Chapter 1

General introduction
‘about two years ago, I was dully walking along a Sydney street, worrying about nothing in particular, when – boom! I was small.
I was turning the corner past the tankstand and putting my hand out to push open the back door of the Ocean Grove house. It was made of diagonal latticed slats painted dark green and rough to the touch. I nearly keeled over with the vividness of that door. It came from nowhere. It hadn’t entered
my mind for over forty years.’

- Helen Garner

An old black and white photo, stuck at one corner to the bottom of the drawer. I ease it out carefully, not to tear it. Its shiny surface is covered in tiny cracks, but the picture’s still quite clear. As I gaze at it, my heart starts beating painfully. All those faces, once so intimately, so intensely known.

- Phil Salmon

Memory can sometimes present itself like a great mystery. Returning to childhood within a fraction of a second, sitting on the couch with your first love, lost nostalgic moments affected by the passage of time suddenly return with great clarity and physical reliving. This class of involuntary memories possesses a kind of intrinsic beauty for the rememberer which inspired the great novelist and memory-explorer Marcel Proust to formulate his famous Petite Madeleine cookie example. Not surprisingly, these memories are also known as aesthetic memories (Berntsen, 2007).

A completely different class of involuntary remembering involves the stressful intrusions after the experience of a traumatic event. According to the most recent version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; APA, 1994), a traumatic event is defined as an experience where a person “experienced, witnessed, or was confronted with an event or events that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others” with a subjective response of “intense fear, helplessness or horror” (APA, 1994, pp. 427-428). These horrific experiences will often result in stressful memories more likely to be described as poison instead of joy. For people who develop a posttraumatic stress disorder (PTSD) after trauma, the repeated experiences of intrusive memories are felt as a heavy burden which could deregulate everyday functioning (e.g., work, family) for decades. Prominent examples are cases of holocaust survivors,
Vietnam veterans and people confronted with sexual abuse in their childhood who remain stuck in the past and become prisoners of their own persistent memories (cf. Schacter, 2001). The psychological symptoms of PTSD comprise: (i) recurrent intrusive distressing recollections of the traumatic event, (ii) avoidance of trauma-related stimuli and/or a general numbing of emotional responsiveness; and (iii) increased levels of arousal (Steel & Holmes, 2007; APA, 1994). Ample evidence has shown that traumatic events appear to be relatively common experiences. For example, the National Comorbidity Survey (NCS) under more than 5800 American citizens aged 15-54 showed prevalence rates of 60.7% of male and 51.2% of female respondents having experienced at least one DSM-III-R traumatic event in their lifetime (Kessler et al., 1995). Another study using the more liberal DSM-IV stressor definition uncovered rates of trauma exposure of 89.6% (Breslau et al., 1998, cited in Duke & Vasterling, 2005). Finally, in a study among 900 US college students, the prevalence rate of having experienced a potentially traumatic event was found to be around 67% (Bernat, Ronfeldt, Calhoun, & Arias, 1998). In spite of this high prevalence of exposure to traumatic stressors, relatively few people exposed to trauma will subsequently develop PTSD. For example, among adults living in metropolitan Detroit, 89.6% reported exposure to DSM traumatic stressors, yet only 13% of the women and 6.2% of the men had developed PTSD (Breslau, Davis, Andreski & Peterson, 1991, cited in McNally, Bryant & Ehlers, 2003). This indicates that most trauma survivors are well able to reduce the occurrence of stressful intrusive memories in the first months after trauma exposure.

