviews.

A limitation of this systematic review is that only published studies were used. Publication bias can lead to an overestimation of the strength of the investigated relationships (Cooper, 2016). Likewise, an *author bias* might have influenced the results as the developers of SDT, Edward L. Deci and Richard M. Ryan, contributed to half of the included studies.

Furthermore, this systematic review was conducted by one researcher. Since the results could not be compared with a second researcher, a general threat to validity of the findings is that the researcher incorrectly retrieved information from the study reports and then misinterpreted the studies in the cumulative analysis. To relativize this threat to a certain degree, uncertainties and inconsistencies have been discussed with two more experienced researchers that possess sufficient knowledge about the topics under investigation.

Although findings of this review are solely based on results of eight studies they represent the best available research on that topic. Nonetheless caution should be exercised in the interpretation of the results before attempting to extrapolate or generalize the findings because of the included studies' great variety in sample size and low variety in samples and contexts.

4.8 Practical implications and directions for future research

Findings of this review suggest that basic need satisfaction is a mechanism through which subjective vitality and subjective fatigue can be improved. Interventions that facilitate

autonomy, competence and relatedness satisfaction could help people who are suffering from increased fatigue or lack vitality. According to SDT, autonomy satisfaction can be supported by providing opportunities for choice, competence satisfaction can be supported by providing structure and informational feedback and relatedness satisfaction can be supported by interest and care for participants involved in the intervention (Deci & Ryan, 1991; Mageau & Vallerand, 2003; Ryan & Deci, 2002). In line with SDT, an autonomy-supportive exercise intervention for patients with RA led to a significant increase in subjective vitality and had a positive effect on the decrease of subjective fatigue (Rouse et al., 2015). Concluding, intervention developers should incorporate need-supportive techniques to improve subjective vitality and fatigue.

Future research should continue and expand the research of this systematic review to contribute to the empirical soundness of SDT. Causal evidence for the assumption that the basic psychological needs are determinants of subjective vitality and subjective fatigue is still insufficient since in some studies, the positive effects of autonomy, competence and relatedness satisfaction on subjective vitality did non-reach statistical significance. In addition, experimental studies should examine whether the basic psychological needs are related but yet distinct requirement for subjective vitality as this systematic review found only partial support for this assumption. Researchers should make sure that they use measurement devices for basic need satisfaction and subjective vitality that possess sufficient psychometric properties. Also, they should take into consideration the findings of this review in their choices concerning manipulation of basic need satisfaction and the control of potential confounding variables. In addition, researchers are encouraged to expand the findings of this review to other settings and populations.

Likewise, the relationship between the basic psychological needs and subjective fatigue was identified as a fruitful but yet uncharted future research topic. For example, it still needs to be explored whether autonomy, competence and relatedness satisfaction are determinants of subjective fatigue and its different components. Also, measurement tools such as the BRAF-MDQ could be adapted to other contexts and populations as they enable a multidimensional assessment of subjective fatigue. Since findings suggest that subjective fatigue is an outcome of basic need satisfaction that SDT is lacking, research on the negative causal relationship between basic need satisfaction and subjective fatigue might improve the

explanatory and predictive power of SDT. Indeed, exploring whether causal evidence supports the assumption that basic psychological needs are determinants of subjective fatigue might provide new insights for SDT research and research on subjective fatigue.

Finally, future researchers are encouraged to explore to what extent subjective vitality and subjective fatigue are related or distinct constructs. In view of Ryan and Frederick (1997) they are distinct constructs that must be distinguished as they represent qualitative different states of energy. However, they might just as well be related constructs in the sense that subjective fatigue is the state of lacking subjective vitality and vice versa. Exploring whether subjective vitality is more than the absence of subjective fatigue and subjective fatigue is more than the absence of subjective vitality also would open the possibility to question and refine the prevailing conceptualization of subjective vitality. For example, findings of this systematic review suggest that the experience of low emotional fatigue, which includes being motivated and interested, might be closely conceptually related to subjective vitality and that relatedness satisfaction might be a determinant of such an emotional dimension of subjective vitality. Indeed, if subjective fatigue is the state of lacking subjective vitality and vice versa, this would mean enrichment of insights, measurement tools, and treatments for SDT research and for research on subjective fatigue.

