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Does collaboration with an intimate partner support memory performance? An exploratory case series of people with epilepsy or acquired brain injury

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Abstract.
BACKGROUND: Intimate couples can become cognitively interdependent over time. If one member of the couple has a neurological condition with associated cognitive impairments, their partner can support or 'scaffold' their cognitive functioning through collaboration.
OBJECTIVE: We explored the phenomenon of 'collaborative memory' in a case series of 9 couples in which one member had a neurological condition, specifically an acquired brain injury (ABI; $n = 7$) or epilepsy ($n = 2$).
METHODS: To investigate collaborative memory, we compared the performance of the patient when remembering alone versus their performance in collaboration with their partner on three memory tasks, assessing anterograde, semantic, and autobiographical memory.
RESULTS: We found that across all tasks and participants, collaboration typically increased overall memory performance (total score), but the patient's contribution to the task was typically lower when they collaborated compared with when they performed the task alone. We identified two distinct styles of collaboration which we termed 'survival scaffolding' (where the healthy partner 'takes over' memory recall) and 'stability scaffolding' (where the healthy partner cues and structures the patient's recall).
CONCLUSION: This exploratory case series contributes to the sparse literature on memory collaboration in people with neurological conditions. Our findings suggest that there are different styles of collaboration that can both help and hinder memory performance.

Keywords: Acquired brain injury, epilepsy, relationship, memory, collaboration, scaffolding

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1. Background

Theoretical perspectives such as "transactive memory" theory (Wegner, 1987) and distributed cognition (Harris, Barnier, Sutton, & Keil, 2014) suggest that, over time, intimate couples become "cognitively interdependent", such that they function together as a cognitive system that is more than the sum of its parts (Barnier, Klein, & Harris, 2018). Such cognitive systems are argued to have benefits and to facilitate memory performance in the individuals by providing effective "scaffolding" (Barnier, Harris, Morris, & Savage, 2018; Barnier et al., 2014; Harris, Barnier, Sutton, & Savage, 2018; Harris et al., 2014). When one individual in the couple experiences a neurological condition such as an acquired brain injury (ABI), therefore, viewing the couple as a system implies that this injury will impact on the couple as a whole and require adjustments in the way that they function together. Indeed, research suggests that experiencing an acquired brain injury places particular stress on intimate relationships (Burridge, Williams, Yates, Harris, & Ward, 2007; Eriksson, Tham, & Fugl-Meyer, 2005). Nevertheless, theories of cognitive interdependence suggest that a healthy partner may be well placed to support and scaffold the memory performance of a partner with a neurological disorder and associated memory impairment (Harris et al., 2014).

There is increasing research interest in how people remember together rather than as isolated individuals. This 'collaborative memory' research has featured primarily in the experimental cognitive psychology literature, but it has important implications for clinical populations, in particular memory rehabilitation in the face of brain injury or disease (Meade, Harris, Van Bergen, Sutton, & Barnier, 2018). To date, collaborative memory research has primarily been conducted in healthy individuals and found *collaborative inhibition*, whereby individuals remember less when they collaborate than they would have remembered alone (Basden, Basden, & Henry, 2000; Harris, Paterson, & Kemp, 2008; Rajaram & Pereira-Pasarin, 2010; Weldon & Bellinger, 1997). This is typically the case when groups consist of randomly assigned, previously unacquainted pairs (as opposed to partners), who learn and recall a list of words.

In contrast, recent studies in healthy older couples have shown *collaborative facilitation* or benefits to memory performance (Barnier et al., 2018; Gagnon & Dixon, 2008; Harris, Keil, Sutton, Barnier, & McIlwain, 2011; Harris et al., 2018; Harris, Barnier, Sutton, Keil, & Dixon, 2017; Johansson, Andersson, & Rönnberg, 2005). Such facilitation can occur for both non-personal stimuli (e.g., a word list learned in the laboratory), but particularly for more personally-relevant shared information (Harris et al., 2011; Barnier et al., 2018), and includes facilitation of specific episodic recall (Barnier et al., 2014; Harris et al., 2017). Collaborative facilitation does not occur in all couples, and is predicted by particular kinds of communication strategies and relationship factors (Harris et al., 2011; Harris et al., 2018). Harris et al. (2014) have highlighted how relationship intimacy of romantic couples is central to their cognitive interdependence, and there is some evidence to suggest that level of relationship intimacy may be associated with enhanced collaborative memory performance. For example, Barnier et al. (2014) found that young couples who scored higher on a measure of relationship intimacy recalled more information during collaborative recall tasks. Interestingly, Barnier et al. (2018) failed to find this in a similar study with older couples, but this may have been due to the generally high ratings of intimacy across all participants. Collaborative recall studies have also noted the potential for collaboration to produce *post-collaborative benefits,* or improved individual memory performance after collaboration, even when individual recall is reduced during collaboration itself (Harris et al., 2008; Rajaram, 2011).

The findings of collaborative facilitation and post-collaborative benefits in neurologically healthy people in relationships suggests the potential for collaboration to be used as a memory rehabilitation strategy in people with memory impairment due to brain injury or disease (see Blumen, Rajaram, & Henkel, 2013; but see Barnier, Harris, & Congleton, 2013). There is, however, scarce research on this topic in the neuropsychological literature to date. There is evidence of collaborative benefits in learning and communication in couples where one partner has amnesia (Duff, Hengst, Tranel, & Cohen, 2006; 2008), and several studies have demonstrated a positive effect of spousal collaboration on memory performance in people with probable Alzheimer's dementia (Kemper, Lyons, & Anagnopoulos, 1995; Neely, Vikstrom, & Josephsson, 2009). One case of a man with a severe ABI showed that collaboration with his wife facilitated his performance of an episodic memory task (describing how they first met) but not a semantic memory task (list-

ing holidays). The enhancing effect on his recall of episodic details persisted when he performed the task alone one week later (Baird & Harris, 2015).

