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Key words: Amnesia; Long Term memory; Imagination, Picture description

Word count: 5018

Abstract

Objective: A recent study indicates that amnesic patients have difficulties not only in describing past and imagined scenarios, but also in describing pictures that are in full view. This finding suggests that impaired memory hampers descriptions of scenarios more broadly. However, no such impairment in picture description in amnesic patients was observed in a related study. One key methodological difference between these studies was the complexity of the pictures to be described, hinting that picture description differences between amnesic patients and controls might be marked only if pictures are sufficiently complex to tax aspects of memory. **Methods:** To test this complexity hypothesis, we examined whether differences in picture description between amnesic patients and controls increase with increasing picture complexity (4 levels). As in previous studies, we also assessed our participants' ability to describe imagined scenarios. **Results:** Amnesic patients reported significantly fewer elements than did controls when describing pictures and imagined scenarios. The group difference in picture description was significantly larger for complex than simple pictures. **Conclusions:** although variations in lesion sites might account for the aforementioned cross-study differences in picture description in amnesic patients, our results suggest that, at least in amnesic patients with extra-medial temporal lobe lesions, the complexity of pictures can determine whether or not a (substantial) picture description deficit is observed. We interpret these findings in terms of a narrative construction deficit. We hypothesise that whereas brief narrative can be constructed via non-memory cognitive processes, the construction of more *detailed* narrative depends upon intact functioning of a temporary memory system such as the episodic buffer. However, future research in patients with confirmed isolated amnesia is required to test this hypothesis further.

It has been suggested recently that patients with amnesia have difficulties not only in recalling their past but also in imagining personal future and atemporal fictitious events (Hassabis, Kumaran, Vann, & Maguire, 2007; Race, Keane, & Verfaellie, 2011; Rosenbaum, Gilboa, Levine, Winocur, & Moscovitch, 2009; Schacter & Addis, 2007; Szpunar, 2010). Evidence for this hypothesis comes from the finding that some amnesic patients produce fewer elements than do healthy controls when asked, for example, to imagine that they are 'lying on a white sandy beach in a beautiful tropical bay' (Hassabis et al., 2007). This impairment has been interpreted in terms of a *scene construction* deficit (Hassabis & Maguire, 2007).

Recent work by Zeman, Beschin, Dewar, & Della Sala (2013) challenges this scene construction hypothesis. In their study, amnesic patients produced fewer elements than did controls, both when asked to describe imagined scenarios *and* when asked to describe drawings or real-life settings that were in full view, i.e. when scene construction was *not* necessary. This finding hints that impairment of the memory system hampers scene description more broadly (Zeman et al., 2013). Possible culprits considered by Zeman et al. (2013) include (i) alteration of the experience of the present associated with memory impairment (Graham, Barense, & Lee, 2010) or (ii) deficient narrative construction resulting from impaired functioning of a temporary memory system such as the episodic buffer, which, via its links with long-term memory (LTM), is hypothesized to far exceed the assumed time scale and storage capacity of the working memory slave systems (Baddeley, 2000; Baddeley & Wilson, 2002). However, findings of related work by Race et al. (2011) and Race, Keane, & Verfaellie (2013) are not in keeping with this overarching scene description deficit hypothesis. Their amnesic patients performed as well as did controls on a picture description task, in spite of impoverished descriptions of the past and future.

Two factors could account for these differences between the picture description findings of Zeman et al. (2013) and Race et al. (2011, 2013). Firstly, while all patients tested by Race et al. (2011, 2013) had focal medial temporal lobe (MTL) lesions and isolated amnesia, the patients tested by Zeman et al. (2013) had extra-MTL lesions and mild and scattered extra-amnestic impairment, including mild deficits in visuospatial and executive function. This extra-MTL pathology/extra-amnestic impairment could have contributed to the picture description deficits observed, although there was no consistent relationship between such impairment and picture description deficit (Zeman et al., 2013). Secondly, while Race et al.'s (2011, 2013) participants had to describe *simple* cartoon drawings, Zeman et al.'s (2013) participants had to describe *complex* paintings (the Calling of Peter and Andrew by Domenico Ghirlandaio, 1481e2 and The Banquet in the Pine Forest by Sandro Botticelli,1482e3) and real-life settings (a room in a museum and the interior of a church). It could be that picture description primarily depends on memory when pictures exceed a certain complexity

level. If so, marked picture description deficits in amnesia should be observed only when to-be-described pictures are sufficiently complex to tax aspects of memory, such as the episodic buffer.