Cognitive models of PTSD have based their ideas regarding dysfunctional processing in response to a traumatic event on theories in the experimental memory and attention literature. The underlying idea is that the wealth of knowledge about basic memory and attention processes that has been acquired in the past decades may help explaining the nature of trauma-related intrusions after the experience of a traumatic event. Prevailing models (e.g., Ehlers and Clark, 2000; Brewin, Power & Dalgleish, 1996) have explained persistent intrusions in such a way that dysfunctional information processing during trauma would result in a weakly integrated representation of the traumatic event in the autobiographical knowledge base (cf. Conway & Pleydell-Pearce, 2000). That is, Conway and colleagues (Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004) suggested that individual autobiographical memories are embedded in higher level structures of life themes (e.g., childhood, work, marriage) and general events (e.g., holiday in Spain, conference in
Finland) which together form an integrated autobiographical knowledge base. Weakened integration of the trauma memory in this knowledge base may facilitate the triggering of intrusive memories after trauma and possibly results in the inability to obtain control over these stressful experiences. Although these models are informative in describing what may go wrong when people are confronted with traumatic events, it remains an open question why some individuals show a strong tendency towards dysfunctional information processing in response to trauma but others do not. A large body of work on risk factors has not yet resolved this more specific issue (see Brewin, Andrews, & Valentine, 2000; Ozer, Best, Lipsey, & Weiss, 2003 for reviews). This crucial why-question points to the possible role of innate or early acquired individual differences in basic memory and attention processes.

In the experimental memory literature, the importance of individual differences in explaining human cognition and behavior has now been widely acknowledged (e.g., Unsworth & Engle, 2007). Theories of working memory have included a homunculus-like supervisory component that may be responsible for differential performance on a wide range of cognitive tasks and behaviors. A collection of theoretical models has given different headers to this component and its functions, such as central executive (Baddeley, 1996), supervisory attentional control (Atkinson & Shiffrin, 1968), attentional control (Unsworth & Engle, 2007) and executive control (Friedman et al., 2008). The central premise of these theories is that people are born with or grow up in early life with differential resources in executive/attentional ability (Friedman & Miyake, 2008; Engle, 1995). This raises the questions about the implications of individual differences in this basic ability for functioning in everyday life, especially, when one is being confronted with intrusive trauma-reminders.

According to working memory models, a well-developed executive ability supports active maintenance of goal-directed information and resistance or inhibition of irrelevant information (Unsworth & Engle, 2007). Thus, executive ability supports flexible control over the contents of consciousness. This would be crucial at times when the risk of being overwhelmed with emotional information during and after a traumatic experience grows. Following this line of reasoning, it can be speculated that a deficit in this basic ability would set people at risk for the persistence of intrusive memories after trauma. A stepwise investigation of this putative prospective relationship between pre morbid executive ability and intrusive memories will be the major theme of the present thesis.
Because ethical considerations prohibit the exposure of people to real traumatic events, the main questions related to pre-morbid cognitive vulnerability and intrusive memories are examined with the methodology of presenting non-selected participants with trauma films as an experimental analogue of real-life trauma. The central idea behind this methodology is that analogue intrusions elicited by trauma-films and intrusive memories after trauma represent qualitatively similar kinds of memory that only differ in intensity. That is, psychopathological intrusions can be viewed as an extension of a continuum from our common, everyday intrusions (see Holmes & Bourne, 2008). This general introduction is built up as follows.

Before introducing the main research questions presented in the empirical studies, I will first discuss the concepts that are critical for the present research project. Following a short definition of the contents and qualities of intrusive memories in the clinical literature, I will discuss how two prominent information-processing accounts of PTSD explain the development and maintenance of intrusive memories: the cognitive model of Ehlers and Clark (2000) and dual representation theory (Brewin, Power & Dalgleish, 1996). Next, relevant models of executive control and working memory are reviewed. In the experimental literature, there is some consensus that executive control may not be conceptualized as a unitary construct, but that it consists of different sub-functions, each with their own involvement in regulating particular aspects of goal-directed behavior. This will result in a specification of the earlier suggested relationship between pre-morbid executive control and intrusive memories. Following this review, I will introduce a model depicting underlying mechanisms for persistent intrusive memories after trauma. Based on this model, the general outline of this thesis is presented with a short overview of the main research questions addressed in the subsequent empirical chapters.
1.1. How do cognitive models of PTSD explain image-based intrusive memories?

Intrusive memories can be defined as vivid sensory-perceptual memories of earlier stressful or traumatic events. For example, Ehlers et al. (2004) describe the case of a patient who kept seeing headlights coming towards him (as he had seen them shortly before his head-on car crash) (see also Ehlers & Steil, 1995; Ehlers et al., 2002). These unwanted memories enter consciousness involuntarily and are often accompanied with a strong sense of reliving of the original emotions. Intrusive memories can be experienced in different modalities, but visual intrusions are most common (Ehlers et al., 2004). Intrusive memories can be differentiated from intrusive thoughts which are more likely to be experienced as verbal rumination (e.g., Ehlers et al., 2004). Although both intrusive memories and thoughts might be explained by similar underlying mechanisms, the focus of the present thesis will be on image-based memories.