The aim of the current study was to explore the effects of collaboration on memory performance across a range of memory tasks, in intimate couples in which one person had an ABI or epilepsy and associated cognitive impairment. Specifically, we aimed to explore patient's performance of anterograde, semantic, and episodic memory tasks, alone and with their partner. Due to the likely asymmetry between the memory abilities of the two people within each couple (patient and healthy partner), we examined the patient's performance at an individual level rather than at a group or couple level as has been done in previous collaborative memory research. We also explored the effects of specific injury and relationship variables such as perceived relationship intimacy, length of relationship, and time since injury/onset on memory performance. Given the very scarce literature examining collaborative memory performance after acquired brain injury, this case series was intended to be exploratory in nature to identify potential patterns to examine in further research.

2. Methods

2.1. Participants

Participants were recruited through a community brain injury service in Australia. Patients were invited to participate if they had a diagnosis of either ABI or epilepsy, had attended the local community brain injury clinic or had undergone a neuropsychological assessment at the first author's private practice, and had a current partner. Exclusion criteria were relationship duration under one year, time since injury less than 3 months, and language impairment that would impact on their ability to complete the study tasks. Nine participants (4 female) with epilepsy ($n = 2$) or various types of ABI ($n = 7$; traumatic brain injury $n = 1$, stroke $n = 3$, tumour resection $n = 1$, hypoxic brain injury due to cardiac arrest $n = 2$) and their partners (total 18 participants) completed the study. Table 1 provides a summary of participant demographics including the main findings of their initial neuropsychological assessments performed for clinical purposes.

2.2. Measures

The Californian Verbal Learning Test – Second Edition (CVLT-II). The CVLT-II (Delis, Kramer, Kaplan, & Ober, 2000) is a verbal learning and memory task in which participants study and recall a list of words. The experimenter administered either the standard or alternate form of the CVLT-II and read aloud the 16 items to participants at the rate of one word every two seconds. After each of three presentations of the list, the experimenter instructed participants to immediately recall aloud as many words as they could remember within a time limit of three minutes. After the three presentation-test cycles (Tests 1-3), there was a 20-minute delay before participants were asked to recall the words again, without hearing them re-presented (long-delay free recall). For simplicity, we analyse and report Test 1 and the long-delay free recall for the CVLT task. We calculated the total number of words correctly recalled during Test 1 and the long-delay free recall of the CVLT task; we considered a word correct if it corresponded with the studied list or was a close approximation (e.g., singular/plural errors were considered correct).

Mutual Friends Task. We developed a personal semantic recall task in which the experimenter asked participants to recall the names of as many mutual friends or acquaintances (shared with their partner) as possible within a three-minute time limit. Specifically, the experimenters instructed participants: "I would like you to tell me all of the mutual friends or acquaintances both you and your partner know. Please only tell me people for whom you know both their first name and last name. Also, please do not include family members in your list. Try to make your list as long as possible. You will have three minutes to do this task". If recall appeared blocked, the experimenter prompted participants to continue trying to think of additional items until three minutes had elapsed. We calculated the total number of friends correctly recalled on the Mutual Friends task; we considered a friend correct if it included both a first name and a surname and was generated within the time limit for that task.

First Meeting Task. Participants were asked to recall in detail the autobiographical event of meeting their partner for the first time, within a time limit of three minutes. Specifically, the experimenter instructed participants, "Think about the time when you first met your partner. I want you to describe this event to me, and make your description as detailed as

Table 1
Demographics of participants with ABI or epilepsy

Case	Sex/ age (yrs)	Injury type	Time post onset	Rship length (yrs)	Neuroimaging (MRI findings)	Estimated premorbid intelligence level[a]	Main cognitive findings[b] (time of assessment post injury)
1	F/22	TBI	7 mths	5	Bifrontal and temporal encephalomalacia	Average	Mildly inefficient verbal recall, reduced speed of processing and executive functions
2	F/28	Stroke	3 mths	10	Right parietal haemorrhage	High average	Reduced speed of processing and executive functions
3	M/51	Stroke	11 mths	30	Left cerebellar infarct	High average	Mildly reduced executive functions
4	F/27	Tumour resection	4 mths	9	Cranio-pharyngioma at base of brain	Low average	Reduced speed of processing, executive functions, and recall
5	M/68	Hypoxic (cardiac arrest)	11 yrs, 7 mths	40	N/A (motion artefact)	Average	Severely reduced speed of processing and globally impaired recall
6	M/37	Stroke	1 yr, 4 mths	10	Intraventricular, left occipital, splenial haemorrhage with right-sided mass effect	Average	Severely reduced speed of processing, recall, executive function, and mildly reduced visual intellectual abilities
7	M/53	Hypoxic (cardiac arrest)	10 mths	33	Not done	Low average	Reduced executive functions and recall
8	M/62	Epilepsy	48 yrs	30	Subcortical white matter disease EEG suggestive of idiopathic generalised epilepsy	Superior	Severely impaired memory
9	F/72	Epilepsy	1 yr	50	Normal MRI Video EEG monitoring: complex partial seizure arising from the left temporal lobe. Frequent interictal bitemporal epileptiform activity	High average	Reduced autobiographical memory recall for childhood and mildly reduced verbal and visual recall

[a]Performance on the Test of Premorbid Function. [b]Main findings of comprehensive neuropsychological assessment. Memory assessment comprised verbal and visual recall memory tasks, and in Case 9 only autobiographical memory was also assessed due to this being her main memory complaint. Rship = relationship; yrs = years; mths = months.

possible, including what happened and where, as well as both of your reactions and emotions and anything else you can remember". We coded the transcripts from the First Meeting autobiographical memory task for Episodic Specific details by tallying the number of details recalled that consisted of unique information relating to a specific episodic event; that is, details that referred to a unique, single event that happened on a particular day.

Personal Assessment of Intimacy in Relationships (PAIR). The PAIR scale (Schaefer & Olson, 1981) is a measure of couple intimacy consisting of 36-items across 5 sub-scales: Emotional Intimacy (6 items), Social Intimacy (6 items), Sexual Intimacy (6 items), Intellectual Intimacy (6 items), Recreational Intimacy (6 items) and a Conventionality Scale (6 items). Participants rate how much a given statement applies to their current romantic relationship on a 5-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). Results were scored out of a possible maximum of 180, with higher scores indicating greater assessment of relationship intimacy.

