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Chapter 2

Perseverative cognition, psychopathology and somatic health

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General introduction: the perseverative cognition hypothesis

The idea that stress can make us sick is not new. A long tradition of research into the effects of stressful events has made clear that stressful events can lead to mental (Hammen, 2005) as well as somatic health problems (Cohen & Williamson, 1991; Rozanski, Blumenthal, & Kaplan, 1999). This is especially the case when stressful circumstances are chronic, such as when providing care for a chronically ill spouse (Schulz, 2004; Vitaliano, 2003). It has also been well documented that the way people perceive and appraise events codetermines whether a situation or event is experienced as stressful and that stressful appraisals in turn initiate and activate the physiological stress reaction (Lazarus, 1991). Thus, stress can make us sick and that is in part due to what we think about stressful events. Yet, stress researchers have confined their attention mainly to what we think *during* these events and how that leads to enhanced physiological stress reactions *during* a stressful situation. Little attention has been paid to how these thoughts, when they persevere after (or before, in anticipation of) stressful events, can prolong the stress response. Yet, as we will argue in this chapter, it is the prolongation of stress responses, and not so much acute stress responses that form a crucial link between stressors and later mental (McEwen, 2003; Thayer & Lane, 2000) and somatic problems (Selye, 1951; Ursin & Eriksen, 2004; Linden, Earle, Gerin, & Christenfeld, 1997; Brosschot, Pieper, & Thayer, 2005; Brosschot, Gerin, & Thayer, 2006). Thus, as yet scientists have hardly addressed the important issue of *when, how often* and *how long* we think about stressful events and how 'perseverative thinking' about stressors might prolong the stress response. In psychopathology research though, during the past decade, perseverative cognitive processes have received increasing attention, and have been recognized as core etiological factors in the maintenance of several mental disorders, such as mood and anxiety disorders. We have recently hypothesized perseverative cognition as the mediator of the effects of stressors on not only mental but also somatic illness, because it prolongs not only psychological but also physiological responses to stressors. Brosschot Gerin & Thayer (2006) have stated that stress can only lead to disease when physiological stress responses are prolonged by perseverative cognition. Perseverative cognition refers to mental representations of the stressful events, such as worrisome anticipation before or ruminative thinking after the stressful events. Just as stressful cognitions during stressful events shape the concomitant physiological and emotional stress reaction, perseveration of these representations is hypothesized to prolong this physiological and emotional activity, thereby adding to the total time that stressors can have an impact on our mental and somatic well-being.

Several reasons can be forwarded why insight into how perseverative thoughts prolong physiological activity after or before a stressful event is likely to improve our understanding of how stress influences our health. First, the prolonged cognitive effects of stressful events seem to outlast

to a great extent the duration of the stressful events themselves. For example, Gilboa and Revelle (1994) found that even minor negative daily events can evoke worrisome thoughts that might last up to 11 hours after the stressful event. Second, many, if not most, stress responses are due to stressors that have not yet occurred or will never occur, but are anticipated (i.e. feared) nevertheless. In other words, their anticipation in the form of worrying is in fact their only manifestation. Anticipated stressors - as opposed to actually occurring stressors - is such an extremely common form of stress-related cognition that it is quite surprising that it has received such little attention in stress science. For example, in a large scale survey amongst Dutch employees, one third reported to experience sleeping difficulties every Sunday night due to worries about the upcoming work week (Monsterboard, 2008). In addition, a majority of employees have difficulties in relaxing after work because they keep on worrying about their next stressful workday. Third, studies on the temporal aspects of emotions show that initial emotional reactivity during stressful events is only weakly related to the duration of the emotional response (6 – 14% shared variance) and that even positive changes in the stressful event, such as when a conflict between an employee and their boss is resolved, are only weakly associated with the duration of the emotional responses to it (6% shared variance; Sonnemans & Frijda, 1994). In conclusion then, it seems clear that cognitive, emotional and physiological reactivity during real life stressful events is only one side of the coin, and that investigating the total duration of stress related psychological and physiological activity, even beyond the presence of the real life stressor is of high importance.

In this chapter we will review recent evidence for the perseverative cognition hypothesis, including its effects on mental as well as somatic health. In it we specifically focus on the real life dynamics of perseverative cognition. Furthermore, we will provide a self regulation perspective on perseverative cognition clarifying the notion that perseverative cognition is in fact the default response to stressful situations, a response which is successfully inhibited by most healthy people. We will illustrate how goal directed cognition can lead to pathological perseverative cognition as seen in mood and anxiety disorders. Finally, we will discuss the neurophysiological underpinnings of perseverative cognition. First, the concept of perseverative cognition itself, its manifestation and prevalence will be introduced.

The concept and prevalence of perseverative cognition

Perseverative cognition is defined as “*the repeated or chronic activation of the cognitive representation of one or more psychological stressors*” (Brosschot et al., 2006). A stressor is defined as a situation involving potential harm, without or with low perceived control, that is a *threat* to the psychobiological integrity of oneself or to the attainment of one’s higher order goals. Although many

terms are used by psychologists to refer to perseverative thinking, such as “rumination”, “repetitive thinking”, “worry” or “depressive rumination”, there are several reasons why we propose to use the term ‘perseverative cognition’ (Brosschot, van Dijk, & Thayer, 2002; Brosschot et al., 2006) within the framework of psychobiological stress research. These reasons are that (1) related terms involve either too broad or too narrow definitions to be used in a stress model, (2) these terms lack an emphasis on the importance of the perseverative process itself for health, and (3) our definition of perseverative cognition as a “mental representation of psychological stressors” allows to include alternative cognitive processes, for example automatic or unconscious cognitive processes, that may have substantial health-relevant effects. Below, we will discuss each of these arguments in more detail.