In the study reported here we assessed whether picture description differences between amnesic patients and controls are accentuated by increasing scene complexity. To this end, we asked 10 patients with amnesia and 10 matched controls to describe pictures of varying levels of complexity. In keeping with previous studies we also assessed our participants' ability to describe imagined scenarios. Given our focus on scene complexity we included both complex and simple scenarios in this imagination task.

Methods

Participants

We tested ten amnesic patients (3F/7M, mean age = 48.7 years, age range = 27-65 years; mean education = 11 years, education range = 8-15 years) and ten age-and-education matched controls (4F/6M, mean age = 49 years, age range = 24-65 years; mean education = 11.2 years, education range = 8-16). All patients (and controls) were right handed. Table 1 details the patients' demographics, clinical features and neuropsychological test performance. The patients' general intellectual abilities were normal, as assessed via the Raven's Coloured Progressive Matrices (Basso, Capitani & Laiacona, 1987). Moreover, with the exception of one patient (patient P2), none of the patients showed evidence of extra-amnestic impairment, as assessed via tests of (i) language function: word comprehension, sentence comprehension, picture naming (Capasso & Miceli, 2001), (ii) executive function: verbal fluency (Carlesimo, Caltagirone & Gainotti, 1996), trail making B-A (Giovagnoli et al., 1996), cognitive estimates (Della Sala, MacPherson, Phillips, Sacco & Spinnler, 2003), (iii) visuospatial attention: star cancellation (Wilson, Cockburn & Halligan, 1987) and (iv) processing speed: trail making A (Giovagnoli et al., 1996). All patients presented with clear evidence of the classical amnesic syndrome characterized by intact immediate verbal recall, as assessed via forward digit span (Carlesimo et al., 1996) but severely impaired LTM, as assessed via word list learning (i.e. total immediate word recall across 5 trials), delayed word recall and delayed prose recall (Carlesimo et al., 1996), and corroborated by the patients' carers' ratings on the Clinical Dementia Rating - Everyday Memory Deficits Scale (Katz, Ford, Mokowitz, Jackson & Jaffe, 1963). Neuroimaging had been performed with CT or MRI for clinical purposes, and therefore the

anatomical delineation of lesions lacked detail. As indicated in Table 1 the lesions involved a number of brain regions including, in some, the temporal lobes.

<<< Insert Table 1 about here >>>

Experimental tasks

Description of imagined scenarios. In order to assess participants' ability to describe future episodic and atemporal imagined scenarios, we adapted the procedure originally devised by Hassabis et al. (2007). Participants were invited to summon up and describe imagined scenes on the basis of a brief cue read out to them by the experimenter (e.g. 'Imagine you are lying on a white sandy beach in a beautiful tropical bay', Hassabis et al., 2007). The scenarios included three *future scenarios* - scenarios requiring 'episodic future thinking/subjective sense of self in time' (a possible Christmas event, a possible event in the next weekend, a possible future meeting with a friend, taken from Hassabis et al., 2007) and three *complex atemporal scenarios* - scenarios involving everyday settings (a beach, a museum and a market, taken from Hassabis et al., 2007). Moreover, given our focus on scene complexity, we also added a complexity factor in the imagination task by including three *simple atemporal scenarios* - scenarios involving constrained settings (a lift, a fitting room and a cubicle in a call centre).

For each scenario, participants were asked to imagine the scene as vividly as they could and to describe it in as much detail as possible. As in Zeman et al. (2013), no time limit was imposed. Participants were asked not to describe specific memories from the past but to create new possible scenarios. They were given non-specific encouragement to continue until they had finished their descriptions, at which point they were asked to confirm that they had done so. A printed text card was placed on the desk in front of them summarizing the main feature of the scenario, to act as a reminder if needed. This ensured that participants maintained the goal of the task throughout. The participants' descriptions were recorded and later transcribed for scoring.