Everyday Memory Questionnaire (EMQ). The EMQ (Sunderland, Harris, & Baddeley, 1983) is a self-reported measure of memory failures in everyday life consisting of 35-items across 5 sub-scales:

Table 2
Personal Assessment of Intimacy in Relationships (PAIR) scores by couple. Max score = 180. Higher scores indicate greater assessment of relationship intimacy

Case number	Patient	Partner
1	140	139
2	105	138
3	138	140
4	140	142
5	134	81
6	107	69
7	150	100
8	140	157
9	162	150

Table 3
Everyday Memory Questionnaire (EMQ) scores. Max score = 140. Higher scores indicate more frequent memory failures

Case number	Patient's self-rating	Partner's rating of patient
1	13	19
2	48	48
3	51	26
4	51	8
5	15	31
6	21	69
7	53	89
8	37	57
9	41	37

Speech (13 items), Reading and Writing (4 items), Faces and Places (6 items), Actions (6 items), and Learning New Things (6 items). Participants rate how frequently each memory failure item has occurred over the past month on a 5-point Likert scale (for sub-scales 1-4, 0 = *never*, 4 = *several times a day*; for sub-scale 5, 0 = *never*, 4 = *on every occasion*). Each patient completed the EMQ in relation to themselves, while the healthy participants completed the EMQ in relation to their partner with an ABI or epilepsy. Results were scored out of a possible maximum of 140, with higher scores indicating greater frequency of everyday memory failures.

2.3. Case descriptions

Case 1 was a 22-year-old woman who sustained a severe traumatic brain injury (with neuroimaging evidence of bi-frontal and bi-temporal damage) in a motor vehicle accident 7 months prior to her participation in the study. She had been in a relationship with her boyfriend ('high school sweethearts') for 5 years with a period of separation for several months just prior to and after her injury. Their relationship intimacy ratings on the PAIR were well matched (see Table 2). Her opinion of her own memory functioning was fairly consistent with her boyfriend's opinion, who rated her as having marginally more difficulties on the EMQ (see Table 3).

Case 2 was a 28-year-old woman who had a right parietal haemorrhage secondary to a ruptured aneurysm 3 months prior to her participation in the study. She had been married to her husband for 10 years. Their relationship intimacy ratings on the PAIR were inconsistent, with the husband rating significantly higher (see Table 2). Her husband's and her own opinion of her memory function were well matched on the EMQ (see Table 3).

Case 3 was a 51-year-old man who had a left cerebellar stroke 11 months prior to his participation in the study. He had been married to his wife for 30 years. Their relationship intimacy ratings on the PAIR were well matched (see Table 2). His wife rated him as having slightly fewer difficulties than his self-rating on the EMQ (see Table 3).

Case 4 was a 27-year-old woman who underwent a tumour (craniopharyngioma at base of brain) resection 4 months prior to her participation in the study. She had been married to her husband for 9 years. Their relationship intimacy ratings were well matched on the PAIR (see Table 2). Her opinion of her memory functioning was inconsistent with her husband, who rated her as having fewer difficulties than her self-rating (see Table 3).

Case 5 was a 68-year-old man who sustained a hypoxic brain injury during a cardiac arrest approximately 11 years prior to his participation in the study. He had been married for 40 years. Their relationship intimacy ratings on the PAIR were highly inconsistent, with his rating much higher than his wife's (see Table 2). His opinion of his memory function was inconsistent with his wife who rated his difficulties as much greater compared with his self-rating on the EMQ (Table 3).

Case 6 was a 37-year-old man who had a stroke (intraventricular haemorrhage of unknown cause) approximately one year prior to his participation in the study. He had been married for 10 years. Their relationship intimacy ratings on the PAIR were highly inconsistent with her rating much lower than his (see Table 2). His opinion of his memory function was inconsistent with his wife who rated his difficulties as much greater compared with his self rating on the EMQ (see Table 3).

Case 7 was a 53-year-old man who sustained a hypoxic brain injury during a cardiac arrest 10 months

prior to his participation in the study. He had been in a relationship for 33 years. Their relationship intimacy ratings on the PAIR were highly inconsistent with her rating much lower than his (see Table 2). His opinion of his memory function was inconsistent with his wife's, who reported his difficulties as much greater on the EMQ compared with his self-rating (see Table 3).

Case 8 was a 62-year-old man who had a diagnosis of temporal lobe epilepsy at 14 years of age that was revised to generalised idiopathic epilepsy in adulthood. He had been married for 30 years. Their relationship intimacy ratings on the PAIR were relatively well matched (see Table 2). His opinion of his memory function was somewhat inconsistent with his wife's, who reported his difficulties as greater than his self-rating on the EMQ (see Table 3).

Case 9 was a 72-year-old woman with recent onset left temporal lobe epilepsy. She had been married 50 years. Their relationship intimacy ratings on the PAIR were relatively well matched (see Table 2). Her opinion of her own memory function was consistent with her husband's, with their ratings on the EMQ well matched (see Table 3).

In summary, participants varied substantially in age, relationship duration and characteristics, and injury variables including nature and degree of cognitive impairment. We were interested in how these different profiles would impact on their individual and collaborative remembering.

3. Procedure

All memory tasks were completed by the patients with ABI or epilepsy in an individual session first and then repeated one week later in collaboration with their partner. Sessions were audio-recorded to enable transcription for detailed analyses and coding of responses.

3.1. Session 1

In Session 1, patients attended the brain injury service or the private practice office of the first author and were tested alone. Participants were first asked to recall autobiographical memories cued by a self-selected song and photograph, the results of which we do not report here. Participants were then asked to complete the CVLT task, followed by the Mutual Friends task and then the First Meeting task. At the end of Session 1 patients completed the PAIR.

