# Perseverative cognition : the impact of worry on health

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# Chapter 10

**General Discussion**

## General discussion

For decades the question that has been the focus of stress research is how stressful events can ultimately lead to disease. The main aim of this thesis was to add knowledge to this quest by examining the effects of worry about stressful events on somatic health, operationalized as somatic health complaints and slowed cardiac recovery after stress, both of which are associated with morbidity and mortality (Cole, 2000; Idler & Benyamini, 1997; Sha et al., 2005). Furthermore, the mechanisms by which worry was hypothesized to affect somatic health were examined. The studies reported in this thesis add to the accumulating number of studies testing the perseverative cognition hypothesis (Brosschot, Gerin, & Thayer, 2006), which is described in chapter 2. This hypothesis states that only prolonged cognitive representations of stressful events (perseverative cognition) lead to sustained or prolonged stress-related physiological activity which, in turn, can lead to somatic disease.

Taken together, the studies reported in this thesis provide evidence for the perseverative cognition hypothesis, that is, worry predicted adverse somatic health outcomes. In addition, the results of the studies presented in the second part of this thesis yielded several new and more specific hypotheses concerning the mechanisms behind the health effects of worry. These results warrant future studies that systematically test these hypotheses, or examine the robustness of the results already found. Below, the main findings from the studies reported in this thesis will be discussed, along with their limitations and their potential implications.

### Measurement of worry

The majority of the studies testing the perseverative cognition hypothesis have relied solely on trait questionnaires measuring the tendency to worry or ruminate (Brosschot, Gerin & Thayer, 2006). It is commonly believed that these trait worry questionnaires are a good reflection of what people experience in their daily lives, but this had never been tested. Therefore, before testing the effects of perseverative cognition on somatic health, we examined the extent to which trait worry questionnaires correspond to worry in daily life. This study (see chapter 3) showed that trait worry questionnaires, like the well validated and reliable Penn State Worry Questionnaire (PSWQ), and momentary assessed real-life worry only have 24% shared variance. We therefore decided to include measures of state worry in our studies, either by using ecological momentary assessments (chapters 4 and 5), by measuring the occurrence of

worrisome thoughts using retrospective state questionnaires (chapters 6 and 7), or by experimentally inducing a worry episode (chapters 8 and 9). The fact that we not only found additional but also differential effects of trait and state measures of worry has important implications for future studies on worry. The decision about which measure to use to assess worry deserves far more considerate thought than it has hitherto been given.

**Worry and somatic health**

We examined the relation between worry and somatic health complaints, such as fatigue, headache and neck pain . Momentary assessed (state) worry in a sample of teachers was found to predict the occurrence of daily somatic complaints (Chapter 4). Furthermore, in line with the perseverative cognition hypothesis, this study was the first to show that worry mediated the effects that stressful events had on the occurrence of daily somatic complaints. This provides evidence for the idea that only prolonged effects of stressful events, in other words, worry, is the pathogenic ingredient in the link between stressful events and somatic health problems.

In addition to these prospective effects, we performed a randomized clinical trial in which we aimed to reduce the effects of worry on somatic and mental health in clinical outpatients suffering from severe work stress. The results (see chapter 5) showed that a simple worry intervention was effective in reducing the frequency and duration of nighttime worries, which in turn were associated with decreases in somatic complaints. Moreover, the intervention added to the effectiveness of a subsequent stress management therapy. In another recent study (not included in this dissertation) we tested the effectiveness of the worry postponement intervention in children and found that it was helpful in reducing worry and somatic complaints in seventh grade children (Jellesma, Verkuil, & Brosschot, 2009). In sum, three studies now provide evidence that reductions in worry are associated with reductions in somatic complaints (i.e. chapter 5; Brosschot & Van der Doef, 2006; Jellesma, Verkuil, & Brosschot, 2009). Yet, the selectivity of the samples used (people suffering from severe work stress, children from primary and high schools) still leaves unexplored how the effects of reductions in worry generalize to the larger populations or other patient groups.

