CORTEX 182 (2025) 29–41

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special Issue Outside the box: A celebration of Sergio Della Sala's contribution.: Research Report

Detecting accelerated long-term forgetting remotely in a community sample of people with epilepsy: Evidence from the Crimes and Four Doors tests

Richard J. Allen [a,*], *Steven Kemp* [b], *Amy L. Atkinson* [c], *Sarah Martin* [b], *Kata Pauly-Takacs* [b], *Courtney M. Goodridge* [a], *Ami Gilliland* [a] *and Alan D. Baddeley* [d]

[a] *University of Leeds, UK*
[b] *Leeds Beckett University, UK*
[c] *Lancaster University, UK*
[d] *University of York, UK*

ARTICLE INFO

Article history:
Received 4 March 2024
Reviewed 1 May 2024
Revised 30 May 2024
Accepted 3 July 2024
Published online 22 August 2024

Keywords:
Accelerated forgetting
Epilepsy
Memory
Remote assessment

ABSTRACT

People with epilepsy often report experiencing memory problems though these are not always detectable using standard neuropsychological measures. One form of difficulty that may be relatively prevalent in epilepsy is termed accelerated long-term forgetting (ALF), typically described as relatively greater loss of memory over days or weeks following initial encoding. The current study used remote assessment to examine memory and forgetting over one week in a broad community sample of people with epilepsy and healthy control participants, using two recently developed tests, one verbal (the Crimes test) and one visual (the Four Doors test). These were administered as part of a short battery of cognitive measures, run remotely with participants over Zoom. Across this community-derived sample, people with epilepsy reported more memory complaints and demonstrated significantly faster forgetting on both the verbal and visual tests. This difference was not attributable to level of initial learning performance and was not detectable through delayed recall on a standard existing test. Our results suggests that ALF may be more common than suspected in people with epilepsy, leading to a potentially important source of memory problems that are currently undetected by standard memory tests.

* *Corresponding author.*
E-mail address: r.allen@leeds.ac.uk (R.J. Allen).

https://doi.org/10.1016/j.cortex.2024.07.018

1. Introduction

Sergio Della Sala (2010) observed in the editor's preface to "Forgetting" that, despite its importance, it has been neglected in comparison with other features of memory. The collection of papers from the major contributors to the field proved timely with the subsequent decade seeing a gradual increase in work on forgetting as summarized in a recent overview (Della Sala et al., 2024). The current paper stems from a phenomenon described in the chapter by Butler et al. (2010), who report cases of accelerated long-term forgetting (ALF). Patients with ALF show rapid forgetting over days or weeks, in some cases despite apparently normal initial learning (Fitzgerald et al., 2013; Mameniškiene et al., 2020). This is potentially important, both theoretically in distinguishing learning from forgetting processes and practically since clinical assessments of memory do not typically test at delays more than an hour and may thus fail to detect important memory problems.

There is therefore an urgent need to supplement existing clinical memory tests with one or more measures that can be applied repeatedly to individual patients after successive delays. As Sergio Della Sala observes in a recent review of the topic (Della Sala et al., 2024), attempting to address this problem reveals two major problems. The first concerns the basic issue of how to measure forgetting, particularly when comparing patients or groups differing in initial learning capacity. This in turn interacts with assumptions regarding the processes underlying the forgetting function and whether it involves unitary, dual, or multiple processes. A clinical measure of forgetting that varies depending on the tester's theoretical assumptions is clearly unsatisfactory. Attempts to resolve this methodological controversy are currently progressing with the contributions of Sergio and colleagues playing a sustained part (e.g., see Della Sala et al., 2024; Dewar et al., 2007; Hoefeijzers et al., 2013; Rivera-Lares et al., 2022, 2023; Sacripante et al., 2023; Stamate et al., 2020).

The second concerns the practical issue of developing measures that allow repeated testing, given that the process of testing memory may influence subsequent retention either positively (e.g. through retrieval practice; e.g. Karpicke & Roediger, 2008) or negatively through interference with subsequent recall of untested items (e.g. through retrieval induced forgetting; e.g. Anderson et al., 1994). Although this might be dealt with by testing separate groups of participants at each delay, this is not of course possible when testing forgetting in a single patient. One way of minimizing effects of repeated retrieval within individuals is to test a different sample of the learned material after each delay (e.g. Baddeley et al., 2021; Contador et al., 2021; Huppert & Kopelman, 1989; Huppert & Piercy, 1979). This, however, demands initial acquisition of a substantial amount of material which may prove problematic for both typical and atypical groups. One possible solution is to enhance performance by using meaningful material and cued recall, as in the recently developed Crimes (Baddeley et al., 2014) and Four Doors (Baddeley et al., 2019) tests. These consist of (respectively) four short vignettes describing relatively minor fictional crimes, or four visual scenes consisting of doors of different styles and colors. The varied pattern of detail within a consistent format allows a matrix structure of cued recall questions to be applied across test sessions, such that associations between features can be probed multiple times with no repetition of individual questions. These can be used to track initial retention and subsequent forgetting of verbal or visual information. The use of visual and verbal tasks also helps ensure that any observed deficits are not material- and/or modality-specific (Elliott et al., 2014).

These tests have shown promise in healthy adults (Allen et al., 2019; Baddeley et al., 2014, 2019) but it is important to extend them to use with groups for whom ALF may be a common problem. One such group is epilepsy. Difficulties with memory represent one of the most common forms of subjectively experienced complaint in epilepsy (Illman et al., 2012, pp. 1–15; Thompson & Corcoran, 1992). However, subjective complaints are often poorly correlated with objective measures in epilepsy (Hall et al., 2009; Piazzini et al., 2001; Thompson & Corcoran, 1992), with subjective memory problems often attributed to factors such as anxiety or depression (Hall et al., 2009; Lemesle et al., 2022). This may partly reflect the limited retention periods typically used in current standard neuropsychological tests of memory, which do not usually assess memory retention over extended delays of days or weeks (Butler & Zeman, 2008; Fitzgerald et al., 2013). A cognitive phenotype involving memory (and language) impairments can be identified in subgroups of epilepsy patients using standard measures implemented within a single session (Baxendale & Thompson, 2020), but problems with long-term forgetting are unlikely to be detected without use of extended tests.

ALF may be more prevalent in temporal lobe epilepsy (Miller et al., 2017; Muhlert et al., 2011), particularly when damage is bilateral (Kemp et al., 2012), although it has been observed in other forms of epilepsy (Davidson et al., 2007; Miller et al., 2017; Puteikis et al., 2022; Ricci et al., 2019). It remains unclear whether a degree of ALF is a common and hence important feature of epilepsy, however (Butler & Zeman, 2008; Mameniškiene et al., 2020), and several studies have suggested that the ALF pattern is not consistently observed in all such patients (Cassel et al., 2016; Cassel and Kopelman, 2019; Contador et al., 2017; Evans et al., 2014; Miller et al., 2017; Muhlert et al., 2011). For example, Contador et al. (2021) found no evidence of differential forgetting of stories and routes over a day or a week, in a group of patients with temporal lobe epilepsy, compared to controls. Thus, the extent to which ALF is reliably observed in patients with epilepsy remains to be fully established. Given apparent heterogeneity of forgetting patterns within epilepsy, the mixed findings that have been reported, and neuropsychological assessments that typically test memory after a relatively short delay, the importance of developing appropriate methods of measuring forgetting for the detection of possible in epilepsy is clear.

The Crimes and Doors tests have so far only been minimally applied in people with epilepsy. Drane (2014, unpublished thesis) found possible evidence for ALF over a one-week delay using the Crimes test in a small group of patients with late-onset TLE, although interpretation was limited by ceiling effects for the healthy individuals. More recently, Laverick et al. (2021) found evidence of ALF over a one-week period

on the Crimes and Four Doors tests in a sample of 14 clinically derived epilepsy patients. In both cases, evidence indicated that faster forgetting may be relatively common in epilepsy, rather than an exceptional feature. However, further research in larger samples is required to establish reliability across different population and testing contexts. In addition, there are no data on the use of these tests with community-derived samples of people living with chronic epilepsy, a group that commonly reports problems with memory and cognition (Fisher et al., 2000).

