The crippling homunculus
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Chapter 7

Discussion
The central aim of this dissertation was to examine the prospective relationship between inefficient executive control and persistent intrusive memories. The current research questions are based on the clinical observation that during natural recovery after trauma, most people experience some form of reliving of the earlier traumatic event, but only a minority of them will show persistent intrusive memories over time (e.g., Rothbaum et al., 1992). This observation raises the question of what mechanisms might underlie individual differences in vulnerability/resilience. Considering this, the empirical chapters described in this thesis were devoted to answering this crucial question by examining the predisposing role of executive control. More specifically, it was explored whether persistent intrusive memories may be the result of innate or early acquired individual differences in the specific executive ability of resisting PI in working memory (e.g., cognitive inhibition). The choice for the potential involvement of this specific executive ability was based on recent developments in the experimental memory literature. That is, it has been argued that executive control may not be conceptualized as a unitary construct, but that it consists of a set of related but separable executive functions, each devoted to a specific aspect of goal-directed behavior (e.g., Hedden & Yoon, 2006; Friedman & Miyake, 2004; Friedman et al., 2008). The executive ability of resistance to PI was most likely to be involved in gradually decreasing interference of stressful intrusive images in the aftermath of a traumatic event.

The analogue methodology of the trauma-film paradigm (e.g., Holmes & Bourne, 2008) presented in chapter 4, 5 and 6 made it possible to investigate the potential involvement of pre-stressor executive control in a fully prospective design. In earlier clinical studies, this idea of pre-trauma vulnerability could only be tested indirectly, by comparing PTSD patients and trauma-exposed controls (e.g., Vasterling & Brailey, 2005) or by retrospectively collecting archival data about more general ability measures such as IQ (Macklin et al., 1998). Thus, positive outcomes of such studies do not address the question whether specific neuropsychological abnormalities are a consequence of PTSD or represent a risk/resilience factor for PTSD (cf. Vasterling & Brailey, 2005). Considering this, the prospective studies in the current thesis were intended to collect preliminary evidence to resolve the issue about the direction of the relationship for the specific symptom of intrusive memories.

A second theme of this dissertation was to examine - from a cognitive perspective - factors contributing to the direct retrieval of intrusive memories. As noted in the introduction,
increased knowledge of the mechanisms supporting involuntary retrieval of intrusive memories may lead to a better understanding of how risk factors such as executive control may contribute to the persistence of these memories. In earlier studies, it was suggested that enhanced perceptual priming (e.g., Michael & Ehlers, 2007; see also Ehlers & Clark, 2000) for stimuli reminiscent of the earlier traumatic event may be responsible for the (early) preferential processing of trauma reminders and subsequent retrieval of intrusive memories. Generally in line with this earlier work, our model as presented in chapter 1 also emphasizes the perceptual nature of trauma reminders as potential triggers of intrusive memories. Moreover, we proposed an additional role for the involvement of attentional control. That is, it was hypothesized that an inability to disengage attention from perceptual trauma-reminders might be crucially involved in the development of persistent intrusive memories after trauma.

In this final chapter, I will provide a summary of the empirical studies presented in chapter 2 to 6, and discuss the results in terms of the model presented in chapter 1. Furthermore, reflections on future work addressing untested aspects of the model are provided. Subsequently, some methodological issues are discussed. I will conclude with clinical implications.

