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RESEARCH ARTICLE

Autobiographical memory impairment in chronic schizophrenia: Significance and clinical correlates

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Abstract

Previous studies of autobiographical memory (AM) in schizophrenia yielded a reduction of specificity, richness of details and conscious recollection, which indicate both, quantitative and qualitative AM changes. However, their associations with psychopathological symptoms and neuropsychological deficits were not resolved. Therefore, we sought to investigate AM with respect to psychopathology and neuropsychology in patients with chronic schizophrenia to rule out the influence of different courses of the disease. AM of four lifetime periods was examined in 75 patients and 50 healthy controls by using a semi-structured interview. The recalled episodes were rated for memory specificity. Subsequently, one single event of each period of life was rated for details and experiential aspects of reliving (originality, vividness/visual imagery, emotional re-experiencing and emotional valence). When contrasted with healthy controls, patients recalled a significantly reduced number of episodes and personal semantic facts; moreover, memory specificity of AM was significantly lower in patients than controls. While the richness of details calculated for single events showed only minor, non-significant group differences, vividness and emotional re-experiencing were significantly less pronounced in the patient group. Along with this, AM performance correlated significantly with negative symptoms including apathy as well as verbal memory and

executive functions. Our results underline the significance of overgenerality as a key feature of AM in schizophrenia as well as a dissociation between intact number of details of single events and reduced vividness and emotional re-experiencing. The extent of negative symptoms including apathy and impairments of verbal memory/executive functions may explain AM deficits in chronic schizophrenia.

KEYWORDS
autobiographical memory, executive functions, memory specificity, negative symptoms, overgenerality, schizophrenia

INTRODUCTION

Autobiographical memory (AM) refers a to late-developing and early-deteriorating memory system, characterized by a sense of subjective time, autonoetic consciousness and emotional re-experiencing (Tulving, 2002). AM includes both, personal episodic and semantic memories: The former refers to personal events (*e.g.* 'my first day at university'), while the latter comprises biographical facts (*e.g.* 'where I went to university'). The ability to recall AM is considered to be essential for processes like planning of actions, problem-solving and future thinking as directive functions. Self-related functions comprise the development of self-continuity, self-coherence and emotion-regulation, while social functions refer to begin/maintenance of social relationships, empathy and knowledge transfer (Bluck, 2003; Conway & Pleydell-Pearce, 2000; Wilson & Ross, 2003). Thus, besides the severity of psychopathology and disorder-related brain changes, the variety of deficits and impairments described in schizophrenia may be related to AM alterations.

Berna et al. (2016) discussed in a meta-analysis the results of 20 studies on AM deficits in schizophrenia (N = 571 patients with schizophrenia spectrum disorder and N = 503 healthy controls). Despite methodological differences between studies, the authors identified three main parameters of AM dysfunction in this patient group: specificity, details (perceptual-sensoric, contextual or emotional) and conscious recollection. Concerning the first two parameters, high effect sizes (−.97/−1.40 Hedges g) were described, while a moderate effect size was reported for conscious recollection (g = −.62). Significant effects of potential confounders such as age, duration of illness, sex, IQ, level of education or symptoms of illness/depressive symptoms were not confirmed. That patients with schizophrenia have an impaired access to specific and detailed autobiographical memories and problems in vividly reliving these events can therefore be considered as a robust finding. This is underlined by the respective effect sizes, which are in the same range as those found for other mnestic domains (Aleman et al., 1999; Reichenberg & Harvey, 2007; Schaefer et al., 2013). In addition, these results indicate that memory deficits in schizophrenia go beyond a reduced retrieval capacity of previously learned items in a laboratory setting (Berna et al., 2016). They rather extend to memories that contain emotional, self-related, subjective and more remote information than materials presented in episodic memory tasks in a standardized environment (Gilboa, 2004; Wheeler et al., 1997). Moreover, the finding of pronounced AM deficits in schizophrenia receives further importance by the fact that impairments in this cognitive domain are better predictors of patients' social performance than clinical symptoms and other neurocognitive deficits (Mehl et al., 2010). These findings were confirmed and extended in another review (Ricarte et al., 2017). There is additional evidence of impairments in contents of AM as assessed by self-defining memories, which refer to components of AM that may underlie the altered sense of self in schizophrenia (Bennouna-Greene

et al., 2012; Conway, 2005; Cuervo-Lombard et al., 2007; Raffard et al., 2010). More recently, Zhang et al. (2019) reviewed 57 studies on AM in patients with schizophrenia spectrum disorders. In addition to less specific AM, patients showed an earlier reminiscence bump than healthy controls. This can be referred to a dysfunctional processing of events due to the manifestation of the disease in early adulthood. However, patients could benefit and improve their AM through cognitive training.

Besides AM deficits in schizophrenia, which mainly refer to reduced specificity, details and conscious recollection, distinct impairments of AM have also been reported with respect to depression or depressive symptoms. Research showed that the way of remembering one's own past—that is, in specific or more general ways—has important implications for psychological functioning (Sumner, 2012). Firstly described in 1986 in a study with people who had recently attempted suicide, overgeneral AM refers to the finding that, when asked for a specific AM subjects recall less specific and/or more overgeneral memories (Williams & Broadbent, 1986). Thus, overgeneral memory is defined as the recall of categoric (*i.e.* repeated events, 'all my summer holidays with my parents') or extended memories (*i.e.* referring to an extended period of time/longer than a day, 'my first semester in Heidelberg') instead of specific and detailed memories (Williams et al., 2007).