First, several concepts involving conscious perseverative thinking exist that are either too broadly defined, such as rumination, defined as “*a class of conscious thoughts that revolve around an instrumental theme and that recur in the absence of immediate environmental demands requiring the thoughts*” (Martin & Tesser, 1996, p. 7) and repetitive thinking, defined as the “*process of thinking attentively, repetitively or frequently about one’s self and one’s world*” (Segerstrom, Stanton, Alden, & Shortridge, 2003, p. 909). Both of these terms can also refer to positive thoughts, whereas perseverative cognition deals with negative thoughts that are specifically concerned with stressors. Other terms are too specifically or narrowly defined, such as depressive rumination: “*behaviors and thoughts that focus one’s attention on one’s depressive symptoms and on the implications of these symptoms*” ((Nolen-Hoeksema, 1991p. 569) and worry: “*a chain of thoughts and images, negatively affect-laden and relatively uncontrollable. The worry process represents an attempt to engage in mental problem-solving on an issue whose outcome is uncertain but contains the possibility of one or more negative outcomes. Consequently, worry relates closely to fear process.*” (Borkovec, Robinson, Pruzinsky, & DePree, 1983, p. 10). Worry as well as depressive rumination deal with stressors, being either future stressors or ones depressive symptoms, and are the most thoroughly investigated types of perseverative cognition. Perseverative cognition encompasses worry as well as rumination, and also other related concepts, such as intrusive thoughts, and negative flashbacks.

Second, the term ‘perseverative’ makes clear that the pathological ingredient of mentally representing stressors is their *perseveration*, that is, the *duration of exposure* of the organism to the (cognitive representation of) the stressor (threat). As argued above, the duration of the stress response is its toxic element, for mental as well as for somatic health. Only persistent emotional or physiological responses can lead to problems in either mental or somatic health.

Third, perseverative cognition not only refers to conscious thoughts about stressors, but also to prolonged *automatic* processing of stressor related information, as reflected in for example

attentional hypervigilance or enhanced memory retrieval of stress related information (e.g., Rothermund, 2003). The perseverative cognition hypothesis is therefore not strictly limited to conscious thinking about stressors, but also accommodates automatic, or unconscious, stress-related cognition. Since the greater part of any cognitive processing appears to operate without awareness (Bargh & Ferguson, 2000), a considerable part of perseverative cognition is likely to be unconscious as well. Even minor stressful events cause people to persistently scan the environment for threat and this attentional hypervigilance is only possible when a mental representation, or ‘cognition’ concerning threat is still present (Wells & Matthews, 1996). This very basic representation of threat is fundamental for survival, and it occurs automatically and without conscious awareness. Although a recent study showed that emotional information reaches conscious access at a lower threshold than neutral information (Gaillard et al., 2006), it is likely that people are not aware of most of their stress-related cognitive processes, as they are not aware of most of the cognitive processes ongoing in daily life.

Perseverative cognition, psychopathology and somatic health problems

Below we provide an overview of the mental and somatic problems that have been associated with perseverative cognition.

Psychopathology: Research into the mental health effects of worry started in the early 1980’s with the finding that frequent nighttime worrying is a predictor of the onset and maintenance of insomnia (Borkovec, 1982). Nowadays, perseverative thoughts like worry and rumination are recognized as fundamental characteristics of several psychopathological conditions (Watkins, 2008). For example, worry is a central feature of generalized anxiety disorder (GAD; Borkovec, 1998; Wells & Matthews, 1996) and depressive rumination is recognized as a central feature of depression (Nolen-Hoeksema, 1991). Moreover, perseverative cognition is found in hypochondriasis (Looper & Kirmayer, 2001), social phobia (Abbott & Rapee, 2004) and post traumatic stress disorder (PTSD; Holeva, Tarrier & Wells, 2001).

Perseverative cognition is not just a symptom or epiphenomenon of these pathological conditions. For example, experimental studies show that perseverative cognition is causally related to negative mood. In addition, in prospective studies it has been observed that perseverative thoughts predict the onset and maintenance of anxious and depressed mood (for a review see: Watkins, 2008). Yet, it is unclear at what levels of intensity, i.e., at which frequency and duration, perseverative thinking can be regarded as pathological. Although most research has focused on clinical conditions, perseverative cognitions are not only experienced by people suffering from

psychological disorders, but also by healthy people. Recent diary studies among several populations (undergraduates, teachers, and a community sample) showed that, on average, the total duration of worry episodes was 30 minutes a day, while only a minor part (< 4%) of the participants reported no worry episodes at all (Brosschot, van Dijk, & Thayer, 2007; Pieper, Brosschot, van der Leeden, & Thayer, 2007; Verkuil, Brosschot, & Thayer, 2007b). Unfortunately, ambulatory studies are not regularly conducted with clinical populations and therefore little is known about the exact frequency and duration of perseverative thoughts in these populations. In one of our own studies we found that whereas clinical outpatients suffering from burnout do not seem to worry more than healthy people during the daytime, but that they do worry more during the nighttime (approximately 30 minutes; Verkuil, Brosschot, Korrelboom, Reul-Verlaan & Thayer, submitted). This is in line with the idea that burnout patients have difficulties with disengaging from work. In addition, one ambulatory study conducted with GAD patients showed that they worry approximately 310 minutes per day suggesting that it places a great burden on their daily lives (Dupuy, Beaudoin, Rheaume, Ladouceur, & Dugas, 2001). Indeed, GAD patients even worry about the possible damaging consequences of the worrisome thoughts themselves that they experience (called meta-worry), which adds to the total time these people are in fact worrying. This meta-worry is often taken as a signal that the worry has become pathological and that the person's condition warrants treatment.