Conclusion

This systematic review contributes to the empirical soundness of SDT since best available research supports SDT's central assumption that the basic psychological needs are determinants of subjective vitality. In addition, the found evidence emphasizes that the explanatory and predictive power of SDT might be improved by incorporating subjective fatigue as an outcome of basic need satisfaction. Causal evidence also supports SDT's conceptualization of the basic psychological needs as theoretical related constructs and requirements for subjective vitality, whether they are three *distinct* constructs still needs to be explored. Causal evidence for the assumptions examined in this review is still insufficient but vital because evidence-based need-supportive interventions seem to provide a way to improve subjective vitality and subjective fatigue. Moreover, exploring to what extent subjective vitality and subjective fatigue are related or distinct constructs would open up the

possibility to question and refine the definition and unidimensional operationalization of subjective vitality.

Box 1. *Take home message*

"*There is nothing more practical than a good theory*" wrote Lewin (1952, p. 169). Causal evidence for the assumptions examined in this review is still insufficient but vital because evidence based need-supportive interventions might provide a way to improve subjective vitality and subjective fatigue. If *you* want to change this, feel encouraged to continue and expand the research of this systematic review!

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Appendix

Appendix A

Table 6. *Inclusion and exclusion criteria*

Inclusion criteria	Exclusion criteria
Type of studies	Type of studies
Systematic reviews	Observational studies
Meta-analyses	Descriptive studies
Experimental/interventional studies	Ecological studies
RCTs	Cross-sectional studies
Completely randomized trials	Case-control studies
Field trials	Cohort studies
Community trials	Qualitative studies
Quasi-experimental studies	Book extracts
	Survey validating studies
Constructs	Constructs
Basic psychological needs for autonomy, competence and/or relatedness	Other constructs
Subjective vitality and/or subjective fatigue	Relationships between constructs
Relationships between constructs	Studies that did not examine or analyze the relationship between basic psychological need(s) and subjective vitality or subjective fatigue
Studies that did examine and analyze the relationship between basic psychological need(s) and subjective vitality or subjective fatigue	Studies that did not report on the relative effect of each basic psychological need
Studies that did report on the relative effect of each basic psychological need	Practical reasons
Practical reasons	Other languages
Written in English, German or Dutch	Research from areas of biochemistry, genetics and molecular biology, agricultural and biological sciences as well as business, management and accounting

Appendix B

Box 2. *Extraction form, Inga Thieler, March 2017*

1. General information
    - Author
    - Year of publication
    - Type of publication

Citation (APA)

2. Study characteristics
   - Aim/objective of the study
   - Study design (e.g. RCT)
3. Sample characteristics and setting
   - Description of the sample (e.g. students)
   - Mean age of the sample
   - Sample size
   - Setting
4. Manipulation/Intervention characteristics
   - Manipulation procedures/intervention
   - Experimental and control groups
   - Manipulation check (yes/no)
   - Results of the manipulation check (successful, not successful, unclear)
5. Constructs of interest: satisfaction of the basic psychological needs for autonomy, competence and relatedness, subjective vitality and subjective fatigue
   - Definition
   - Measurement tools
6. Examined relationship(s) of interest:
   - Relationship between satisfaction of the three basic psychological needs and subjective vitality or subjective fatigue
   - Relationship between satisfaction of the basic psychological need for autonomy and subjective vitality or subjective fatigue
   - Relationship between satisfaction of the basic psychological need for competence and subjective vitality or subjective fatigue
   - Relationship between satisfaction of the basic psychological need for relatedness and subjective vitality or subjective fatigue
7. Results regarding the relationships of interest
   - Type of relationship (positive or negative)
   - In case of mediation: kind of mediation (full or partial)
   - Significance of the relationship (e.g. strong, marginal, small)
   - Statistical results (e.g. p-value, confidence intervals, mean differences)