7.1. Summary of empirical findings

Prior research has shown that image-based intrusive memories usually found in response to trauma also occur on a regular basis in the normal non-traumatic population (Bywaters et al., 2004). These earlier findings were confirmed in the first analogue study presented in chapter 2. The results of this cross-sectional examination showed a positive association between self-reported distractibility and the frequency of intrusive and avoidance symptoms related to a stressful life event. Furthermore, it was shown that the relationship between distractibility and intrusive memories was still present after controlling for differences in depressive feelings, indicating unique explanatory properties for cognitive ability. Interestingly, we also found a main effect (but no significant interaction with distractibility) for repressive coping. That is, people with a repressive coping style reported fewer recent intrusive memories. This indicates that both a well-developed cognitive ability as well as a motivational tendency to avoid negative affect may protect people from experiencing persistent intrusive memories related to stressful life events.
The cross-sectional study presented in chapter 3 used objective performance-based measures of resistance to PI and response inhibition to explore their relationship with intrusive memories related to a stressful life event. The results were in line with our predictions. That is, after correcting for possible confounding effects of depression and age of the reported stressful life event, a unique relationship between intrusive memories and the ability to resist PI appeared. Moreover, this relationship was especially pronounced in the group of female participants. By contrast, this was not the case for the executive ability of response inhibition. These results are in line with the idea that separate executive abilities may underlie different aspects of (abnormal) behavior (e.g., Nigg, 2000). For example, it has been suggested that a lack of response inhibition might be involved in dysfunctional impulsive behavior (e.g., ADHD; Nigg, 2000; Pennington & Ozonof, 1996). In chapter 3, we also proposed that resistance or inhibition of unwanted material from working memory might have consequences for the accessibility of that unwanted material at a later point in time. It was hypothesized that an inefficient ability to resist PI would result in a relatively increased accessibility for earlier interfering material at a later point in time. More importantly, it was hypothesized that this increased accessibility would be related to a relatively high frequency of intrusive memories of an earlier experienced stressful life event. Inspection of the results showed that this last hypothesis could not be confirmed. No relationship between an index of memory accessibility (i.e., reaction times) and intrusive memories emerged.

The study reported in chapter 4 was intended as a first step in exploring the prospective relationship between self-report executive control and intrusive memories. In this study, a trauma film was used as an analogue stressor for eliciting intrusive memories. We further explored whether the instruction to keep an intrusion diary would trigger unforeseen recording strategies. These potential strategies may interfere with the natural course of experiencing intrusive memories. Results showed that for participants who were asked to fill in a diary, a negative relationship between self-reported executive control and intrusive memories at a follow-up session emerged. By contrast, in the group of control participants, no evidence was found for a prospective relationship between executive control and intrusive memories. These results provide preliminary evidence for the idea of inefficient executive control as a pre-trauma vulnerability factor for persistent intrusive memories. Furthermore, the results of our diary manipulation suggest that the instruction to fill in a diary can be a valid method for recording spontaneous intrusive memories related to a stressful film.
However, the small sample size of this study (n= 17 in the diary group) calls for careful interpretation of the results.

The design of the prospective study presented in chapter 5 integrated several ideas tested in the foregoing chapters. The main goal was to examine whether individual differences in pre-stressor resistance to PI would predict the frequency of image-based intrusive memories one week after the experience of a stressful event (a film fragment). The results were in line with these expectations. That is, low performance on the index of resistance to PI was related to a high frequency of diary intrusions and intrusive memories at a one-week follow-up session. Moreover, results showed that resistance to PI was still able to predict intrusive memories over and above prior trauma exposure, depression and impact of the stressful event (film). These findings provide some evidence for the idea that the specific executive ability of resistance to PI may function as an independent pre-morbid risk factor for persistent intrusive memories after trauma. Important to note, inspection of the modalities of the diary intrusions showed that the majority of the recorded memories were experienced as visual intrusions. This is in line with earlier clinical observation regarding the modality of trauma-related intrusive memories (e.g., Ehlers et al., 2004), thereby providing evidence for the external validity of the diary method.