Finally, as a third type of evidence supporting the PC hypothesis, we found that induced state worry increased cardiac activity (chapter 9) and that trait as well as state worry were associated with slowed cardiac recovery after stress (chapter 6). In the latter study, state worry was operationalized as explicit worry (the amount of self-reported negative intrusive thoughts)

as well as implicit worry (automatic vigilance measured with a lexical decision task). However, the results concerning implicit state worry were less straightforward than those from explicit state worry. Slowed recovery of the heart rate associated with slowed responses to control words depicting positive personality traits, and not with speeded responses to target words depicting task relevant / intelligence related information. Still, the results from the study provide further evidence for the perseverative cognition hypothesis and suggest that future studies should examine how implicit worry can be measured in more adequate ways.

All in all, evidence, in real life as well as in the laboratory, now makes clear that worry might play a substantial role in threatening somatic health. In addition, it was shown that a simple intervention focused on retraining the ability of worriers to disengage from worrisome thoughts can be helpful in reducing worries and somatic complaints.

**Worry and health: mechanisms**

In the second part of this thesis, three mechanisms behind worry and its health effects were examined. The effect of worry on the occurrence of somatic health complaints that was shown in chapters 4 and 5 posed the important question how these effects are brought about. As mentioned above, one mechanism might be the one proposed by the perseverative cognition hypothesis, that is, that worry induces prolonged activity that may lead to somatic problems. Another mechanism was tested in chapter 7, namely whether somatic complaints are caused by worry about specific health complaints. The theoretical rationale for this study was based on the work of Ursin and Eriksen (2001) and Brosschot (2002), who proposed that somatic health complaints are produced by sensitization ('amplified processing') of neural networks that are involved in the processing of pain signals, both at somatic as well as cognitive levels. Sensitization would be reflected in lowered tolerance of pain (somatic sensitization) and enhanced elaboration of health information (cognitive sensitization). The results of the study indeed showed that the severity of somatic health complaints was associated with lowered tolerance of cold-pressor pain and with enhanced recall of health related information. Importantly for the context of this thesis, worry about specific health complaints mediated the association between recall of health related information and somatic complaints. This suggests that at least part of the somatic complaints can be explained by the fact that people keep on worrying about them. This also increases the chances that people decide to consult their general practitioners (Looper & Kirmayer, 2001), which adds to the economical costs that are associated

with these somatic complaints. The other route, the prolonged physiological activation one, was not extensively tested (see the next section for some reasons). However, we tested and found support for one important part of that hypothesis, namely that worry is associated with increased physiological activity. In doing this, we corroborated existing empirical evidence but also extended this by testing whether the physiological (i.e. cardiac) effects of worry (chapter 6) were due to its emotional components, rather than to pure mental load (chapter 9). The amount of worry after a stressful task can not be easily controlled experimentally and leaves much room for individual differences. Therefore, instead of focusing on worry measured after stressful events, as done in chapter 6, we decided to use an often used worry induction procedure. Furthermore, we used a within-subjects design in which the cardiac effects of induced worry were compared to the cardiac effects of relaxation and cognitive problem solving. As expected worry clearly increased cardiac activity compared to relaxation, a finding that corroborated a still limited set of previous studies' findings (Lyonfields, Borkovec, & Thayer, 1995; Thayer, Friedman, & Borkovec, 1996; Davis, Montgomery, & Wilson, 2002; Hofmann et al., 2005). However, worry did this to nearly the same extent as non-worry problem solving, which pointed towards the interesting possibility that the cardiac effects of worry are mainly due to mental load, in contrast with the largely held position that worry enhances heart rate due to its emotional components.