The present study therefore has several broad aims. Firstly, we wanted to apply the Crimes and Four Doors tests to a community-derived sample of people with epilepsy. We do not attempt to resolve the various questions concerning the nature of ALF, whether it comprises one, two or more types, or its prevalence within the population, but instead have the more pragmatic aim of developing two promising tests by applying them to a broad sample of patients with epilepsy. This is a necessary stage if the tests are to prove useful in clinical practice. Although we do not aim to establish prevalence, we hope to gain some indication of overall likelihood of ALF across a broader epilepsy population and throw light on the extent to which ALF is a frequent source of memory complaints, rather than a rare but theoretically important occurrence. This would have implications for the likely extent of memory problems that may not be detected by current tests and suggest a possible need for testing as part of standard memory assessment in epilepsy or indeed potentially more widely.

Our second aim was to develop and evaluate the feasibility of remote testing versions of Crimes and Four Doors. Remote 'teleneuropsychology' is a growing area of interest in neuropsychological assessment, with studies beginning to explore and establish its use in clinical contexts (e.g. Adams et al., 2020; Butterbrod et al., 2022; Hewitt & Loring, 2020; Requena-Komuro et al., 2022; Rizzi et al., 2023; Rogers et al., 2023) including epilepsy (e.g., Samia et al., 2023; Tailby et al., 2020). To our knowledge though, there is no existing data using remote testing of memory and forgetting over multiple sessions. Remote assessment via online video-conferencing platforms has become increasingly popular following the covid-19 pandemic and is beneficial in increasing accessibility for patients, while from the researchers' perspective it helps ensure a larger and more varied sample.

Both the Crimes and Four Doors tests allow for memory to be tested after four separate delays. However, for practical reasons we opted at this stage to use only two (after a 60-s filled delay to minimize the contribution of working memory, and after one week). Our earlier studies (e.g. Laverick et al., 2021) suggested that ALF effects would appear in at least some people with epilepsy at the one-week test. The patients were volunteers recruited through the charity Epilepsy Action and who were prepared to participate in two sessions separated by one week. The nature of our sample meant that we did not have access to medical records nor was extensive further testing practicable. We were however able to include one standard memory test, the list learning and delayed recall task drawn from the Brain Injury Rehabilitation Trust Memory and Information Processing Battery (BMIPB-II, Oddy et al., 2019), a recent adaptation of the earlier BMIPB (Coughlan et al., 2007). This latter task is rare in including a delayed, one-week assessment, and was therefore added as an additional comparison measure of memory and forgetting over time alongside the two ALF-oriented tests, and to gauge whether any atypical patterns of forgetting in epilepsy generalize across different methods of assessment. We therefore implemented adapted, remote versions of Crimes and Four Doors, along with the BMIPB-II list learning and delayed recall task. For each test we implemented, evidence of ALF in the epilepsy group would be indicated by a greater reduction in accuracy compared to controls on the one-week test, relative to any group differences observed in the first session.

2. Method

We report how we determined our sample size, all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study. No part of the study procedures or analyses were pre-registered prior to the research being conducted.

2.1. *Participants*

Laverick et al. (2021) implemented the Crimes and Four Doors tasks with 14 epilepsy patients and 14 controls and found large group differences at the one-week delay on each task (Crimes, $d = 1.74$; Four Doors, $d = 1.48$). Detecting the smaller of these effect sizes (two-tailed, alpha = .05, 95% power) requires a minimum of 13 participants per group.

Participants in the epilepsy group were required to have a diagnosis of epilepsy, while those in the control group were required to have no known neurological condition. All participants had to be aged 18 years or over.

There were 82 participants with datasets for the initial questionnaire and for both live sessions. The sample included 49 people with epilepsy (39 females, mean age = 45.3 years, range = 22–79), recruited via the charity Epilepsy Action, and 33 healthy control participants (24 females; mean age = 45.7 years, range = 22–74).

Patients in the epilepsy group self-reported their epilepsy diagnosis during the initial questionnaire, and these diagnostic descriptions were classified as follows; temporal lobe epilepsy (26), generalized epilepsy (12), juvenile myoclonic epilepsy (3), simple partial (4), frontal (1), and other/missing information (3). Where TLE lateralization was reported, 9 had left TLE, 6 right, and 3 bilateral. Mean time since epilepsy onset was 23.2 years (SE = 2.52), and current medication was mixed (23 polytherapy; 24 monotherapy; 2 no current medication).

The research was approved by the ethics committee at the School of Psychology (University of Leeds). All participants (patients and controls) gave informed consent.

2.2. *Design, materials, & procedure*

The testing schedule involved one online pre-test questionnaire, followed by two 'live' one-to-one sessions carried out

via the remote communication platform Zoom. A mixed 2 × 2 × 2 design was implemented, with population group (epilepsy vs. healthy controls) and test group (Crimes vs. Doors) as between-subjects factors, and test point (Short delay vs. One week) as a within-subjects factor. Participants were randomly assigned to one of two test groups (Crimes vs. Doors), with the constraint that any individual who self-reported color vision difficulties were placed in the Crimes group (this applied to two people in the epilepsy group). This resulted in 24 epilepsy patients and 17 control participants in the Crimes group, and 25 epilepsy patients and 16 controls in the Doors group. The main dependent variable was cued-recall accuracy on the Crimes and Doors tasks. We also examined recall scores on the BMIPB-II list learning and recall task after each delay.

2.3. Questionnaires

The pre-test questionnaire was completed in the week prior to the first session, and collected information on demographics, educational history, vision, and mood. The latter was a single question about general mood over the past week, with responses on a 5-point scale (ranging from *"I am not feeling anxious or depressed"* to *"I am feeling extremely anxious and depressed"*). If the participant had a diagnosis of epilepsy, they were asked further questions specific to their condition, including epilepsy diagnosis, status, and medication. All participants also completed the memory satisfaction subscale of the Multifactorial Memory Questionnaire (Troyer & Rich, 2018).[1] This is an 18-item scale probing subjective experience of everyday memory, with responses recorded on a 5-point scale. This produces normative scores regarding memory satisfaction that can be categorized from very low to very high, with average as a mid-point. Finally, there were also asked a few additional questions probing subjective experience of memory ability that are not further reported here.

2.4. Cognitive testing in the live sessions

Each participant took part in two live sessions conducted on an individual basis with a researcher over Zoom. Session 1 lasted around 45 min and consisted of Spot the Word, BMIPB list learning and recall, and the encoding and short delay test phase for Crimes or Doors.[2] The one-week test lasted around 15 min, and included the follow-up tests for Crimes or Doors, plus BMIPB delayed recall.

2.5. Spot the Word

In this measure of verbal intelligence based on lexical decision (Baddeley et al., 1993), participants attempt to identify real words from within word–nonword pairs. The task was implemented using Gorilla and presented via Zoom screen-sharing. Each pairing was presented on screen, with one word to the left of the screen center and one to the right. The number '1' was presented above the left item and '2' above the right. Real and non-words could appear in either position. The participant was asked to verbally respond with the number that denoted the real word, which the experimenter then recorded. There were 6 practice and 60 test pairs.

2.6. BMIPB-II list learning and recall

The List learning and recall subtest was drawn from the BMIPB-II (Oddy et al., 2019), a recent development of the BMIPB batteries (Coughlan et al., 2007). This subtest includes a free recall test one week after learning and is one of very few published batteries with such a delayed test. For the first session, this task consisted of a 15-word list (list A) presented over 5 learning and recall trials (A1-5). The researcher read out the sequence which the participant then attempted to verbally recall (in any order). Responses were manually recorded by the researcher. A different 15-word list (B) was then presented for immediate recall, followed by a prompt to recall list A again (A6). Subsequently, at the one-week test session, the participant was asked to recall as many words as possible from either list, noting where possible which list (A or B) their responses were drawn from. This test therefore provides both an initial measure of memory performance and the potential for detecting accelerated forgetting over the one-week delay.

2.7. Crimes and Four Doors tests

The Crimes and Doors tests were implemented using methodology based on Baddeley et al. (2019) and Laverick et al. (2021), and the materials are provided in Baddeley et al. (2019). An initial pilot experiment was carried out (Epilepsy $N = 30$, Controls $N = 28$) with half the participants allocated to each test group, assessing memory performance over three test sessions (short delay; 24 h; one week). As in Laverick et al. (2021), controls received one round of presentation for the Crimes or Four Doors material, and the epilepsy group two rounds of presentation. Participants in the pilot study indicated that the general methods were highly acceptable. However, results indicated considerable performance variability and no forgetting over one week was found in any group (see Fig. 1, and supplementary materials for full methodological details and analysis outcomes).