Automatic, unconscious or other 'low-level' stress- or threat-related cognitive processes have been associated with mental health in a plethora of studies during the past 30 years (Williams, Watts, MacLeod, & Mathews, 1997; Mineka, 1992). Thus, attentional hypervigilance, for example operationalized as selective attention for threat related stimuli, as well as automatic vigilance, for example operationalized as enhanced memory for threatening stimuli, have been amply documented to play a role in mental health problems. Yet, very few of these studies have actually sought evidence that such forms of perseverative cognition preceded or caused the disorder. A thrilling recent development in experimental psychopathology is that researchers are now attempting to address these automatic processes in order to develop new therapeutic tools. Evidence is now growing that reversing cognitive biases by 'attentional retraining' procedures can reduce symptoms of mood and anxiety disorders suggesting that these biases may have a causal role in the onset and maintenance of such disorders (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Hazen, Vasey, & Schmidt, 2009; Wilson, MacLeod, Mathews, & Rutherford, 2006).

Somatic health: Importantly, for *somatic* outcomes, the perseverative cognition hypothesis is not restricted to *pathological* worry. It is likely that somatic problems can be caused by much less severe, or intense, levels of worry, if only maintained long enough. One of the earliest findings suggesting

that perseverative cognition plays an important role in the link between stress and somatic disease was that among elderly men who had a myocardial infarction, those who frequently worried were at heightened risk for experiencing a second myocardial infarction (Kubzansky et al., 1996). In addition, it has been shown that during experimentally induced worry as well as during worry in daily life cardiovascular activity is increased (Lyonfields, Borkovec, & Thayer, 1995; Thayer, Friedman, & Borkovec, 1996; Verkuil, Brosschot, Borkovec, & Thayer, in press; Pieper et al., 2007). Furthermore, a recent review concluded that perseverative cognition is associated with enhanced activation in endocrine and immune systems (see Brosschot et al., 2006). Finally, more recently it was shown that worry is associated with lowered levels of antibody titers in caregivers (Seegerstrom, 2008) and that ruminating after emotional events is linked to enhanced levels of cortisol, in daily life (McCullough, Orsulak, Brandon, & Akers, 2007), as well as in the laboratory (Zoccola, Dickerson, & Zaldivar, 2008).

These findings are in line with the perseverative cognition hypothesis (Brosschot et al., 2006), stating that perseverative cognition prolongs physiological activity which, in turn, leads to a pathogenic state in which one is more vulnerable to developing a somatic disease. However, the discussed studies have mainly focussed on physiological activity, and not so much on disease outcomes. Few studies have suggested that perseverative cognition can indeed lead to somatic disease. Recently, a study by Holman et al. showed that in US citizens suffering from acute stress after the 9/11 attacks, ongoing worries about terrorism predicted cardiovascular health problems up to three years after the attacks (Holman et al., 2008). More indirect evidence for the impact of perseverative cognition on somatic disease is provided by the fact that risk for cardiovascular problems is heightened in people suffering from anxiety disorders and depression (e.g., Wulsin, Vaillant, & Wells, 1999), which are characterized by high perseverative cognition. In addition, studies focusing on work stress have found that reduced mental recovery, or reduced 'unwinding' after work is predictive of cardiovascular mortality (van Amelsvoort, Kant, Bultmann, & Swaen, 2003; Kivimaki et al., 2006). Furthermore, at least two studies among patients suffering from somatic health problems have suggested that perseverative cognition might be an important mediator of the effects of some somatic treatments. In one study it was found that in patients awaiting surgery for their hernia, greater worry about the surgery predicted lower levels of immune cells at the wound site, greater pain, poorer self-rated recovery and a longer recovery time (Broadbent, Petrie, Alley, & Booth, 2003). Furthermore, heightened levels of trait worry in psoriasis patients were predictive of a slowed recovery from photochemotherapy (Fortune et al., 2003). Still, more evidence is needed to test the perseverative cognition hypothesis with respect to disease outcomes. An important venture for future research is to conduct more prospective studies examining whether perseverative cognition is

indeed the pathogenic link between stressful events and the onset and maintenance of somatic disease.