Appendix C

Table 7. *Characteristics of included studies*

Martela & Ryan (2016)

Aim	To determine whether in a situation that does not involve any contact with the beneficiary, prosocial behavior will increase the benefactor's subjective vitality and whether this effect is mediated by satisfaction of the basic needs
Design	RCT
Manipulation	Manipulation of prosocial impact of behavior: (1) Benevolence group was informed about the benevolent impact of their gameplay. (2) Control group was not. Successful: perceived prosocial impact was significantly greater in the beneficence condition ($M_{benevolence}$ = 19.85 vs. $M_{control}$ = 8.55, t(72) = 8.86, p = <.001)
Sample	N = 76, university students, USA, M = 20.4 years
Setting	Laboratory
Definition	Basic psychological needs for autonomy, competence and relatedness: no definition provided. References indicate that the constructs were derived from basic needs theory
Measurement	Self-assessment tool: Basic Need Satisfaction and Frustration Scales Subjective vitality and ego depletion: both refer to energy available to the self Self-assessment tool: Subjective Vitality Scale (SVS) Behavioral measure: Stroop Task
Solberg, Halvari & Ommundsen (2013)	
Aim	To identify and test mediators (e.g. perceived competence) of the relation between exercise and subjective vitality
Design	RCT
Manipulation	Exercise intervention: (1) Training group followed different training protocols (endurance, functional or strength training). (2) Wait-list control group continued their daily activities as before Successful: groups most likely differed in amount of physical activity due to inclusion criteria (sedentary older adults) and instructional manipulations
Sample	N = 125, older adults, Norwegian, M = 74.2 years
Setting	Exercise
Definition	Perceived competence: bears a similarity to the concept of self-efficacy; people are perceived as competent when they feel able to attain and control outcomes of their behavior
Measurement	Self-assessment tool: 12 items selected from Reeve (2002) Subjective vitality: is one's conscious experience of possessing energy and aliveness Self-assessment tool: Subjective Vitality Scale
Howell & Hill (2009)	
Aim	To determine whether experiential purchases (= money invested in an experience), as opposed to materialistic purchases (= money invested in a material good), are likely to increase subjective-vitality and whether this increase is likely to be due to increased satisfaction of psychological needs

Design	Completely randomized controlled trial
Manipulation	Manipulation of type of purchase: (1) Experiential group was instructed to write about a recent experiential purchase. (2) Material group was instructed to write about a recent material purchase Successful: ruled out the possibility that group differences in well-being are due to a priori existing group differences in negative purchase decisions (=purchases with the intention of increasing wellbeing and find the purchase does not make them happier)
Sample	N =154, students, USA, M = 24,3 years
Setting	Laboratory
Definition	Basic psychological need for autonomy: the need to view one's actions as self-determined.
Measurement	That is, motivated by an internal locus of causality. Competence: entails the sense that one has control over desired outcomes (self-efficacy), is optimistic about such outcomes, and feels competent to deliver them. Relatedness: the need for human beings to belong, to feel connected, and to be understood by others Self-assessment tool: developed a measure by themselves Subjective vitality: a positive state of energy and alertness that reflects organismic integration and actualization Self-assessment tool: 5 items (no source provided)

Nix, Ryan & Deci (1999) Study I	
Aim	To test the hypothesis that conditions designed to foster an internal perceived locus of causality would result in greater maintenance or enhancement of subjective vitality relative to conditions conducive to an external perceived locus of causality (also in study II-III)
Design	Completely randomized controlled trial (*also in study II-III*)
Manipulation	Manipulation of perceived locus of causality: (1) Internal perceived locus of causality (IPLC) group: could self-organize behavior during a Wisconsin Card Sort Task Vs. (2) External perceived locus of causality (EPLC) group engaged in externally organized behaviors Successful: IPLC condition experienced more autonomy than the EPLC condition, $F(1, 92) = 9.81$, $p < .01$
Sample	N = 93, undergraduates, USA, Mean age?
Setting	Laboratory