The main goal of the study presented in chapter 6 was to explore cognitive mechanisms underlying the retrieval of intrusive memories after a stressful or traumatic event. Based on earlier work on the role of enhanced perceptual priming in explaining intrusive re-experiencing (e.g., Michael & Ehlers, 2007), we proposed an additional role for attentional control in predicting persistent intrusive memories. It was hypothesized that a relative inability to disengage attention from perceptual “trauma”-reminders in an RSVP paradigm would be associated with a relatively high frequency of subsequent intrusive memories. Results showed a pattern of findings in line with these expectations. That is, performance on the RSVP task significantly predicted the frequency of subsequent intrusions. To further explore whether this relationship would indeed reflect genuine differences in the (in)ability to disengage attention, several other variables were included in the analyses. First, self-report indices of film-related distress and neuroticism were included to control for any effects of increased levels of anxiety (state and trait) on the processing of film-related distracters on the RSVP (see Barnard et al. 2005). Furthermore, a pre-film self-report index of attentional control was included (see chapter 4) to more directly test the involvement of
attentional control in RSVP performance. Inspection of the data showed that the relationship between film-related interference on the RSVP and the frequency of diary intrusions remained significant after controlling for effects of neuroticism and film-related distress. Moreover, a significant association between pre-film self-reported attentional control and RSVP target detection emerged, suggesting that individual differences in the disengagement component of attention played a role in the prevention of processing film-related distracter stimuli.

7.2. Discussion of the results in terms of the intrusion model

In this paragraph I will return to the model introduced at the end of chapter 1. Based on an integration of ideas presented in the experimental memory literature and the clinical literature on PTSD, the model provides a schematic overview of underlying mechanisms/processes involved in persistent intrusive memories after trauma. More specifically, it was intended to explain how pre-trauma resistance to PI as a specific executive function may contribute to persistent intrusive memories or natural recovery after trauma. The empirical chapters of this thesis were devoted to test the tenability of several components of this model.

First, the results of the studies presented in chapter 2, 3 (retrospective) and 4 (prospective) were used as steppingstone for the design of the study presented in chapter 5. This study was used to test the supposed prospective link between resistance to PI and SAM-based intrusive memories. The results supported the model’s assumptions and were in line with an earlier prospective investigation of Wessel et al. (2008). That is, a relatively low pre-“trauma” ability to resist PI in working memory was associated with a relatively high frequency of SAM-based intrusions (i.e., large dark oval in the model p.15). These analogue findings present important information about the potential role of low resistance to PI as a cause (instead of a consequence) of persistent intrusive memories after an actual traumatic event and may therefore help explaining unresolved issues in earlier clinical studies. As mentioned in the introduction, Vasterling et al. (1998) found a positive relationship between performance on indices of interference control (e.g., commission errors) and re-experiencing symptoms in a group of PTSD patients (see also Vasterling & Brailey, 2005). The study of Vasterling and coworkers (1998) presents evidence for the idea that deficient executive control plays a role in the persistence of intrusive memories. However, it remains undecided whether this deficit was already present prior to the traumatic situation.
Second, further inspection of the model shows a strong link (thick black arrow) between perceptual reminders of earlier trauma and the frequency of SAM-based intrusive memories. This link emphasizes the potential importance of biased processing of perceptual trauma reminders in the prediction of image-based intrusive memories. The idea is that prolonged engagement with these reminders would be associated with a high frequency of intrusive memories (large black oval). The results of the analogue RSVP study presented in chapter 6 supported this part of the model. That is, the degree of film-related interference on the RSVP task was related to the frequency of intrusive memories. Furthermore, the majority of these memories were experienced in the visual modality, supporting the idea that intrusive memories are indeed mainly image-based. Together, these findings support the view that an inability to disengage attention from perceptual trauma reminders may set people at risk for the persistent experience of SAM-based intrusive memories after real trauma.

Considering the foregoing discussion of results in terms of the intrusion model, it will be clear that several questions remain unanswered. For example, it would be an interesting avenue for future research to further explore whether individual differences in the (prolonged) engagement with perceptual trauma reminders would depend on pre-trauma resistance to PI. One of the most important proposals of the model is that the established association between pre-trauma resistance to PI and SAM-based intrusive memories (see chapter 5) will be (partly) mediated by an individual’s ability to disengage attention from perceptual trauma reminders. This proposal is depicted in the model by an inhibitory connection between resistance to PI and the association between the perceptual cue and SAM-based memories. Future analogue studies may explore this more complex relationship by testing whether film-related interference on the RSVP task would mediate the relationship between performance-based indices of pre-film resistance to PI and SAM-based intrusive memories.

