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Retrograde episodic memory and emotion: A perspective from patients with dissociative amnesia

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ABSTRACT

With his recent definition of episodic memory Tulving [Tulving, E. (2005). Episodic memory and autonoesis: Uniquely human? In H. Terrace & J. Metcalfe (Eds.), *The missing link in cognition: Evolution of self-knowing consciousness* (pp. 3–56). New York: Oxford University Press] claims that this memory system is uniquely human and thereby distinguishes human beings from other, even highly developed, mammals. First we will define the term episodic memory as it is currently used in neuropsychological research by specifying the three underlying concepts of subjective time, autonoëtic consciousness, and the self. By doing so, we will strongly focus on retrograde episodic memory and its relation to emotion and self-referential processing. We support this relation with a discussion of autobiographical memory functions in psychiatric disorders such as dissociative amnesia. To illustrate the connection of emotion and retrograde episodic memory we shortly present neuropsychological data of two cases of dissociative amnesia. Both cases serve to point to the protective mechanism of a block of self-endangering memories from the episodic memory system, often described as the mnestic block syndrome. On the basis of these cases and supportive results from further cases we will conclude by pointing out similarities and differences of patients with organic and dissociative (psychogenic) amnesia.

1. Introduction

On a content-based view, memory can be seen as a multidimensional concept. With respect to the kind of processed information long-term memory can be demarcated into four (Markowitsch, 2000a; Tulving, 1987), recently into five different memory systems: procedural memory, priming, perceptual memory, semantic, and episodic memory (Markowitsch, 2003; Reinhold, Kuehnel, Brand, & Markowitsch, 2006). These systems are hierarchically ordered with episodic memory at the top (cf. Fig. 1), reflecting their ontogenetic and phylogenetic development. Tulving (1995, 2001) emphasized in his *SPI*-model that encoding of information occurs *serially*, storage in *parallel*, and retrieval is *independent* of the condition during encoding, implying that information, encoded as an episode, may be retrieved on the basis of the procedural memory system.

Introducing the term 'episodic memory' in the early 1970s of the last century, Tulving (1972) summarized the ability to recall events of one's own life with a strong relation to time and space and with a clear emotional connotation. Tulving thereby extended Nielson's (1958, p. 25) view of 'two separate pathways for two kinds of memories. The one is memories of life experiences centering around the person himself and basically involving the element of time. The other is memories of intellectually acquired knowledge not experienced but learned by study and not personal'. In a relatively young science like the neurosciences and neuropsychology those definitions commonly change and are refined throughout the research process. With respect to Tulving's early definition, some researchers used the term 'episodic memory' for word-list paradigms in laboratory tasks.

This and other observations led Tulving (2005) to a renewal and redefinition of his episodic memory definition. Currently, episodic memory is characterized as a conjunction of three concepts, namely subjective time, autonoëtic consciousness, and the experiencing self. With this definition Tulving stresses the importance of the self-relatedness of episodic memories. This is supported by the results of Gilboa (2004) who reviewed prefrontal cortex activation in laboratory word-list paradigms and autobiographical memory tasks. Although detecting overlapping activations for both tasks he was able to also reveal differential activation pattern in ventromedial (primary left-sided) prefrontal activations that are solely associated with autobiographical memory retrieval. It is concluded that both memory retrieval processes can be differentiated with regard to their modes of post-retrieval monitoring and verification. Whereas pure autobiographical-episodic memory retrieval induces an intuitive 'feeling of rightness' and a relation to an activated self-schema, retrieval of episodic memories (e.g., word lists)

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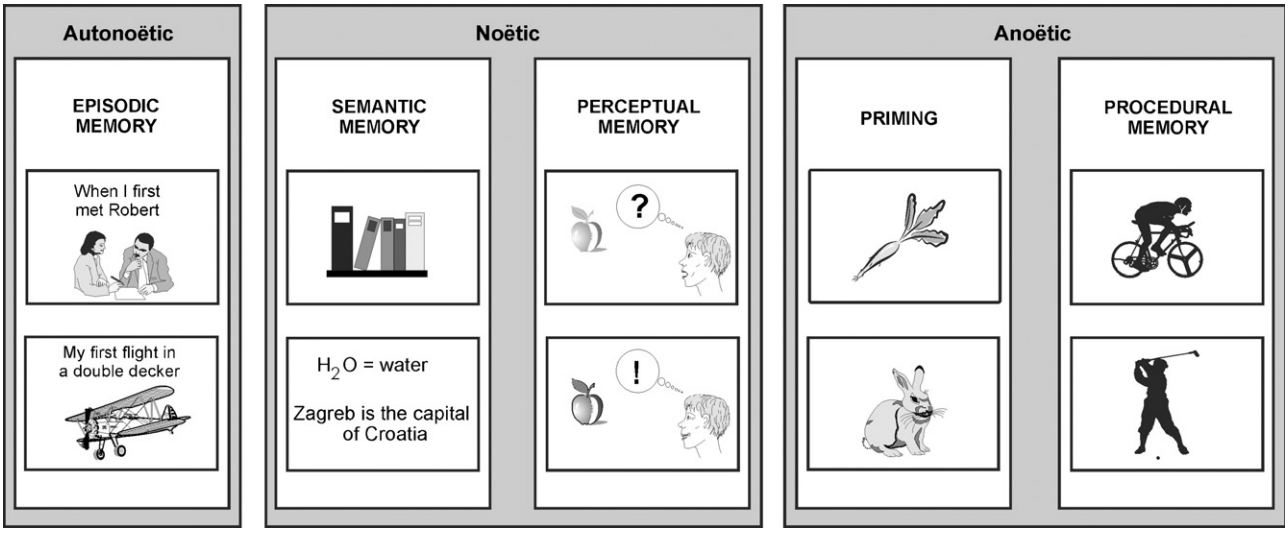

Fig. 1. Sketched pictograms to exemplify the five content-based divisions of long-term memory with their corresponding levels of consciousness. The memory systems are hierarchically ordered with procedural memory as the hierarchically lowest memory system (right) and episodic memory at the top (left).

requests a more conscious and sophisticated monitoring (Gilboa, 2004).