This absence of forgetting likely in part reflects retrieval practice effects (Baddeley et al., 2019; Karpicke & Roediger, 2008), with the 24-h test serving to reduce forgetting at the one-week test. It is important to minimize such effects when examining ALF (Baddeley et al., 2019; Elliott et al., 2014). The main study therefore only tested recall after the first short delay and at one week, with no intervening testing. It also embedded questions directly into the encoding phase to ensure initial learning level, and implemented learning to criterion during encoding, to ensure appropriate initial performance that was matched between groups (Elliott et al., 2014). Both Crimes and Four Doors were administered using

[1] The MMQ is freely publicly available at the following link: https://www.baycrest.org/Baycrest_Centre/media/content/form_files/MMQ-Manual-2018_ebook.pdf.

[2] The Crimes and Four Doors materials are provided via Gorilla at https://app.gorilla.sc/openmaterials/852393. We do not have legal permission to publicly archive the Spot the Word or BMIPB-II list recall tasks. Readers seeking access to the materials should contact the owners. For Spot the Word, contact https://www.pearsonclinical.co.uk. For BMIPB-II, contact info@brainkind.org.

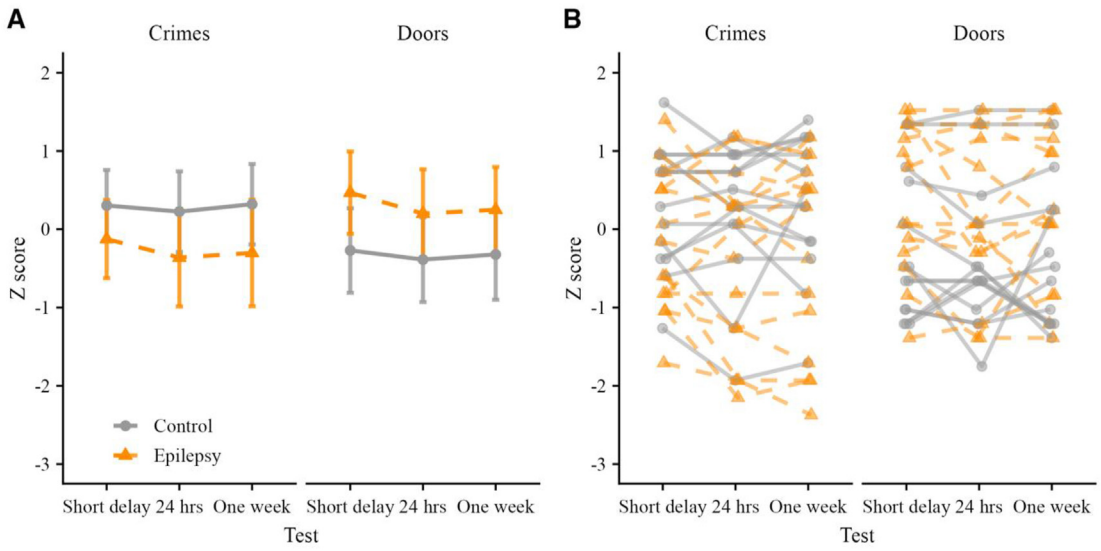

Fig. 1 – Z scored performance on the Crimes and Doors tests in the pilot experiment, presented as summary statistics (and SE) (A) and by individual participants (B).

Gorilla on the researcher's computer and presented to participants using Zoom screenshare.

2.8. *Crimes test*

The to-be-remembered materials consisted of four short vignettes each setting out a fictional crime, including a relatively minor criminal act, a perpetrator, victim, and location, as well as some additional (untested) detail (see Baddeley et al., 2019 for full information). Each crime vignette was auditorily presented in a digitized middle-aged male English voice. Five questions were asked following presentation of each vignette (concerning the crime, location, victim nationality, age/sex of victim, and identity of perpetrator, e.g. "What was the nationality of the victim?"), and presentation of the crime repeated (up to three times) if an incorrect response was given.

The encoding phase was followed by a 60-s interval. This contained a visual 'spot the difference' filler task, in which participants were asked to identify and verbally list the differences between a line-drawn scene and a similar copy presented simultaneously on screen.

The short delay cued recall test then followed. For this test and the one-week delay, 20 questions were each presented on screen and simultaneously read out by the researcher. Each question probed a particular association within one of the crime stories. There was no repetition of question across the sets, though the same association might be tested in the opposite direction (see Baddeley et al., 2019). Questions probing each crime were randomly intermixed within the set of 20, and different sets of questions were used at the session 1 and one-week tests. Participants responded verbally, and the researcher manually recorded all responses.

The learning to criterion approach was implemented as follows (for both the Crimes and Four Doors tasks). The first session was completed if the participant achieved a minimum score of 15/20 on the short delay recall test. If they failed to achieve this criterion, the encoding and short delay recall process was repeated in full (using a different filler task, but the same set of 20 questions). Up to three rounds of encoding and recall were implemented for each participant. If they still had not achieved the minimum required score, the session was nevertheless ended as normal, and the one-week test subsequently implemented.

2.9. *Four Doors test*

Each of the four scenes consisted of a different style and color of door, color surround, object above the door, and animal in front of the door. The scene category name (e.g., FACTORY) was presented under the scene (Baddeley et al., 2019). Participants were first introduced to the components of the scenes to ensure they were aware of what to focus on. Each scene was presented for 10 s. Participants were asked to say the name three times prior to presentation (e.g., "factory-factory-factory"), and then another five times during presentation. Each scene was immediately followed by five questions probing memory for each of the key components (e.g. "What was the animal in the scene?"). If any question was answered incorrectly, the scene was re-presented for 2 s at the end of the question set (max = three repetitions).

A verbal filler task was then performed during a 60-s retention interval. The word HIPPOPOTAMUS (or similar alternatives if re-presentation was required) was presented on screen and participants were asked to generate and report as many words as possible from the constituent letters. The short delay cued recall test then followed. All testing procedures, including learning to criterion (based on a score of 15/20 correct), followed the same principles as the Crimes test. Different sets of questions were used at the session 1 and one-week tests, with no repetition of questions, and items probing each door scene were randomly intermixed within the set of 20. Participants responded verbally, and the researcher manually recorded all responses.

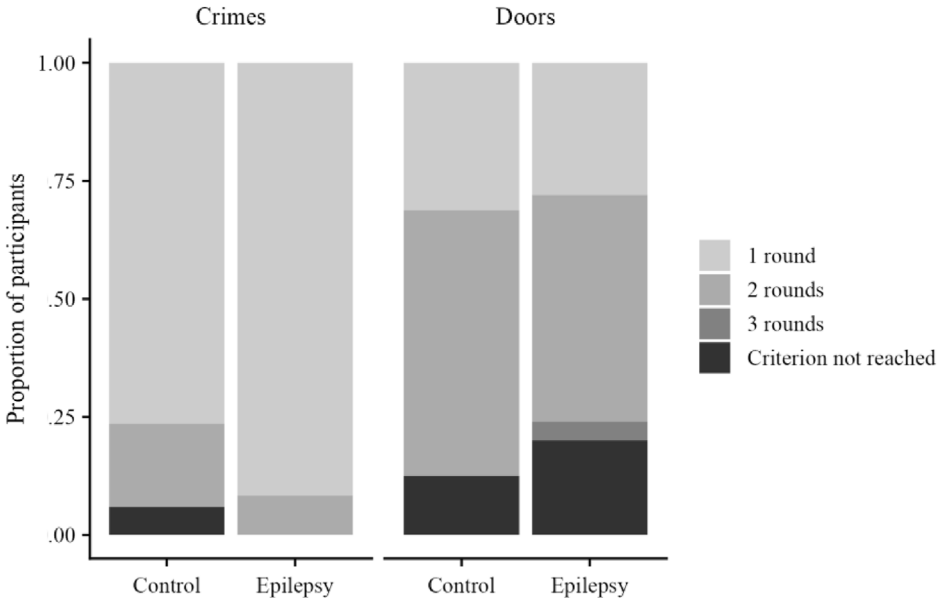

Fig. 2 – Frequency distribution for the encoding round on which participants achieved 15/20 correct on the Crimes or Four Doors test.