Several cognitive models have been put forward to address the core phenomena of PTSD. These models vary widely in their level of abstraction and number of representational elements or components that describe these phenomena (see Dalgleish, 2004 for a review). For example, higher level schema-based models try to deal with the integration of the subjective meaning of traumatic events into pre-existing knowledge structures (i.e., schemas) of the self and the world. In contrast, other models are more trauma-centered and try to explain the (pathological) nature of the trauma memory and its relationship with the persistence of trauma-related symptoms such as intrusive memories. Important to mention here is the clinical observation of a compelling difference between intentional/generative retrieval and direct/associative retrieval of the trauma memory. Intentional retrieval consists of a strategic and effortful search process for the recall of knowledge in long term memory (e.g., Conway & Pleydell-Pearce, 2000). For example, when you meet a person you recognize as someone you met regularly in college, it will often require an effortful strategic search process to come up with sensory-perceptual details of the specific moments you shared together. In contrast, direct retrieval is an associative and more automatic retrieval process in which there is direct match between a retrieval cue and the content of a specific representation in long term memory. In the context of trauma, intentional recall of the trauma memory is often fragmented and poorly organized with an additional difficulty of recalling the exact temporal order of events. On the other hand, direct retrieval of the trauma memory
results in intrusive reliving experiences of very specific moments during trauma that involuntary enter awareness in a very vivid and emotional way (Ehlers & Clark, 2000).

In the following, I will discuss two prevailing trauma-centric cognitive models that have specifically focused on the imbalance between the degree of intentional and direct retrieval of the trauma memory in explaining persistent intrusive memories and PTSD. I will start with Ehlers and Clark’s (2000) cognitive model for persistent PTSD. This model, primarily intended to provide a theoretical context for the development of a new cognitive behavioral treatment for PTSD (Ehlers et al., 2003; Dalgleish, 2004), gives a detailed account of how dysfunctional encoding of the trauma memory may lead to a processing bias for cues that resemble the earlier traumatic event. This processing bias may then – among other things – be responsible for the unbidden occurrence (i.e., direct retrieval) of stressful intrusive memories after trauma.

The second model is dual representation theory (DRT) of PTSD as developed by Brewin and colleagues (Brewin et al., 1996; Brewin, 2001). DRT has its main focus on the representation of the traumatic event in long term memory. The model accounts for the imbalance between the degree of intentional and direct retrieval after trauma by arguing that direct retrieval of image-based intrusive memories and intentional retrieval of autobiographical knowledge are supported by different memory systems in long term memory. Persistent intrusive memories are the result of a relatively large amount of information stored in the memory system supporting direct retrieval of the trauma memory.

**Ehlers & Clark’s (2000) Cognitive Model of PTSD**

Central to Ehlers and Clark’s (2000) cognitive model for persistent PTSD is a sense of serious current threat. That is, in contrast with people who recover from trauma within a relatively short period of time, for people with persistent PTSD the world remains a dangerous place in which normal functioning is impossible. This appraisal of current threat is intimately linked with reliving experiences in the form of intrusive memories, hyperarousal symptoms and strong emotions that apparently come out of the blue. Intrusive memories are interpreted as a sign of an incomplete integration of the trauma memory into the general structure of autobiographical memory which supports *direct retrieval* of sensory-perceptual details. The model proposes that this lack of integration is the result of dysfunctional processing during the encoding of the traumatic event. In this respect, conceptually-driven
(meaning-based) processing is differentiated from data-driven processing (i.e., processing sensory impressions). Conceptual processing is thought to support intentional retrieval of the trauma due to integration of trauma-related information with other autobiographical information whereas data-driven processing supports re-experiencing symptoms. The idea is that people with a tendency to encode the trauma in a sensory/perceptual way will show enhanced perceptual priming for stimuli with a temporal association with the traumatic event. Enhanced perceptual priming can be conceptualized as increased activation of sensory fragments of the trauma in long-term memory. This perceptual priming will support a biased processing of trauma-reminders in the external environment and the subsequent emotional reliving (via direct retrieval) in the form of distressing intrusive memories.