It is a highly exciting idea that automatic or unconscious perseverative cognition can cause prolonged stress-related physiological activity, and in the long term even somatic disease. To date, no study has directly addressed the possibility that automatic vigilance or other forms of unconscious perseverative cognition have physiological effects. Three exceptions are studies showing relatively subtle effects of subliminal emotional stimulation on brain activity (Morris, Öhman, & Dolan, 1999), startle reflex (Ruiz-Padial & Vila, 2007) and skin conductance (Öhman & Mineka, 2001). Moreover, two of our own recent studies have yielded some indirect evidence for the somatic effects of unconscious perseverative cognition. Firstly, in an ambulatory study we found - quite unexpectedly - that worry episodes were not only associated with enhanced heart activity, but that the worry episodes *themselves* also had prolonged cardiac effects, until up to two hours *after* the worry episode had ended (Pieper et al., 2007). This effect was independent of ongoing worry, emotions, health behaviors and physical activity, and therefore we concluded that it must have been due to some unconscious, or at least not verbally reportable form of worry. It is important to note, that this finding can not be due to 'just slow recovery', since such a mild high cardiac increase when caused by a non-emotional stressor such as physical effort normally recovers within a matter of minutes. Secondly, in another ambulatory study we found that conscious daytime worrying predicted heightened heart rate during the subsequent night (Brosschot, van Dijk & Thayer, 2007). During sleep people obviously do not worry consciously, but the hypervigilance that is evoked by stressful events might be prolonged into the night. This was also demonstrated by Hall and colleagues (2004), who found that participants who had to give a speech in the morning, showed decreased levels of parasympathetic activity (low heart rate variability) during the following non-rapid eye movement and rapid eye movement sleep periods (Hall et al., 2004). Although a lot has to be discovered on what exactly happens cognitively during sleep, studies with rats and humans have shown that daytime neuronal activity seems to be repeated or 'replayed' just before or during sleep (Skaggs & McNaughton, 1996; Stickgold, Malia, Maguire, Roddenberry, & O'Connor, 2000). Furthermore, sleep promotes procedural learning and consolidation of memories (Walker & Stickgold, 2004). It is therefore not unlikely that daytime stressful events are mentally represented during sleep in one way or another and that this interferes with physiological recovery during sleep. It is obvious that this will prolong the total amount of physiological 'wear and tear' that stressful events have on the human body, since sleep covers about one third of our lives. Sleep is generally considered to be a basically stress-free recovery period, and therefore the most important restorative period. Future

studies are warranted to investigate to what extent and how stressful events and hypervigilance influence physiological recovery during sleep.

Subjective Somatic Health. Ambulatory studies by our group have shown that in several non-clinical populations (students, high school teachers; worry duration of 30 minutes per day on average) non-clinical levels of worry were positively and prospectively associated with subjective health complaints like fatigue, headache and lower backpain (Brosschot & Van Der Doef, 2006). A simple worry intervention, consisting of postponing worry to a daily 30-minute worry period, reduced these health complaints. The effects of the intervention were not restricted to certain types of complaints, but pertained to a range of different complaints (e.g. cough, palpitations, neck pain). Interestingly, worry *duration* and not or not so much worry *frequency* predicted increases in health complaints and mediated the effect of the worry intervention (Brosschot & Van der Doef, 2006), which is in line with the perseverative cognition hypothesis. Further evidence for the effects of perseverative cognition on subjective health comes from another ambulatory study in which it was found that people who reported to be ruminating a lot about conflicting goals reported heightened levels of somatic complaints (Emmons & King, 1988).

Perseverative cognition specifically related to health problems, that is, health worry or illness worry seems to be of specific importance for subjective somatic health complaints. Being – often even severe - stressors themselves, somatic health problems often give rise to worries. For example, chronic pain patients have been found to worry about pain for 20 minutes per day on average, compared to 17 minutes for non-pain-related topics (Eccleston, Crombez, Aldrich, & Stannard, 2001). Except for having physiological effects just as other worries, these health worries may affect subjective somatic health through an alternative pathway: Enhanced worrisome thinking about somatic signals might promote complaining about them. Indeed, health worry has been found to predict the occurrence of health complaints (Kaptein et al., 2005; Petrie et al., 2005; Devoulyte & Sullivan, 2003) and is associated with increases in pain (Turner, Mancl, & Aaron, 2004). Furthermore, not surprisingly, health worry has been associated with increased doctor consulting (Hay, Buckley, & Ostroff, 2005) and with intensive health care utilization (Looper & Kirmayer, 2001). One mechanism that may underlie these effects is that in people who worry excessively about illness bodily sensations are more likely to trigger illness-related cognitive networks which promote selective cognitive processing and misinterpretations of these bodily sensations as symptoms of illness (Brosschot, 2002; Brown, 2004). In turn, such worries might lower the threshold for actually complaining about these presumed symptoms of illness. Indeed, we recently found that the

association between illness-related cognitive bias (increased recall of illness information) and health complaints was mediated by illness worry (Verkuil, Brosschot, & Thayer, 2007a; Brosschot, 2002).

In short, perseverative cognition, even at non-clinical levels, might influence somatic health either via prolonged activity in endocrine, immune and cardiovascular systems or, in the case of specific health worry, via enhanced processing of illness related information.

A self regulation perspective on perseverative cognition

The stress response, and therefore its prolongation via perseverative cognition, can be basically understood as the (default) response to threats to the attainment of a person's goals. The detection of potential threats to one's goals and of signs of failure in attaining these goals is a continuous process. Environmental stimuli are first quickly and briefly – and largely automatically - scanned for their threat value (i.e. 'fast route', LeDoux, 2000) and once something has been detected that could be a possible threat to one's goals, it immediately leads to an rapid and indiscriminate defensive response, even if it eventually turns out to be only a novel or ambiguous stimulus (LeDoux, 2000; Thayer & Lane, 2000). This defensive response, or motivational state, consists of changes on several levels in the organism: Cognitive changes (attentional hypervigilance and 'higher' perseverative cognition), physiological changes (e.g. increased autonomic nervous activity and release of stress hormones) and behavioral changes (avoidance or approach behavior), known in psychophysiology as the 'defense response' (Lang, 1995). The duration of this defensive response depends on how quickly the system ascertains the safety of the situation. This shutting down of the response because of safety is dependent on a more deliberate cortical processing ('slow route'; LeDoux, 2000) of the potential threat. Thus, the *default* response to any potential threat is this immediate defensive response, served by subcortical networks in the brain, which, under normal circumstances, is under chronic inhibitory control by the prefrontal cortex (Amat et al., 2005; Thayer & Sternberg, 2006; see below for more neurophysiological underpinnings). Interestingly, this default response to threat has been found to be enhanced in females, who, when presented with an equal amount of threat information, showed more persistent activation of subcortical structures in the brain compared to males (Williams et al., 2005). From an evolutionary perspective it makes sense that this defense system initially 'errs on the side of caution' by often responding initially to novel or ambiguous neutral information as if it was threatening, and subsequently either continues or stops after a more deliberate appraisal process has taken place. As a consequence when no safety signals can be provided the stress response is prolonged. This seems to be the case in conditions such as anxiety disorders and during chronically stressful situations. There is some evidence that at least in some

people, especially high worriers, this is due to a failure to recognize these safety signals. We will return to this possible explanation later in the chapter.