Taking into account the discussion of episodic word-list learning and autobiographical-episodic memory, Tulving (2001) also strictly differentiates between the terms 'remember' and 'know'. To 'remember' a specific event means that the memory has a strong self-relation (autonoësis) and emotional connotation and thereby goes far beyond of just 'knowing' that this event occurred (see also Gardiner & Richardson-Klavehn, 2000). For this reason, the distinction of 'remember' and 'know' is often part of studies dealing with autobiographical memory. For instance, Piolino et al. (2007) used the remember/know paradigm to detect developmental differences between semantic and episodic subcomponents of autobiographical memory in school-age children. With the age of the children the 'remember' responses which were justified by contextual information of the event increased. Thus, Piolino and colleagues concluded that the ability of mental time travelling in subjective time is the last feature of the autobiographical memory system that becomes fully operational.

Tulving argues that remembering is a central function of episodic memory and thereby distinguishes this memory system from semantic memory. The experiencing person – the mental-time traveller – is referred to as the 'rememberer'. Autobiographical memory is often used synonymously for episodic memory though it needs not to be same as autobiographical memory additionally comprises autobiographical-semantic facts (e.g., date of birth). Cabeza and St Jacques (2007) illustrated in their recent review article of functional neuroimaging of autobiographical memory a continuum from the purest episodic to the purest semantic memory. This also reflects the discussion of a possible distinction of semantic and episodic subcomponents constituting autobiographical memory. Retrieving facts related to one's own biography, like date and place of birth, relates to the semantic portion of autobiographical memory since we 'know' and do not 'remember' these facts. In contrast, when we 'remember' a specific personal event like our last birthday party, the memory is associated with a clear emotional connotation and further perceptual features like the taste of our birthday cake. These features make the difference to just knowing where the party took place and who baked the cake. The usage of the term 'autobiographical-semantic memory' when relating to self-related facts and semantic knowledge and 'autobiographical-episodic memory' when talking of specific self-related and emotionally laden events reflects this segregation. Both subcomponents (autobiographical-semantic and autobiographical-episodic) contain self-related information but their contents differ concerning their emotional colouring. Thus, self-related and emotional processes are separable when looking at autobiographical memory. To judge whether this hand belongs to me or another person is a clearly self-related but un-emotional decision. In the following we will use the term episodic memory when referring to memories of the autobiographical-episodic memory system, since episodic memory as defined by Tulving (2005) still constitutes the core facet of autobiographical memory.

Returning to Tulving (2005) definition, we will have a closer look at the three concepts constituting episodic memory: subjective time, autonoëtic consciousness, and experiencing self.

Tulving's concept of 'subjective time' enables the 'rememberer' to mentally travel to any given point of his or her individual lifeline. It is also referred to as chronaesthesia (Tulving, 2002). With the term 'subjective time', Tulving highlights the fact that the time in which events are remembered differs from physical time. Though episodic memory is often related to the past it also enables us to anticipate future events and consequences or needs. The ability of prospective mental time travelling is subject of some recently published papers (e. g., Addis, Wong, & Schacter, 2007; Buckner & Carroll, 2007; Szpunar et al., 2007) and is currently defined by: "allows us not only to go back in time, but also to foresee, plan, and shape virtually any specific future event" (Suddendorf & Corballis, 2007, p. 1; see also Tulving & Kim, 2007). However, in this manuscript we will focus on retrograde episodic memory and therefore on the past-related aspect of mental time travelling.

The second concept, in which episodic memory is embedded, is autonoëtic consciousness. Related to each of the above-introduced five content-based memory systems there are corresponding levels of consciousness. Procedural memory and priming as the hierarchically lowest memory systems remain on an 'anoëtic' level of consciousness, meaning that processed information is not subject to conscious attention. The perceptual and semantic memory systems require mindful processing of information what is referred to as 'noëtic' consciousness. Forming or retrieving episodic memories involves self-related and thus 'autonoëtic' information processing. Tulving (2005) considers autonoëtic consciousness to be a uniquely human trait. The corresponding levels of consciousness can also be derived from Fig. 1. Autonoëtic (self-)consciousness is defined as

"the capacity that allows adult humans to mentally represent and to become aware of their protracted existence across subjective time" (Wheeler, Stuss, & Tulving, 1997, p. 335).

Next to subjective time and autonoëtic consciousness the experiencing self amounts to the concept of episodic memory. Building up autobiographical memories enables us to experience our self as an entity over time and therefore enables the formation of an identity or "personality". Our personality relies on past experiences, is strongly associated with our personal beliefs and allows us to consistently behave with our own beliefs and desires. The experiencing self assures the autobiographical memory to be a continuous memory system that is built up along a subjective time line (Markowitsch, 2005b). Although the term 'experiencing self' can also be used to name the 'rememberer', the concept of the experiencing self implies the perceptual component of remembering a specific event from one's own biography with contextual information like time, space, emotional state. However, the experiencing self has to be distinguished from the concept of the self as the self constitutes a multidimensional (moral, physical, personal, social, etc.) and outlasting construct, while the experiencing self refers to a momentaneous state.