**Brewin, Power & Dalgleish’ (1996) Dual representation theory**

Brewin et al.’s (1996; see Brewin, 2001) dual representation theory shares assumptions about encoding with the Ehlers and Clark (2000) model, but makes the additional claim that the representation of the trauma in long-term memory is distributed over two different memory systems. First, intentional retrieval of the traumatic event is supported by a Verbally Accessible Memory system (VAM). VAM memories have in common with normal autobiographical memories that they are accompanied with autonoetic awareness (a feeling of remembering; Tulving, 2002) and can be communicated. Second, involuntary intrusive memories are supported by a different Situational Accessible Memory system (SAM). SAM is a perceptually-based memory system that can be accessed by situational cues with a temporal association with the traumatic event. This memory system echoes earlier proposals for a perceptual representation system (PRS, Tulving & Schacter) in the literature on implicit memory. SAM-based intrusions lack contextual integration in autobiographical memory and are often accompanied with a strong sense of stressful reliving. Furthermore, this memory system is not accessible for voluntary retrieval/introspection. Brewin et al. (1996) argue that individual differences in the tendency to encode the traumatic event in a sensory/perceptual way will predict the amount of information stored in the SAM (for direct retrieval) and VAM systems (for intentional retrieval). Considering this, a relatively large amount of information stored in SAM would result in a relatively high frequency of image-based intrusive memories. The crucial point here is that recovery after trauma heavily depends on the ability to transport information stored in the SAM system into the VAM system. A more complete
VAM system will result in an integrated trauma memory which will ease intentional retrieval and significantly reduce the probability of intrusive re-experiencing.

Both Ehlers & Clark’s (2000) cognitive model and DRT (Brewin et al., 1996) highlight aspects of dysfunctional information processing (i.e., encoding, storage) in patients with persistent PTSD. However, these models are less able of explaining individual differences in dysfunctional/healthy processing during the first weeks after a traumatic event. For example, it remains unclear which underlying mechanisms might help trauma survivors to transport information from the SAM to the VAM system during natural recovery. Similarly, it is unclear which underlying mechanisms are responsible for a gradual reduction in perceptual priming, intrusive memories and eventually, the sense of current threat in the aftermath of a traumatic event. In the present dissertation I propose a model that describes a role for individual differences in pre-trauma executive control in explaining the difference between healthy processing towards natural recovery or persistent pathology as described by both clinical models. Before presenting a more detailed account of this model, it is important to introduce some key concepts in the experimental memory literature and summarize relevant earlier findings in the neuropsychological literature.

1.2. Theories of working memory and executive control

*Working memory as a dynamic system instead of a passive store.*

According to recent conceptualizations, working memory is described as a set of temporary active LTM representations under supervision of an executive attentional controller. This attentional controller manipulates working memory contents in line with currently activated goals (Kane et al., 2007). This dynamic conception of active memory has important consequences for explaining individual differences. Important in this respect is the construct of working memory capacity (WMC). WMC has been defined as the *ability* to actively maintain or recover access to goal-relevant information in a wide range of contexts that also trigger irrelevant interfering responses/memories/behaviors. This use of the term capacity strongly differs from the view of primary memory as a passive store with a limited number of items or chucks (7 ± 2; Miller, 1956, cited in Kane et al., 2007). WMC as ability depends on the amount of executive resources available for goal-directed behavior. Thus, WMC is just as important in the retention of a single representation of a goal as it is in determining how
many representations can be maintained. WMC does not refer to memory, but to how executive attention is used to maintain or suppress information. WMC is usually measured with complex span tasks (e.g., Operation Span; Conway et al., 2005) that have been found to predict performance on a wide range of intelligent behaviors. These WM-span tasks present participants with the traditional memory span demand to immediately recall short lists of unrelated stimuli. Additionally and critically, these tasks also consist of a secondary processing component (to prevent rehearsal) through which the maintenance of memoranda is challenged. Operation span (e.g., Conway et al., 2005) for example requires subjects to read aloud and verify arithmetic equations in combination with the instruction to memorize unrelated words following the equations (e.g., IS 6 + 5 = 11? Yes/NO Ball). Empirical work has shown relationships between WM-span tasks and standard measures of intelligence (Kane et al., 2004), active goal maintenance during Stroop performance (“name the color, ignore the word”; Kane & Engle, 2003) and flexible target responding in an attentional orienting task (Unsworth & Engle, 2004). More importantly, Brewin and Smart (2005) showed a negative relationship between performance on a measure of WMC (i.e., Operation span) and the frequency of personally relevant intrusive thoughts using a thought suppression paradigm (Wenzlaff & Wegner, 2000). In general, these studies on WMC provide accumulating evidence for the prominent role of executive control in explaining individual differences on a wide range of everyday behaviors. However, the literature on WMC does not speak about the possible existence of specialized executive abilities that would be independently involved in different aspects of cognition and behavior.