Based on the model of AM by Conway and Pleydell-Pearce (2000), Williams et al. (2007) developed the CaR-FA-X model, whose mechanisms—alone or in combination—can be used to explain the phenomenon of overgeneral AM in affective disorders (for revisions see Sumner, 2012). (1) Processes of capture and rumination (CaR) mean self-related repetitive and passive thinking is activated by information used during retrieval and therefore for example cues are not elaborated adequately. This may limit the cognitive resources that are required for the construction of specific AM. (2) Functional avoidance (FA) occurs when episodic material is perceived as threatening and results in affective distress. Therefore, recollection of rather general information instead of specific AM is used to reduce emotional disturbance. (3) Reduced executive capacity (X) leads to retrieval problems of specific AM by limiting the usage of successful search strategies.

Originally created to explain overgeneral AM in affective disorders, the mechanisms of this model may also be applied to AM overgenerality in patients with schizophrenia. Therefore, our results are discussed within the scope of the CaR-FA-X model.

As potential associations between AM deficits and psychopathological symptoms and cognitive impairments are yet unresolved, we focused on chronically ill patients. Given persisting deficits and a chronic course of the disorder, influences of different courses with changes in psychopathology and/or cognition can be diminished. AM bears important functions for constituting and maintaining the self; therefore, one may expect to find its deficits to be correlated with psychopathological symptoms, in particular negative symptoms. Moreover, as AM represents the most complex form of human memory (Tulving, 2002), correlations with a variety of neuropsychological parameters can be expected.

MATERIAL AND METHODS

Study design and participants

Seventy-five patients with DSM-IV chronic schizophrenia were recruited among the inpatients treated at the Department of Psychiatry at the University of H. and the residential care St. Thomas, H. Psychopathological symptoms were rated on the Scale for the Assessment of Positive and Negative Symptoms[1] (SAPS, SANS, Andreasen, 1984a; Andreasen, 1984b), the Brief Psychiatric Rating Scale[2] (BPRS, Overall & Gorham, 1962) and the Apathy Evaluation Scale (AES, Lueken et al., 2006; Marin et al., 1991), respectively.

[1]SAPS: 4 symptom scales (hallucinations, delusions, bizarre behaviour and positive formal thought disorder). SANS: 5 symptom scales (affective flattening or blunting, alogia, avolition–apathy, anhedonia–asociality and attention)

[2]BPRS: 5 subscales: anxiety/depression, anergia, thought disturbance, activity and hostility/suspiciousness

TABLE 1 Demographic characteristics of patients and healthy controls

	Patients ($n = 75$)	Controls ($n = 50$)	Main effects, F-values$_{[df]}/\chi^2$-values, effect size η^2/φ
Age (years)	49.89 (11.88)	52.30 (11.02)	$F_{[1123]} = 1.304$; $p = .256$; $\eta^2 = .010$
Sex (m/f), N	44/31	25/25	$\chi^2 = .911$; $p = .364$; $\varphi = .340$
Education (years)	12.55 (2.74)	13.58 (2.23)	$F_{[1123]} = 4.939$; $p = .028$; $\eta^2 = .039$

Note: Data are means (standard deviations), unless otherwise indicated.

Diagnoses were established according to DSM-IV criteria (Saß et al., 2003) by two experienced psychiatrists on basis of clinical findings, patients' history and retrospective chart review. All patients were clinically stable without recent changes in medication. Exclusion criteria were any evidence of organic mental illness or mental impairment, alcohol or drug abuse (DSM-IV criteria), history of brain injury and current severe physical illness.

The comparison group consisted of 50 healthy subjects, who were recruited via local advertisements and among hospital staff. They were screened for mental illness by using the Mini International Neuropsychiatric Interview (MINI, Lecrubier et al., 1998, Sheehan et al., 1998). Diagnostic groups were closely matched with respect to age and sex. As to be expected controls had undergone a longer time of school education ($p = .03$), given a minimal duration of education of 8 years in both groups (Table 1).

The ethics committee of the Medical Faculty/H. University approved the study. All subjects gave written informed consent after full explanation of the study procedure in accordance with the Declaration of Helsinki.

Assessment of autobiographical memory and additional neuropsychology

AM was tested with a semi-structured autobiographical interview (Erweitertes Autobiografisches Gedächtnisinventar, E-AGI; Fast et al., 2007) adapted from Kopelman et al. (1990, Autobiographical Memory Interview) and Levine (2002, Autobiographical Interview) incorporating non-restrictive categories across the lifespan from preschool (up to 6 years of age), to primary school (from 6 to 11 years of age) and to secondary school (from 11 years of age to school graduation). In addition, recent memory (last 5 years) was also addressed. To avoid interferences with the typical age of onset of schizophrenia (Rajji et al., 2009), we spared out the originally included period of early adulthood in this analysis. The control for delusional memories was guaranteed via consultation of staff members and review of patients' case notes and psychiatric reports. Psychometric properties of the semi-structured autobiographical interview (Cronbach's $\alpha = .572–.863$; interrater reliability: .954–.979) were established in previous studies of our group (Ahlsdorf, 2009; Frankenberg et al., 2021).