The participants' descriptions were scored according to the criteria by Hassabis et al. (2007). A point was given for each element depicting any of the following: (i) Spatial Reference (SR), involving descriptions of spatial relationships between the different entities mentioned; (ii) Entities Present (EP), i.e., objects and people mentioned; (iii) Sensory Description (SD), involving descriptions of the sensory properties of the entities mentioned; and (iv) Thought/Emotion/Action (TEA), including introspective reports and descriptions of the thoughts, emotions and actions of

others described in the scenes. In line with Hassabis et al.'s (2007) criteria, repetitions and irrelevant utterances were not included. For each participant a mean element score was computed for each scenario type (complex a-temporal scenarios, simple a-temporal scenarios, future scenarios) by averaging the total number of elements described across each scenario.

Description of pictures of varying complexity. In order to assess the effect of picture complexity on the ability to describe visual scenes, we asked participants to describe four colour photos (50 cm x 35 cm). The pictures depicted everyday settings and varied systematically in their level of visual complexity (Level 1 = simple, Level 2 = intermediate, Level 3 =complex, Level 4 = very complex, see Figure 1), as determined by thorough pre-study piloting. During piloting, 10 young participants were asked to count the number of elements in each of 25 pictures. The four pictures which we selected for the study showed a clear step-wise increase in the number of elements identified.

During the picture description task participants were shown the four pictures one by one, in a random order, and asked to describe them while inspecting each picture. Participants were instructed to report only what was depicted in the picture without adding any other elements. They were given non-specific encouragement to continue until they had finished their descriptions, at which point they were asked to confirm that they had done so. As in the imagination task, no time limit was imposed. The descriptions were scored according to the criteria by Hassabis et al. (2007) (see above).

Picture description control tasks. On completion of the picture description task participants engaged in three control tasks: firstly, in order to verify that the levels of complexity used in the present study were supported by the participants' *subjective ratings of picture complexity*, all participants were presented again with the four pictures described in the main task and asked to rate, on a 5-point scale, the perceived complexity of each of the four pictures. Secondly, in order to explore potential differences between the amnesic patients and controls in *subjective ratings of their picture description performance and of strategy use*, we added a fifth picture description trial (average complexity, see Supplemental Materials). This trial followed the same procedure as that of the four experimental trials. However, it was followed immediately by a structured post-experimental interview about this specific trial, including questions such as *'Did you think your description was detailed?', 'Did your description include all the items in the picture?', 'Did you find it was difficult to describe the picture?', 'Did you organize your description a bit before starting it?'* (see Supplemental Materials).

Lastly, in order to rule out the possibility that patients' performance in the picture description task was affected by semantic LTM difficulties, participants were engaged in a *'semantic control test'* consisting of naming various items depicted in the pictures described in the main task. To this end, participants were presented again with the Level 1-3 pictures and asked to name, one by one, a number of items in the these pictures (Level 1 picture: N=4; Level 2 picture: N=9; Level 3 picture: N=13), pointed out by the experimenter in the same pre-established order across participants.

<<<INSERT FIGURE 1 ABOUT HERE>>>

Subjective measure of visual imagery abilities. Following all tasks described above, we administered the Test of Visual Imagery Control (TVIC) (Gordon, 1949; Richardson, 1969) and the Vividness of Visual Imagery Questionnaire (VVIQ) (Marks, 1973) in order to assess participants' subjective appraisal of their imagery abilities. The TVIC assesses the ability to form and modify a visual image, using 10 questions scored on a 5-point rating scale, yielding a maximum score of 50. The VVIQ contains 16 items rating the vividness of evoked visual imageries each scored on a 5-point scale, yielding a maximum score of 80.

The study was approved by the local Ethics Committee of the S Antonio Abate Hospital, Gallarate, and written informed consent was obtained from each participant according to the Declaration of Helsinki.