The success of the interventions (chapter 5) in reducing worry and health complaints suggest that it is possible to reverse some of the processes that cause worry. Since the interventions explicitly focused on disengaging from the worrisome thoughts, by observing them from a distanced perspective (chapter 5), it is tempting to believe that this was the process that was indeed changed. However, there was no proof of reduced disengagement in worriers in the literature, and it was difficult to test in these real life studies. Therefore we did this in a laboratory setting (chapter 8) and found evidence that worriers indeed have trouble disengaging from threatening information. More specifically, we showed that people who reported high worry as well as high anxious mood showed prolonged attention (sometimes referred to as ‘dwell time’ (Fox, Russo, & Dutton, 2002)) to threatening stimuli in an exogenous cueing task. This was taken as evidence that these people have difficulties in disengaging attention from threat. Therefore, training anxious worriers to disengage from such information might be beneficial. Interestingly, it might explain the finding in chapter 5 that worry registering on itself

was already beneficial in terms of reducing daytime worry. It is possible that registering facilitates disengaging.

Below we will provide a theoretical integration of the main findings and will discuss these findings more in depth.

**Theoretical integration of the main findings**

The results of this thesis provide evidence for the extended perseverative cognition model that was presented in the introduction (see figure 1). The combined studies of the thesis suggest that perseverative cognition influences somatic health (chapter 4 and 5), either via prolonged physiological activity (chapters 6 and 9), or via a 'purely' cognitive route (chapter 7). In this thesis we found evidence for both these pathways, and it is interesting to speculate how they may be related.

It is likely that worry about health, just like worry about other stressful events, affects somatic health by prolonging physiological responses. Prolonged physiological activity may not only be detrimental for health in itself, but may also produce bodily sensations that can be interpreted by individuals who worry about their health as additional signs that one is suffering from a serious disease. In an extreme form this vicious cycle is observed in people suffering from hypochondriasis. It is a similar vicious cycle as the one observed in panic disorder in which catastrophic interpretations of harmless bodily sensations trigger physiological responses that evoke panic attacks (cf. Olatunji, Deacon, & Abramowitz, 2009).

A special comment should be made about the role of negative affect that is included as a factor in the perseverative cognition model. As stressful events evoke worry as well as negative affect, it was examined if the effects of worry depended on negative affect or exceeded its effects. In line with previous studies (Watkins, 2008), we found that momentary assessed state worry predicted state negative affect (chapter 4). In turn, state negative affect predicted somatic health complaints independently from worry (chapter 4). State negative affect (anxiety) was also positively associated with prolonged attention towards threat, independently of the interaction between trait worry and trait anxiety (chapter 8). Yet, in chapter 9, heightened negative affect did not explain the cardiac effects of worry. As negative affect was associated with subjective health and prolonged attention to threat, but not with objective indicators of health, these studies together suggest that negative affect might affect health mainly via the cognitive pathway, that is, by prolonging the attention that is paid to (the detection of) bodily

signals and towards their catastrophic misinterpretation. In addition, negative affect enhances the prolongation of worry episodes by signaling that a problem hasn't been dealt with effectively, called mood-as-input (Startup & Davey, 2001; Davey, 2006). This prolonged worrying is likely to be accompanied by prolonged increases in physiological activity that, via the physiological route, also threaten somatic health – via increased mental load rather than negative affect.