3.2. Session 2

One week after the initial individual recall session, patients returned together with their partners and participated in a collaborative recall session. The experimenter administered the CVLT task using the alternate list to Session 1 and the same procedure of four recall tests but with an instruction for participants to work together to jointly recall the words. The experimenters did not instruct participants on how to collaborate or how to resolve disagreements, except that they should "work together to help each other to recall as many items as possible". Next, participants completed the Mutual Friends task with the same instructions as in Session 1 except that couples should "work together to tell me all of the mutual friends or acquaintances that you both know". We limited participants to three minutes for each of these joint recall tasks. If recall appeared blocked, the experimenter prompted participants to continue trying to think of additional items until three minutes had elapsed. As in Session 1, the experimenters asked participants to jointly recall in detail a number of autobiographical memories, including the memory of their first meeting, for which they were given three minutes. The instructions were the same as in Session 1, except that they were asked to "work together to recall as many details as possible". At the end of Session 2, both patients and partners completed the EMQ and PAIR.

3.3. Coding and scoring

Two trained research assistants transcribed all sessions in full from the audio recordings. We scored the CVLT and Mutual Friends memory tasks for the total number of items (words, friends) recalled and the individual contribution of the patient during collaborative recall. Two independent raters coded for the amount of Episodic Specific detail during the First Meeting tasks from Session 1 and 2; their inter-rater reliability was $r = .84$. We retained the ratings of the first coder for analysis following discussion of any disagreements.

4. Results

For each memory task, we examined the individual recall performance of patients, the couple's joint collaborative performance, and individual patient contribution during collaboration. Table 4 shows the

Table 4
Patients' individual (Session 1) and Couples' collaborative (Session 2) scores on (a) verbal learning and (b) long-delay free recall on the CVLT, and their individual contribution during collaboration

Case number	S1 individual score	S2 collaborative score	S2 patient contribution to collab
(a) Test 1 initial learning			
1	7	8	6
2	6	11	8
3	7	11	2
4	5	10	4
5	4	5	0
6	5	8	2
7	5	11	2
8	4	6	2
9	4	7	5
(b) Long-delay free recall			
1	15	15	8
2	15	15	8
3	13	16	6
4	11	15	9
5	3	14	1
6	3	14	2
7	1	16	0
8	1	14	1
9	11	16	6

S1 = Session 1; S2 = Session 2; collab = collaboration.

Table 5
Patients' individual (Session 1) and Couples' collaborative (Session 2) scores on the Mutual Friends task, patients' individual contribution during Session 2 collaboration, number of new items contributed by the patient in Session 2, and number of previously (Session 1) recalled items contributed by the healthy partner during collaboration (Session 2)

Case number	S1 individual score	S2 collaborative score	S2 patient contribution to collab	S2 patient contributed new items	S2 partner contributed old items
1	17	29	18	7	3
2	12	15	6	2	3
3	33	55	36	17	4
4	11	15	3	1	6
5	3	31	2	2	1
6	6	13	5	3	0
7	8	14	2	1	5
8	9	28	10	5	1
9	22	29	16	9	0

S1 = Session 1; S2 = Session 2; collab = collaboration.

Table 6
Patients' individual (Session 1) and Couples' collaborative (Session 2) scores on the First Meeting task, and patient's individual contribution during collaboration (Session 2)

Case number	S1 individual score	S2 collaborative score	S2 patient contribution to collab
1	12	15	11
2	14	23	12
3	6	14	6
4	7	4	1
5	4	2	1
6	6	17	10
7	12	33	14
8	14	32	10
9	15	17	6

S1 = Session 1; S2 = Session 2; collab = collaboration.

results for the initial learning (Test 1) and delayed recall of the verbal memory task (CVLT), Table 5 for the Mutual Friends task (listing friends), and Table 6 for the First Meeting task (describing how they first met). A summary of the main findings for each task in turn is provided below.

4.1. Verbal learning and delayed recall

On the word list task, recall scores of the couple together were higher than for the patient alone across both initial learning and delayed recall, except when the patient was effectively at ceiling, in which case there was no room for significant improvement (i.e., Case 1 and 2 delayed recall score, see Table 4). In regard to the contribution of the participant with ABI or epilepsy during collaboration, with the exception of Cases 2 and 9 who showed marginally better Test 1 performance during collaboration compared with their individual performance, in all other cases, the patients contributed less during collaboration for both initial learning and delayed recall performance than when they performed the task alone (see Table 4). Therefore, collaboration typically resulted in decreased performance of the participant with ABI or epilepsy, and the improved overall score during collaboration was due to the contribution of their healthy partner.

4.2. Personal semantic memory

On the Mutual Friends task, performance (total score) of the couple together was higher than for the patient recalling alone in all cases (see Table 5). When we examined the contribution of the patients to the score during collaboration, three patients (Cases 1, 3 and 8) showed improved performance, recalling more names when collaborating with their partner than when they did the task alone. The remainder (6/9) contributed less names during collaboration compared with when they did the task alone (see Table 5). Of note, some patients generated new names during collaborating which they had not produced when doing the task alone. Therefore, there was evidence that in some cases, collaborating with a partner enabled patients to recall more names overall (Cases 1, 3 and 8), or to recall new items not previously recalled when doing the task alone (e.g., Cases 1, 3 and 9). Nevertheless, the majority of patients contributed less names overall when collaborating on this task.

4.3. Autobiographical memory

On the First Meeting autobiographical memory task, the majority of couples (7/9) recalled more episodic details when they collaborated together than the patient recalled alone (see Table 6). In two cases, however, collaboration actually decreased the overall score (Cases 4 and 5), in that the couple together provided fewer episodic details than the patient had been able to recall alone. When we examined the contribution of the patients during collaboration, in the majority of cases (6/9) they contributed fewer episodic details to the collaboration than they had been able to recall alone (see Table 6). In one couple (Case 3) the contribution was the same, and in two couples (Cases 6 and 7) collaboration improved patients' individual performance. In summary, collaboration typically improved overall performance of the autobiographical memory task, but this was due to the healthy partner's contribution, as in the verbal learning and recall task, while the patient's contribution was typically less during collaboration than when they completed the task alone.