Taken together, it is hard to look at the three components of episodic memory (subjective time, autonoëtic consciousness and experiencing self) separately since they strongly rely on the existence and full development of each other. Therefore, we will have a closer look especially at the neural interrelation of episodic memory, emotion, and the self in the following paragraphs. Their interdependencies are central for an understanding of the relevance of the phenomenon of 'dissociative amnesia' to the concept of episodic memory, which is also reflected in the current definitions of the concepts of dissociative amnesia and dissociative identity disorder in DSM-IV-TR (American Psychiatric and Association, 2000).

We outlined before that episodic memory is characterized by self-related and emotional processing of information. In general, processing of information into different memory systems is frequently divided into several steps from information registration, encoding, consolidation and storage to the retrieval of information (but see Craik & Lockhart, 1972; Moscovitch, 2000). Dependent on the different processes and the kind of processed information, specific brain regions and structures are involved (for a comprehensive review of the neuroanatomy of memory see Markowitsch, 2005a). Formation and storage of autobiographical memories recruits mostly limbic structures, involving the Papez circuit, the amygdala and other structures of the so-called basolateral-limbic loop (Brand & Markowitsch, 2003, 2009) as well as connecting fibers. Even though also engaged in memory acquisition and consolidation, regions of the prefrontal cortex are especially involved in the retrieval of episodic memories. In a recent review, Brand and Markowitsch (2008) highlight the specific role of several parts of the prefrontal cortex in episodic memory, particularly the orbitofrontal cortex (Brand & Markowitsch, 2006). Due to reciprocal connecting fibres with limbic and diencephalic structures, primary functions of the orbitofrontal cortex can be seen in the integration of emotion and self-relatedness information which is indispensable for the retrieval of distinct episodic memories. Taken together, an orchestra of limbic, diencephalic and prefrontal structures as well as several fiber tracts collaborate on encoding, consolidating, storage, and retrieval of personal events which are emotionally coloured and have a strong relation to the self (Fujiwara & Markowitsch, 2006; Markowitsch, 2003). Additionally, there seems to be evidence that autobiographical memory is, among other features, organized in terms of its emotional valence (Piefke, Weiss, Zilles, Markowitsch, & Fink, 2003; Schulkind & Woldorf, 2005).

Processing of self-related information is a crucial element of autobiographical-episodic memory function (Conway & Pleydell-Pearce, 2000; Wilson & Ross, 2003). This can also be seen in overlapping neural networks of self-related and autobiographical-episodic memory processing which comprise the prefrontal cortex (Johnson et al., 2002; Northoff & Bermpohl, 2004) and further cortical midline structures (Northoff et al., 2006). Next to shared neural networks both functions are usually emotionally coloured. Northoff et al. (2007) therefore tried to disentangle neural correlates of self-related and emotional processing by using parametric modulation to correlate neural activity and the degree of self-relatedness while subjects perceived emotional stimuli. They found opposite parametric modulation of self-relatedness and emotion in the dorsomedial prefrontal cortex and the ventral striatum/nucleus accumbens while further subcortical regions were modulated in the same direction. This led the authors to the conclusion that processing of the self and emotions is strongly related to subcortical regions. However, higher cortical regions as the dorsomedial prefrontal cortex allow us to easily discern the self from emotional processing and thereby essentially contribute to the ability of self-consciousness.

The interaction of self-related processing and episodic memory as well as the relation of emotion and episodic memory is also observable in various neurological and psychiatric patients. For example, patients with schizophrenia often suffer from changes in autobiographical memory abilities (Corcoran & Frith, 2003; Danion et al., 2005). Additionally, autobiographical memory disturbances are often reported and discussed as part of the pathology in patients with predominantly impaired emotional processing capabilities (e.g., major depression) (Lemogne et al., 2006; Williams et al., 2007). In patients with neural damage in limbic structures like the amygdala (e.g., in patients with Urbach-Wiethe or temporal lobe epilepsy) deficits in memory or other cognitive functions are also observable (Bengner & Malina, 2007; Hurlemann et al., 2007; Markowitsch et al., 1994; Richardson, Strange, Duncan, & Dolan, 2006; Siebert, Markowitsch, & Bartel, 2003; Weniger, Bouscein, & Irle, 2004).

In conclusion there is a strongly overlapping and integrative network of brain structures engaged in emotional and self-related processing which corporately contribute to the processing of episodic memories. Due to its complex structure the episodic memory system is highly vulnerable as apparent in the phenomenon of dissociative amnesia. Since this psychiatric disease is a relatively rare condition we shortly introduce its main characteristics before describing two cases with this condition.

1.1. Dissociative amnesia

Dissociative amnesia is a syndrome that combines disrupted emotional and self-related processing abilities with deteriorations in episodic memory. It is classified as one of the dissociative disorders according to DSM-IV (American Psychiatric and Association, 2000). Dissociative disorders are mental disorders in which the normally well-integrated functions of memory, identity, perception, or consciousness are separated (dissociated). Patients with dissociative amnesia often report recurring episodes in which they forget important autobiographical information or events. Amnesia can comprise the complete or just parts of the lifespan and may affect all autobiographical memories, or discrete contents, for example family affairs. The extent of the observed retrograde amnesia is too massive to be (solely) attributable to absent-mindedness or age-related forgetfulness and cannot be related to neurological impairments such as focal structural brain damage (Markowitsch, 2003; Reinhold et al., 2006). The appearance of dissociative amnesia is usually connected with recent or long-lasting psychic traumata or severe stress (Brandt & van Gorp, 2006).