Subsequently, a detailed scoring system was applied to one single event (chosen by the participant) of each of the four life periods. A maximum of 11 points could be awarded for a single event on the details´ subscale (for more information see: Herold et al., 2013). Additionally, the same single event was rated for experiential aspects of reliving: originality (max. 3 points), vividness/visual imagery (max. 3 points), emotional re-experiencing (yes/no) and emotional valence (positive/negative). The total pool of memories analysed on the event details´ subscale and on the experiential subscale amounted to 186 single events in the patient group and 174 single events in the control group.

Additionally, a comprehensive neuropsychological test battery was used to examine verbal memory, short-term and working memory, information processing speed, executive functioning and verbal fluency, that is, domains typically involved in chronic schizophrenia. For cognitive screening, the Mini-Mental State Examination (MMSE) was applied (Folstein et al., 1975). The subtests logical memory I (immediate recall) and II (delayed recall) from the Wechsler memory scale-revised (WMS-R) were used to test verbal memory (Härting et al., 2000); the subtests digit span forward and backward from the WMS-R were applied to evaluate short-term and working memory; with Trail Making Test (TMT)

version A and B we assessed processing speed and executive functions (Reitan, 1992); a semantic verbal fluency task ('animals') completed the battery (Aschenbrenner et al., 2001).

Data sets of both groups were complete with respect to the AM parameters 'semantic, sum score', 'number of remembered episodes', 'specificity, sum score', all psychopathological variables as well as the neuropsychological domains examined. Missing data of AM refer to the patient group only and are due to reduced motivation and/or capacity of our participants with a chronic course of the disease (reduced *N* as indicated below the respective tables).

Statistical analyses

SPSS version 23 (IBM SPSS Statistics) was used for all statistical analyses. Demographic characteristics of patients and healthy controls were analysed by analysis of variance (ANOVA) or chi^2 test (variable 'sex'), respectively.

Group differences with respect to AM performance were calculated by multivariate ANOVAs. We compared AM performance between groups using the semantic sum scores (maximum score = 20: max. 5 points/period), the number of episodes (independent of their level of specificity, maximum score = 8 episodes: max. 2 per period), the specificity sum scores (maximum score = 24: max. 6 points/period) and the average details´ score per single event (maximum score = 11) as well as the experiential aspects of reliving: originality (max. 3 points), vividness/visual imagery (max. 3 points), emotional re-experiencing (quotient 'yes') and emotional valence (quotient 'negative'). Neuropsychological performance between groups was compared with multivariate ANOVA using the respective raw scores.

Pearson product–moment correlation coefficients were calculated to evaluate the relationships between AM performance and duration of illness and variables indicating the severity of psychopathology (SAPS, SANS, AES and BRPS) as well as neuropsychological performance parameters. Correlations (two-tailed) between AM and psychopathological symptoms or neuropsychology were in a second step corrected for multiple tests using Bonferroni correction, which resulted in a significance level of $p = .05/80 = .000625$ (psychopathology) and $p = .05/56 = .00089$ (neuropsychology).

In order to get a more thorough understanding of the components underlying AM deficits in schizophrenia, we additionally performed a hierarchical stepwise linear regression analysis. Age, years of education and sex were introduced in the model as covariates (method: enter). As predictors, we used the respective clinical (illness duration, CPZ equivalents, sum scores of SAPS, SANS, BPRS and AES) and neuropsychological variables (logical memory I and II, digit span forward and backward, TMT A and B, verbal fluency).

RESULTS

The clinical characteristics of our patient sample are summarized in Table 2. Patients were severely disabled as indicated by a mean duration of illness of more than two decades, with about 50% living hospitalized.

Autobiographical memory in schizophrenia

While 77% of the episodes remembered by the healthy controls were single events with accessible event-specific knowledge, this value was remarkably lower in the patients with 56% only ($F_{[1;\,123]} = 22.821$, $p < .001$, partial $\eta^2 = .157$). In contrast, episodes recalled by patients more frequently referred to general events ($F_{[1;\,123]} = 14.442$, $p < .001$, partial $\eta^2 = .105$) or—at the lowest specificity level—lifetime periods ($F_{[1;\,123]} = 6.098$, $p = .015$, partial $\eta^2 = .047$) (see Figure 1).

TABLE 2 Clinical characteristics of the patient sample

	Patients (n = 75)
Onset age (years)	26.91 (9.30)
Illness duration (years)	22.99 (13.55)
Inpatient/Psychiatric long-term unit, *N* (%)	40 (53.3)/35 (46.7)
CPZ equivalents (mg)	665.27 (670.77)
antipsychotic medication, *N* (no medication/AT/T/AT+T)	6/34/8/27
additional benzodiazepines, *N*	7
SAPS, Sum Score	17.71 (15.70)
SANS, Sum Score	33.47 (21.98)
BPRS, Sum Score	38.72 (9.44)
BPRS—Anxiety/Depression	10.77 (4.95)
BPRS—Anergia	10.08 (4.69)
BPRS—Thought disturbance	8.33 (3.86)
BPRS—Activity	4.79 (2.15)
BPRS—Hostility/Suspiciousness	4.75 (2.56)
AES, Sum Score	27.58 (11.27)

Note: Data are means (standard deviations), unless otherwise indicated.