3. Results

Analyses were carried out in JASP .18.3. Data and analysis code (extracted in R form from JASP .18.3) are available on the OSF at the following link: https://osf.io/cfkme/. Analyses only includes those participants who reached criterion (at least 15/20 correct following up to three rounds of presentation, as established prior to analysis) on the Crimes or Four Doors tests. Note that outcomes remained the same when including all participants with complete data sets.

Overall, 30/33 controls (16 in the Crimes group and 14 in the Four Doors group) and 44/49 people with epilepsy (24 in the Crimes group and 20 in the Four Doors group) achieved criterion (see Fig. 2). A similar distribution was apparent for each population group ($X^2 = .63$, $p = .73$), though participants required more rounds for Four Doors, compared to Crimes ($X^2 = 26.55$, $p < .001$). For Crimes, one participant from each group failed to reach criterion. For Four Doors, two controls and five people with epilepsy failed to reach criterion after three rounds of presentation.

Within the final group of participants who achieved criterion, the epilepsy and control groups did not differ in age (control $M = 44.5$, $SE = 2.8$; epilepsy $M = 45.6$, $SE = 2.3$), $t(72) = .31$, $p = .76$, $d = .08$, or verbal intelligence as measured by Spot the Word (control scaled score $M = 8.97$, $SE = .49$; epilepsy $M = 9.48$, $SE = .39$), $t(72) = .82$, $p = .41$, $d = .20$, but the epilepsy group reported lower mood (reverse coded, $M = 3.65$, $SE = .17$) than controls ($M = 4.55$, $SE = .13$), $t(70) = 3.95$, $p < .001$, $d = .95$.

For the MMQ Memory Satisfaction scale, distribution of participants across normed categories significantly differed between groups, $X^2 = 26.50$, $p < .001$ (Epilepsy: 0 above average; 21 average; 19 below average; 4 low; Controls: 8 above average; 21 average; 1 below average; 0 low). Thus, over half of our final epilepsy sample were classed as having low or below average satisfaction with their memory, compared to only 1/30 controls.

3.1. *Crimes and Four Doors: recall in the short delay and one-week tests*

Each participant's short delay recall score was taken from the final round of questions in session 1. Performance on the Crimes and Four Doors tests were analyzed together, using z-scores calculated based on overall grand means for each task (Crimes $M = 14.79$, $SD = 5.02$; Doors $M = 14.03$, $SD = 4.49$; raw scores are presented in Supplementary materials). Aggregated and individual data are displayed in Fig. 3.

A mixed $2 \times 2 \times 2$[3] ANOVA showed a main effect of test point, $F(1,70) = 167.93$, $p < .001$, $\eta^2_p = .71$, with better performance at the short delay than the one-week test, and population group, $F(1,70) = 7.85$, $p = .007$, $\eta^2_p = .10$, with poorer performance in the epilepsy group compared to controls. There was no effect of test group, $F(1,70) = .02$, $p = .88$, $\eta^2_p < .01$. The test point by population group interaction was significant, $F(1,70) = 9.01$, $p = .004$, $\eta^2_p = .11$. Planned comparisons revealed no group difference on the short delay test (controls $M = .71$, $SE = .07$, PWE $M = .58$, $SE = .06$), $t(72) = 1.45$, $p = .15$, $d = .35$, but the epilepsy group was less accurate on the one-week test (controls $M = -.21$, $SE = .17$, PWE $M = -.92$, $SE = .17$), $t(72) = 3.12$, $p = .003$, $d = .74$. There was no interaction between test point and test group, $F(1,70) = 1.26$, $p = .27$, $\eta^2_p = .02$, and no three-way interaction, $F(1,70) = .37$, $p = .54$, $\eta^2_p = .005$.

To further illustrate forgetting over time in each population and test group, Fig. 4 shows absolute change in number of correct responses from the short delay test to the one-week

[3] Given the difference between population groups in self-rated mood, all reported analyses were repeated with mood as a covariate, with the same pattern of outcomes.

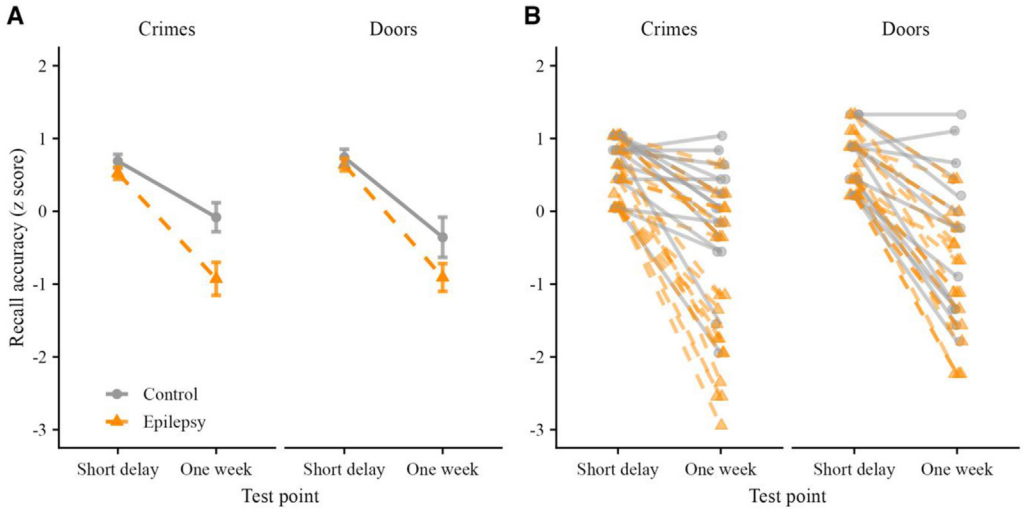

Fig. 3 – Mean performance (and SE) on Crimes and Four Doors tests presented as summary statistics (A) and by individual participants (B).

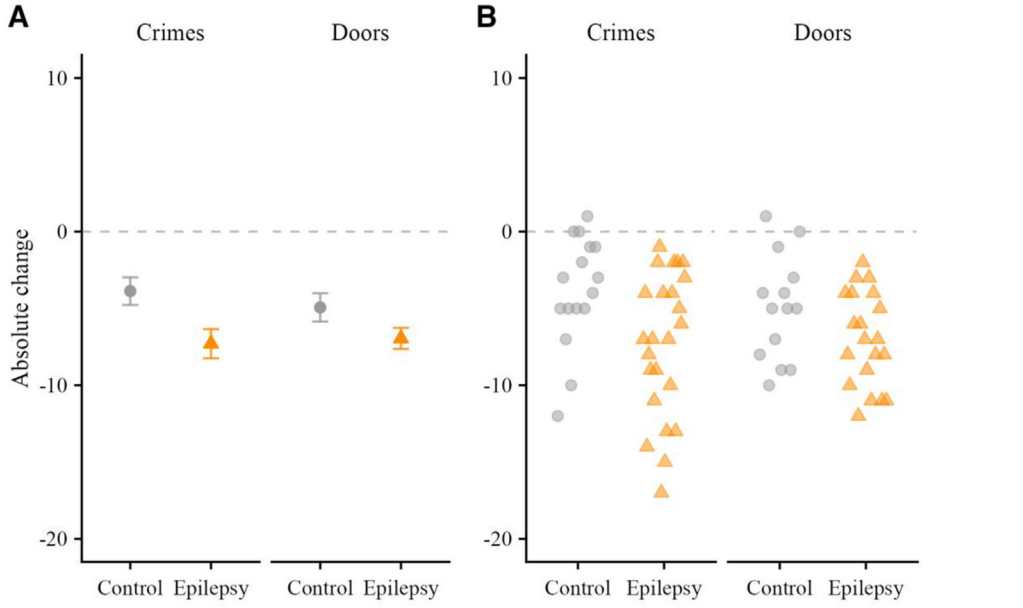

Fig. 4 – Mean change in number correct (and SE) on Crimes and Doors from short delay test to one-week test, presented as summary statistics (A) and by individual participants (B).

test. A 2 × 2 ANOVA indicated an effect of population group, $F(1,70) = 8.94$, $p = .004$, $\eta^2_p = .11$, but no effect of test group, $F(1,70) = .15$, $p = .70$, $\eta^2_p = .002$ and no interaction, $F(1,70) = .59$, $p = .45$, $\eta^2_p = .008$. The epilepsy group showed a higher rate of absolute loss ($M = -7.12$, $SE = .58$) compared to controls ($M = -4.40$, $SE = .70$).