Statistical analysis

We used mixed factors ANOVAs to assess the effects of group and scenario complexity on scenario descriptions. Planned comparisons were conducted using independent t-tests (between groups at each complexity level) and paired t-tests (Level 1 vs. Level 2, Level 2 vs. Level 3, Level 3 vs. Level 4, and Level 1 vs. Level 4). We also used independent t-tests to compare the groups on the future imagination task and measures of imagery. T-tests assuming unequal variances were applied if the assumption of equal variances was violated (according to the Levine's test for equality of variance). The Greenhouse–Geisser correction for nonsphericity was applied if the sphericity assumption was violated (according to the Mauchly's test of sphericity). We used a Pearson correlation to examine the association between descriptions of imagined scenes (average score of simple and complex scenario) and pictures (average score across Levels 1- 4), and between

descriptions of complex pictures (Level 4) and the patients' neuropsychological test scores. The alpha level was set to 0.05 for all mixed factors ANOVAs. In order to avoid type 1 error accumulation in the planned comparisons, we adjusted the planned comparison alpha level to 0.0125, using a Bonferroni correction, i.e., 0.05/4 comparisons (4 between-subjects comparisons, i.e., one at each complexity level; 4 within-subject comparisons, i.e., between consecutive pairs of complexity level and between Level 1 and Level 4).

Since Race et al (2011, 2013) imposed a 3-min limit for their descriptions, we also repeated all analyses using the data from the first 3 min only. These analyses are reported in full in the Supplemental Materials.

Results

Description of imagined scenarios

Elements reported – future scenarios. The patients described significantly fewer elements (mean = 4.30, SD = 4.61) than did the controls in the future scenarios (mean = 23.9, SD = 13.91) ($t(10.956) = -4.23$, $p < .005$).

Elements reported – simple vs. complex atemporal scenarios. The patient group described significantly fewer elements than did the controls ($F(1, 18) = 25.88$, $p < .001$, $\eta_p^2 = .59$) across scenarios (patient mean simple = 3.63, SD = 4.44, patient mean complex = 5.48, SD = 4.86; control mean simple = 25.57, SD = 9.5, control mean complex = 26.00, SD = 16.35). The number of elements described did not differ significantly between the simple and complex atemporal scenarios ($F(1, 18) = .493$, $p = .491$, $\eta_p^2 = .027$), and there was no significant interaction between Scenario complexity and Group ($F(1, 18) = .19$, $p = .668$, $\eta_p^2 = .01$). Example patient and control descriptions can be found in the Supplemental Materials.

Irrelevant utterances and repetitions. Overall, the patient group produced more irrelevant utterances and repetitions than the control group when describing the scenarios ($F(1, 18) = 4.732$, $p < .05$, $\eta_p^2 = .208$, patient mean simple = 3.95, SD = 2.69, patient mean complex = 5.25, SD = 3.5; control mean simple = 2.1, SD = 1.01, control mean complex = 3.17, SD = 1.95). The number of utterances and repetitions did not differ significantly between the simple and complex atemporal scenarios, although the difference approached significance ($F(1, 18) = 3.546$, $p = .076$, $\eta_p^2 = .165$).

There was no significant interaction between Scenario complexity and Group ($F(1, 18) = .034$, $p = .856$, $\eta_p^2 = .002$).

The same pattern of results was observed whether the full description or only the first 3 minutes of each description was analysed (see Supplemental Materials).

Description of pictures

Elements reported. Overall, picture description increased significantly with increasing picture complexity ($F(2.04, 36.63) = 6.853$, $p < .005$, $\eta_p^2 = .276$). As shown in Figure 2, the patient group described significantly fewer elements than did the controls ($F(1, 18) = 33.146$, $p < .001$, $\eta_p^2 = .648$), and this was the case at each of the four complexity levels (Level 1, $t(10.588) = -6.238$, $p < .001$; Level 2, $t(18) = -5.737$, $p < .001$; Level 3, $t(9.540) = -4.088$, $p < .005$; Level 4, $t(10.949) = -4.803$, $p < .005$). Crucially, this group difference increased significantly with increasing picture complexity (significant interaction between Picture complexity and Group ($F(2.04, 36.63) = 5.715$, $p < .01$, $\eta_p^2 = .241$)). In the control group the number of elements described increased significantly from Level 1 to Level 4 ($t(9) = 4.311$, $p < .005$). This was not the case in the patient group ($t(9) = .638$, $p = .539$) in whom the number of elements described increased moderately but not significantly from Level 1 to Level 2 ($t(9) = 2.627$, $p = .027$, not significant at alpha = .0125) and then decreased moderately but not significantly from Level 2 to Level 3 ($t(9) = -2.596$, $p = .029$, not significant at alpha = .0125) (see Figure 2). Examination of individual patient data (see Figure 3) revealed that only one patient (patient P4) showed a sizeable increase in number of elements described (N=23) between Level 1 and 4. Example patient and control descriptions for Levels 1 and 4 can be found in the Supplemental Materials.