Abbreviations: AES, Apathy Evaluation Scale; AT, atypical antipsychotics; AT+T, atypical and typical antipsychotics; BPRS, Brief Psychiatric Rating Scale; CPZ, chlorpromazine; SANS, Scale for the Assessment of Negative Symptoms; SAPS, Scale for the Assessment of Positive Symptoms; T, typical antipsychotics.

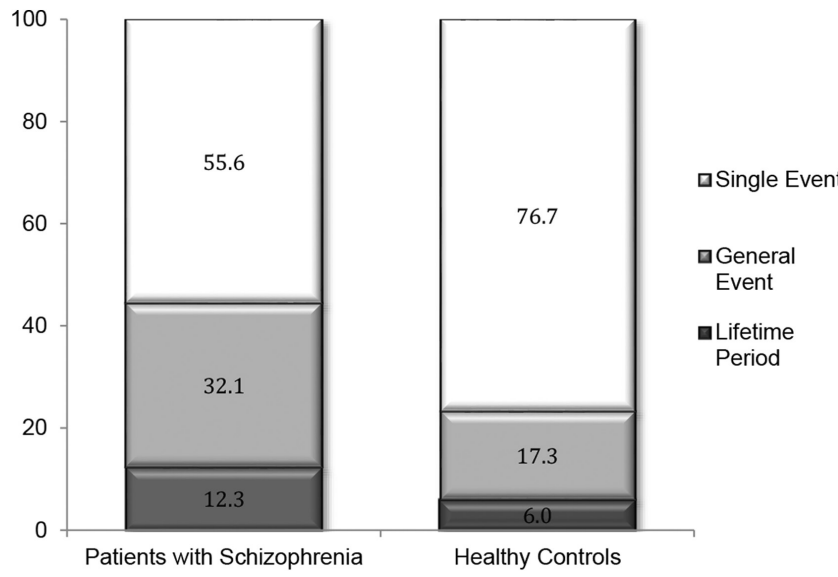

FIGURE 1 Specificity levels of the remembered episodes in %

Group comparisons yielded highly significant impairments of the patient group concerning number and specificity of remembered episodes (Table 3) with large effect sizes ($p < .001$). With respect to semantic autobiographical knowledge, we also found significantly reduced scores for the patient in comparison with the healthy control group ($p = .014$).

TABLE 3 Autobiographical memory in patients and healthy controls

	Patients	Controls	Main effects, F-values$_{[df]}$, effect size partial η^2
Semantic, sum score (max. 20)	17.76 (2.39)	18.76 (1.88)	$\mathbf{F_{[1123]} = 6.204*; \eta^2 = .048}$
Remembered episodes[a], N (max. 8)	6.19 (1.83)	7.68 (0.71)	$\mathbf{F_{[1123]} = 30.224***; \eta^2 = .197}$
Specificity, sum score (max. 24)	15.19 (5.70)	20.76 (3.14)	$\mathbf{F_{[1123]} = 39.654***; \eta^2 = .244}$
Details of single events (max. 11)	8.51 (1.71)	9.03 (1.67)	$F_{[1119]} = 2.732$; $\eta^2 = .022$
Originality of single events (max. 3)	2.55 (0.46)	2.41 (0.45)	$F_{[1119]} = 2.973$; $\eta^2 = .024$
Vividness/Visual imagery of single events (max. 3)	2.37 (0.59)	2.66 (0.54)	$\mathbf{F_{[1119]} = 7.226**; \eta^2 = .057}$
Emotionality of single events, quotient	0.67 (0.36)	0.89 (0.19)	$\mathbf{F_{[1119]} = 15.935***; \eta^2 = .118}$
Negative valence of single events, quotient	0.56 (0.39)	0.43 (0.34)	$F_{[1108]} = 3.253$; $\eta^2 = .029$

Note: Data are means (standard deviations).

Bold values indicates *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$ (two-tailed).

[a]Independent of their specificity level.

In contrast, the details´ score of the remembered single events and their originality differed not significantly between the groups ($p > .05$), while vividness/visual imagery ($p = .008$) and emotional re-experiencing ($p < .001$) of the reported single events were significantly reduced in the patient group. However, emotional valence showed only minor, non-significant differences between the groups ($p > .07$).

In contrast to the healthy control group, patients showed significant impairments in all neuropsychological tests applied with effect sizes up to $\eta^2 = .5$ (Table S1).

Autobiographical memory, psychopathology and neuropsychology

Pearson's correlations showed significant negative associations between AM scores and negative symptoms (SANS, AES, BPRS anergia). These results remained significant after Bonferroni correction for the AM scores 'number of remembered episodes' and 'specificity sum score' with $-.5 < r < -.6$ (Table 4). As a further step, we used the SANS subscores to calculate correlations between AM and more specific negative symptoms (Table S2). The results revealed significant negative associations between the AM scores 'number of remembered episodes' and 'specificity sum score' and the SANS subscores 'affective flattening', 'alogia', 'avolition/apathy' and 'attentional impairment' (Bonferroni corrected $p = .05/48 = .00104$).