3.2. *BMIPB-II list learning and recall*

Number correct recall for List A items on each test of the BMIPB list learning and recall task are presented in Fig. 5A. A mixed 7 × 2 ANOVA (Greenhouse-Geisser corrected) indicated main effects of test point, $F(4,266) = 174.05$, $p < .001$, $\eta^2_p = .71$, with accuracy improving over the learning trials (A1-5) and then declining to the first post-interference trial (A6) and again to the one-week test. There was no significant effect of group, $F(1,872) = .87$, $p = .355$, $\eta^2_p = .01$, or interaction, $F(4,266) = .79$, $p = .53$, $\eta^2_p = .01$. Finally, Fig. 5B and C shows proportional loss from A6 (Session 1) to the one-week test. An independent samples *t*-test revealed no significant difference between epilepsy and controls $t(72) = .07$, $p = .95$, $d = .02$. Based on this test therefore, the epilepsy group do not appear to show a memory impairment. Possible reasons for this are discussed below.

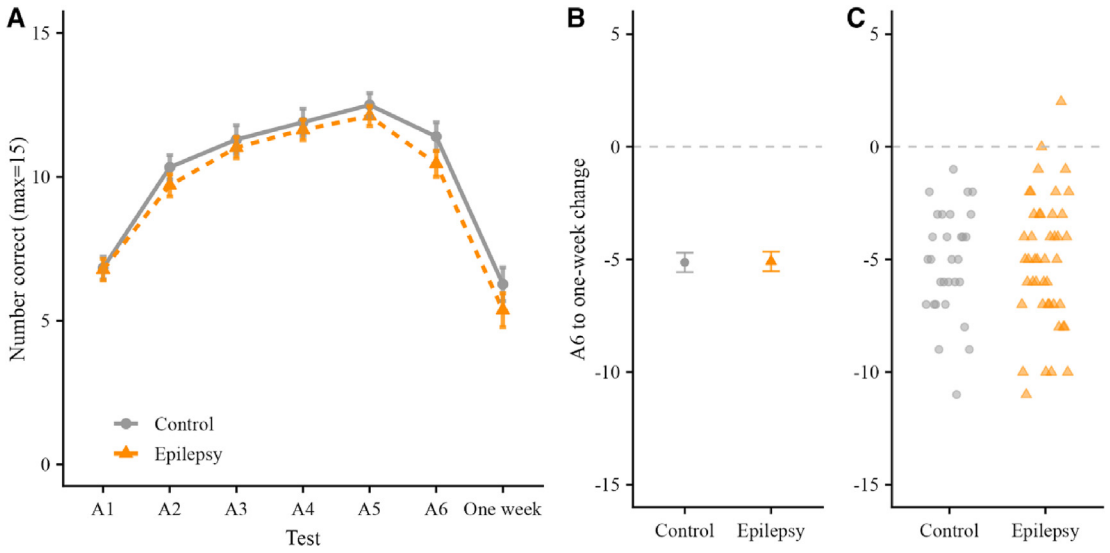

Fig. 5 – A. Mean number correct (and SE) on each test of the BMIPB list learning and recall task. B. Mean change from test A6 to one-week. C. Change per individual participant.

4. Discussion

We began our study with the aim of extending the Crimes and Four Doors Tests to a wider range of people with epilepsy and to adapt it for remote testing, In doing so we hoped that we would gain some indication as to whether ALF is likely to prove a rare condition or whether it is sufficiently common as to raise concerns about the lack of attention to potential contribution of ALF to reported memory complaints and the failure of current standard memory tests to address rates of forgetting. Memory and forgetting over a one-week period were remotely assessed across a broad community sample of people with epilepsy and healthy controls using the Crimes and Four Doors tests, along with BMIPB verbal recall. The results of this exploration provide new evidence regarding ALF in epilepsy and contributes to methodological development on how best to capture forgetting over time in typical and atypical groups.

At a group level, more forgetting was evident on the Crimes and Four Doors tasks across the one-week period for the people with epilepsy, relative to controls. Although well-matched at the short delay test, the epilepsy group produced lower recall accuracy and more loss one week later. This indicates some evidence for ALF on these measures in our community-derived sample. This is in keeping with the findings of Laverick et al. (2021) using Crimes and Four Doors in a clinically derived sample, and studies using other types of material and test method (e.g. Fitzgerald et al., 2013; Hoefeijzers et al., 2015), though atypical forgetting over extended delays is not always observed in epilepsy (Cassel et al., 2016; Contador et al., 2017, 2021). In the context of the overall group differences found in the present study, there was a range of forgetting for all participants, on both the Crimes and Four Doors. The epilepsy group were more likely to show greater loss, though not universally so, with many individuals showing similar levels of forgetting to controls. This heterogeneity is broadly in line with patterns of ALF observed in clinically derived samples of epilepsy patients (e.g., Mayes et al., 2019; Muhlert et al., 2011). Although there was no strong evidence of qualitatively distinct clustering in the epilepsy group, it is notable that five participants with epilepsy showed a degree of separation from the rest of the sample in terms of negative change on the Crimes test across the one-week delay. Whether this represents a separate group or part of a broader range will require a more extensive sample of patients.

Our study was motivated in large part by the work of Sergio Della Sala and colleagues on adopting pragmatic approaches to measuring forgetting (Della Sala et al., 2024), and by the aim of developing appropriate tools to measure atypical forgetting over extended time periods that may not be successfully captured by existing neuropsychological tools. The importance of doing so is illustrated by the observation that over half of our epilepsy sample were classed as having low or below average satisfaction with their memory as measured by the MMQ, in contrast to our control sample who generally had average or above average memory satisfaction. Thus, many (though clearly not all) of the epilepsy group in our study reported subjectively poor memory in their everyday lives (Illman et al., 2012, pp. 1–15; Thompson & Corcoran, 1992). In contrast to such prevalent subjective difficulties, they did not show any evidence of objective group differences in the first session as measured on the short delay tests of Crimes/Four Doors (or BMIPB). It was only the one-week assessment of Crimes/Four Doors that elicited such evidence. We also tentatively note that, of the five people with epilepsy who show the most forgetting on the Crimes test, four are classed as having low/below average memory satisfaction on the MMQ. Developing objective neuropsychological measures that align with subjective experiences will continue to be a valuable aim for researchers in this field.

Despite the overall group differences on the one-week test for Crimes/Four Doors, there was no evidence of learning

deficits in this epilepsy group, as indexed by the number of encoding rounds needed. The use of learning to criterion was successful in producing appropriate and matched short delay recall performance while avoiding ceiling or overlearning effects (Elliott et al., 2014). This approach may be a preferable method of achieving appropriate initial performance levels in clinical and control groups, relative to other approaches such as varying the number of presentation rounds at a group level (as in the pilot study). For example, Laverick et al. (2021) used one round of presentation for controls and two rounds for their epilepsy group, which may have produced more overlearning for the epilepsy group and makes direct comparison more challenging.

A secondary aim of the study was to extend our exploration to the BMIPB verbal memory task, an existing test that unusually includes a one-week delayed recall. There were no group differences during the learning or delayed recall phases of this task, with the epilepsy group showing the same profile as controls on each test point. Thus, this measure was able to detect initial learning improvement and subsequent forgetting over short and extended delays but did not produce evidence for atypical forgetting in the epilepsy group. The present study was not designed to preferentially differentiate between the Crimes, Four Doors, and BMIPB list tests, and we acknowledge the differences in methodology between these measures. Nevertheless, at least in their current versions, group differences were more apparent in the Crimes/Four Doors tests.