The effects of stressful and traumatic life events on cognitive and mnestic functions are especially apparent in patients with post-traumatic stress disorder (PTSD) (Sapolsky, 1994, 1996a, 1996b) and can even be seen in their offspring (Federenko et al., 2006;

Yehuda, Blair, Labinsky, & Bierer, 2007). Numerous studies have observed changes in spine formation, dendritic density etc. in individuals subjected to prolonged stress conditions (e.g., Mitra et al., 2005; Smith, 2005; Yamasue et al., 2003). Volume losses in memory- and emotion-related structures like the amygdala and hippocampus (Vermetten, Schmahl, Lindner, Loewenstein, & Bremner, 2006) as well as the prefrontal cortex can be related to autobiographical memory impairment. Disruptions in this coherent system of amygdala, hippocampus, and prefrontal cortex often lead to autobiographical memory impairments (Bright et al., 2006; Gilboa et al., 2005). Traumata and/or stress are potential triggers for such disruptions as they provoke hormonal changes, especially in the glucocorticoid system. Detrimental alterations in glucocorticoids affect, among other structures, the hippocampal formation, the amygdala, and the prefrontal cortex (Schore, 2002, 2005)—structures closely involved in episodic memory and emotional processing. The influence of cortisol on memory has not only been described in various patients (Bremner, 2005; Newcomer, Craft, Hershey, Askins, & Bardgett, 1994; Newcomer et al., 1999; O'Brien, Lloyd, McKeith, Gholkar, & Ferrier, 2004; Winter & Irle, 2004; Wolf, Fujiwara, Luwinski, Kirschbaum, & Markowitsch, 2005; Yehuda et al., 2005) but also in healthy individuals (Brunner et al., 2006; Gianaros et al., 2007; Kuhlmann, Piel, & Wolf, 2005; Lupien & Schramek, 2006; Maheu, Collicutt, Kornik, Moszkowski, & Lupien, 2005; Oei et al., 2007; Szeszko et al., 2007; Yasik, Saigh, Oberfield, & Halamandaris, 2007). Furthermore, it was proposed that excessive and long-lasting release of stress hormones might lead to premature aging and dementia (Pardon & Rattray, 2008; Porter & Landfield, 1998). Models trying to specifically explain autobiographical memory impairments in patients with PTSD, postulate that the traumatic or stressful memory remains separated from the autobiographical memory system (e.g., Ehlers & Clark, 2000; LeDoux, 2000). This also accounts for flashbacks or intrusions as prominent symptoms of PTSD (Brewin, 2001; Brewin, Dalgleish, & Joseph, 1996). Patients with PTSD often report a changed sense of self, meaning that they do not feel as the same person anymore (Koenen, 2006; Sutherland & Bryant, 2005).

As outlined before there are two subcomponents constituting to autobiographical memory, namely autobiographical-semantic and autobiographical-episodic memories. While the latter requires self-related and emotional processing of information, autobiographical-semantic memory is usually just self-related. A disrupted processing of self- and identity-related information is the hallmark of dissociative amnesia thus affecting both components of autobiographical memory (see also case descriptions by Hennig-Fast et al., 2008; Piolino et al., 2005).

To illustrate the interrelation between emotion, the self, and episodic memory in dissociative amnesia we present two recent cases that we have studied. Both cases highlight environmental and emotional influences on mnestic functions and point to an identity-protecting block of self-endangering memories. Their behaviour with respect to changes in identity, self-reflection, and emotional expression corresponds to what Janet (1907) termed the state of "belle indifference" (cf. Brand & Markowitsch, 2009). While one patient's dissociative amnesia includes the entire autobiographical and most of her semantic memories (patient DF) the other patient's amnesia comprises only the last 14 years of her autobiography (patient BC). Firstly, we sketch the patient's history for a better understanding of the protective function of the dissociative amnesia (Markowitsch, 1999) followed by a presentation of their neuropsychological profile.

1.1.1. Case 1: 32-year-old female patient BC

In this patient, the dissociative amnesia only comprised approximately the last 14 years of her autobiography. At the time point of amnesia onset the patient was hospitalized in a psychiatric clinic for the treatment of her severe depressive pathology and suicidal tendencies. One evening BC was found unconsciously by a nurse on a hallway floor. She did not react when being approached by her name. Instead she claimed to be called by her maiden name. Asked for the current date, she stated a date in the early 1990s of the last century. A subsequent extensive neurological investigation and structural brain imaging via MRI (with contrast material) revealed no abnormalities.

We investigated BC with an extensive neuropsychological test battery about one month after the onset of her amnesia when she was still hospitalized. Her amnesia comprised the time until the age of 18 years when she finished school and had a relationship with her first love. When she first looked in a mirror after her fainting she was shocked since she assumed to be 18 and not 32 years old. The patient described her abilities to remember events from her non-amnesic time as clear and vivid with a feeling of "normal" remembering. She described her parents as being strict but fair and her education based on high moral beliefs (e.g., with respect to punctuality, honesty, and justice). She was able to recall semantic and personal facts as well as specific events from that time period. BC stated that all information concerning her life after 1989 was newly learned. She reports that she started an apprenticeship at the "Deutsche Bahn" (German Railways) where she met her later husband. In her marriage she experienced physical abuse from her choleric husband. Their son was diagnosed with Asperger Syndrome but due to the patient's high commitment he was able to attend a regular school. According to her medical report, BC arranged her life around her son's needs and put much effort in his integration. The marriage was divorced after 9 years and BC got back to her first love with whom she is happily married until now. Some weeks before her hospitalization, BC's son showed massive behavioural problems so that it was suggested to send him to a stationary facility or specialized school. The patient reacted with a high sense of guilt and failure that summed up to her depressive and suicidal symptoms leading to her commitment to a psychiatric hospital. All information was confirmed by the patient's husband.