4.4. Interaction and scaffolding processes

There was variability in scaffolding styles and task performances across and within couples, indicating the contextual sensitivity of the scaffolding phenomenon. Nevertheless, we found that patients tended to recall less with their spouse than they were able to recall alone. Why did this reduction in contribution occur and why was it more marked in some couples than others? Analysis of the transcripts provides insights into the patterns of interaction that drove this overall tendency for patients to recall less when they collaborated with their spouse. We identified two distinct styles in the way that patients and their partners approached the task of collaborating together.

The first, we term "*survival scaffolding*". This was characterised by healthy partners promptly 'taking over' the recall task, while the patients' contributions tended to be repetitions and acknowledgments of their partner. This interaction style was particularly evident in Couples 5, 6 and 7, as the following transcript examples illustrate. The dialogue below shows Couple 6's joint recall on the CVLT long-delay recall task:

Patient: Cricket.

Partner: Drill, watermelon, cricket, hats, coats, shorts, cherries, peaches, chisel, pliers, butterfly, wrench, termite. Drill, watermelon, butterfly. Drill, watermelon, butterfly, termites, hats, coats . . .

Patient: Grasshopper, grasshopper. Grasshopper, is it?

Partner: Grasshopper.

Patient: Yeah, cricket, have you mentioned that one?

Partner: Cricket, I think I did mention.

The patient contributes the first item but then pauses, prompting their partner to take over, and their partner repeats the item 'cricket' without acknowledging that the patient had in fact already recalled it. Subsequently, the patient contributes the new item 'grasshopper', but is uncertain, repeating the word several times and seeking confirmation from their partner. Finally, the patient contributes 'cricket' again, but can't recall whether he or his partner have already said it. Similarly, during Couple 5's joint recall on the Mutual Friends task[1], the healthy partner contributed most of the unique recall items:

Partner: Chris and Pat Harrison. John and Bob March. Robert May.

Patient: Yep.

Partner: Greg and Debbie Bourke. Paul and Rose Lawson. Jack and Sue Baker.

Patient: Yep.

Partner: Karen and Don Campbell. Melissa and David Berger.

Patient: Who? Melissa?

Partner: Melissa and David Berger. Can't remember?

Patient: I don't remember.

Partner: We haven't seen them for a while. Peter and Shelly Ashton.

In the example above the healthy partner begins the recall, with the patient providing acknowledgements but not contributing new items. Later, when the patient doesn't recognise the recalled names 'Melissa and David Berger', their partner provides a justification, "We haven't seen them for a while", before continuing with the task.

During Couple 5's recall on the First Meeting task, the partner similarly begins recall and contributes most of the unique information:

Partner: I think I might have met you, seen you there, just before we became closer friends. I think I probably saw you the Macquarie Hotel or the Innes Tavern with Cindy McPherson and Rob Brown. And that was when we first met, after you left the air force and you were living in Port Macquarie. Yeah, so yeah, so we became friends through our mutual friends.

Patient: Acquaintances, yeah.

Partner: Mutual friends. And then, yeah, and then . . .

Patient: Progressed from there.

Partner: . . . progressed from there. I think we spent a lot of time . . . At that point in time you were living with Harry Abram and that group of guys, and it was after that that you moved in with Ned.

Patient: Hmmm.

Partner: I think when we started going out together you moved in with Ned. Yes, would that be right?

Patient: Yeah, right, yeah.

In the example above, the partner provides an opportunity for the patient to contribute, but their response does not provide any new information, instead a vague indication that the story is complete ("progressed from there"). Later, the partner seeks confirmation of their recall with the question, "would that be right?", but this is met by a simple acknowledgment without the patient providing any further detail.

When Couple 7 attempt the Mutual Friends task together, the healthy partner similarly directs the recall:

Partner: Okay. So, Andrew and Anne O'Leary. Chris and Linda Cotton.

Patient: [Graham]

Partner: [Pauline] and Graham Fischer. Pauline and Betty Hudson.

[1]Names have been changed throughout.

Patient: Yep.

Partner: Wendy-, Julie and Steve . . .

Patient: Parr.

Partner: Parr. Lexi and Peter Grant.

Patient: Mhm.

Partner: Keep going!

Patient: That's about it. The rest are all family, aren't they?

Partner: Ah, you could probably extend it further if you think about it. Butlers.

Patient: Yeah.

Partner: Cathy and . . .

Patient: Cat-

Partner: Scott Walsh

Patient: Mm.

In this example, the patient's early attempt to contribute the recall item "Graham" is lost while his wife simultaneously recalls friends' names. When she later prompts him to continue with the task ("Keep going!") he is hesitant and indicates that there are no more names to recall. His further contributions are limited to simple acknowledgements and repetition of his wife's recall, as seen in Cases 5 and 6.

Interestingly, Couples 5, 6 and 7 all showed similar patterns on the EMQ and PAIR measures. On the EMQ, these three couples showed asymmetric results with the partners rating the patients as having significantly more everyday memory failures than the patients themselves (Table 3). On the PAIR, these three couples also showed highly asymmetric results with the patients reporting much higher relationship intimacy than their partner's assessment of their relationship intimacy (Table 2). Therefore, it appears that mismatched ratings of memory function and intimacy between couples may be associated with this particular 'survival scaffolding' style in which the healthy partner takes primary responsibility for remembering.

This can be contrasted with a second style, which we term "*stability scaffolding*". This was characterised by more symmetrical contributions to recall, and more frequent and strategic cueing by the healthy participants of their partner with a cognitive impairment. This interaction style was particularly evident in Couples 1, 2 and 9, as the following transcript examples illustrate. The dialogue below shows Couple 1's joint recall on Test 1 of the CVLT task:

Partner: You say as many as you've got.

Patient: Okay, bookcase, cabbage, zebra. Giraffe, I'm pretty sure? Squirrel, truck . . .

Partner: Spinach, motorcycle.

Patient: Yeah.

Partner: Have you already said that one?