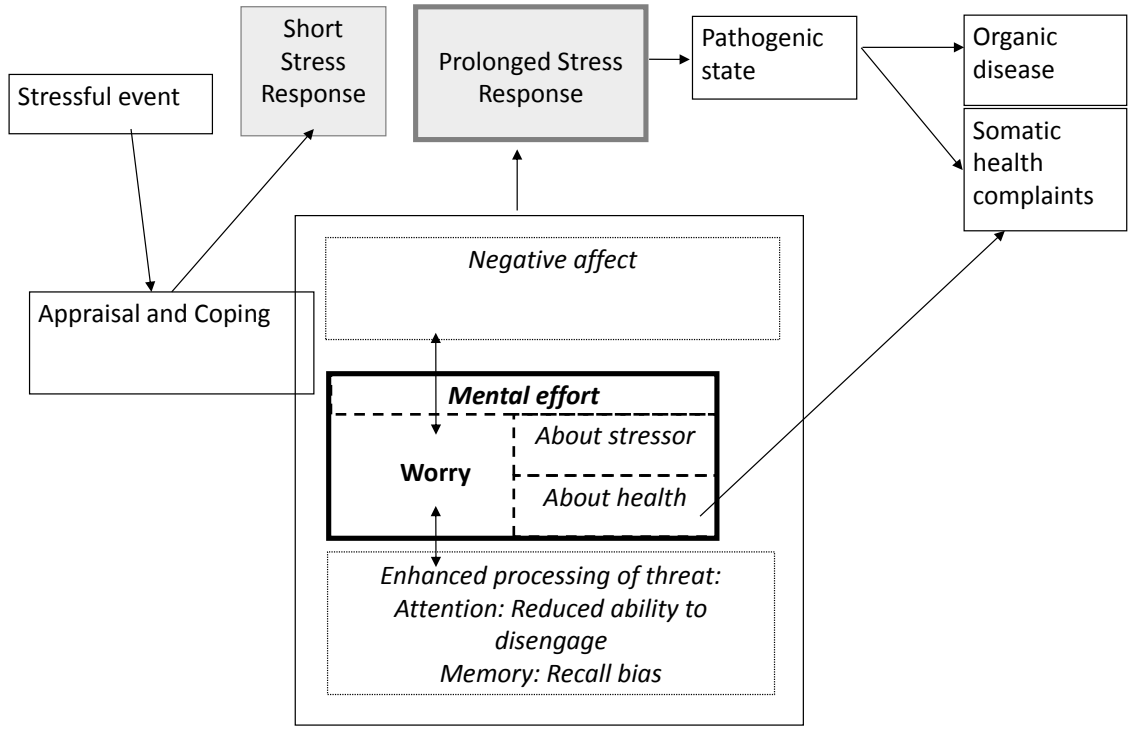


*Figure 1.* The extend perseverative cognition model

**Worry, prolonged physiological activity and somatic complaints**

In this thesis somatic health was operationalized as somatic health complaints and slowed cardiac recovery. The latter is actually an intermediate step between the experience of stressful events and ill health. Our main interest was in examining the role of worry in explaining these two adverse health outcomes, and therefore we did not address whether slow cardiac recovery mediated the effect of stressful events on somatic health complaints, nor did we test the cognitive pathway leading from daily worries about ones health to daily somatic complaints. A practical reason not to test these mediating pathways was that this would have required an elaborated real life study that would have covered a whole thesis (e.g., Pieper, 2008). Thus,

future research should certainly consider investigating the link between somatic complaints and prolonged physiological activity. In fact, the cardiac effects of worry in real life as found by Brosschot et al., (2007) and Pieper et al. (2007) makes it tempting to speculate that at least a part of the health complaint effects of worry found in the current studies is due to prolonged physiological activity in real life. According to the perseverative cognition model, prolonged physiological activity should lead to increased somatic, organic problems. These organic problems should eventually be accompanied by bodily signals that can eventually be reported as somatic complaints. Yet, to date, relatively little is known about how prolonged activity of several bodily (e.g., cardiovascular, immune, endocrine) systems leads to somatic complaints, although several promising theories exist that are being currently investigated. In the context of chronic fatigue, Wyller et al. (2009) recently proposed that severe fatigue is due to prolonged physiological activity. Correlational evidence supported this idea by showing that people suffering from the chronic fatigue syndrome had elevated blood pressure and heightened body temperature when compared to controls (cf. Wyller, Eriksen, & Malterud, 2009). Yet, other studies found no differences in stress-related physiological activity between people suffering from multiple somatic complaints and healthy controls (Houtveen & van Doornen, 2007). In addition, another model for the link between prolonged physiological activity and somatic complaints was provided by Dantzer (2004; 2005) who proposed that pro-inflammatory cytokines, which can be induced by immune as well as non-immune (e.g., psychological) stressors, trigger sickness behavior, including somatic complaints, without necessarily inducing substantial activity in other physiological systems, such as the autonomic systems.

Future studies are clearly warranted to test both the physiological and the cognitive pathway in real life and also to gain more insight into how worry affects other physiological systems and how they are related to somatic complaints.