As can be seen in Table 5 Pearson's correlations revealed significant associations between semantic and episodic parameters of AM and all neuropsychological domains. The strongest correlations remained significant after Bonferroni correction between 'number of remembered episodes/specificity sum score' and logical memory (verbal memory), digit span forward and backward (short-term and working memory), TMT A/B (processing speed/cognitive flexibility) and verbal fluency ($p \leq .001$). However, in the control group these associations were considerably weaker and failed to survive the Bonferroni correction (table: see supplement 3). Semantic and episodic AM was not significantly correlated with age in both groups ($p > .20$).

To identify predictors of AM deficits in schizophrenia, we calculated regression analyses for the specificity sum score as the most affected AM feature in our patient group (Table 6). These analyses identified beyond the variables age, education and sex (explaining 12.6% of the variance), negative symptoms (SANS and AES) and the neuropsychological tasks digit span forward and verbal fluency as significant predictors for AM specificity, which resulted in a model explaining 51.5% of the variance.

TABLE 4 Correlations between autobiographical memory scores and psychopathology

	DOI	SAPS	SANS	AES	BPRS	BPRS-*ANDP*	BPRS-*ANER*	BPRS-*THOT*	BPRS-*ACTV*	BPRS-*HOST*
Semantic, sum score[a]	−.19	−.01	**−.28***	**−.27***	−.16	−.01	**−.31****	.03	.04	−.07
Number of remembered episodes[a]	−.04	.05	**−.55*****	**−.55*****	−.21	.03	**−.55*****	.09	.03	.01
Specificity, sum score[a]	−.08	.04	**−.51*****	**−.51*****	−.15	.05	**−.51*****	.14	.03	.04
Details[b]	−.17	**−.25***	**−.25***	.03	**−.25***	−.13	−.23	−.20	**.24***	−.16
Originality[b]	−.08	−.08	.14	.22	−.01	−.10	.17	.03	**−.26***	.04
Vividness/Imagery[b]	.06	−.07	−.15	−.16	−.08	−.00	−.17	−.01	.03	−.00
Emotional re-experiencing[b]	−.01	−.06	−.02	−.23	−.16	.00	−.06	−.20	.19	**−.36****
Negative emotional valence[c]	.15	**.30***	−.15	−.02	.09	.24	−.18	.21	−.16	−.03

Abbreviations: AES, Apathy Evaluation Scale; BPRS, Brief Psychiatric Rating Scale (BPRS-ANDP, Anxiety/Depression, BPRS-ANER, Anergia, BPRS-THOT, Thought disturbance, BPRS-ACTV, Activity, BPRS-HOST, Hostility/Suspiciousness); DOI, duration of illness; SANS, Scale for the Assessment of Negative Symptoms; SAPS, Scale for the Assessment of Positive Symptoms.

Bold values indicates *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$ (two-tailed).

[a]$N = 75$.

[b]$N = 71$.

[c]$N = 60$.

TABLE 5 Correlations between autobiographical memory scores and neuropsychology in the patient group

	Logical Memory I	Logical Memory II	Digit Span forward	Digit Span backward	Trail Making Test A	Trail Making Test B	Verbal fluency, semantic
Semantic, sum score[a]	.215	**.249***	**.260***	**.301****	**−.256***	**−.283***	**.295****
Number of remembered episodes[a]	**.493*****	**.441*****	**.295****	**.487*****	**−.419*****	**−.362*****	**.569*****
Specificity, sum score[a]	**.521*****	**.492*****	**.369*****	**.505*****	**−.399*****	**−.382*****	**.552*****
Details[b]	.061	.038	−.066	.084	−.225	−.096	.132
Originality[b]	.078	.094	.143	−.026	.029	−.188	−.076
Vividness/Imagery[b]	.180	.161	**.246***	.214	.132	−.061	.164
Emotional re-experiencing[b]	−.025	−.056	−.052	.126	.081	.064	.035
Negative emotional valence[c]	.036	.023	−.140	−.021	.115	−.106	.081

Bold values indicates *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$ (two-tailed).

[a]$N = 75$.

[b]$N = 71$.

[c]$N = 60$.

DISCUSSION

The present study revealed these major results:

- Patients were significantly impaired in freely recalling autobiographical episodes, they generated less events, and their reported events were rather general in contrast to those of the healthy control group.
- Significantly reduced vividness and emotional re-experiencing were further characteristics of patients´ AM, while reported details differed not between patients and healthy controls.
- Especially episodic AM (number of episodes, specificity) was inversely associated with negative symptoms (SANS, AES, BPRS anergia), verbal memory and executive deficits.

Overgeneral AM in schizophrenia

In line with our results, Berna et al. (2016) described in their meta-analysis a large effect size of memory specificity. Together with a significantly reduced number of remembered episodes, our results underline the significance of overgenerality/unspecificity as a key feature of AM in schizophrenia.