Executive control as a multi-component construct

A separate literature (e.g., Friedman & Miyake, 2004) has used latent variable analyses to address the question of the unity and diversity of executive functions. The general idea behind these studies is that executive control can be defined as a group of semi-independent abilities, each responsible for a different aspect of behavior. For example, Miyake et al. (2000) divided executive functioning into three correlated but separable abilities: Shifting between task sets, Updating of working memory contents and Inhibition of prepotent response tendencies. Furthermore, these abilities were found to be separately related to performance on neuropsychological tasks of frontal functioning such as the Wisconsin Card Sorting test (WCST) and the Tower of Hanoi. Another division of executive functioning
which may be of particular importance for the present purposes is the distinction between
inhibition at the response level and inhibition at the cognitive level. Friedman and Miyake
(2004) examined the relationships between executive measures of inhibition of prepotent
responses (Response Inhibition; e.g., the Stroop, stop-signal and antisaccade tasks; see also
Miyake et al., 2000) and executive measures of resistance to proactive interference or
cognitive inhibition (resistance to PI; indexed by list-learning paradigms). Response
inhibition may be involved in preventing the natural but socially inappropriate tendency to
say something embarrassing about a colleague’s new purple dress. As an example of
resistance to PI, consider the first weeks after purchasing a new mobile phone. During this
period, it would be difficult to access the new number in long term memory because the
extensively used old number will persistently intrude into conscious awareness. Flexible
access to the memory representation of the new number would require a well-developed
ability to resist unwanted interference from the old number. This executive ability of
resistance to PI seems to play an important role in explaining individual differences on
complex measures of WMC (e.g., Kane & Engle, 2000; Rosen & Engle, 1997, 1998). This
could mean that part of the variance of well-known indices of WMC may be attributed to the
specific ability to resist or inhibit interference from working memory. Considering this, in the
study of Friedman and Miyake (2004) resistance to PI (but not response inhibition), showed a
relationship with everyday self-reported intrusive thoughts. As trauma-related intrusive
memories may be seen as a profound example of experiencing unwanted interference in real
life, a deficit in the general ability to resist PI in working memory may set people at risk for
persistent intrusive re-experiencing and PTSD.

A large body of work in the neuropsychological literature has compared PTSD
patients and trauma-exposed controls on a wide range of cognitive measures. Several studies
which focused specifically on indices of proactive and retroactive interference, found recall
deficits in PTSD patients when initial learning was taken into account (Uddo, 1993;
Vasterling et al., 1998, 2001; Yehuda et al., 1995; see also Vasterling & Brailey, 2005).
Moreover, Vasterling et al. (1998) found that the tendency to make intrusion errors on
cognitive interference tasks was positively correlated with re-experiencing symptoms. These
clinical results could be informative about underlying pathogenic mechanisms such as
resistance to PI. However, they leave undecided whether neuropsychological abnormalities
are a consequence of PTSD or represent a pre morbid vulnerability factor (e.g., Vasterling &
Inhibition theory

Until now, I have discussed the role of executive control in the service of the ongoing processing of active goals in working memory. It is unclear however what would be the consequences of exerting control over material deemed as unwanted or irrelevant. When irrelevant/unwanted material such intrusive memories no longer interfere with the goals in working memory has it become less accessible, or less available? Inhibition theory of executive control deals with this important question by taking the activation metaphor (i.e., the idea that memories can become activated or de-activated) one step further. Inhibition theory as formulated by Anderson and coworkers (Anderson & Spellman, 1995; Levy & Anderson, 2002; 2008) proposes that a healthy functioning memory system needs an active ability to forget as well as the well-known ability to remember.