Given potential evidence of domain specific memory loss in epilepsy (e.g., Baxendale et al., 1998), we should ideally continue to work towards use of tests that assess across different domains (Elliott et al., 2014). However, sometimes that may not be possible or ideal from a pragmatic perspective, if we need to consider time constraints, avoiding patients becoming overwhelmed or fatigued by multiple tests, and reduction of interference between the tests themselves. In this case, with test group as between-subjects factor, the present study was not designed to systematically compare Crimes and Four Doors, the former may be slightly preferable given the lower number of presentation rounds required to achieve criterion and criterion failure rates. Nevertheless, the present outcomes, couple with those of Laverick et al. (2021), indicate that these tests might represent useful tools in assessing forgetting over extended delays in epilepsy. While research interest in ALF has been principally driven by possible problems in epilepsy, there is some evidence that atypical forgetting may also be a feature in other clinical groups, including Alzheimer's disease (Weston et al., 2018; Rodini et al., 2022; though see Stamate et al., 2020), Parkinson's (Hanoğlu et al., 2019), and multiple sclerosis (Stalter et al., 2024). It would be worth exploring whether the current tests usefully extend to the detection of possible atypical forgetting in individuals with these conditions.

We interpreted the absence of any reliable forgetting on the one-week test across epilepsy or control participants in the initial pilot experiment as likely reflecting retrieval practice effects (Baddeley et al., 2019; Karpicke & Roediger, 2008) induced by the 24-h test in that pilot experiment. The omission of this intervening test in the full experiment allowed observation of forgetting for both groups, indicating the importance of considering retrieval practice when studying ALF. However, we acknowledge that this lack of an intermediate test point between the first (short delay) and second (one-week) test represents a potential limitation in the main study. We have been able to demonstrate ALF as a form of faster forgetting in long-term memory, but we cannot unequivocally differentiate earlier from longer-term forgetting (e.g. Audrain & McAndrews, 2019; van der Werf et al., 2016; Weston et al., 2018), or detect any qualitative changes in forgetting profiles that might emerge after certain delays (Mayes et al., 2019). The question of whether atypical forgetting might emerge over distinct time periods for different patients and clinical populations remains an important subject of debate (e.g. Cassel & Kopelman, 2019; Cassel et al., 2016; Mayes et al., 2019), though this is not an issue that the current study was intended to address.

Retrieval practice represents a challenge for assessment of clinical forgetting over time (Elliott et al., 2014). If the intention is to capture fine-grained forgetting gradients across multiple time points, alternative solutions are required that reduce retrieval practice effects while avoiding floor effects at long delays (Baddeley et al., 2021). However, it also offers an opportunity as a possible tool to support memory and mitigate against ALF in epilepsy. Initial findings suggest possible beneficial effects of retrieval practice in PWE (Jansari et al., 2010; Ricci et al., 2019), and we can derive similar conclusions when comparing the pilot and main experiments in the present work. This seems a promising avenue for further research, but more work is needed across populations and contexts to understand under which task conditions and for which populations such benefits emerge, and the extent to which they might be generalized to everyday memory.

More broadly, the present work usefully informs an emerging area of research exploring remote implementation of neuropsychological assessment (Hewitt & Loring, 2020; Requena-Komuro et al., 2022; Rogers et al., 2023). We have previously demonstrated that telephone-based administration provides a suitable method of implementing the Crimes follow-up tests (Allen et al., 2019). Remote video-calling offers a much more versatile and interactive form of communication, and the recent growth in sophistication and popularity of such platforms makes this method a feasible tool for experimental and clinical assessment. Our findings indicate that carefully implemented remote assessment offers effective measurement of typical and atypical episodic memory and forgetting over multiple sessions and extended delays, while improving accessibility of assessment for patients and researchers alike. The combined use of an online questionnaire and live sessions administered over a popular remote communication platform generated detailed and informative datasets while enabling inclusion of participants from across the UK in a way that removed any costs or disruption that would otherwise be associated with travel for in-person assessment.

In conclusion, we began with the aim of extending and further developing two tests of ALF (Crimes and Four Doors) by their remote application to a wider community-derived sample of people with epilepsy and controls. We found it necessary to modify test presentation using a criterion-based approach and to avoid early testing which can serve as a

relearning session. Repeated testing thus remains a challenge in this area, but retrieval practice may also represent an opportunity for support. The modified versions of Crimes and Four Doors were then shown to be readily performed typically involving a single encoding session. More forgetting on these tests was apparent for people with epilepsy at a group level after a one-week delay, albeit with variability within group and with many patients showing no apparent atypicality. This finding was not detected by an existing comparison test (BMIPB verbal learning and recall) that is relatively rare in including a one-week follow-up test. Our data suggest that some degree of ALF is likely to be present in a at least a proportion of people with epilepsy and that although it appears to be reflected in subjective complaints of memory problems, it may not be detectable by standard assessments over shorter timescales. As such, it reinforces Sergio Della Sala's case for increased attention to forgetting (Della Sala, 2010; Della Sala et al., 2024), still an important but comparatively neglected aspect of memory, and offers a practical way to assess the potential importance of rate of forgetting in people reporting memory problems.

Ethical publication statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines. All participants gave informed consent to take part in this study.

Funding statement

This work was funded by the Experimental Psychology Society.

Data access statement

Data and analysis code (extracted in R form from JASP 0.18.3 are available on the OSF at the following link: https://osf.io/cfkme/.

Open practices

The study in this article has earned Open Data for transparent practices. The data and materials studies are available at: https://osf.io/cfkme/.

TOP Guidelines Statement

- All available raw and processed data supporting this research are publicly available. See TOP Guidelines Assessment in Supplementary Information for details.
- Some study materials supporting this research are publicly available, while some are subject to TOP-compliant restrictions. See manuscript for details.
- This article reports, for all studies, how the author(s) determined all sample sizes, all data exclusions, all data inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures.
- No part of the study procedures was pre-registered in a time-stamped, institutional registry prior to the research being conducted.
- No part of the analysis plans was pre-registered in a time-stamped, institutional registry prior to the research being conducted.

CRediT authorship contribution statement

Richard J. Allen: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Steven Kemp:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Conceptualization. **Amy L. Atkinson:** Writing – review & editing, Writing – original draft, Software, Methodology, Funding acquisition, Conceptualization. **Sarah Martin:** Project administration, Investigation, Data curation. **Kata Pauly-Takacs:** Writing – original draft, Writing – review & editing. **Courtney M. Goodridge:** Project administration, Investigation, Data curation. **Ami Gilliland:** Project administration, Investigation, Data curation. **Alan D. Baddeley:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

None of the authors has any conflict of interest to disclose.

Acknowledgments

This work was funded by the Experimental Psychology Society. We also appreciate the support of Epilepsy Action.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cortex.2024.07.018.

REFERENCES

Adams, J. L., Myers, T. L., Waddell, E. M., Spear, K. L., & Schneider, R. B. (2020). Telemedicine: A valuable tool in neurodegenerative diseases. *Current Geriatric Reports, 9*(2), 72–81. https://doi.org/10.1007/s13670-020-00311-z

Allen, R., Kemp, S., Morson, S., Wells, C., Grindheim, K., & Baddeley, A. (2019). Does telephone testing of long-term memory retention and forgetting influence performance in

young and older adults? An examination using the crimes test. *The Neuropsychologist*, 8. ISSN 2396-8540.