Besides semantic AM, described as personal facts (*e.g.* names of classmates and former address), generalized memories of repeated ('my holidays in France each summer') or extended events ('my first semester at university') are considered as semantic AM (Levine et al., 2002; Piolino et al., 2006). Therefore, the effect of a reduction of AM specificity in schizophrenia can be interpreted as a process of semantization with less reported single events and more general events. This is reflected in our study by a significant difference in the proportion of specific and general events between patients and controls, with 77% of the episodes remembered of the healthy controls being single events in contrast to 56% in the patient group. In contrast, the patients´ episodes were more frequently scored as general event or—with the lowest level of specificity—as lifetime period.

The CaR-FA-X model of Williams et al. (2007) explains overgeneral AM in affective disorders by three different and interacting mechanisms (for revisions see Sumner, 2012): (1) Disruption of retrieval

TABLE 6 Results of regression analyses: patient group

Variable	Standardized Beta	*T*	*p*	R^2	$F_{[df]}$	R^2 Change	Sign. *F* Change
Specificity sum score							
Model 1				.126	$F_{[368]}$ = **4.419****	.163	.007
Age	−.028	−.245	.808				
Education	.404	3.629	<.001				
Sex	−.019	−.167	.868				
Model 2				.311	$F_{[167]}$ = **9.007*****	.187	<.001
Age	−.122	−1.182	.242				
Education	.245	2.325	.023				
Sex	−.100	−.978	.332				
SANS, sum score	−.482	−4.384	<.001				
Model 3				.382	$F_{[166]}$ = **9.762*****	.075	.004
Age	−.116	−1.185	.240				
Education	.112	1.024	.310				
Sex	−.206	−1.999	.050				
SANS, sum score	−.369	−3.332	.001				
AES, sum score	−.362	−2.943	.004				
Model 4				.477	$F_{[165]}$ = **11.795*****	.096	<.001
Age	−.131	−1.455	.151				
Education	−.088	−.765	.447				
Sex	−.279	−2.873	.005				
SANS, sum score	−.415	−4.041	<.001				
AES, sum score	−.392	−3.456	<.001				
Digit span forward	.362	3.612	<.001				
Model 5				.515	$F_{[164]}$ = **11.790*****	.042	.016
Age	−.046	−.491	.625				
Education	−.150	−1.324	.190				

TABLE 6 (Continued)

Variable	Standardized Beta	*T*	*p*	R^2	$F_{[df]}$	R^2 Change	Sign. *F* Change
Sex	−.306	−3.256	.002				
SANS, sum Score	−.329	−3.139	.003				
AES, sum Score	−.307	−2.685	.009				
Digit span forward	.359	3.722	<.001				
Verbal fluency, semantic	.282	2.481	.016				

Bold values indicates $^{**}p \leq .01$, $^{***}p \leq .001$.

due to ruminations, triggered by self-relevant information (capture by rumination, CaR). (2) Avoidance of negative events, thus preventing access to specific personal memories that cause affective disturbance (functional avoidance, FA). (3) Executive dysfunction that prevents the usage of effective cognitive search strategies and, therefore, limits access to specific AM (impaired executive control, X).

With respect to the first factor, the interaction between rumination and overgeneral AM in patients with schizophrenia is still unknown (Ricarte et al., 2017).

Functional avoidance as regulation process of negative emotions might be given in schizophrenic patients, who are likely to have experienced early trauma (Bebbington et al., 2004; Shevlin et al., 2007) or later, disease-related traumatic events (symptoms and/or hospitalization: Berry et al., 2013, Harrison & Fowler, 2004). At least indirectly a relationship between an overgeneral style of recalling AM and avoidance of traumatic memories in patients with schizophrenia can be assumed (Ricarte et al., 2017). However, the percentage of negative valence of the remembered single events in our patient group was not significantly reduced, which argues against the hypothesis of functional avoidance of negative memories and affects. This is in contrast to a recent finding of Barry et al. (2019), who described a particular difficulty of patients with chronic schizophrenia to recall specific negative memories to negative cue words. Nevertheless, while in some former studies a biased access to negative autobiographical memories was described in schizophrenia, others found a weakening of the facilitating effect of emotions in AM recall (Kwok et al., 2021).

In contrast to this rather inconclusive evidence of the first two mechanisms in schizophrenia, significantly reduced working memory and executive functions have been reported in a variety of studies in patients (Dickinson et al., 2007; Heinrichs & Zakzanis, 1998; Johnson-Selfridge & Zalewski, 2001; Thai et al., 2019) and were confirmed with the present study. Additionally, our results showed significant correlations between number of remembered episodes/specificity sum score and verbal memory, short-term and working memory, processing speed and executive functions. However, an executive contribution to AM impairment in schizophrenia was not definitely supported (*e.g.* Allé et al., 2016; Bennouna-Greene et al., 2012; Berna et al., 2011; Blairy et al., 2008; D'Argembeau et al., 2008). In contrast, functional imaging studies established the impaired involvement of frontal sites in processes of AM in patients with chronic schizophrenia (Cuervo-Lombard et al., 2012; Fornara et al., 2017). Furthermore, the benefit of cues to AM recall in chronic schizophrenia has also been documented (Potheegadoo et al., 2014), thus supporting the hypothesized contribution of disturbed executive function to overgeneral AM in schizophrenia.