The model further shows that pre-trauma resistance to PI may also support the formation of newly acquired VAM association to the trauma cue. This idea was based on Dual Representation Theory (DRT; Brewin et al., 1996; Brewin, 2001) of PTSD which stated that the formation of verbally accessible association to trauma cues would be crucial for recovery after trauma. This ability to form new VAM-based associations after trauma exposure can be expressed by the degree of coherence and or fragmentation of the trauma narrative (cf. Brewin et al., 1996). Thus, a first step to investigate this part of the model
would be to relate performance on indices of (pre-trauma) resistance to PI with subjective ratings of the coherence and fragmentation of the trauma narrative. This will probably require the use of clinical groups because the degree of memory fragmentation after viewing a stressful film might be very low and not useful for exploring individual differences. Follow-up studies may then further explore whether a more detailed and coherent trauma narrative may be predicted by an individual’s ability to disengage attention from perceptual trauma reminders.

7.3. Methodological issues

7.3.1. Use of analogue groups and trauma films

The empirical studies presented in chapter 2 to 6 used student samples to investigate the relationship between inefficient executive control and the (sub-)clinical phenomenon of intrusive memories. Studying the natural occurrence of intrusive memories related to stressful life events or trauma films in a sample of healthy undergraduates may result in floor effects and a restriction of range on self-report measures of individual differences. Similarly, the use of student samples with above average scores on measures of intelligence may result in ceiling effects and restriction of range on indices of executive ability.

Although the mean frequency of intrusive memories was generally low in the studies using the trauma-film paradigm, the range of these intrusions, together with the intrusions reported in two retrospective studies presented in chapter 2 and 3 was substantial enough to detect the expected correlations with executive ability. These findings concur with earlier observations that image-based intrusions also occur on a regular basis in the normal non-traumatic population (Bywaters et al., 2004). Regarding individual differences in executive control, the modified versions of the interference tasks used in this dissertation (i.e., AB-AC-AB list-learning, CVLT) were difficult enough to create a considerable amount of variance on these measures. Taken together, after inspection of the relevant distributions, there is no reason to believe that methodological artifacts such as restriction of range could have reduced the sensitivity to find significant correlations between cognitive ability and intrusive memories. However, the generally low frequency of elicited diary intrusions in the present studies (chapter 5: m = 1.56; chapter 6: m = 2.00) might cause problems when designing future experimental studies. That is, follow-up studies may want to explore protective effects of certain personality traits. Such studies are designed to show a reduction in the frequency of
intrusive memories in a group of people selected on the personality trait in comparison with a non-selected control group. The presently used trauma-film may not be sufficiently intense to elicit a considerable amount of intrusions, needed for investigating difference between groups in future experimental work.

A more general point of concern for working with first-year undergraduates is that these students are often obliged to participate in a large number of experimental studies. This may potentially result in a reduction of their motivation to successfully complete every study to the best of their ability. This may be especially problematic in less structured assignments as recording naturally occurring intrusions in a one-week diary. One way to circumvent this problem might be to ask participants to fill in a confidential questionnaire at follow-up with questions about motivation during the whole procedure. Of course, it must be clear to them that their responses would have no consequences for payment or study credits. Participants with low motivation during one or more parts of the experiment could then be excluded from further analyses. A better, but more time-consuming and expensive procedure would be using community samples in future studies. These samples are often better motivated to participate in experimental psychology studies and do often better represent the general population than a sample of university students.