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 20*(5), 1063–1087. https://doi.org/10.1037/0278-7393.20.5.1063

Audrain, S., & McAndrews, M. P. (2019). Cognitive and functional correlates of accelerated long-term forgetting in temporal lobe epilepsy. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 110*, 101–114. https://doi.org/10.1016/j.cortex.2018.03.022

Baddeley, A. D., Atkinson, A. L., Hitch, G. J., & Allen, R. J. (2021). Detecting accelerated long-term forgetting: A problem and some solutions. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 142*, 237–251. https://doi.org/10.1016/j.cortex.2021.03.038

Baddeley, A., Atkinson, A., Kemp, S., & Allen, R. (2019). The problem of detecting long-term forgetting: Evidence from the crimes test and the four doors test. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 110*, 69–79. https://doi.org/10.1016/j.cortex.2018.01.017

Baddeley, A., Emslie, H., & Nimmo-Smith, I. (1993). The spot-the-word test: A robust estimate of verbal intelligence based on lexical decision. *The British Journal of Clinical Psychology, 32*(1), 55–65. https://doi.org/10.1111/j.2044-8260.1993.tb01027.x

Baddeley, A., Rawlings, B., & Hayes, A. (2014). Constrained prose recall and the assessment of long-term forgetting: The case of ageing and the crimes test. *Memory, 22*(8), 1052–1059. https://doi.org/10.1080/09658211.2013.865753

Baxendale, S., & Thompson, P. (2020). The association of cognitive phenotypes with postoperative outcomes after epilepsy surgery in patients with temporal lobe epilepsy. *Epilepsy & Behavior, 112*, Article 107386. https://doi.org/10.1016/j.yebeh.2020.107386

Baxendale, S. A., Van Paesschen, W., Thompson, P. J., Connelly, A., Duncan, J. S., Harkness, W. F., & Shorvon, S. D. (1998). The relationship between quantitative MRI and neuropsychological functioning in temporal lobe epilepsy. *Epilepsia, 39*(2), 158–166. https://doi.org/10.1111/j.1528-1157.1998.tb01353.x

Butler, C., Muhlert, N., & Zeman, A. (2010). Accelerated long-term forgetting. In S. Della Sala (Ed.), *Forgetting* (pp. 211–237). Psychology Press.

Butler, C. R., & Zeman, A. Z. (2008). Recent insights into the impairment of memory in epilepsy: Transient epileptic amnesia, accelerated long-term forgetting and remote memory impairment. *Brain: a Journal of Neurology, 131*(9), 2243–2263. https://doi.org/10.1093/brain/awn127

Butterbrod, E., Zevenhoven, P., Waterink, L., van Leeuwenstijn, M., van der Flier, W. M., van den Heuvel, D. M., & Sikkes, S. A. (2022). Teleneuropsychology in the memory clinic setting: Evidence for reliability and usability of videoconference-based neuropsychological testing. *Alzheimer's & Dementia, 18*, Article e067059. https://doi.org/10.1002/alz.067059

Cassel, A., & Kopelman, M. D. (2019). Have we forgotten about forgetting? A critical review of 'accelerated long-term forgetting'in temporal lobe epilepsy. *Cortex, 110*, 141–149. https://doi.org/10.1016/j.cortex.2017.12.012.

Cassel, A., Morris, R., Koutroumanidis, M., & Kopelman, M. (2016). Forgetting in temporal lobe epilepsy: When does it become accelerated? *Cortex, 78*, 70–84. https://doi.org/10.1016/j.cortex.2016.02.005

Contador, I., Sánchez, A., Kopelman, M. D., de la Aleja, J. G., & Ruisoto, P. (2021). Accelerated forgetting in temporal lobe epilepsy: When does it occur? *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 141*, 190–200. https://doi.org/10.1016/j.cortex.2021.03.035

Contador, I., Sánchez, A., Kopelman, M. D., & González de la Aleja, J. (2017). Long-term forgetting in temporal lobe epilepsy: Is this phenomenon a norm? *Epilepsy & Behavior: E&b, 77*, 30–32. https://doi.org/10.1016/j.yebeh.2017.09.020

Coughlan, A. K., Oddy, M., & Crawford, J. R. (2007). *BIRT memory and information processing battery (BMIPB)*. London: Brain Injury Rehabilitation Trust.

Davidson, M., Dorris, L., O'Regan, M., & Zuberi, S. M. (2007). Memory consolidation and accelerated forgetting in children with idiopathic generalized epilepsy. *Epilepsy & Behavior: E&b, 11*(3), 394–400. https://doi.org/10.1016/j.yebeh.2007.05.004

Della Sala, S. (Ed.). (2010). *Forgetting*. Psychology Press. https://doi.org/10.4324/9780203851647.

Della Sala, S., Baddeley, A., Peng, N., & Logie, R. (2024). Assessing long-term forgetting: A pragmatic approach. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 170*, 80–89. https://doi.org/10.1016/j.cortex.2023.11.009

Dewar, M. T., Cowan, N., & Sala, S. D. (2007). Forgetting due to retroactive interference: A fusion of Müller and Pilzecker's (1900) early insights into everyday forgetting and recent research on anterograde amnesia. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 43*(5), 616–634. https://doi.org/10.1016/s0010-9452(08)70492-1

Drane, E. (2014). Accelerated long-term forgetting of verbal material in adults with late-onset temporal lobe epilepsy. *DClinPsych. Dissertation. University of Oxford. unpublished*.

Elliott, G., Isaac, C. L., & Muhlert, N. (2014). Measuring forgetting: A critical review of accelerated long-term forgetting studies. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 54*(1), 16–32. https://doi.org/10.1016/j.cortex.2014.02.001

Evans, S. J., Elliott, G., Reynders, H., & Isaac, C. L. (2014). Can temporal lobe epilepsy surgery ameliorate accelerated long-term forgetting? *Neuropsychologia, 53*(1), 64–74. https://doi.org/10.1016/j.neuropsychologia.2013.11.007

Fisher, R. S., Vickrey, B. G., Gibson, P., Hermann, B., Penovich, P., Scherer, A., & Walker, S. (2000). The impact of epilepsy from the patient's perspective I. Descriptions and subjective perceptions. *Epilepsy Research, 41*(1), 39–51. https://doi.org/10.1016/S0920-1211(00)00126-1

Fitzgerald, Z., Mohamed, A., Ricci, M., Thayer, Z., & Miller, L. (2013). Accelerated long-term forgetting: A newly identified memory impairment in epilepsy. *Journal of Clinical Neuroscience, 20*(11), 1486–1491. https://doi.org/10.1016/j.jocn.2013.04.037

Hall, K. E., Isaac, C. L., & Harris, P. (2009). Memory complaints in epilepsy: An accurate reflection of memory impairment or an indicator of poor adjustment? A review of the literature. *Clinical Psychology Review, 29*(4), 354–367. https://doi.org/10.1016/j.cpr.2009.03.001

Hanoğlu, L., Ercan, F. B., Mantar, N., Helvaci Yilmaz, N., Sitrava, S., Özer, F., & Yuluğ, B. (2019). Accelerated forgetting and verbal memory consolidation process in idiopathic nondement Parkinson's disease. *Journal of Clinical Neuroscience, 70*, 208–213. https://doi.org/10.1016/j.jocn.2019.08.012

Hewitt, K. C., & Loring, D. W. (2020). Emory university telehealth neuropsychology development and implementation in response to the COVID-19 pandemic. *The Clinical Neuropsychologist, 34*(7–8), 1352–1366.

Hoefeijzers, S., Dewar, M., Della Sala, S., Butler, C., & Zeman, A. (2015). Accelerated long-term forgetting can become apparent within 3–8 hours of wakefulness in patients with transient epileptic amnesia. *Neuropsychology, 29*(1), 117. https://doi.org/10.1037/neu0000114.

Hoefeijzers, S., Dewar, M., Della Sala, S., Zeman, A., & Butler, C. (2013). Accelerated long-term forgetting in transient epileptic amnesia: An acquisition or consolidation deficit?

Neuropsychologia, 51(8), 1549–1555. https://doi.org/10.1016/j.neuropsychologia.2013.04.017

Huppert, F. A., & Kopelman, M. D. (1989). Rates of forgetting in normal ageing: A comparison with dementia. *Neuropsychologia, 27*(6), 849–860. https://doi.org/10.1016/0028-3932(89)90008-0

Huppert, F. A., & Piercy, M. (1979). Normal and abnormal forgetting in organic amnesia: Effect of locus of lesion. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 15*(3), 385–390. https://doi.org/10.1016/S0010-9452(79)80065-9

Illman, N. A., Butler, C. R., Souchay, C., & Moulin, C. J. A. (2012). *Déjà experiences in temporal lobe epilepsy*. Epilepsy Research and Treatment. https://doi.org/10.1155/2012/539567, 2012.