In the remainder of this section the concept of perseverative cognition will be regarded from a self-regulation perspective. More specifically, we will argue that perseverative cognition can be conceptualized as the perseveration of mental representations of goal discrepancies (hypervigilance and 'higher' perseverative thinking), and that perseverative cognition is the cognitive part of the default response to goal discrepancies. We will further contend that this response is enhanced in high worriers because: (1) they have psychological characteristics that make them likely to be more motivated to reduce goal discrepancies; (2) perseverative cognition is reinforced in these people in several possible ways; (3) their perseverative cognition is due to a deficiency in recognizing signals of safety which causes them to respond with the default perseverative cognition response not only when faced with threat, but to any situation containing ambiguity or novelty.

Why people persevere: perseverative cognition as the default response to potential threat to goal attainment

The essence of perseverative cognition is to keep attention directed towards ones goals, to anticipate threats to goal attainment and, in the case of rumination, to protect oneself from the recurrence of mistakes made in the past (for related theoretical accounts see: Wells & Matthews, 1996; Martin & Tesser, 1996). It has been consistently shown that intensive engagement in the pursuit of a goal has effects on information processing (Johnson, Chang, & Lord, 2006). Goal engagement leads to alterations in pre-attentive processes and the content of thoughts and dreams, and it enhances the perception and processing of goal related stimuli, (Klinger, 1975).

In terms of self-regulation, a psychological stress response arises when people experience a discrepancy between an expected state and the actual state that they are in (Ursin & Eriksen, 2004). Expected states can either be desired states in the present ('standards', such as being healthy or having enough money to buy food) as well as desired states that lie in the future ('goals', such as becoming a successful employee (Boldero & Francis, 2002)). In daily life, one's actual state is continuously monitored, occurring mostly automatically, and compared to these desired states, or, reference values. Discrepancies can be detected between a standard (e.g., being healthy) and one's actual state (e.g., having received a diagnosis of cancer) which will result in the stress response. In the case of goals that lie in the future it is not so much the discrepancy that gives rise to the stress response, as setting a goal automatically implies that one hasn't attained this goal. In this case it is the perceived rate or speed with which one is making progress towards attaining this desired state that is compared to one's actual state (Carver & Scheier, 1990). When this speed is perceived to be

too low this will also result in the stress response. In the remainder of this chapter we will refer to both types of discrepancies as goal discrepancies.

When people are confronted with such goal discrepancies, information concerning these discrepancies tends to stay activated in the brain, whereas when goals are attained information about goal discrepancies is inhibited. Again, this suggests that the default response to perceiving a goal discrepancy is cognitive *perseveration*, in the sense that this response is simply maintained as long as the discrepancy is present. This was first shown by Zeigarnik more than 80 years ago, who showed that memory for interrupted tasks is better than for completed tasks (Zeigarnik, 1927). Perseveration of goal directed cognition has been found in several other studies (Marsh, Hicks, & Bink, 1998; Goschke & Kuhl, 1993; Rothermund, 2003). For example, Rothermund (2003) found that failure on a cognitive task was associated with slowed responses in a dual tasking experiment when participants were presented with failure related words, indicative of hypervigilance after failure. In another study, participants who were made to believe that they had failed on an intelligence task reacted faster to concern-relevant information on a lexical decision task (Koole, Smeets, van Knippenberg, & Dijksterhuis, 1999). In line with these findings on hypervigilance, conscious perseverative cognition has also been found to be associated with experiencing discrepancy, for example between one's actual self and one's ideal self (Roelofs et al., 2007; Jones, Papadakis, Hogan, & Strauman, 2009).

Most studies have taken place in laboratory settings and have measured this perseveration of stressor related cognition immediately after the goal frustration (e.g., Rothermund, 2003) or after six minutes (Koole et al. 1999). Thus, it remains to be established how long this initial perseveration of stressor related cognition lasts. There are some interesting clues however. A study by Zadro et al. suggests that this perseveration can last much longer after a stressful event (Zadro, Boland, & Richardson, 2006). In this study participants that had been socially excluded from an online ball tossing game after 45 minutes still showed a bias towards interpreting ambiguous social situations in a more threatening manner.

Psychological moderators of perseverative cognition duration

In the next sections we will discuss how perseverative cognition can get enhanced, thereby foremost discussing studies that have been conducted with chronic (trait) worriers.

(1) Goal commitment

Although hypervigilance doesn't have to be pathological per se, several authors have proposed that it is the fundamental process that underlies clinical worry and rumination (Martin & Tesser, 1996;

Nolen-Hoeksema, 2000). Indeed, most anxiety- and mood disorders are characterized by extreme hypervigilance and perseverative thinking. What determines difficulties to stop perseverating, or – to the same end - stimulates its continuation, to the extent that it starts to have health consequences?