Besides an impairment of retrieval processes in patients with schizophrenia, also disturbed encoding of AM information (due to executive dysfunction) may contribute to their AM deficits (Elvevåg et al., 2003; Riutort et al., 2003). In the aforementioned study by Potheegadoo et al. (2014), a specific cueing method improved patients´ ability to recall some, but not all categories of details, therefore suggesting a poor encoding of those details, that remained without benefit by retrieval cues. Moreover, in another recent study the comparison between involuntary and voluntary retrieval of AM revealed a similar impairment of patients in both conditions (Allé et al., 2021). Considering voluntary retrieval as effortful process involving executive functions and involuntary retrieval as a rather automatic process, results argue against solely retrieval problems but rather point to encoding deficits. However, as a matter of fact, the encoding situation as well as the encoded material cannot be controlled in case of AM. Generally, in studies on episodic memory in schizophrenia a failure of strategic processing during information encoding has been repeatedly reported (Achim & Lepage, 2005; Danion et al., 2007). This difficulty of spontaneously linking and organizing different aspects together or relational memory impairment (Danion et al., 1999; Hannula et al., 2010; van Erp et al., 2008) points to impaired hippocampal function (Hannula & Ranganath, 2009). The importance of hippocampal involvement in AM recall in schizophrenia has been underlined in two own publications (Herold et al., 2013, 2015). However, Berna et al. (2012) could not confirm significant correlations between AM performance and executive functions, whereas verbal-logical memory was significantly correlated with AM performance in a group of old-aged participants with mild cognitive impairment. This finding parallels our own results in the present study with significant correlations between episodic AM/specificity and scores of logical memory (verbal memory).

Details, emotional re-experiencing and negative symptoms

Restricting the analyses to reported single events only, we could not find significant differences between the groups with respect to richness of details. This means, if patients have access to single events, their number of details is not reduced. A result that seems to contradict—at first sight—our former publications, that refer to a subgroup of the present sample, with significantly reduced detail scores in patients with schizophrenia compared with controls (Herold et al., 2013, 2015). Nevertheless, this difference can be explained by diverging scoring schemes.[3] In the present analysis, we decided for an assessment of details considering single events only, to compare more directly the mean number of details in single events between patients and controls, as patients not always report at least one single event per life period.

Besides the scoring concerning the number of details, in the present study every single event was rated for the following experiential aspects of reliving: originality, vividness/visual imagery, emotional re-experiencing and emotional valence. While patients and controls differed not significantly with respect to originality, patients´ AM was characterized by significantly reduced vividness and emotional re-experiencing. In fact, a reduced consciousness during retrieval of AM has been repeatedly reported (Berna et al., 2016; Ricarte et al., 2017) and this component may play a crucial role in the known rupture of the self in schizophrenia (Conway, 2005). In this context, the predominance of negative symptoms in our sample has to be considered, with distinct affective flattening in almost all patients, which, from a clinical standpoint, may have contributed to the significantly reduced emotionality and vividness of AM in the patients' group.

This finding of reduced vividness and emotional re-experiencing is paralleled by our results of the correlational analyses between AM and psychopathology: In the present study, especially the severity of negative symptoms, indicated by sum scores of SANS and AES and the BPRS subscore anergia, was negatively correlated with episodic AM. A detailed analysis of the SANS subscores with AM parameters revealed a rather unspecific inverse correlation pattern with all but one of the five subscores correlating significantly with the AM scores 'number of remembered episodes' and 'specificity sum score'. These results point to a relationship between episodic AM deficits and general severity of negative symptoms. This is well in line with previous studies in which negative symptoms have been found to be associated with a lack of specificity in AM (Harrison & Fowler, 2004; Raffard et al., 2010), an impaired ability to give a meaning to personally significant events (Berna et al., 2011) and a reduced number of self-defining memories (Holm et al., 2017). Moreover, there is also evidence for associations between apathy and a lower capacity to imagine future pleasant events in patients with schizophrenia, even after controlling for working memory (Raffard et al., 2013). However, meta-analytically a significant influence of negative or positive symptoms on AM parameters was not confirmed (Berna et al., 2016, for review see also: Kwok et al., 2021), while cognitive impairment in general is mostly associated with negative symptoms (Aleman et al., 1999; Dominguez et al., 2009; Pelletier et al., 2005). As apathy can arise in several severe psychiatric disorders, besides schizophrenia also in mild cognitive impairment and Alzheimer's disease (Lueken et al., 2006, 2007), respective correlations have been reported between AM and apathy, but not for AM and depressive symptoms, in a sample of 239 nursing home residents (Seidl et al., 2011).

Our results of negative symptoms and neuropsychological deficits underlying AM impairment in schizophrenia were confirmed and extended by additional regression analyses. Our models revealed as significant predictors for AM specificity negative symptoms, reflected by SANS and AES sum scores, and the neuropsychological tasks digit span forward and verbal fluency, that is, short-term memory and executive functions/cognitive flexibility (Pflüger et al., 2003). Together with the covariates (age, sex and education), more than 50% of the variance could be explained.