Noteworthy, BC's depressive symptoms vanished shortly after the onset of her amnesia, instead she seemed emotionally flattened (cf. Markowitsch, 2000b). Nevertheless, her symptoms reappeared about two weeks later which was mainly related to great concerns about the future of her son.

1.1.2. Case 2: 29 years old female patient DF

DF grew up in the former German Democratic Republic (GDR). In 2004 she went on a study trip to China. The tight program was very exhausting for the travelling group. One night, after a joint evening event, DF was found unconsciously and undressed in a public bath of the hotel. Except for a small bump on the forehead there were no signs of bodily harm. She was brought to a hospital where neither structural brain lesions (CT) nor further neurological abnormalities could be observed. No signs of any drug, poison or hypnotic influence were found. After her awakening the patient was unable to recall her name, home address or any other detail or event from her autobiography. She was reassured that her memories would recover when she gets back to her family and home town; so she finished the trip. In the following two weeks she was able to normally acquire new information and to build up new episodic memories. After her return she was hospitalized again, but subsequent structural (MRI) and functional (FDG-PET) brain imaging showed no pathological changes either. Moreover, even in her familiar environment DF's amnesia remained. She did not recognize anyone (parents, friends, and colleagues) nor had she any feeling of being home.

We visited the patient about five months after the critical incident and administered a broad neuropsychological test battery. At that time, the patient had already been in psychological and hypnotic therapy for two months with no success. Nonetheless, the

treatment was continued to ease the patient's reintegration in her former life.

Her medical history revealed that DF suffered from idiopathic neuropathy which led to pain in her muscles and a progressive loss of strength in her right leg. At the time point of the assessment, the patient had strong feelings of guilt towards her parents. She knew that she had to love and feel close to them instead of feeling strange and being unable to rely on shared memories. During the assessment and in talks with the patient's psychotherapist, DF's high moral and ethic standards became obvious accounting for her strong feelings of guilt. Since she was able to acquire and store new information and events, DF was able to build up a new identity and this enabled her reintegration. She also started a new relationship.

About 10 months after the onset of her amnesia DF attended a slaughter at her partner's farm. When she felt the blood on her fingers she showed strong signs of dissociation. After being hospitalized for a couple of days processing of the traumatizing events were supported by her therapist. DF was able to recall what happened at the critical night in China. She reported that she witnessed a homicide. Just when DF wanted to help the victim she heard steps behind her so she fearfully ran away. Everything that happened afterwards is still blocked. Until today, the patient has strong feelings of guilt that she did not intervene or helped so she still keeps this particular memory away from friends and family. Next to the traumatic memory further portions of her autobiography became re-available although a number is still blocked.

2. Methods

Both patients were investigated with various standardized neuropsychological tests. They are described below. Besides an evaluation of the patient's intellectual abilities with the German version of the *Wechsler Adult Intelligence Scale* (HAWIE-R Tewes, 1991) the administered tests focused on anterograde memory and executive functions. The subtest *digit span* of the German version of the *Wechsler Adult Intelligence Scale–Revised* (Tewes, 1991) was used to assess numeric short-term memory (forward) and numeric working memory (backward). The delayed recall of the Complex Figure Test (Rey-Osterrieth-Figure, Osterrieth, 1944) served to estimate the patient's figural long-term memory. For the assessment of verbal memory we applied the German adaptation of the *California Verbal Learning Test* (CVLT, Niemann et al., 2008). The CVLT comprises a list of 16 words that is presented five times consecutively. The CVLT gives information about the patient's verbal short-term memory (number of words recalled after the first presentation), learning abilities (sum of words remembered throughout the five trials) and verbal long-term memory (number of words recalled after a delayed period of approximately 30 min).

Executive functions were assessed with the Concentration Endurance Test d2, Trail-Making-Test A + B, controlled oral word association test (FAS) and a modified version of the Wisconsin Card Sorting Test. The Concentration Endurance Test d2 (Brickenkamp, 1994) is a speeded letter cancellation task to assess sustained attention and visual scanning abilities. Part A of the Trail-Making-Test was used for the evaluation of speed of attention, as well as for visual search and motor functions, while part B estimated the patient's ability of mental flexibility and sequencing (Tombaugh, 2004). Spontaneous production of words beginning with a given letter within a limited amount of time was measured by the controlled oral word association test (Spreen & Strauss, 1991). The modified version of the Wisconsin Card Sorting Test is supposed to assess the ability to form abstract concepts, to shift and maintain set, and utilize feedback (norms by Lineweaver, Bondi, Thomas, & Salmon, 1999; see also Nelson, 1976).

For the assessment of autobiographical-episodic memories we used the autobiographical memory inventory (Autobiographisches Gedächtnis-Inventar AGI, abstract in: Fast, Fujiwara, & Markowitsch, 2001; built on the basis of the Autobiographical Memory Interview of Kopelman, Wilson, & Baddeley, 1990). This semi-structured interview was used to rate the patient's ability to retrieve autobiographical-semantic and autobiographical-episodic memories for different life-periods (childhood, elementary school, adolescence, early adulthood, and recent events). For each life-period, patients are first asked for facts like date and place of birth, street addresses of the nursery or elementary school to assess autobiographical-semantic memory. Subsequently, patients are asked to remember two specific events for each life-period and rate attributes, e.g., context, vividness, and emotionality of the memory to quantify the patient's autobiographical-episodic memory ability.