At this point, it is important to note that there are two conceptualizations of the construct of cognitive inhibition. First, in its weaker sense, cognitive inhibition is described as an executive control function or ability to prevent irrelevant information from entering working memory (e.g., resistance to PI) (see Hasher et al., 1999; Lustig et al., 2001). Second, in a stronger sense, cognitive inhibition is described as the consequence of an activation reducing suppression mechanism. In the latter description, inhibition reflects a reduced activation level of the memory representations of earlier interfering material (see Anderson & Spellman, 1995). The central premise behind this idea is that a target memory can be made (temporarily) less available by suppression of its representation below a certain baseline state of activity in LTM.

In the literature, two case examples of memory situations are described in which LTM (below baseline) inhibition would be involved: The need for selection during retrieval and the need to stop retrieval itself. As an example of selection during retrieval, imagine a situation in which a person’s goal is to retrieve the name of an old classmate after seeing an old high school picture. Although this retrieval cue seems quite specific, it will often not be specific enough to prevent the activation of several memory traces with potential candidate names. Inhibition theory states that in this situation, inhibitory mechanisms (i.e., executive abilities) are recruited to inhibit competing traces, resulting in the selection of the appropriate name.
into consciousness awareness. In contrast, the inhibited competing traces are temporarily less available due to a below baseline activation level. This inhibition process during selective retrieval is widely known as “retrieval induced forgetting” (Anderson & Spellman, 1995). The need to stop retrieval arises when someone is confronted with a cue or reminders and does not want an associated memory come to mind. In case of trauma-reminders in the external environment, this would mean that repeated attempts to stop retrieval of the overwhelming intrusions would result in a gradual decrease in activation of the representation of the trauma memory (see Levy & Anderson, 2008 for a suggested link between inhibition in its stronger sense and trauma-related intrusive memories). In the past decade, empirical studies have tried to test the ideas behind the need for selection and the need to stop retrieval. Standard methodologies such as the retrieval practice paradigm for selective retrieval (Anderson, Bjork, & Bjork, 1994; Anderson & Spellman, 1995) and the think-no-think task (Anderson & Green, 2001) for stopping retrieval have been developed to test the crucial claim of below baseline activation of LTM representations.

Although the ideas presented by inhibition theory may sound intriguing from the perspective of a memory theorist, they are in apparent contrast with some basic assumptions in the clinical literature. For example, in the clinical psychology literature, not talking about and trying to forget a traumatic experience is a first step towards development of psychopathology such as PTSD (i.e., avoidance; APA, 1994). One solution to these inconsistent views may be found in the proposal that motivated attempts at avoidance after a traumatic event are the expression of an inability to exert executive (inhibitory) control (see Levy & Anderson, 2008). Although this sounds plausible, it may be quite challenging to conduct an empirical test of this hypothesis in the context of real life intrusive memories. More importantly, before addressing questions about the role of inhibition in a stronger sense, it is important to establish whether there is, indeed, a link between executive control and image-based intrusive memories. Hence the main focus of the present thesis will be on the prospective relationship between pre-morbid executive control (i.e., resistance to PI) and the frequency of intrusive memories after a stressful or traumatic event.
1.3. Direct retrieval of intrusive memories after trauma: underlying mechanisms and individual differences

Studies investigating intrusive memories will almost by definition use subjective indices such as questionnaires, structured interviews and diaries. This may give information about several aspects of intrusive remembering such as the frequency over time, experienced modalities (e.g., visual, tactile, auditory) and unhealthy appraisals (“I am going mad”, “the world is no longer safe” [e.g., Ehlers et al., 2004]). However, a relatively unexplored aspect of intrusive re-experiencing is the retrieval process itself. What is the exact process by which retrieval cues are (automatically) selected and how does this cue interact with the memory contents of the intrusions? Increased knowledge of the mechanisms supporting the retrieval process of intrusive memories may lead to a better understanding how risk factors such as executive control may contribute to the persistence of these memories.