Jansari, A. S., Davis, K., McGibbon, T., Firminger, S., & Kapur, N. (2010). When "long-term memory" no longer means "forever": Analysis of accelerated long-term forgetting in a patient with temporal lobe epilepsy. *Neuropsychologia, 48*(6), 1707–1715. https://doi.org/10.1016/j.neuropsychologia.2010.02.018

Karpicke, J. D., & Roediger, H. L. (2008). The critical importance of retrieval for learning. *Science, 319*(5865), 966–968. https://doi.org/10.1126/science.1152408

Kemp, S., Illman, N. A., Moulin, C. J. A., & Baddeley, A. D. (2012). Accelerated long-term forgetting (ALF) and transient epileptic amnesia (TEA): Two cases of epilepsy-related memory disorder. *Epilepsy & Behavior: E&b, 24*(3), 382–388. https://doi.org/10.1016/j.yebeh.2012.04.119

Laverick, T., Evans, S., Freeston, M., & Baddeley, A. (2021). The use of novel measures to detect Accelerated Long-term forgetting in people with epilepsy: The Crimes Test and Four Doors Test. *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 141*, 144–155. https://doi.org/10.1016/j.cortex.2021.03.024

Lemesle, B., Barbeau, E. J., Rigal, E. M., Denuelle, M., Valton, L., Pariente, J., & Curot, J. (2022). Hidden objective memory deficits behind subjective memory complaints in patients with temporal lobe epilepsy. *Neurology, 98*(8), e818 LP–e828 LP. https://doi.org/10.1212/WNL.0000000000013212

Mameniškienė, R., Puteikis, K., Jasionis, A., & Jatužis, D. (2020). A review of accelerated long-term forgetting in epilepsy. *Brain Sciences, 10*(12), 1–24. https://doi.org/10.3390/brainsci10120945

Mayes, A. R., Hunkin, N. M., Isaac, C., & Muhlert, N. (2019). Are there distinct forms of accelerated forgetting and, if so, why? *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 110*, 115–126. https://doi.org/10.1016/j.cortex.2018.04.005

Miller, L. A., Mothakunnel, A., Flanagan, E., Nikpour, A., & Thayer, Z. (2017). Accelerated long term forgetting in patients with focal seizures: incidence rate and contributing factors. *Epilepsy & Behavior, 72*, 108–113. https://doi.org/10.1016/j.yebeh.2017.04.039.

Muhlert, N., Grünewald, R. A., Hunkin, N. M., Reuber, M., Howell, S., Reynders, H., & Isaac, C. L. (2011). Accelerated long-term forgetting in temporal lobe but not idiopathic generalised epilepsy. *Neuropsychologia, 49*(9), 2417–2426. https://doi.org/10.1016/j.neuropsychologia.2011.04.018

Muhlert, N., Grünewald, R. A., Hunkin, N. M., Reuber, M., Howell, S., Reynders, H., & Isaac, C. L. (2011). Accelerated long-term forgetting in temporal lobe but not idiopathic generalised epilepsy. *Neuropsychologia, 49*(9), 2417–2426. https://doi.org/10.1016/j.neuropsychologia.2011.04.018.

Oddy, M., Ramos, S. D. S., Crawford, J. R., & Coughlan, A. K. (2019). BIRT memory and information processing battery II (BMIPB-II) manual. *Brainkind*.

Piazzini, A., Canevini, M. P., Maggiori, G., & Canger, R. (2001). The perception of memory failures in patients with epilepsy. *European Journal of Neurology, 8*(6), 613–620. https://doi.org/10.1046/j.1468-1331.2001.00287.x

Puteikis, K., Wolf, P., & Mameniškienė, R. (2022). Accelerated long-term forgetting in adult patients with genetic generalized epilepsy. *Epilepsia, 63*(2), 474–482. https://doi.org/10.1111/epi.17144

Requena-Komuro, M. C., Jiang, J., Dobson, L., Benhamou, E., Russell, L., Bond, R. L., … Hardy, C. J. (2022). Remote versus face-to-face neuropsychological testing for dementia research: A comparative study in people with Alzheimer's disease, frontotemporal dementia and healthy older individuals. *BMC Ophthalmology, 12*(11). https://doi.org/10.1136/bmjopen-2022-064576

Ricci, M., Wong, T., Nikpour, A., & Miller, L. A. (2019). Testing the effectiveness of cognitive interventions in alleviating accelerated long term forgetting (ALF). *Cortex; a Journal Devoted To the Study of the Nervous System and Behavior, 110*, 37–46. https://doi.org/10.1016/j.cortex.2017.10.007

Rivera-Lares, K., Logie, R., Baddeley, A., & Della Sala, S. (2022). Rate of forgetting is independent of initial degree of learning. *Memory & Cognition, 50*(8), 1706–1718.

Rivera-Lares, K., Sala, S. D., Baddeley, A., & Logie, R. (2023). Rate of forgetting is independent from initial degree of learning across different age groups. *The Quarterly Journal of Experimental Psychology: QJEP, 76*(7), 1672–1682. https://doi.org/10.3758/s13421-021-01271-1

Rizzi, E., Vezzoli, M., Pegoraro, S., Facchin, A., Strina, V., & Daini, R. (2023). Teleneuropsychology: Normative data for the assessment of memory in online settings. *Neurological Sciences, 44*, 529–538. https://doi.org/10.1007/s10072-022-06426-9

Rodini, M., De Simone, M. S., Caltagirone, C., & Carlesimo, G. A. (2022). Accelerated long-term forgetting in neurodegenerative disorders: A systematic review of the literature. *Neuroscience and Biobehavioral Reviews, 141*, Article 104815. https://doi.org/10.1016/j.neubiorev.2022.104815

Rogers, F., Bane, E., Dwyer, C. P., Alvarez-Iglesias, A., Joyce, R. A., & Hynes, S. M. (2023). Remote administration of BICAMS measures and the Trail-Making Test to assess cognitive impairment in multiple sclerosis. *Neuropsychological Rehabilitation, 33*(5), 903–926. https://doi.org/10.1080/09602011.2022.2052324

Sacripante, R., Logie, R. H., Baddeley, A., & Della Sala, S. (2023). Forgetting rates of gist and peripheral episodic details in prose recall. *Memory & Cognition, 51*(1), 71–86. https://doi.org/10.3758/s13421-022-01310-5

Samia, P., Sahu, J. K., Ali, A., Caraballo, R. H., Chan, J., Coan, A. C., … Cross, J. H. (2023). Telemedicine for individuals with epilepsy: Recommendations from the international league against epilepsy telemedicine task force. *Seizure: the Journal of the British Epilepsy Association, 106*, 85–91. https://doi.org/10.1016/j.seizure.2023.02.005

Stalter, J., Pars, K., & Witt, K. (2024). Accelerated long-term forgetting reveals everyday memory deficits in early-stage multiple sclerosis. *Journal of Neurology*, 1–7. https://doi.org/10.1007/s00415-024-12359-4

Stamate, A., Logie, R. H., Baddeley, A. D., & Della Sala, S. (2020). Forgetting in Alzheimer's disease: Is it fast? Is it affected by repeated retrieval? *Neuropsychologia, 138*, Article 107351. https://doi.org/10.1016/j.neuropsychologia.2020.107351

Tailby, C., Collins, A. J., Vaughan, D. N., Abbott, D. F., O'Shea, M., Helmstaedter, C., & Jackson, G. D. (2020). Teleneuropsychology in the time of COVID-19: The experience of the Australian epilepsy project. *Seizure: the Journal of the British Epilepsy Association, 83*, 89–97. https://doi.org/10.1016/j.seizure.2020.10.005

Thompson, P. J., & Corcoran, R. (1992). Everyday memory failures in people with epilepsy. *Epilepsia, 33*(Suppl 6), S18–S20. http://europepmc.org/abstract/MED/1486831.

Troyer, A. K., & Rich, J. B. (2018). Multifactorial memory questionnaire. *Professional Manual. Baycrest*.

Van der Werf, S. P., Geurts, S., & De Werd, M. M. (2016). Subjective memory ability and long-term forgetting in patients referred for neuropsychological assessment. *Frontiers in Psychology, 7*, Article 186081. https://doi.org/10.3389/fpsyg.2016.00605

Weston, P. S., Nicholas, J. M., Henley, S. M., Liang, Y., Macpherson, K., Donnachie, E., … Fox, N. C. (2018). Accelerated long-term forgetting in presymptomatic autosomal dominant Alzheimer's disease: A cross-sectional study. *Lancet Neurology, 17*(2), 123–132. https://doi.org/10.1016/S1474-4422(17)30434-9