Irrelevant utterances and repetitions. The patient group and control group produced a comparable number of irrelevant utterances and repetitions when describing the pictures ($F(1, 18) = 0$, $p < 1$, $\eta_p^2 = .0$, patient mean Level 1 = 1.3, SD = 1.25, patient mean Level 2 = 2.5, SD = 4.14, patient mean Level 3 = 2.3, SD = 1.83, patient mean Level 4 = 2.4, SD = 2.59; control mean Level 1 = 2.4, SD = 1.9, control mean Level 2 = 1.9, SD = 1.37, control mean Level 3 = 1.9, SD = 2.47, control mean Level 4 = 2.3, SD = 2.31). The number of utterances and repetitions did not differ significantly between the four complexity levels ($F(3, 54) = 0.317$, $p = .813$, $\eta_p^2 = .017$), and there was no significant interaction between Picture complexity and Group ($F(3, 54) = 1.039$, $p = .383$, $\eta_p^2 = .055$).

The same pattern of results was observed whether the full description or only the first 3 minutes of each description was analysed (see Supplemental Materials).

<<<INSERT FIGURES 2 AND 3 ABOUT HERE>>>

Association between descriptions of imagined scenes and pictures

There was a significant positive correlation between the scores on the imagination and picture description tasks in the patients (r=.843, p <.005) and controls (r=.795, p <.01).

Association between neuropsychological test scores and descriptions of complex pictures (patients only)

There was a significant correlation between the scores on the picture description task and the scores on the immediate prose recall test (r=.728, p =.017; non-significant when adjusting for multiple comparisons with alpha level = .0036). This correlation was largely explained by patient P4's high scores on the picture description task (see Figure 3) and the immediate prose recall test (see Table 1). When P4 was excluded from analysis, the correlation became non-significant (r=.110, p =.779). No other correlations between picture description scores and neuropsychological test scores were significant (all p > .397).

Subjective ratings of picture complexity

In line with our pre-determined complexity levels the participants' complexity ratings increased significantly and in a step-wise manner from Level 1 to 4 ($F(1.637, 29.457)$ = 8.140, p < .005). Overall, the controls' complexity ratings were significantly higher than those of the patients ($F(1, 18)$ = 12.533, p < .005, Level 1: $t(13.53)$ = -1.998, p = .066; Level 2: $t(18)$ = -2.245, p < .05; Level 3:

$t(13.45) = -3.202$, $p < .01$; Level 4: $t(18) = -2.555$, $p < .05$). However, there was no significant interaction between Group and Complexity ($F(1.637, 29.457) = .015$, $p = .972$).

Subjective ratings of picture description performance and strategy use (extra picture)

Although the patients (M = 12.2, SD = 8.53) reported significantly fewer elements than did the controls (M = 52.2, SD = 9.47) ($t(18) = -4.07$, $\eta^2 = .48$, $p < .001$) when describing the extra picture, the two groups did not differ significantly in their subjective ratings of picture description performance (see specific questions and results in the Supplemental Materials).

Semantic control test

All participants were able to name correctly each of the picture elements pointed out to them in the 3 pictures (i.e. 100% naming performance).

Subjective measures of visual imagery abilities - VVIQ and TVIC

The mean scores in the TVIC were 49.9 (SD = 11.808) for the patients and 51.4 (SD = 7.486) for the controls. The mean scores in the VVIQ were 65.8 (SD = 5.37) for the patients and 69.5 (SD = 3.629) for the controls. Patients and controls did not significantly differ in the TVIC ($t(18)= -.339$, $p = .738$) or in the VVIQ ($t(18)= -1.805$, $p = .088$).

Discussion

Our results replicate the finding of impaired descriptions of imagined atemporal scenes and future scenes in amnesic patients with MTL and/or extra-MTL lesions (Hassabis et al. 2007; Zeman et al., 2013; Race et al., 2011, 2013). They also replicate the previous finding of impaired descriptions of pictures in amnesic patients with extra-MTL lesions (Zeman et al., 2013), and suggest that such

deficits are not confined to patients with evident extra-amnestic deficits (but see below and Race et al., 2011, 2013).