Definition	Perceived locus of causality: an internal perceived locus of causality or autonomous
Measurement	motivation, is characterized by a sense of agency or personal causation. And a controlled motivation or an external perceived locus of causality involves feeling coerced or pressured to behave in specific ways by inter- or intrapersonal forces (*also in study II-III*)
	Self-assessment tool: 5 items from the Perceived Choice subscale taken from the Intrinsic Motivation Inventory (*also in study II-III*)
	Subjective vitality: feeling of possessing energy available to one's self (*also in study II-III*)
	Self-assessment tool: Subjective Vitality Scale
Nix, Ryan & Deci (1999) Study II	
Manipulation	Manipulation of perceived locus of causality: (1) IPLC group focused on properties of the puzzle task, without performance pressure. In (2) EPLC group puzzles introduced as measures of intelligence to create a performance pressure
	Successful: IPLC condition experienced more autonomy than t the EPLC condition, $F(1, 62) = 4.50$, $p < .05$
Sample	N = 64, undergraduates, USA, Mean age?
Setting	Laboratory
Measurement	Implicit measure for subjective vitality: Disguised Measure of Affect
Nix, Ryan & Deci (1999) Study III	
Manipulation	Manipulation of perceived locus of causality: In (1) IPLC group vignette asked to think about taking a course for autonomous reasons. In (2) EPLC group vignette asked to think about taking a course for controlled reasons
	Successful: IPLC condition experienced more autonomy than the EPLC condition, $F(1, 139) = 43.2$, $p < .001$
Sample	N = 14, college students, USA, Mean age?
Setting	Laboratory
Measurement	Self-assessment tool for subjective vitality: Activation Deactivation Adjective Check List
Klassen, Perry & Frenzel (2012)	
Aim	Answering the question: How does satisfaction of the need for two components of relatedness — relatedness with colleagues and relatedness with students — influence teachers' engagement and emotions?
Design	Quasi experiment within-subject design, counterbalanced
Manipulation	Manipulation of two components of relatedness satisfaction: (1) Jamie scenario featured a teacher who had high student relatedness, coupled with low colleague relatedness. (2) Kelly scenario featured a teacher who presented with high colleague relatedness coupled with low student relatedness
	Successful: discussion with pilot study participants revealed that the scenarios were believable and understood to elicit intended high and low relatedness reactions

Sample	N = 185, practicing teachers, North-America, M = 41.8 years
Setting	Educational workplace
Definition	Perceived satisfaction of the need for relatedness: the need for relatedness is seen in
Measurement	employees' perceived need to feel connected to others, to be a group member, and to develop close and intimate relationships with others
	Qualitative measure: discussing face validity with pilot participants.
	Emotional exhaustion: feelings of being emotionally overextended and exhausted by one's work
	Self-assessment tool: Maslach Burnout Inventory

Vazou-Ekkekakis & Ekkekakis (2009)	
Aim	To examine if the causal effect of changes in perception of autonomy can have an impact on affective responses (e.g. subjective vitality) in the context of physical activity
Design	Quasi-experiment, within-subject design
Manipulation	Manipulation of perceived autonomy: In the (1st) high perceived autonomy exercise session participants could set their own exercise pace in physical exercise session. In the (2nd) low perceived autonomy exercise session the speed of the treadmill was controlled by investigator
	Successful: participants scores on perceived autonomy after the first exercise session were significant higher than after the second session, while controlling for pretest scores on perceived autonomy, $F(3, 16) = 77.86$, $p < .001$
Sample	N = 19, university students, Greek, M = 21 years
Setting	Laboratory/Exercise
Definition	Perceived autonomy or perceived self-determination: extent to which a person feels free to
Measurement	exhibit the behavior of his/her choice, with an inner endorsement of his/her own actions. It combines three qualities of self-determination: perceived locus of causality, volition, and perceived choice
	Self-assessment tool: 12 items selected from Reeve (2002)
	Subjective vitality: should be reflected in feelings of energy and vitality, it is a central indicator of eudaimonia
	Self-assessment tool: Activation Deactivation Adjective Check List