Psychiatric symptoms and personality were evaluated with standardized questionnaires. Depressive symptoms were evaluated with the Beck Depression Inventory (BDI, Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The BDI raw scores enable a classification into no, mild or moderate, and severe depressive pathology. Psychological stress and psychiatric symptoms were assessed by the Symptom-Check-List (SCL-90-R, Franke, 2002) comprising nine different scales: somatization, obsession-compulsion, interpersonal sensitivity, depression, anxiety, anger-hostility, phobic anxiety, paranoid ideation, and psychoticism. A global severity index (GSI), derived from all subscales, describes the general psychological stress

Table 1
Neuropsychological profile of the two presented cases.

	Max	BC		DF	
		RS[a]	P[b]	RS[a]	P[b]
Intelligence					
Wechsler Adult Intelligence Scale—revised					
IQ		114	84	101	54
Anterograde memory					
Digit span					
Forward	12	5	5[d]	5	5[d]
Reverse	12	7	56	5	17
Complex Figure Test					
Copy	36	36	99	36	99
Delayed free recall	36	21	60–71	27	82–93
California-Verbal-Learning Test—German Adaptation					
Short-term memory (Trial 1)	16	9	71	7	43
Learning abilities	80	57	49	59	54
Delayed free recall	16	12	33	16	92
Executive functions					
Concentration endurance test (d2)					
Total-errors		324	27.4	469	94.5
Trail-Making-Test A					
sec.[c]		20	65	18	75
Trail-Making-Test B					
sec.[c]		55	35	74	≤10[d]
Controlled oral word association (FAS) Test					
Total		36	30	53	85
Modified Card Sorting Test (MCST)					
Perseveration		2	50	0	>70

[a] RS, raw score.
[b] P, percentile.
[c] Sec, seconds.
[d] Below average.

Table 2
Results of the autobiographical memory inventory separated for autobiographical-semantic and autobiographical-episodic information in both patients.

	Preschool	Elementary school	Secondary school	Early adulthood
BC				
Autobiographical-semantic information	++	++	++	–
Autobiographical-episodic information				
Emotional colouring	++ (negative)	++ (negative)	++ (negative)	–
Temporal and spatial context	++	++	++	–
Vividness	+	+	+	–
DF				
Autobiographical-semantic information	+	–	–	
Autobiographical-episodic information				
Emotional colouring	–	–	–	n/a
Temporal and spatial context	+	+	–	n/a
vividness	++	+ +	–	n/a

++, full information;+, fractional information; –, no information; n/a, not applicable.

level. The self-rating personality inventory (Freiburger Persönlichkeitsinventar (FPI), Fahrenberg, Hampel, & Selg, 2001) assesses personality on 12 dimensions. These include: life satisfaction, social orientation, achievement motivation, inhibition, excitability, openness, extraversion, neuroticism, aggressiveness, stress, physical complaints, and worries about health. The subscale 'openness' works as a validity scale. Low results (standard scores one to three) indicate socially desirable response tendencies, with the consequence that interpretation of all other responses becomes limited (Fahrenberg et al., 2001).

3. Results

Both patients showed a mainly unimpaired neuropsychological profile (see Table 1 for individual scores) as assessed with the applied tests. Their intellectual abilities were average and their abilities to store new information (verbal or figural) short- and long-term were unaffected, except for numeric short-term memory which was below average in both patients. However, their executive and attentional functions were unimpaired (despite DF's below average performance in Part B of the Trail-Making-Test).

In accordance with their diagnosis of dissociative amnesia, both patients were unable to remember any event from their individual amnesic time period. DF was only able to recall two tiny episodic fragments from two life time periods which she described as 'flashes of memories'. These fragments lacked any emotional colouring, had only little spatial but no temporal context but were of great vividness. Only with the help of her parents she was able to put the 'events' into a larger context. In contrast, BC could recall facts and specific events from her life until early adulthood. She knew autobiographical-semantic facts from her childhood, her time in elementary school, and adolescence. For each of the three periods she remembered at least two specific events. BC was able to state contextual details like exact place and time of the year, to build up a vivid mental image as well as to report her emotions and emotions of others for every recalled event. Her amnesic period starts around the age of 18–20 years. To that point of her life, BC met her first husband during her apprenticeship and her autistic son was born. For the following years she was able to recall neither autobiographical-semantic facts nor autobiographical-episodic events. Though being able to recite some newly learned facts, BC failed to recall any specific event like her marriage to her first but also that to her second husband, birth of her single child or why she was hospitalized. Table 2 gives more detailed information about both patients' performance in the autobiographical memory inventory separately for autobiographical-semantic information and autobiographical-episodic memories. The quality of each event is rated for its emotional colouring, temporal and contextual context as well as its vividness. Please note, that all of the remembered events of patient BC were negatively coloured, potentially reflecting her current but also premorbid depressive pathology (Lemogne et al., 2006).

The administered psychiatric questionnaire revealed the following psychiatric profile. Both patients scored high (raw scores: BC = 30; DF = 18) in the Beck Depression Inventory (BDI) indicating severe depressive pathology (Beck, Steer, & Hautzinger, 1995). Similarly, both patients scored above average (T-score > 60) in all assessed subscales of the Symptom-Check-List (Franke, 2002) as well as for their individual psychological stress level as judged by the global severity index (GSI, BC: T-score = 80; DF: T-score = 80). In the personality inventory, BC showed a tendency to be dissatisfied with her life, to feel insecure and stressed but not worried about her health. She described herself as introverted, reserved, emotionally unstable and frightened. DF's profile was quite similar. She also stated to be dissatisfied with her life and less concerned about her health. Additionally, she characterized herself as controlled, reserved and oriented to social norms (standard score 3), so the interpretation of her answers is limited. In sum, both patients revealed a profile indicating depressive pathology and emotional weakness (neuroticism).