Taken together, AM in schizophrenia seems to be characterized by a dissociation between intact number of details of single events and reduced vividness and emotional re-experiencing at the same time. This finding may have implications for the adaptation of therapeutical approaches to improve AM in this patient group. Albeit a relative stability of AM deficits, therapeutical interventions targeting AM have been proven to be effective in affective disorders (Ahmadi Forooshani et al., 2020;

[3]In Herold et al. (2013, 2015), we considered all reported episodes for the analysis of details and scored 0 details for general or repeated events.

Dalgleish & Werner-Seidler, 2014; Hitchcock et al., 2017). Given the pronounced deficits of AM in schizophrenia, the development and implementation of therapeutical approaches to improve AM is important as those deficits can be compensated for by specific interventions (diary method: Blairy et al., 2008, Ricarte et al., 2014, Ricarte et al., 2012). In view of limitations like motivational problems for time-consuming diary writing, wearable digital cameras are a promising alternative. Recently, the efficacy of this tool in reinforcing the encoding of recent daily personal events in patients with schizophrenia has been confirmed (Dassing et al., 2020). And, moreover, cognitive remediation programmes for AM in schizophrenia may not only improve AM as such, but also the feeling of a coherent sense of identity (Prebble et al., 2013), the ability to anticipate the future (de Oliveira et al., 2009) or social functioning (Alea & Bluck, 2003). In fact, it has been shown that patients' difficulties in understanding other's intentions may be partially due to problems in retrieving specific events from their own past (Corcoran & Frith, 2003; Mehl et al., 2010). Moreover, as AM provides a sense of continuity for the self through time, AM deficits in patients with schizophrenia may be one of the underlying mechanisms that account for the lack of cohesion of the self in schizophrenia (Bennouna-Greene et al., 2012; Raffard et al., 2010). The same applies for problems with future anticipations (D'Argembeau et al., 2008). Therefore, it can be speculated that, according to the associations between AM and executive functions, the latter could also be improved by specific AM training interventions, as AM seems to be a higher-order and perhaps a key competence containing the above-mentioned functions.

Methodological considerations

A general problem in AM research is basically the verification of the reported semantic and episodic memories. In the present study, distinct impairments of semantic and episodic AM were obvious, thus arguing against confabulations. Moreover, in previous studies there was no evidence for elevated false recognition errors (Elvevåg et al., 2004; Huron & Danion, 2002; Moritz et al., 2004, 2006) or false memories/confabulations in patients with schizophrenia (Danion et al., 2005; Neumann et al., 2007). A further verification of the truthfulness of the reported memories for example by interviewing relatives is difficult with respect to practicability; this procedure also reduces the choice of possible memories to shared experiences.

Furthermore, confounding effects like reduced cognitive capacities (*e.g.* speed of information processing) can be ruled out, as AM was examined without temporal limitation.

Given a cross-sectional design, possible effects of age and cohort cannot be ruled out. Although the groups were matched with respect to age and sex, a significant difference remained concerning years of education. From a clinical perspective, lower educational achievements of patients correspond to the prodrome/onset of the disease in early adulthood, which prevents subjects from achieving higher educational levels (van Oel et al., 2002). Considering this as a characteristic phenomenon of the disorder, we run all analyses without years of education as covariate.

The clinical assessments were performed according to standardized proceedings by experienced raters, and interrater agreements were ensured. Blinding with respect to diagnostic group was not possible, given a severely disabled patient sample.

Effects of neuroleptic medication on AM and the respective correlations have to be taken into consideration in a sample of chronically ill. While data concerning their treatment in the past were unfortunately not available, at the time of assessment the majority of the patients were receiving antipsychotic medication. In fact, the beneficial impact of atypical and typical antipsychotic medication on cognition in patients with schizophrenia was described in the past and already discussed in a former publication of our group (Herold et al., 2017).

As our sample consists of patients with chronic schizophrenia effects of long-term hospitalization on AM have to be considered, especially as almost 50% of our patients lived hospitalized in psychiatric

long-term units at time of examination. This means, although these institutions offer activities for the patients, a more restricted life with less memorable life events in contrast to healthy controls. However, the choice of a sample of chronically ill excludes the influence of different courses of the disease. As a further step, the long-term course of AM impairment in patients with chronic schizophrenia will be analysed in a longitudinal approach by our group.

SUMMARY AND CONCLUSIONS

With the present study, we confirmed the extensive deficits of AM in chronic schizophrenia, with reduced episodic and semantic personal memories. AM of patients was characterized by unspecificity and, if single events were available, these memories contained less vividness and emotional valence. These deficits were correlated with psychopathological scales addressing negative symptoms and the neuropsychological domains 'verbal memory' and 'executive functions'. However, the details score of the remembered single events and their originality differed not significantly between the groups, which points to possible approaches to foster the access of single events.

AUTHOR CONTRIBUTIONS

Christina Josefa Herold: Formal analysis; investigation; writing – original draft. **Marc M. Lässer:** Investigation; methodology. **Johannes Schröder:** Conceptualization; funding acquisition; project administration; supervision.

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All authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL APPROVAL

The investigations were approved by the ethics committee of the Medical Faculty, H. University. Written informed consent was obtained from all participants in accordance with the 1964 Declaration of Helsinki and its later amendments after the procedures of the study had been fully explained.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1
Table S2
Table S3

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