Patient: No, I didn't.

In the example above, the healthy partner begins the task by prompting the patient to contribute the items that they can remember first, and only contributes additional items after the patient pauses. In Couple 1's joint recall on the Mutual Friends task, the partner similarly prompts the patient shortly after they begin recall:

Partner: Yeah, I said Jack. Let's go through your friends. Mel Blake.

Patient: Oh yeah. Mel Blake. Melanie Byrne, Tilly Steele, Talia Rhodes.

Partner: Hmmm.

Patient: Samantha Brook, Phoebe Carlton-Jones. I don't know Mick's last name for some reason.

Partner: Mick McCormack.

Patient: Oh yeah.

The partner suggests the strategy, "Let's go through your friends", choosing a category relevant to the patient and therefore perhaps easier for her to remember. The partner waits for the patient to contribute the items that she can remember, but provides the missing information when the patient states, "I don't know Mick's last name". Couple 2 showed similar patterns of interaction when completing the First Meeting task together:

Patient: I thought you were crazy, and you tried to put me in a pyramid scheme.

Partner: I was selling stuff, and I saw her in Gloria Jeans at Jesmond, which is close to where we're living now.

Patient: But back then it was just close to me.

Partner: Yeah. And I thought she doesn't want to buy the product, I can ask her out, and if she says yes, great, if she says no . . .

Patient: It wasn't really asking me out, it was getting me to give you my address, so you can pick up a CD. So, it's not really the same thing.

Partner: Anyway, she said no. [giggle] I still went back to pick up the CDs and then I asked her out.

Patient: I gave him the CD, I said, "okay, thanks . . . "

Experimenter: What was the CD?

Patient: It was a . . .

Partner: It was one of those things they talk to you about the advantages of the actual product.

Patient: The pyramid scheme. So, I gave it to him . . . and I went back inside and shut the door. [laugh]

Partner: But anyway, I contacted her again and asked her to go out on a movie. Was it a movie?

Patient: Yeah, it was a movie, it was something.

In the above dialogue, the couple engage back and forth, with both participants contributing unique information to the recall. The patient interjects several times to clarify their partner's contributions, but also elaborates on the recall with new information. Later, the partner seeks confirmation from the patient by asking, "Was it a movie?", which she confirms.

Couple 9's dialogue during the Mutual Friends task similarly reveals a combination of mirrored repetitions, turn-taking and strategic cueing:

Partner: Okay, I'm thinking of Caitlin and Tim, but I can't think of their various names. Caitlin Fry, who's in your knitting . . . no, that's...

Patient: What's Kelly's surname? It's Adam Sunderland, isn't it? And Kelly.

Partner: Kelly Galbraith.

Patient: Galbraith, yes.

Partner: Other neighbours – Harold Schmidt and . . .

Patient: Oh, Wilsons! Laurie Wilson and Jim Wilson. I couldn't remember Wilsons.

Partner: Myra Wilson and Deb Wilson.

Patient: I like these friends you're choosing.

Partner: What about your old work people?

Patient: Heather Parsons, and Pat Mansour and Gordon Mansour, Bob Hoffman and Larissa Hoffman.

Partner: Your work . . .

Patient: Oh, Mia Lowry and Tom Farrow, and Julia Darby.

Partner: And Trevor Oakes.

Patient: And Trevor Oakes.

During this exchange, the healthy partner uses categories ("other neighbours", "your old work people") to assist in cueing his wife, who responds in each case with unique recall items. There is also evidence of the couple listening and responding to each other's contributions, through the use of direct questions ("What's Kelly's surname?") and mirrored repetitions ("and Trevor Oakes").

In contrast to Couples 5, 6 and 7, Couples 1, 2 and 9 showed more symmetric results on the EMQ and PAIR measures. Among these couples, the patients each rated themselves as having a similar frequency of memory failures as their partner's assessment of their memory (Table 3). In contrast to Couples 5, 6 and 7, they also showed more symmetric results on the PAIR, with the patient in Couple 2 rating their relationship intimacy somewhat lower than their partner, while Couple 1 and Couple 9 were both well matched (Table 2). Therefore, matched ratings of memory function and intimacy may be associated with a 'stability scaffolding' style. Interestingly, these cases also showed the relatively rare pattern of patients' improved recall during collaboration, at least for some tasks, with Cases 2 and 9 recalling more items during collaboration than alone on the CVLT Test 1 (see Table 4), and Case 1 recalling more items during collaboration than alone during the Mutual Friends task (see Table 5), suggesting that their partners were particularly effective at cueing and supporting their recall.

4.5. Comparing scores across scaffolding styles

While we could identify instances of these two different scaffolding styles across different couples, we also note that the roles adopted during collaboration and the effects of collaboration varied across tasks. Therefore, it was not straightforward to classify particular couples as always using a particular scaffolding style, or consistently being more or less effective collaborators. Couples did not always adopt

the same scaffolding style across all tasks, rather, it appeared to depend on the task at hand, and could also reflect their existing perceptions of relative expertise within the couple. Furthermore, some couples' collaborative performances did not readily fit into these two proposed scaffolding styles (Cases 3, 4 and 8). Nevertheless, we examined potential differences across measures in these two types of couples.

To assess group level differences between couples identified as adopting 'survival' and 'stability' scaffolding styles, we conceptually compared patterns of means across a range of measures (see Table 7). Although the numbers of couples in each scaffolding type were small, the differences between these groups are marked. Interestingly, all the couples we identified as 'stability' scaffolders were relatively recent post-onset of ABI or epilepsy, while the 'survival' group were on average much later post-onset (see Table 7). Perhaps this suggests a trajectory of relationship interaction with the 'stability' group still negotiating the recent cognitive changes and reflecting pre-onset interaction styles.