**Specific components of worry, cardiac activity, and the moderating role of gender**

The results from chapter 9 indicated that the cardiac effects of worry are mainly due to mental load. This could possibly mean that people who are continuously mentally occupied with problems, even when they are non-emotional, are at heightened risk of developing health problems (although it is likely that it is easier to disengage from non-emotional topics than from emotional ones). However, the results from this study are in contrast with another recent study. In this study, the physiological difference between worry and mental load, that is, mental

arithmetic (Oathes, Bruce, & Nitschke, 2008) was tested in a sample of men. Transcranial magnetic stimulation of the primary motor cortex yielded larger corticospinal motor responses during worry than during mental load. This was taken as evidence that in contrast with pure mental load, worry, due to its emotional component, is more closely associated with action preparation to escape from a threatening situation (the so called 'fight-flight' response). Yet, one could cast some doubt on the successfulness of the worry induction used in this study as differences in motor responses between the worry induction and a resting baseline were only marginally significant and only so for just one of the used indices of motor preparation. Inspection of the exact instructions provided to participants showed that during the worry induction, participants were instructed to relax their bodies, in order to allow an uncontaminated measurement of the motor responses. This instruction to 'relax while worrying' questions the validity of the procedure to induce worry. Nevertheless, it seems imperative to use a combination of physiological indices to further elucidate which components of worry are responsible for its physiological effects.

Another interesting finding from the studies described in chapters 6 and 9 pertains to gender differences. In line with animal studies showing gender differences in physiological responses to stress (Taylor et al., 2000), the studies reported in chapters 6 and 9 suggest that differences exist between men and women in cardiac vagal control during or after task performance. These differences were moderated by the tendency to ruminate (chapter 6) or worry (chapter 9). This gender difference was most clearly shown in chapter 9, in which we found that only female high trait worriers responded with increased heart rate variability during both cognitive problem solving and worrying compared to relaxation. Males and female low trait worriers showed reduced HRV during these mental tasks when compared to relaxation. In chapter 6 we found that in a largely female sample (80%), the tendency to brood about ones negative mood predicted increases in HRV during recovery after a stressful task. However, this effect was not found for the tendency to worry, which predicted decreases in HRV during recovery. It remains unclear why we did not consistently find that trait worry was associated with increased HRV during or after mental stress in women. Furthermore, a firm empirical basis for gender differences in physiological stress reactions is still lacking. Yet, as proposed in chapter 6, it is likely that trait worry and trait rumination exert their influence on cardiac activity via prolonged explicit and implicit cognitive representations of stressful events that arise in the anticipation or aftermath of these events. Recent work on the content of these representations

showed that thinking about recent experiences of anger from a 'self-distanced' rather than a 'self-immersed' perspective reduced blood pressure reactivity (Ayduk & Kross, 2008). If we assume that some cognitive representations of stressful events more easily trigger physiological responses than others, and men and women differ in the amount of these thoughts, this could possibly explain the inconsistency in the current findings. Furthermore, it could suggest that the function of perseverative cognitions differs by gender. For example, men might be more prone to show a prolonged fight-flight response in reaction to prolonged worry, while worry might encourage women to engage in tend-and-befriend behavior (Taylor et al., 2000), like communicating about their sorrows and fears with others. This latter form of perseveration is termed co-rumination (Rose, Carlson, & Waller, 2007) and might facilitate a self-distanced perspective on stressful events. It might explain several rather puzzling findings, not only the enhanced HRV in high trait female worriers in this study, but also enhanced HRV in depressed women (Thayer, Smith, Rossy, Sollers, & Friedman, 1998; Chambers & Allen, 2007) and even the lower cardiovascular risk of depressed women as opposed to depressed men (Hybels, Pieper, & Blazer, 2002).

The above makes clear that asking how frequent or long participants were thinking about a stressful event is not enough, and that more information is needed on *in what way* they where thinking about this event (that is, self-distanced versus self-immersed; concrete versus abstract; verbal thoughts versus images). Future studies that manipulate the exact content of the cognitive representations of stressful events among males and females are clearly needed to clarify gender differences in stress-related physiological responses.