Most importantly, our study showed that picture description deficits in our amnesic patients were particularly conspicuous when to-be-described pictures were complex rather than simple. Whereas the controls described more elements when supplied with more complex pictures, the patients described a more or less constant number of elements, irrespective of picture complexity level (see Figure 2). This finding suggests that the patients' spared cognitive functions allowed them to complete the task up to a certain level of complexity, but that their impaired cognitive function(s) prevented them from providing a full description of more detailed scenes.

In contrast to the picture description task, no effect of complexity or complexity x group interaction was observed in the imagined scenario task. That is, the controls provided an equally high number of elements for the simple and complex scenarios. This appears to have been the result of methodological limitations rather than of a dissociation between the effects of complexity on descriptions of imagined and in-view scenes: although we constrained the overall context of the scenario to be imagined (e.g. an elevator) we did not impose any constraints on its content. As is apparent from the example 'elevator' transcript (see Supplemental Materials), the controls (but not the patients) imagined in detail the possible contents of such contexts (e.g. other people and interactions in the imagined elevator), thus rendering them 'complex'. Recent work by Romero and Moscovitch (2012) suggests that a complexity effect is in fact observed in controls in imagination tasks when complexity is controlled more tightly. They provided participants with a set number of elements to be included in their scenarios. In keeping with our complexity findings in the picture description task, they showed that imagined scene description deficits in amnesic patients were especially marked in trials in which participants had to include a large set of relational scenario elements in their descriptions.

It is of note that our controls significantly outperformed the patients in the description of even the simplest of our four pictures (Level 1, Mean patients = 7.1 elements, Mean controls = 20.3 elements). This finding contrasts with the finding by Race et al., (2011, 2013) of comparable descriptions of relatively simple pictures in their controls and MTL-amnesic patients. In fact, their MTL-amnesic patients described substantially more elements (mean = ~ 25) than our amnesic patients. This indicates that their pictures were not simpler than our Level 1 picture, and therefore, that the deviation in picture description performance between our and their patient samples are unlikely to be the result of variations in picture complexity. Instead, it is likely that this deviation can be explained by differences between the patient groups themselves. It is possible that our patients described fewer elements because they assumed that they had to provide only a few elements.

Although we cannot rule out this possibility, it appears unlikely since all of our participants were given non-specific encouragement to continue their descriptions (see also Zeman et al., 2013). It is more likely that our patients' overall reduced picture description performance can be accounted for by their extra-MTL lesions, which distinguished them from the MTL-amnesic patients tested by Race et al. (2011, 2013). Inspection of individual patient data in the present study (patient P4) and in the study by Zeman et al., (2013) (their patient P2) certainly supports the view that picture description impairments are not observed in all patients with amnesia.

Although our data speak against a complexity account of the deviation between the findings by Race et al. (2011, 2013) and by ourselves (see also Zeman et al., 2013), they do support our complexity hypothesis in at least some types of amnesia. Specifically, our data suggest that, at least in amnesic patients with extra-MTL lesions, the complexity of to-be-described pictures can determine whether or not a (substantial) picture description deficit is observed.

What hampers picture description in those patients showing such impairment? It is possible that subtle impairments of perceptual discrimination/experience impeded the patients' picture description. Although this account cannot be ruled out via the data at hand, the patients' normal performance on two perceptually demanding tests - the Raven's Coloured Matrices and Star Cancellation (see Table 1) - is suggestive of normal perceptual abilities in our patient sample. Additionally, the patients showed a step-wise increase in their subjective ratings of picture complexity from Level 1 to 4. This finding suggests that the patients were visually aware of the variations in the quantity of picture elements but that the detail of their picture descriptions did not vary accordingly.

It is unlikely that the picture description deficit was the result of impaired retrieval of element names from semantic memory, given that all patients were able to (i) name correctly all picture elements pointed out to them in the semantic control test and (ii) perform normally in a standard picture naming test (see Table 1). This finding resonates with the cognitive profile of the amnesic patient KC, who, although impaired in the description of familiar stories, had intact knowledge of story details, as assessed via a story recognition test (Rosenbaum et al., 2009).