As mentioned above, the healthy partners in 'survival' scaffolding couples rated their partners as having greater memory difficulties on the EMQ compared to the 'stability' group. This assessment corresponded with actual patient performance on both the CVLT and Mutual Friends tasks, with patients in the 'survival' scaffolding group recalling, on average, fewer items during both the individual and collaborative sessions compared to their 'stability' scaffolding counterparts (see Table 7). Nevertheless, we did not find evidence of differences between groups during the First Meeting task in Session 2, with 'survival' scaffolding patients contributing as many details during collaboration as their 'stability' scaffolding counterparts on this task. This suggests that recalling highly personal autobiographical memories (such as a first meeting) with one's partner might elicit different modes of interaction to more straightforward semantic or verbal learning recall tasks.

To assess the extent to which both patients' and healthy partners' assessment of the patient's memory functioning was associated with actual patient performance, we obtained correlations between patient EMQ scores, partner EMQ scores, and patient recall performance across all couples. There was no relationship between patient EMQ scores and recall performance on any task, (all $rs < .361$, all $ps > .340$). That is, patients' ratings of their everyday memory failures did not reflect their actual memory performance. In contrast, partners' ratings appeared more consistent with objective performance. There was a significant negative correlation between partner EMQ and patient performance on both the individual Session 1 CVLT-LD, $r = -0.672$, $p = 0.047$, and on the patient contribution during Session 2 CVLT-LD, $r = -0.739$, $p = 0.023$. Therefore, partners might provide more accurate assessments of memory function than patients themselves. Interestingly, there was a positive correlation between partner EMQ and patient contribution to the First Meeting task in Session 2, where higher scores on the EMQ were associated with more details provided during collaborative recall, $r = 0.706$, $p = 0.034$, perhaps reflecting successful scaffolding of performance on this personally relevant task. We did not find significant correlations between partner EMQ measures and patient performance on other tasks.

In summary, patients within 'survival' scaffolding couples generally recalled fewer items across the memory tasks, both at the baseline individual level, and during collaborative recall (i.e., they contributed less when working together with their partner). Their generally poorer performance (compared to the 'stability' group) was accurately reflected by their partners' EMQ measures, which rated them as having greater memory difficulties than their own self-ratings. Patient self-ratings on the EMQ did not differ across groups, suggesting that poorer performing 'survival' scaffolder patients were not aware of their own memory failures. For the 'stability' scaffolding group, measures on the EMQ do not differ between partners and patients, suggesting that each member of the couple has a similar assessment of the patient's memory functioning. Moreover, 'survival' scaffolding couples had highly asymmetric intimacy measures on the PAIR, with healthy partners within 'survival' scaffolding couples reporting much lower intimacy assessments than the patient. As with the EMQ results, 'stability' scaffolding couples report more symmetric intimacy, with no significant difference between patient and partner PAIR scores among these couples.

5. Discussion

This case series contributes to the scarce literature investigating the effects of collaboration with an intimate partner on memory performance in people with neurological conditions. In the current study, we explored the effects of collaboration on both the

Table 7
Means compared by scaffolding style. S1 = Session 1 (Individual). S2 = Session 2 (Collaborative). SD = Standard Deviation. 'Survival' Group $n = 3$, 'Stability' Group $n = 3$

	'Survival' group		'Stability' group	
	Mean	SD	Mean	SD
Length of relationship	27.67	15.70	21.67	24.66
Months since onset	55.00	72.81	7.33	4.51
Patient PAIR total	130.33	21.73	135.67	28.75
Partner PAIR total	83.33	15.63	142.33	6.66
Patient EMQ total	29.67	20.43	34.00	18.52
Partner EMQ total	63.00	29.46	34.67	14.64
S1 CVLT-LD Hits	2.33	1.15	13.67	2.31
S1 Friends Hits	5.67	2.52	17.00	5.00
S1 First Meeting Detail	7.33	4.16	13.67	1.53
S2 CVLT-LD Hits (Patient)	1.00	1.00	7.33	1.15
S2 Friends Hits (Patient)	3.00	1.73	13.33	6.43
S2 First Meeting Detail (Patient)	8.33	6.66	9.67	3.21

overall memory performance (total score) and the contribution of people with ABI or epilepsy during collaboration across three memory tasks assessing verbal learning and delayed recall, semantic and episodic, specifically autobiographical memory functions.

We found that across most tasks and participants, collaboration with their intimate partner resulted in a greater total score than that obtained when the participant with the neurological condition performed the task alone. This is not surprising perhaps, in that "two heads are better than one". In contrast, however, the patients' (with ABI or epilepsy) contribution to the collaborative memory performance was typically lower than their individual score when they performed the task alone. This pattern was demonstrated in the majority of cases across all three memory tasks, although it was noteworthy that in some cases collaboration improved patients' performance on the Mutual Friends task in that they produced more names, or produced new names that they had not recalled when doing the task alone. This suggests that the effects of collaboration on patients' memory performance are not exclusively positive or negative, but are highly dependent on the task at hand, in addition to other variables which will be discussed below.

Previous collaborative memory research in healthy couples has found evidence of collaborative inhibition and facilitation, depending on the relationship between participants. Collaboration between strangers tends to inhibit memory performance (Harris et al., 2008; Marion & Thorley, 2016; Rajaram, 2011), while intimate partners can show facilitated performance (Barnier et al., 2018; Harris et al., 2017), which varies according to their use of communication strategies (Harris et al., 2018; Harris et al., 2011). In previous research focusing on healthy younger and older adults, inhibition and facilitation have been indexed at the couple level: does the couple as a unit recall more or less together compared to separately? In the case of neurological impairment, it is informative to conceptualise collaborative inhibition and facilitation as occurring at both the couple and individual level, such that an individual with cognitive impairment might be facilitated when remembering with their partner.