**Worry and the processing of concern-relevant information**

Although investigating the cognitive correlates of worry was not the main aim of this thesis was per se, the cognitive elaboration of concern-relevant information was measured in chapters 6, 7 and 8. One perspective on how worry might be associated with information processing was offered in chapter 2. In general, information pertaining to a discrepancy between ones current state and ones goals (goal discrepancy) tends to stay activated until this discrepancy has been resolved, making it likely that people will start worrying about the discrepancy. We also proposed that in extreme worriers this discrepancy is persistently activated because they interpret even neutral or safety information as a threat to their current concerns (cf. Nitschke et al., 2009). Although methodological differences between the studies presented in this thesis

limit firm conclusions, it might be interesting to summarize and discuss what this thesis adds to the current knowledge on worry and information processing.

First, in contrast with Koole et al. (1999) and Forster et al. (2005), we did not find that inducing a goal discrepancy (failure versus mixed failure and success) in chapter 6 led to perseveration of concern relevant information, that is, either explicit worry or implicit worry (automatic vigilance), which was assessed with a lexical decision task. Nor did we find that performing an unsolvable task predicted speeded reactions to concern-relevant information (i.e. words related to intelligence) in the lexical decision task. The data of the lexical decision task made clear that the interpretation of this task is difficult as one can both expect speeded as well as slowed reactions to concern-relevant words (see also: Siegle, Ingram, & Matt, 2002; Algom, Chajut, & Lev, 2004). Yet, the slowing down of responses to concern-relevant words would be in line with the idea that worry and its associated emotional states (anxiety and sadness) are associated with prolonged attention towards concern-related information (chapter 8). As these effects have not yet been systematically examined, we do not recommend using the lexical decision task to measure implicit perseverative cognition.

In a second study (chapter 7) we found that after having exposed participants to a cold-pressor task, health worry was associated with enhanced recall of concern-relevant information (measured with an incidental free recall task). This finding is in line with studies showing that people suffering from generalized anxiety disorder and other anxiety disorders have biases in explicit memory (Friedman, Thayer, & Borkovec, 2000; Russo et al., 2006; Mitte, 2008). However, we did not find that health worry was associated with enhanced attention towards health information (measured with a modified Stroop task), which is in contrast with studies finding Stroop interference in patients suffering from generalized anxiety disorder (Mogg, Bradley, Millar, & White, 1995; Taghavi, Dalgleish, Moradi, Neshat-Doost, & Yule, 2003) We already proposed that this might have been due to the cold-pressor task that preceded the modified Stroop task which might have overruled the association between health worry and biased attention. Another explanation for not finding an association between health worry and biased attention might be that it is just not present in a healthy sample, or too subtle to be captured with a modified Stroop task. Health worry involves enhanced processing of current internal bodily sensations, and information about one's own health that is stored in memory ('I am a person who gets a cold easily, having a cold is terrible'). This attentional focus inwards might not be captured by a Stroop task that presents information externally on a computer

screen. Attention towards external health information might only be observed when people have more severe complaints such as asthma or psoriasis (e.g., Fortune et al., 2003; Jessop, Rutter, Sharma, & Albery, 2004), or when they have read about and communicated with others about these complaints.

Still, worry in general, not limited to health, was associated with attentional processes in chapter 8. In this study we were the first to show that worry and anxiety interact and together predict prolonged dwell time on threat (angry schematic faces). In contrast with the modified Stroop task used in chapter 7, the task used in chapter 8 (exogenous cueing task) assessed *spatial* attention, that is, attention towards objects that are not presented at the location where one is currently looking at (e.g., a fixation point), but at peripheral locations that require a shift in attention. This makes it possible to distinguish between the components of attention (orienting, engaging and disengaging), whereas the results from a modified Stroop task do not permit this distinction. Given that the interpretation of modified Stroop tasks are also under debate (Algom et al., 2004) and exogenous cueing tasks have yielded consistent results (e.g., Goeleven, De Raedt, Baert, & Koster, 2006; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006), we advise future studies into the attentional correlates of worry to use exogenous cueing tasks.