It is possible that subtle deficits in executive function, in particular organisational ability, could have impeded picture description performance in our patient sample. However, the patients' normal performance on three executive function tests – verbal fluency, trail making and cognitive estimates (except P2) - is suggestive of normal executive function ability in our patient sample. Moreover, there were no significant correlations between the performance on these tests and the picture description task. In fact, only one patient (P4) was able to describe the complex pictures in any detail, and her executive function scores fell within the lower to middle portion of the patients' score range (see Table 1). This cognitive profile would not be predicted by an executive function account

of the picture description deficit. Finally, the subjective data derived via the post-experimental interview did not reveal any significant differences between the amnesic patients and controls in picture description strategy (see questions 4 - 6 in Supplemental Material). This all notwithstanding, we acknowledge that we did not assess organisational ability specifically, and, therefore, that a potential contribution of organisational deficits to the observed picture description deficit cannot be ruled out conclusively via the data at hand.

It has been proposed that picture description deficits in amnesia are associated with impairment of a temporary memory system such as the episodic buffer (Zeman et al., 2013), which is thought to be impaired in many patients with amnesia (Baddeley & Wilson, 2002). Such impairment could prevent patients from retaining their recent descriptions, thus hampering their ability to refer back to prior descriptions and construct detailed 'nested' narrative (Romero & Moscovitch, 2012; Zeman et al., 2013). Although we only measured narrative detail, impairment of the episodic buffer could additionally hamper narrative structure by reducing linguistic integration, as shown recently in amnesia (Race, Keane, & Verfaellie, 2015). Previous research suggests that the episodic buffer is necessary for immediate recall of prose (Baddeley, 2000; Baddeley & Wilson, 2002). Interestingly, patient P4, who was the only patient to show a reliable effect of picture complexity (increase by 23 elements, see Figure 3) and good performance in the imagination task, also had the highest score amongst the patient group in immediate prose recall (score = 8, see Table 1). Given that this patient's delayed recall for words and for prose was at floor (0) her spared ability in the aforementioned tasks cannot be accounted for by an overall milder amnesia. Although this parallel sparing of immediate prose recall and picture/imagined scenario description ability in a single patient needs to be treated tentatively, it is in keeping with the hypothesis that description of complex scenarios requires intact/spared episodic buffer function (Zeman et al., 2013).

The present study replicates the finding that picture description can be markedly reduced in patients with amnesia, and suggests that the complexity of pictures can determine whether or not a (substantial) picture description deficit is observed in such patients. Given the presence of mixed and extra-MTL lesions in our sample, the precise cognitive and anatomical bases of this deficit remain unclear. The finding of intact picture description in focal MTL- amnesic patients (Race et al., 2010, 2013) hints that picture description deficits might arise as a consequence of extra-MTL lesions. We acknowledge that we cannot rule out the presence and involvement of subtle extra-amnestic deficits, for example subtle impairment of executive function. However, since our patients presented with profound amnesia and no evident extra-amnestic impairment (bar one patient), we hypothesise that the picture description deficit observed can be accounted for largely by impaired memory function.

Specifically, we hypothesise that whereas brief narrative can be constructed via non-memory processes, the construction of *detailed* narrative depends upon intact functioning of some aspects of memory, capable of online retention (and possibly integration) of preceding utterances, e.g. the episodic buffer. However, future research in patients with confirmed isolated amnesia is required to test this hypothesis further. Finally, although picture description and imagined scene description were correlated significantly in the present study (see also Craig, Della Sala, & Dewar, 2014), it remains to be established whether deficits in the description of imagined scenes in our patient group can be accounted for primarily by (i) impaired narrative construction, (ii) impaired scene construction, or (iii) impairment of an overarching construction/binding system, affecting both the construction of narrative and scenes.