The initial duration of perseverative cognition after one has encountered a threat to goal attainment depends on how strong one is committed to attaining the goal, which differs between individuals and between situations. According to several authors (Shah & Higgins, 1997; Feather, 1963) the strength of goal commitment is a function of the interaction between (1) the importance or value that people attach to their goals, and (2) the expectancy that one can either cope or not cope with the goal discrepancy and is either still able to attain the goal or not any more: both expectancies appear to produce perseverative cognition. Here we will review evidence that shows that high worriers are likely to be more committed to their goals when confronted with threats to attainment.

a) Value of the goals

Several studies have found that the duration of hypervigilance is a function of *higher level goals*. For example, Koole et al. (1999) showed that hypervigilance persisted longer after failure on a task when people believed that completing this task successfully was very important for one of their higher order goals, for example obtaining a good job later in life, in contrast when people had the opportunity to scale down the importance of this task by focusing on other goals. In addition, in a study by Magee et al. (2003) it was shown that women who were over-invested in becoming a parent after recurrent miscarriage had more negative thoughts about the future than women who had other goals to focus on than becoming a parent (Magee, MacLeod, Tata, & Regan, 2003). Furthermore, the tendency to link the (non-) attainment of lower level goals to the (non-)attainment of higher level goals has been related to rumination and depression (McIntosh, Harlow, & Martin, 1995). In one study we also found that in a sample of single females higher commitment to the goal of finding a partner was associated with higher rumination about not having attained this goal (Gebhardt, Massey, van der Doef, Verhoeven & Verkuil, 2007). Several other studies have shown that perfectionism, the tendency to strive after high level self-set goals that are higher than one's current performance level, is associated with the tendency to ruminate (e.g., O'Connor, O'Connor, & Marshal, 2007).

b) Expectancy of goal attainment: negative outcome expectancies

A second important factor that influences the initial duration of goal directed cognition is the expectancy of the outcome of the stressful event, or goal discrepancy. In their Cognitive Activation

model of Stress, Ursin and Eriksen (2004) distinguish three kinds of outcome expectancies that are associated with different kinds of responses: positive outcome expectancies (coping), negative outcome expectancies (hopelessness) and no outcome expectancies (helplessness). As perseverative cognition is the default response to stress, it will arise when people hold negative or no outcome expectancies. Indeed, worry was found to be associated with doubts concerning ones problem-solving skills and the tendency to be pessimistic about the outcome (Robichaud & Dugas, 2005). Likewise, people with low self-esteem are more prone to ruminate (Wood & Dodgson, 1996).

(2) Reinforcement of perseverative cognition: coping

Although people who frequently worry or ruminate might lack confidence in general coping skills, they paradoxically report to be very motivated to use perseverative cognition as a strategy to cope with goal discrepancies. For example, Szabó and Lovibond (2002) asked students to keep a log of their worries for a week and they found that almost 50% of the reported worries consisted of problem solving attempts. Furthermore, cross-sectional studies have shown that people who frequently worry think that "worrying helps solving problems" or that "ruminating about the problem will help gaining insight" (Roelofs et al., 2007; Papageorgiou & Wells, 2001). In addition, people suffering from GAD report that worry serves as a distraction from more emotionally laden topics (Borkovec & Roemer, 1995), suggesting that in some people worry might serve to cognitively avoid intense negative emotions. Both the motivated use of perseverative cognition as a problem solving strategy and the use of perseverative cognition as a cognitive-avoidance strategy have been proposed to be reinforcing perseverative cognition.

Despite many worriers' beliefs that that worrying is helpful in solving one's problems, research has shown that worry and rumination are ineffective strategies to cope with stressful situations, yielding only more perseverative cognition as a result. First, worry and rumination are characterized by an abstract way of thinking about problems, and "abstract models are unlikely to lead to concrete actions" (cited from: Borkovec, Ray, & Stöber, 1998, p. 566). For example, in the case of rumination, Watkins and Baracaia (2002) found that depressed patients who were led to ask themselves abstract, ruminative problem solving questions ('why do I feel this way?') in a problem solving task came up with less relevant solutions than depressed patients who were led to ask themselves concrete, process focused questions ('how am I deciding what to do next?'). This abstract way of thinking might be due to the fact that trait worriers link the frustration of lower order goals to the frustration of higher order, or abstract goals, and therefore might focus more on solving abstract problems. Second, even if worrying leads to concrete solutions, worriers are not highly likely to come into action and implement their solutions. Worriers have less confidence in their problem solving

skills (Davey, 1994), have elevated needs for evidence that a given solution will work (Tallis, Eysenck, & Mathews, 1991) and try to come up with as many solutions as possible before trying out these solutions (Startup & Davey, 2003; Davey, 2006). Behaviorally implementing a solution is also difficult when the problems that people are worrying about have already happened or might happen in the future. Additionally, worry also seems to become reinforced as the worst case scenarios that people worry about almost never happen, which might lead to the superstitious belief worry has been a successful coping strategy (Borkovec et al., 1998).

In sum, although worry itself might be appraised by the individual as helpful, enhancing one's positive outcome expectancy about worry, negative outcome expectancies will likely persist as no concrete action will be taken to reduce or remove the current or future threat, leading to a vicious cycle in which possibly threatening events are coped with by worrying. Furthermore, although the discussed studies have mainly focused on the outcome expectancies associated with *conscious* perseverative cognition, unconscious perseverative cognition (threat related hypervigilance or cognitive bias) is suggested to be part of a worrisome coping style (Wells & Matthews, 1996) and is likely to be subject to the same reinforcing factors. Although the authors are not aware of studies showing operant conditioning of for example threat-related cognitive biases, indirect evidence for the effects of outcome expectancies on automatic processing comes from a recent study showing that expectancies of reward can modulate saccadic eye movements (Milstein & Dorris, 2007).