4. Discussion

Two cases with dissociative amnesia were reported. In both female patients there was no structural brain pathology detectable. Their neuropsychological profile revealed no remarkable impairments in anterograde memory or executive functions and attention. This result is in conformity with that found in other patients with dissociative amnesia (Markowitsch, Calabrese et al., 1997; Markowitsch, Fink, Thöne, Kessler, & Heiss, 1997; Markowitsch et al., 2000; Markowitsch, Thiel, Kessler, von Stockhausen, & Heiss, 1997) but in contrast to results obtained in a few other patients with dissociative (psychogenic) amnesia, e.g., patient FF of Glisky et al. (2004) who demonstrated executive dysfunctions and reduced activation of frontal brain regions. Cases described by Fujiwara et al. (2008) also exhibited deficits in executive functions and attention. They found three of four patients impaired in set shifting and cognitive flexibility. The authors suggest that these functions contribute to remote memory deficits as proposed by the model of Kopelman (2000). An alternative explanation for unimpaired executive functions but dysfunctional episodic memory recollection give the results of Anderson et al. (2004) who revealed prefrontal activations associated with a suppression of unwanted memories. This argumentation is in line with our assumption of a self-protecting mechanism underlying the blockade of episodic memories and might also account for the extension to the semantic components of autobiographical memory. Further un-emotional and not self-related memories from the amnesic time might also be suppressed as also seen in other cases of patients with probable psychogenic amnesia (e.g., patient BC of Serra, Fadda, Buccione, Caltagirone, & Carlesimo, 2007).

Our patients' performance in the autobiographical memory inventory was concordant with their diagnosis of dissociative amnesia as well as with their subjective complaints. Although DF

was able to repeat newly learned information about personal facts like home address or name of friends or family, she was unable to remember any single event from her life. Even confrontation with shared memories that were told to her for example by her parents or looking at family pictures triggered neither memories nor any feelings of familiarity. Instead, it made her feel inadequate and guilty. DF stated that she felt uncomfortable and like a stranger at home. Thus she felt bad for her parents because she knew she had to love and feel close to them. The fragments remembered by DF were vivid like flashbacks reported by patients with posttraumatic stress disorder but lacked any emotional colouring and contextual information. Therefore, her reports are not interpreted as episodic remembering. BC's performance in the autobiographical memory inventory reflected a temporal gradient in her dissociative amnesia. For the first 18–20 years of her life, BC showed no abnormalities in remembering specific episodes from this time. She recalled names of friends and her home address as well as two specific events for each period. Remembrance of a single event was accompanied by contextual details and her emotions as well as those of others. BC also reported that remembering events from her adolescence felt like these things just happened recently and not almost 15 years ago. However, when asked even for events that are usually highly emotionally coloured, but occurred after 1989, e.g., meeting her first husband or the birth of her son, she stated to remember nothing. Noteworthy, when she first met her husband after the critical incident, she immediately felt close to him since at the time of her amnesia onset they had still been together—a finding corresponding to the existence of the perceptual and the priming memory systems. In contrast, but according to her amnesic time-frame, seeing her son after her amnesia onset elicited no feeling of closeness or familiarity. Her husband stated that she reacted very protectively and that her thoughts are again strongly focused on her son's well-being.

The patients' results in the administered psychiatric and personality inventories are well in line with other reports of patients with dissociative amnesia (Fujiwara et al., 2008; Kritchevsky, Chang, & Squire, 2004) indicating current psychiatric symptoms as well as a psychiatric history that is often characterized by traumatic events in the childhood and/or currently stressful environments in most of the presented cases. Fujiwara and colleagues also found evidence for a repressive personality style in their patients. Since we administered all tests including the psychiatric and personality inventories weeks after the initiating event it is impossible to distinguish premorbid psychiatric pathology from psychiatric symptoms as a result from the patients' dissociative amnesia. Nevertheless, at the time point of amnesia onset BC was hospitalized due to her severe depressive pathology indicating a significant premorbid psychiatric history for this patient.

To sum up, both patients showed widely impaired retrograde memory functions while anterograde memory and further cognitive functions were mostly unimpaired. Although this pattern can also be observed in organic retrograde amnesia (Kopelman, 2002), we favour the diagnosis of psychogenic (dissociative) retrograde amnesia for a couple of reasons. First, there was no organic causation related to their amnesia onset and there were no signs of any structural brain damage in both patients that would account for the observed retrograde amnesia. Second, we found evidence in the patients' current and previous personal background that are comparable to earlier reports of patients with dissociative amnesia (Brandt & van Gorp, 2006; Kritchevsky et al., 2004). Most of the patients experienced one or more severely stressful life events. Although in patient BC there is no single event related to her amnesia onset, her current personal background was characterized by high psychological distress and high worries about her son triggered by his relapse. In patient DF her amnesia also comprised the triggering event and we were unable to reconstruct what had happened. About a year later, similar sensory stimuli (warm blood on her hands and arms) elicited the recall of the triggering event. It showed clear characteristics of a traumatic and highly stressful incident (e.g., violence and life threatening circumstances). The re-experiencing via similar sensory stimuli enabled DF to regain further access to formerly blocked information. Such sudden and broad rehabilitation is very unusual for amnesias with organic aetiology but fits well in the concept of the mnestic block syndrome. The term was introduced by Markowitsch (1998) and accounts for the phenomenon that irretrievable autobiographical memories are blocked instead of lost. The case of DF is similar to that of AMN, a patient described by Markowitsch, Kessler, Van der Ven, Weber-Luxenburger, and Heiss (1998) and Markowitsch et al. (2000). After being re-exposed to a stressor reminding AMN of a very stressful and traumatic event from his childhood AMN showed impaired cognitive function, in particular an inability to retrieve autobiographical information from the last 6 years of his life. This was accompanied by a grossly reduced brain metabolism. Through therapeutic interventions (pharmacology and psychotherapy) AMN was able to largely regain his cognitive and mnestic functions. This was accompanied by a normalized brain metabolism as objectified by FDG-PET.