Earlier in this introduction, I briefly introduced a model on the role of executive control in explaining natural recovery/persistent symptoms after a traumatic event. A more detailed account of this model – which heavily relies on an integration of different ideas presented in cognitive theories of PTSD - will be given below.

Central to the retrieval of intrusive memories is the direct mapping of the cue and the memory contents. Simple cues in the external environment may be powerful enough to directly trigger stressful contents without the cue elaboration process needed for the intentional recall of everyday autobiographical memories (Conway & Pleydell-Pearce, 2000). In an attempt to explain why seemingly unimportant cues can obtain such a powerful intrinsic meaning, cognitive models of PTSD have used insights from the literature on implicit memory (priming; e.g., Tulving & Schacter, 1990), episodic memory (encoding specificity, transfer-appropriate processing; e.g., Tulving, 2002) and autobiographical memory (direct retrieval, weakly integrated representations; e.g., Conway & Pleydell-Pearce, 2000).

Considering this, it has been argued that the expression of an implicit perceptual representation system (PRS) in long-term memory (i.e., perceptual priming [Tulving & Schacter, 1990]) might explain the maintenance of intrusive memories (Ehlers et al., 2006; Ehlers & Clark, 2000). This enhanced perceptual priming hypothesis (e.g., Ehlers et al., 2006; Michael & Ehlers, 2007) states that a primary focus on sensory (i.e., visual) details during trauma encoding, would give rise to the preferential processing (due to enhanced activation in
PRS) of those environmental stimuli that bear a strong perceptual resemblance to the actual traumatic situation. This preferential processing of perceptual trauma-reminders would then increase the probability that the trauma memory would intrude in conscious awareness due to direct retrieval (Conway & Pleydell-Pearce, 2000) of fragments of the sensory-perceptual representation. Taken together, the foregoing discussion indicates that sensory reliving of a traumatic situation triggered involuntary by cues reminiscent of those present during the experience is mediated by a different (i.e., more perceptual) memory system (i.e., SAM; Brewin et al., 1996) than the retrieval of normal verbally accessible memories (i.e., VAM; Brewin et al., 1996).

In terms of the model depicted in figure 1, well-developed executive control (i.e., resistance to PI) existing prior to the exposure of a traumatic event allows gradual control over the processing/attentional bias for perceptual trauma reminders (i.e., retrieval cues) in the external environment (i.e., Ehlers & Clark, 2000). This gradual control may counter the direct retrieval of stressful intrusive memories in SAM and support the formation of more healthy associations with the trauma reminders in VAM (i.e., Brewin et al., 1996; see Brewin 2001 for a slightly different account of the effects of exposure therapy). In contrast, inefficient executive control may set people at risk for a prolonged engagement with perceptual reminders in the post-trauma environment. This inability to disengage attention from the stressful aspects of the trauma reminders (e.g., “danger”) may maintain imagery (SAM) reliving of the trauma and prevent the formation of more healthy VAM associations to the trauma cue.
1.4. Aim and outline of the present dissertation

The central aim of the present dissertation is to explore the role of pre-trauma executive control on the persistence of image-based intrusive memories after trauma. Based on the foregoing discussion of the experimental memory literature, it is proposed that this relationship might be restricted to the specific executive ability of resistance to proactive interference. A second aim of the present thesis is to explore the mechanisms by which executive control may counter the retrieval process of intrusive memories after trauma (see the model presented in figure 1). The idea is that individual differences in the (in)ability to disengage attention from perceptual reminders after trauma predicts the frequency of
intrusive re-experiencing. This ability to disengage attention is thought to depend on the amount of executive resources existing prior to experiencing a traumatic event.

Based on this model, the empirical chapters of the present thesis focus on three target questions:

1. Is there a prospective relationship between pre-“trauma” executive control and the frequency of subsequent “trauma”-related intrusive memories?
2. If so, is this relationship based on a relative (in)ability to resist PI from working memory?
3. Is there a relationship between the ability to disengage attention of visual trauma-reminders and the frequency of subsequent image-based intrusive memories?