7.3.2. RSVP task

In chapter six, we found a significant relationship between film-related interference on the RSVP-task and subsequent (diary) intrusions. Based on earlier RSVP studies (e.g., Most et al., 2005; Smith et al., 2006) and on the significant correlation with an index of self-report attentional control we proposed that good performance on the RSVP task would depend on an individual’s ability to disengage attention from visual film reminders. Although this proposal seems plausible, it has to be noted that the correlational nature of the study presented in chapter six did not definitely rule out alternative explanations. For example, because it was very difficult to match our film distracters with appropriate neutral control stimuli, it is possible that the significant relationship between interference for film distracters and intrusive memories was unrelated to the earlier presentation of a stressful film. That is, the significant correlation with intrusive memories would not depend on film distracters as genuine reminders with acquired emotionality, but on particular aspects (e.g. brightness, color) of these distracters. Without a control condition in which half of the participants would
7. Future directions

Based on the predictions made by our model, future studies should test whether a pre-morbid deficit in the ability to resist interference in working memory is also involved in the prediction of intrusive memories after real trauma. For example, a prospective study of soldiers before deployment to a war zone would provide a fruitful research direction for further examining resistance to PI as a vulnerability factor for persistent intrusive memories.
In an ideal study, soldiers are tested shortly before deployment and than followed and tested on their symptoms for at least one year after returning from their mission.

Furthermore, a commonly held view in the clinical literature is that in the immediate wake of trauma, repeated exposure to the stressful trauma memory may support emotional processing and eventually, recovery. Based on this assumption, early intervention programs have been developed. The aim of these psychological debriefing programs is to focus on the traumatic event and to educate people about post-traumatic stress. Although talking about the traumatic experience might seem helpful at first sight, outcome studies have come up with mixed and, in some respect even disappointing results. That is, some studies show no differences between debriefing programs and no intervention at all, while other studies even suggest that such programs could work counterproductive because they would intensify the very symptoms they try to prevent (Mayou, Ehlers, & Hobbs, 2000). Thus, it is possible that early exposure to trauma memories via debriefing procedures interferes with the normal cognitive processing leading to recovery. In line with this, in a recent monograph, McNally, Bryant, and Ehlers (2003) suggested that massive debriefing programs may underestimate the psychological resilience of trauma survivors and that it would be more helpful to focus attention on individuals whose symptoms have failed to abate within the first weeks post-trauma. These persons may be at the highest risk for developing psychopathology such as PTSD. In the current dissertation, I propose that people with a well-developed executive ability would not need an intervention to support the formation of healthy associations to trauma reminders. Executive control and more specifically resistance to PI may help trauma-exposed people to *disengage attention* from the threatening aspects/associations of trauma reminders which may help them with the formation of integrated verbally accessible associations (see the model presented in chapter 1).

Building on these last conclusions, a fruitful direction for future research would be to investigate the possibility to train executive control in people with an increased risk of persistent intrusive memories after trauma. Although this may seem in contrast with our earlier proposal of the genetic origins of executive control, high heritability does not mean that environmental factors cannot and do not affect executive functions (cf. Friedman et al., 2008). According to Friedman et al. (2008): “…heritability is an estimate of the genetic influence on individual differences around a population mean (i.e., the population variance), rather than an estimate of the influences on the mean itself. Thus, environmental factors can
influence a population’s average at the same time that genetic factors influence its variance (Scarr, 1992). The effects of training on executive functions may be analogous.” (Friedman et al., 2008, p. 218). In line with this reasoning, accumulating evidence in the experimental and neuro-imaging literature has shown that executive processes and their underlying brain regions are plastic and adaptive and can be modified by training (e.g., Erickson et al., 2007; Kramer, Larish & Strayer, 1995). For example, some studies have investigated rehabilitation of executive functions in clinical (e.g., ADHD; White & Shaw, 2006) and aging populations (Kramer et al., 1995). Whether these observed training induced changes in behavior and brain activity would transfer to traumatized people with inefficient executive control is an important question that deserves further research.