Although both of the presented cases differed in the length of their amnesic time period, we argue that there is a shared background in the psychological function of their dissociative amnesia. We argue that in patients with dissociative amnesia, the disintegration of traumatic memories, as observed in PTSD, has a self or identity-protecting function. Based on a model introduced by Fujiwara and Markowitsch (2003) (modified by Reinhold & Markowitsch, 2007b), we assume that in dissociative amnesia the blocking of memory retrieval has an identity-protecting function by keeping the individual able to interact with his or her environment. Both of our patients described themselves as having high moral standards and beliefs. The onset of their retrograde amnesia was coupled with the confrontation of personal failure. BC attributed the recent relapse of her son as her personal shortcoming and DF had high feelings of guilt that she failed to prevent the observed homicide. Thus, both patients' behaviour mismatched their high standards and therefore constituted a threat for their identity or self-concept leading to a blockade of such self-endangering memories.

Admittedly, some of the above mentioned arguments may also account for organically caused retrograde amnesia. Therefore, we provided a chart comparing both aetiologies of retrograde amnesia on several dimensions (see Table 3). Information was gathered from various case reports from patients with psychogenically caused retrograde amnesia (e.g., Fujiwara et al., 2008; Kritchevsky et al., 2004; Markowitsch, Fink, Thöne, Kessler, & Heiss, 1997; Markowitsch et al., 2000) and from patients with organically caused retrograde amnesia (cf., Brandt & van Gorp, 2006; Calabrese et al., 1996; Kopelman, 2002; Kopelman & Kapur, 2001; Kroll, Markowitsch, Knight, & von Cramon, 1997; Markowitsch et al., 1993; Markowitsch & Ewald, 1997). Depending on the damaged brain region, organic, compared to psychogenic, retrograde amnesia is a more variable condition. Patients with right-hemispheric temporo-frontal damage behave quite similar to patients with psychogenic amnesia (Calabrese et al., 1996; Kapur, Ellison, Smith, McLellan, & Burrows, 1992; Kroll et al., 1997; Markowitsch et al., 1993; Markowitsch & Ewald, 1997). Patients with damage to diencephalic structures are more variable, in particular they seem to have partially preserved retrograde memories, either surrounding a topic ("landmark") (Hodges & McCarthy, 1993) or with reference to childhood and youth (following Ribot's gradient) (Markowitsch et al., 1993). However, there are arguments that at least some of the temporo-frontal patients may have shown psychogenic signs as well.

Table 3
Similarities and differences between organic and psychogenic causes of retrograde amnesia.

	Organically caused isolated retrograde amnesia	Psychogenically caused isolated retrograde amnesia
Initiating event	Severe pathological event (stroke, trauma, etc.) Possibility of accompanying psychiatric symptoms (personality disorder)	(often) Mild head trauma Precipitating stress Possibility of accompanying psychiatric symptoms (personality disorder)
Brain alteration		
Structural	Bilateral brain damage in various regions, with a preponderance of right-hemispheric damage; most frequently in both temporopolar and inferolateral prefrontal areas	No (or just minor) structural brain alteration
Functional		Reduced brain metabolism, primarily in right inferolateral prefrontal regions and anterior temporal regions
Congruence of brain damage and severity of memory disorder	More likely given	Usually not given
Clinical appearance	Frequently no loss of self-identity knowledge (or at least fast recovery after onset) Insecure personality	Loss of self-identity knowledge Belle indifference Insecure personality and possibility of further psychiatric signs
Psychopathology	Usually no evidence of psychiatric disease or personality disorder	Possibility of premorbid psychiatric history or of subtle personality disorder
Neuropsychological profile		
Functions other than retrograde autobiographic memory	Intellectual functions partially disturbed, but large variance	Intellectual functions sometimes partially or temporarily disturbed, but frequently largely preserved
Retrograde autobiographic memory	Sometimes negative temporal gradient of retrograde autobiographical amnesia, sometimes total loss	Frequently homogeneous loss of retrograde autobiographical memory, sometimes just for certain life epochs or events

Additionally we incorporated papers discussing differences and commonalities of organically and psychogenically caused retrograde amnesias (Kopelman, 1987; Markowitsch, 1996a, 1996b, 2008; Reinhold et al., 2006; Serra et al., 2007). Most of these papers emphasise that the same mechanisms potentially underlie both forms of retrograde amnesia leading to a blockade or disruption of the access to stored information. As a further consequence the decoupling of emotion, self, and autobiographical memory may contribute to retrograde amnesia (Reinhold & Markowitsch, 2007b) and to a condition described as "belle indifference" (Brand & Markowitsch, 2009; Janet, 1907; cf. Table 3). A recent case report by Reinhold and Markowitsch (2007a) also highlights the importance of autobiographical-episodic memory retrieval for the regulation of emotion thus supporting the hypothesis of strong binding mechanism of the self, emotion and autobiographical memory (Fujiwara & Markowitsch, 2006). These interrelations can also be seen in overlapping neural networks comprising different brain regions specialized either for cognitive or for emotional processes and their connecting fibres. Through their high degree of connectivity the latter are central for combining and integrating of information among different brain regions (Pessoa, 2008).

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