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Table 1
Demographics, clinical features and neuropsychological test performance of the patients with amnesia

	Cut-off score	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Sex		M	M	F	F	F	M	M	M	M	M
Age		44	41	42	27	64	65	59	44	65	27
Education		8	12	13	8	15	13	13	8	8	12
Aetiology		An	TBI	H	A	H	TBI	I	TBI	SAH	TBI
Lesion site		RT	RFT	RF	RF	RLO	L[1]	RF-PT	AX	LFT-RLP	LFT
Months post onset		24	163	13	3	54	19	13	73	17	124
Coloured Raven Matrix[a]	< 17.5	18	30	31	34	35	22.5	36	36	28	36
Digit span[b]	< 3.5	4	5	5.5	4.75	4.75	3.75	6	5.25	4.25	5.75
Total Immediate Word Recall[b]	< 28.53	20.8*	16.8*	31.8	23.9*	25.7*	22.3*	28*	9.8*	25*	26.9*
Delayed Word Recall[b]	< 4.69	0*	0*	2.1*	0*	0*	0*	0*	0*	0*	0*
Immediate Prose Recall[b]	< 3.10	1*	4.1	4.7	8	3.4	1.2*	3.2	1.7*	4.1	4.3
Delayed Prose Recall[b]	< 2.39	0*	0*	0*	0*	0*	2.3*	0*	0*	0*	0*
Word Comprehension[c]	< 18.4	20	20	20	20	20	20	20	20	20	20
Sentence Comprehension[c]	< 11.6	11.8	14	14	14	14	14	14	14	14	14
Picture Naming [c]	n< 8.2, v< 6.1	nouns=9 verbs=6.9	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10	nouns=10 verbs=10
Verbal Fluency[b]	< 17.35	20.1	48.7	21.5	22.4	31	31	25.8	21	37.9	43.7
Trail Making Test[d]	A> 93 B> 282 B-A>186	NA	A=35 B=77 B-A=41	A=59 B=150 B-A=91	A=45 B=115 B-A=70	A=45 B=110 B-A=81	A=71 B=124 B-A=50	A=34 B=89 B-A=55	A=36 B=82 B-A=45	A=34 B=181 B-A=172	A=53 B=147 B-A=82
Cognitive Estimates[e]	> 18	16.97	19.9*	15.2	17.2	13.2	13.97	17.97	15.97	13.97	17.97
Star cancellation[f]	right/left> 3	right27 left27	right27 left27	right27 left27	right27 left27	right27 left27	right27 left27	right27 left27[2]	right27 left27	right27 left27	right27 left 27
CDR-Everyday Memory Deficits Scale[g]	range 0-3	2*	3*	2*	2*	3*	2*	2*	2*	2*	3*
Activities of Daily Living[h]	range 0-6	6	2	6	6	6	6	3	6	6	6

Aetiology: A= ruptured angioma, An= ruptured aneurysm, H= haermorrhage, I= ischemia, SAH= Subarachnoid hemorrhage;TBI= traumatic brain injury; Lesion site: F= frontal, P= parietal, O= occipital, T= temporal, AX= axonal damage; Lesion side: L= left, R= right; [1]multiple left sided parafalcine lesions; [2]immediately post-onset (13 months before entering the experiment) performance was right27 left19, indicative of a neglect which recovered over time; NA= movement impairment; *performance below cut-off score (i.e. abnormal)
[a](Basso, Capitani, & Laiacona, 1987); [b](Carlesimo, Caltagirone, & Gainotti, 1996) ; [c](Capasso & Miceli, 2001); [d](Giovagnoli et al., 1996); [e](Della Sala, MacPherson, Phillips, Sacco, & Spinnler, 2003); [f](Wilson, Cockburn, & Halligan, 1987); [g](Morris, 1993); [h](Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963).

Figure captions

Figure 1. The four pictures used in the picture description task. The pictures varied systematically in their level of visual complexity: Level 1 (L1) = simple, Level 2 (L2) = intermediate, Level 3 (L3) = complex, Level 4 (L4) = very complex. The four pictures were selected from a larger pool of pictures following thorough piloting.

Figure 2. Mean number of picture elements described by the amnesic patient group and control group as a function of picture complexity (Level 1 = simple, Level 4 = very complex; all pictures are provided in the Supplemental Materials). Error bars = Standard error of the mean (SEM).

Figure 3. Number of picture elements described by each amnesic patient and by the control group (group mean) as a function of picture complexity (Level 1 = simple, Level 4 = very complex; all pictures are provided in the Supplemental Materials). Error bars = Standard error of the mean (SEM).