Another way in which perseverative cognition is reinforced has been put forward by Borkovec et al. (1998). In studies with non-clinical as well as clinical populations he demonstrated that worry might be a cognitive avoidance response to threat. High worriers are thought to have learned to use worry as an emotion regulation strategy because worry suppresses somatic anxiety, due to the verbal nature of worrying (Borkovec, Lyonfields, Wiser, & Deihl, 1993; Borkovec & Hu, 1990). Indeed, threatening thoughts yield smaller cardiovascular responses than threatening images about the same material (Vrana, Cuthbert, & Lang, 1986). In addition, worry, in contrast to relaxation, has been associated with blunted cardiovascular responses to threatening imagery (Borkovec & Hu, 1990). Furthermore, worry is likely to bias information processing away from threatening images. Several studies have shown that verbally memorizing information impairs the retrieval of the visual memory of this material, called 'verbal overshadowing' (Schooler & Engstler-School, 1990). Importantly, suppressing, blunting and 'verbal overshadowing' result in a reduction of the total time that people are exposed to aversive, possibly traumatic, images and this is thought to negatively reinforce the use of worry as an emotion regulation strategy. Although this might be adaptive in the short term, persistently avoiding threatening information and its associated somatic arousal, by relying on worrisome thought, interferes with the integration and extinction of

threatening material in memory (Foa & Kozak, 1986). It increases the risk that threatening information is repetitively retrieved from memory (for example in the form of intrusive thoughts; Holmes, Brewin, & Hennessy, 2004) and warrants further use of worry.

Although most studies have focused on the avoidance function of worry, it is likely that rumination has the same function, which is also a verbal and abstract thinking style. Furthermore, it is unknown whether this avoidance function also pertains to unconscious perseverative cognition, and to date it is unclear to what extent unconscious mental representations consists of verbal or imaginary parts. Yet, one study has shown that being consciously motivated to cognitively avoid certain information, enhances the automatic cognitive bias for this information (Lavy & Van den Hout, 1994), providing some indirect evidence that attempts to avoid threat-related imagery might prolong threat-related unconscious perseverative cognition.

In short, there are several reasons why worrying might become associated with positive outcome expectancies, and as a result might be prolonged and difficult to unlearn (disengage from). Since worry seldom actually helps to solve problems, these positive reinforcers suggest a vicious circle leading to ever more worry.

(3) Not recognizing safety signals

A third important factor that influences the duration of perseverative cognition is the (in)ability to recognize novel and ambiguous stimuli as safe. As mentioned above, the default cognitive response to stressful events will cease once a safety signal is recognized that signals that no goal is currently threatened. In line with this idea, Woody and Rachman (1994; p. 745) stated that: *"Safety signals delimit the range and duration of threat and, hence, of fear. In the presence of an established safety signal the animal/person is assured of safety from threat in that place at that time. Having attained a safety signal, the person/animal can rest and reduce vigilance for a time."* As mentioned earlier, pathological worriers are strongly engaged in the pursuit of their goals and they require a lot of evidence before they dare to implement a solution to try solve the problem. A consequence of this might be that at least pathological worriers do not easily recognize novel and ambiguous situations as safe. Recent evidence supports this idea. For example, in a study conducted with GAD patients and healthy controls where participants were repeatedly shown cues (colored dots) that signaled either novel neutral or threat-related words while their cardiac responses were recorded simultaneously. It was shown that whereas the cardiac responses of healthy control participants to the neutral words showed habituation to the repeated presentation of neutral words, the GAD patients showed no habituation to these words, suggesting that they have difficulties in disengaging attention from these novel neutral stimuli in the context of threat (cf. Thayer, Friedman, Borkovec, Johnsen, & Molina,

2000). Other authors suggested that GAD patients show subcortical brain activity to neutral information as if it was threatening (Hoehn-Saric, Schlund, & Wong, 2004; Nitschke et al., 2009). Thus, high worriers seem to indiscriminately keep on responding to threatening as well as neutral stimuli, and thereby do not recognize safety signals. Not recognizing safety signals is possibly due to elevated requirements for evidence that has been found in high worriers, which in this case could be enhanced requirements for proof that a signal indeed signifies safety. By not recognizing safety, the fear response and perseverative cognition are therefore prolonged.

Biological vulnerability for perseverative cognition

In the sections above we referred to how the default stress response, and with it perseverative cognition, initiated by sub-cortical brain structures, is under tonic inhibitory control by the prefrontal cortex (Amat, et al., 2005; Thayer et al., 2006). There are several conditions in which this prefrontal inhibition is tuned down, making one vulnerable for perseverative cognition. Conditions involving low prefrontal inhibition include being in a chronic stress situation or being an anxiety patient. In their Neurovisceral model of perseverative thinking Thayer and Lane (2000) and Thayer and Brosschot (2005) explain how low prefrontal inhibition is characterized by low parasympathetic activation, which can be measured by low heart rate variability (HRV), and how low prefrontal inhibition leads to prolonged and indiscriminate responses to environmental stimuli. We will provide a shortened account below.