In sum, worry was most strongly related to biases in explicit memory and to prolonged attention for threat in this thesis. This knowledge is of particular importance since cognitive biases now can be modified which might reduce emotional distress (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). Furthermore, as we proposed in chapter 2, these cognitive biases might have adverse physiological consequences that have to be examined in future studies.

**Strengths and limitations**

One of the major strengths of the studies presented in this thesis is that worry was not only measured using trait questionnaires. Besides being a more sensitive and better reflection of current real-life experiences of people, the advantage of using these state measures is that they can provide more information about the temporal dynamics (daytime versus nighttime worry) and the pathogenic ingredients of worrying (frequency, duration or intensity). For example, in chapter 5 we showed that especially nighttime worry was associated with health outcomes. Furthermore, daily worry predicted somatic complaints in chapter 4, while a trait measure of

worry that provided a more global estimate of daily worries, the PSWQ, did not. However, a complication of the use of more than one index of daily worry is that they did not yield a consistent pattern of results concerning what aspects of worry were most detrimental for one's health. In chapter 4 we found that somatic complaints were predicted by worry duration and to a lesser extent by worry frequency, although these effects diminished when worry intensity was entered into the model. In chapter 5 we found that somatic complaints were best predicted instead by the frequency of worry episodes in the nighttime, and not by worry duration. These contrasting findings could likely be explained by differences in the methodology used (time based sampling in chapter 4 versus event based sampling of worry frequency and daily retrospective assessments of worry duration in chapter 5), but limit firm conclusions and warrant studies that test this explanation.

A second strength of this thesis is that the findings are not limited to one specific population, but can be easily generalized to a broader Western population. We studied the health effects of worry in relatively young and healthy student (chapters 3, 6, 7, 8 and 9) who are well suited to study worry on the full severity range (Ruscio, Borkovec, & Ruscio, 2001). However, we also studied the effects of worry on somatic health complaints in a population at risk for the development of work stress (that is, teachers, chapter 4) and in people suffering from severe work stress, diagnosed with adjustment disorders (chapter 5). This latter population has only received little attention from clinical psychologists who are merely focused on more severe clinical populations. Non- or sub-clinical worry and somatic health complaints are very common and are responsible for huge personal suffering and high economical costs. More work on how to reduce the detrimental effects of worry is clearly required.

A third strength is that we did not solely rely on self-report questionnaires in the operationalization of our outcome measure, somatic health. Although subjective evaluations of one's health are the main determinant of whether one will visit a doctor or will call sick from work, the combination of subjective and objective measurements of ones health status results in more convincing evidence in support of the perseverative cognition hypothesis.

One could argue that the correlational / prospective nature of some of the findings is a limitation of this thesis. Yet, the cross-sectional and prospective findings that worry is associated with somatic complaints and cardiac activity (chapters 4 and 6) were followed up by studies using experimental designs that were aimed to directly manipulate worry (chapter 5: between subjects design; and chapter 9; within subjects design), thereby aiming to provide information of

the causal relation between worry and health. Furthermore, in the introduction we already mentioned that the studies concerning the mechanisms behind worry (chapter 8) and its health effects (chapter 7) were set up to provide initial evidence for the proposed hypotheses, and to stimulate further research. We therefore believe that in order to test these hypotheses, it was justified to start off with cross-sectional designs. Yet, since the hypotheses tested were confirmed, experimental studies should further examine their tenability.

Another limitation to the results is that we can not provide a definite answer to the question at what level worry becomes detrimental to one's health. As described in chapter 2, worry can be regarded as a primarily adaptive response to threat. Only when people have repeated or continuous difficulties inhibiting worrisome thoughts, it is usually regarded as a clinical mental problem. Normative data exist for scores on trait worry questionnaires that facilitate decisions made by general practitioners and other clinicians on whether someone worries too much (and likely suffers from generalized anxiety disorder) and needs psychological treatment, such criteria have to be regarded with caution and cannot replace clinical interviews. With respect to somatic health, studies have shown that even non-clinical worry can be detrimental to one's somatic health (e.g. chapter 4). Yet, it is highly questionable whether a precise dose-response relationship between worry and somatic complaints will ever be established. Other factors that were not the main focus of the present studies also co-determine whether people will be more or less vulnerable for the development of somatic complaints or, in the long run, cardiac problems. For example, genetic differences exist that predispose people for the development of somatic complaints (Gillespie, Zhu, Heath, Hickie & Martin, 2000), making it likely that individual differences exist in the total physiological load that people can handle before their health is affected.