The first two chapters explore the relationship between executive control and intrusive memories related to a stressful life event in a retrospective design. As our main hypothesis of a specific relationship between resistance to PI and intrusive memories has not been tested before, we used these cross-sectional examinations as stepping stone for testing the prospective model depicted in figure 1. The main goal of the study described in chapter 2 was to test the relationship between self-reported distractibility (as an index of executive control) and the frequency of recent intrusive memories in a large sample of undergraduates (N = 400). In chapter 3, we tested the idea that persistent intrusive memories can be best explained by inefficient executive control at the cognitive level. Non-selected participants filled in a standard index of intrusive memories (i.e., IES; Horowitz et al., 1979) and completed objective measures of executive control at the cognitive level (termed “resistance to proactive interference”; i.e., paired associates list-learning) and objective measures of executive control at the response level (termed “response inhibition”; i.e., Stroop, Random Number Generation). It was hypothesized that intrusive memories would be primarily related to individual differences in the ability to resist PI. Yet, no relationship was expected with indices of response inhibition. Based on the ideas presented by inhibition theory, it was also examined whether individual differences in the ability to reduce the accessibility/availability of irrelevant material (i.e., an effect of well-developed ability to resist PI) would be related to the frequency of intrusive remembering.
The last three chapters of this dissertation use a prospective design with a trauma film as an analogue stressor for eliciting intrusive memories. Before discussing details of the studies presented in these chapters, I will present an overview of the ins and outs of the trauma film paradigm (e.g., Holmes & Bourne, 2008).

**The use of trauma films in analogue settings**

An important conclusion from early studies using analogue stressors to induce intrusions was that the tendency to experience intrusive memories was common in the population at large and expected to occur following mild as well as severe stress events (see Holmes & Bourne, 2008 for a historical review). This earlier work has given input to more recent developments of the trauma-film paradigm (e.g., Holmes et al., 2004; Holmes & Bourne, 2008) in which participants are presented with a short film (8-12 min) depicting traumatic events (e.g., scenes of a traffic accident; Holmes et al., 2004; Holmes & Steel, 2004; Stuart, Holmes & Brewin, 2006) or horrific movie scenes (e.g., Kindt & van den Hout, 2003). During the film, participants could either be asked to view the film as they would naturally do or to adopt a specific processing task or instruction manipulation. After film viewing, participants complete some post-film control indices (e.g., film-related distress) and are subsequently asked to record any spontaneously occurring intrusive memories of the trauma film in a one-week diary. After one week, participants return to the lab to submit their diaries and to complete some follow up measures. As noted earlier, the trauma-film paradigm supports experimental control over trauma which has the opportunity to study the role of potential *pre morbid* risk factors such as executive control on persistent intrusive memories in an analogue setting. The remaining chapters were designed as follows.

The prospective studies in chapter 4 and 5 addressed the first two target questions more specifically. These questions were based on the model’s underlying assumption of a link between pre-trauma resistance to PI and SAM-based intrusions. In chapter 4, we explored the relationship between pre-film self-report executive/attentional control and the frequency of intrusive memories in the four days after the presentation of a stressful film. Furthermore, we also tested whether the diary method would be preferable above retrospective ratings of intrusive memories via a questionnaire. The main goal of chapter 5 was to examine the
relationship between a performance-based measure of resistance to PI (as a specific executive ability) and image-based intrusive memories related to an earlier presented stressful film. These memories were recorded in a one-week diary and via a questionnaire (i.e., a modified IES) at a follow-up session after 7 days.

Finally, chapter 6 was devoted to the second theme and third question in this dissertation: control over the involuntary retrieval of intrusive memories after a stressful event. In terms of the model: we examined the association between the perceptual cue and SAM-based intrusive memories. It was tested whether an inability to disengage attention from visual reminders of an earlier presented stressful film would predict subsequent intrusive memories recorded in a one-week diary. Biased processing of visual film reminders was explored in a single target rapid serial visual presentation paradigm (RSVP; Most et al., 2005). The degree of interference by these film-reminders during the detection of neutral targets was used as an index of the (in)ability to disengage attention. To further support the role of attentional disengagement in the prediction of image-based intrusive memories, we also included a self-report measure of attentional control that was presented before the presentation of the stressful film. This made it possible to undertake a preliminary investigation of the model’s link between pre-trauma executive control and biased processing of perceptual trauma reminders.
Chapter 1