Heart rate variability (HRV) is the variability of the time periods between adjacent heart beats, e.g. interbeat intervals (IBI). This variability is the result of the dynamic interplay between the fast acting parasympathetic nervous system and the relatively slower sympathetic nervous system. Cortical and subcortical areas in the brain that are responsible for the integration of internal and environmental information, including emotionally relevant information, are directly linked to HRV. These circuits are referred to as the Central Autonomic Network (CAN). Structurally, the CAN includes the anterior cingulate, insular, and ventromedial prefrontal cortices, the central nucleus of the amygdala, the paraventricular and related nuclei of the hypothalamus, the periaqueductal gray matter, the parabrachial nucleus, the nucleus of the solitary tract (NTS), the nucleus ambiguus, the ventrolateral medulla, the ventromedial medulla, and the medullary tegmental field. The primary output of the CAN is mediated through the preganglionic sympathetic and parasympathetic neurons. Importantly, these neurons innervate the heart via the stellate ganglia and the vagus nerve. The interplay of these inputs to the sino-atrial node of the heart is the source of the complex variability that characterizes the healthy heart rate time series (Saul, 1990). Thus, the output of the CAN is directly linked to HRV. It is logical that systems that control emotion, attention and autonomic

nervous system activity are strongly interconnected and even largely overlap. Attention is always in the service of information that pertains to an organism or person's important goals, and hence related to the emotional value of the information. Likewise, when highly relevant goals are at stake autonomic activity is strongly needed to support approach or avoidance behavior. Therefore, these structures are bound to be highly interconnected and often activated in concert.

Low tonic levels of HRV might indicate a predisposition to keep on 'erring on the side of caution' when confronted with threat, novelty and ambiguity because such a chronically low HRV represents a breakdown of the inhibitory influences discussed earlier, that allows for efficient self-regulation including the interruption of on-going behavior. As such, an excitatory *positive feedback loop* is allowed to emerge, reflected on the psychological level in hypervigilance and perseverative thinking. As we discussed in the previous section, this response might become ever more enhanced once people implicitly or explicitly start to believe that this response actually helps them in solving their problems. As a consequence, the normally fine-tuned ability to adjust to changing environmental factors becomes a rigid, inflexible response disposition, which is in fact a continuation of the default defense response in the absence of clear threat signals. This is reflected in a failure to recognize safe environmental signals and in responding to them as if they are threatening. In support of this idea patients suffering from GAD have been shown to have lower tonic levels of HRV, when compared to non-anxious controls (Thayer et al., 1996). Furthermore, people low in HRV have been shown to have an attentional bias for threatening information, and interpret ambiguous situations more negatively (Shook, Peña, Fazio, Soller III, & Thayer, 2007).

Besides in mood- and anxiety disorders, there might be several not so obvious conditions that are also associated with low prefrontal inhibition such as having a low aerobic fitness (Hansen, Johnsen, Sollers, Stenvik, & Thayer, 2004) or suffering from somatic health problems (e.g., diabetes and immune dysfunction (Masi, Hawkey, Rickett, & Cacioppo, 2007; Thayer & Lane, 2007; Thayer & Lane, 2000; Thayer & Sternberg, 2006). These conditions are associated with heightened risks to develop other stress-related mental and somatic problems, which may in fact be associated with the above mentioned excitatory positive feedback loop. For example, normotensive salt-sensitive men, a group that is at risk of developing hypertension, has been shown to have low levels of HRV at rest and during mental challenge (Buchholz, Schachinger, Wagner, Sharma, & Deter, 2003), indicating low prefrontal inhibition. Other studies have also shown that these men, compared to matched healthy controls, are also characterized by enhanced startle responses to negative information (Buchholz et al., 2001) and enhanced cortisol responses during stress (Weber et al., 2008), suggesting that default responding to stress is not only enhanced but also perseverates. It is an intriguing idea, that people that have low HRV for other reasons than chronic stress, i.e. diabetes, obesity, low aerobic fitness

etc., would also cognitively perseverate (worry, ruminate) more as a result of the lower prefrontal inhibition associated with their condition. To the authors knowledge, this has never been tested.

In sum, we propose that low prefrontal inhibition reflected in low HRV predisposes people to respond with enhanced cognitive, affective and physiological activity to stressors. This, in combination with the psychological vulnerability factors for perseverative cognition discussed above, causes even seemingly neutral stimuli to trigger the stress response. As a consequence, the total time that people worry about stressful events increases, thereby adding to the total duration of exposure to stress representations, or perseverative cognition, and their physiological effects in daily life.

Conclusions

In this chapter we have provided an overview of the role that perseverative cognition plays in the onset and maintenance of stress-related mental and somatic health problems. Perseverative cognition is a common reaction to stressful events in everyday life, and it can account for stress-related physiological activity that is prolonged beyond the presence of actual real life stressors. This prolonged physiological activity is proposed to be the missing link in the relationship between psycho-social factors and the chronic pathogenic state in which one is more prone to develop mental and somatic problems. Furthermore, we have discussed that perseverative cognition forms part of the default response to threat, novelty and ambiguity, which basically is an adaptive self-regulatory response. We also outlined which psychological and biological factors enhance this default response. Excessive commitment to one's goals, the motivated but exaggerated use of perseverative cognition as a strategy to cope with possible threats to goal attainment and the inability to recognize signals of safety were forwarded as pathogenic psychological processes that lead to a vicious cycle where one worry episode enhances the likelihood of the occurrence of another episode. This increases the total amount of time that stressful events have a prolonged 'wear and tear' effect on the human body.

Although the pivotal (causal) role of unconscious perseverative cognition in psychopathology has been acknowledged for a long time, its effects on somatic health have remained largely unexplored. However, while evidence is accumulating, numerous studies have already supported the perseverative cognition hypothesis. We have speculated on a role of unconscious perseverative cognition that may be as important or even more important, than that of conscious perseverative cognition. By focusing on conscious perseverative cognition alone we may have been only touching the tip of the iceberg of stress-related causes of mental and somatic problems.