**Practical implications**

This thesis resulted in the formulation of innovative hypotheses concerning the effectiveness of costly and time consuming stress management therapies (SMTs). The results of the study reported in chapter 5 suggest that SMTs can be enhanced if specific attention is being paid to the reduction of worry. Part of this intervention already forms part of the manual of occupational physicians on how to deal with work related stress (van der Klink & van Dijk, 2003) and the results of chapter 5 evidently advocate its use.

Besides the worry postponement and disengagement intervention, several other worry interventions exist, such as Competitive Memory Training (Korrelboom, Van der Gaag, Hendriks, Huijbrechts, & Beretty, 2008); Mindfulness Meditation (Jain et al., 2007), Attentional Bias Retraining (Hazen, Vasey, & Schmidt, 2009) and Concreteness Training (Watkins & Moberly, 2009). These interventions are aimed at different aspects of the worry process. As such, it is recommendable to compare the effectiveness of several of these interventions and to examine for who a specific intervention works best, which likely depends on factors like the severity of one's complaints, personality characteristics and co-morbid problems.

**Conclusions and future directions**

We can conclude from the studies presented in this thesis that when people keep on worrying about stressful events they report more somatic complaints and that they physiologically recover more slowly from such events compared to people who do not worry. Several ventures for future research have already been mentioned in the foregoing, here we will summarize the most important suggestions.

One important next step would be the replication of the studies presented in the second part of this thesis that examined the mechanisms behind worry and its health effects (chapters 7 – 9). Studies using ecological momentary assessments should be conducted to test whether worry about specific health complaints indeed predict somatic health complaints ('the cognitive pathway'). Furthermore, the cardiac effects of worry in daily life should be compared to that of non-emotional problem solving. In these studies gender differences should also be a main aim of investigation, given that the results of these studies suggest that men and women respond differently to stress.

A second venture would be to study the effects of implicit perseverative cognition. As mentioned in chapters 2 and 6, it is likely that cognitive representations of stressful events persevere without conscious awareness and these might have physiological consequences. A first aim of studies should be to investigate how to capture implicit perseverative cognition. Thereafter, the physiological effects of implicit perseverative cognition during the daytime as well as during the nighttime, during sleep, should be examined.

Third, the effectiveness of relatively easy to administer worry interventions should be examined in larger populations. Dissemination of effective worry interventions can help preventing severe forms of work stress, anxiety, depression and somatic health problems.

Besides being beneficial for individuals suffering from sub-clinical forms of these complaints, such interventions might also help to reduce the negative effects that these complaints have on job performance or absenteeism. Furthermore, they might as well help reducing the burden that clinical forms of these complaints currently place on health care systems (Jorm & Griffiths, 2006).

In sum, since it's publication in 2006 (Brosschot et al., 2006), the perseverative cognition hypothesis has received gaining interest from researchers and has received support from several new studies (Pieper, Brosschot, van der Leeden, & Thayer, 2007; Zoccola, Dickerson, & Zaldivar, 2008; Holman et al., 2008; Brosschot, van Dijk, & Thayer, 2007). The studies presented in this thesis yielded additional support that worry is associated with somatic health complaints and prolonged cardiac activity, and extended the perseverative cognition model by pointing toward several new cognitive mechanisms underlying these relationships. Notably, two commonly held beliefs were challenged: (1) trait questionnaires are not sufficient to measure worry as they only predict a small extent of worry experiences in daily life and (2) the cardiac effects of worry are not due to its negative emotional experiences as we found that non-emotional problem solving yielded similar cardiac effects. All in all, this thesis further strengthens and extends the evidence for the view that prolonged cognitive representations of stress (worry) are crucial in the link between stressful events and somatic health and provide new avenues for future research.