The current findings suggest that in the case of neurological conditions, specifically ABI or epilepsy, collaborating with a partner tends to reduce patients' recall, in that the patient contributes less when they collaborate than when they do the task alone. We are unaware of any other collaborative recall studies of people with these neurological disorders, but several studies have examined collaborative memory in couples in which one person has probable Alzheimer's dementia (AD). There are various methodological differences between these studies, but they have typically found that collaboration enhances performance of the person with AD. For example, Kemper et al. (1995) examined the person with AD's performance at an individual level when doing a narrative task alone and with their spouse, and found that the person with AD told "significantly longer and more elaborated personal narratives in collaboration with their spouses than they were able to tell in the solo condition" (p. 214). Hydén (2011) outlined the facilitating strategies (which he termed 'narrative scaffolding') that were used by couples during 'collaborative story telling' when one person has AD. Although he did not directly compare individual versus collaborative performance, he commented on factors that impact on narrative scaffolding, and highlighted that such

activities are linked to the moral obligations of both participants who are committed to the joint activity. Their mutual commitment to it is "based on their longstanding relationship and their attempt to sustain this relationship in the face of the progressive disease" (p. 346).

There are important and significant differences between the nature of AD, ABI and epilepsy that are likely to underpin the differences in the effects of collaboration between these populations. AD is a neurodegenerative disease, which causes a gradual and progressive decline in cognitive functioning, whereas an ABI causes a very sudden onset of cognitive impairment followed by a period of recovery, although not necessarily to pre-injury levels. In the case of people with AD, because of their typically advanced age, they are likely to be in a longstanding relationship of several decades. As the cognitive decline is gradual, the healthy partner can adapt to provide emergent and progressive "scaffolding" that increases over time. In contrast, an ABI typically occurs at a younger age, therefore the duration of the relationship may not be very long (years rather than decades in the case of AD). The healthy partner is suddenly catapulted into the "scaffolder" role with no warning. This typically causes significant relationship strain, which is evident in the high incidence of relationship breakdown post ABI (Webster, Daisley, & King, 1999). This was also evident in the difficulty recruiting ABI participants for this study. It was challenging to recruit participants to attend an experimental session together with their partner, due to the stress that occurs in couples after an ABI, as they navigate the aftermath of the injury. In the case of epilepsy, the age of onset and frequency of seizures may impact on cognition and adjustment to the diagnosis and impact on relationships. These factors vary in our two epilepsy cases, with Case 9 having a recent seizure onset in the context of a longstanding relationship, while Case 8 had a seizure onset in childhood prior to the onset of the relationship. Injury/seizure related variables (e.g., severity, time since injury/onset) and relationship factors (length of relationship, perceived intimacy) are also likely to influence the impact of collaboration. Differences in time of onset of the neurological condition relative to relationship length, and the nature of progression or recovery of cognitive deficits appear to contribute to the different scaffolding styles that develop in intimate relationships. These issues warrant further research in a larger sample of couples and in different neurological conditions.

We were able to identify specific scaffolding types during collaboration in some couples during some tasks, which we have termed *survival* and *stability* scaffolding. For example, in the case of severe ABI and associated memory impairment (e.g., Case 5), we propose that the healthy partner engages in survival scaffolding and tends to take over the task at hand in order to complete it successfully. This was particularly evident in couples and on tasks for which the patient had significant difficulty. Patients in survival scaffolding couples had lower memory scores across tasks. In engaging in survival scaffolding, however, the patient contributes even less than they would when doing the task alone, perhaps in a sort of learned reliance on their partner. In everyday life, such scaffolding may be highly adaptive for tasks where it is important that they are done correctly and completely, such as remembering to take medication or completing a form. Interestingly, this survival style of scaffolding was evident in couples in whom there was a mismatch in ratings of intimacy and memory function, suggesting that such asymmetries may have implications for rehabilitation and relationship quality. Following a period of post injury rehabilitation patients are typically discharged home into the care of their partner. Therefore, addressing such asymmetries could help to optimise rehabilitation.

In contrast, in some patients with less severe memory impairment post ABI (e.g., Case 1) or onset of epilepsy (e.g., Case 9) and in the early stages post injury, their healthy partner appeared to engage in stability scaffolding, enabling them to contribute what they can and assist in a mutually beneficial way to succeed in performing the task. They may be still be learning how to collaborate during cognitive tasks (given the relatively early stage post injury or onset of seizures). There was some evidence of this in Cases 1 and 2 during initial learning on the verbal task in which they appeared to share the responding (contributing approximately half each) despite the person with the ABI obtaining a near perfect score alone. In Case 9, both the patient and healthy partner contributed similarly to the Mutual Friends and First Meeting tasks, despite the patient recalling more information when completing these tasks alone. In everyday life, such stability scaffolding may have particular application to tasks in which accuracy and completeness are less important than joint contribution, such as joint reminiscing. Compared with the couples who showed survival scaffolding styles, the couples who demonstrated stability scaffolding showed well matched ratings of intimacy and

memory function, suggesting that these factors may predispose to this scaffolding style. It is important to note, however, that couples did not consistently and exclusively adopt one scaffolding style across all tasks. Identifying the factors that contribute to these variations requires further research.

There are a number of limitations of this case series which we acknowledge. First, the sample size was small and heterogeneous, with variations in injury type and relationship factors. We did not assess baseline individual recall performance for healthy participants, as our focus was on the patients, but it is possible that collaboration also impacts on the healthy partner's performance during memory tasks. Further, we did not examine the patients' individual performance post collaboration, as a means of exploring post-collaborative benefits. This warrants further research as it has implications for the rehabilitative potential of collaboration. Further research on collaborative memory in the context of cognitive impairment associated with sudden onset neurological disorders such as ABI, or gradual onset neurological diseases such as dementia is needed to understand the impact of pre-existing relationship styles and cognitive interdependence on post-injury or disease functioning. Future research on a larger sample of couples with specific neurological conditions could help to disentangle the contribution of specific variables such as level of intimacy, time since onset, and length of relationship.

In conclusion, this case series provides an exploration of how collaboration with an intimate partner affects the performance of a person with an ABI or epilepsy on three memory tasks. We found that overall task performance is typically improved during collaboration, but that the contribution of the person with the neurological condition is typically reduced compared with when they do the task alone. In other words, collaboration both helps and hinders task performance in the face of ABI or epilepsy, and more research is required to identify the contextual factors that impact on these variations. We hope that our initial exploration of these phenomena in this case series stimulates further research.

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Conflict of interest

The authors report no conflicts of interest.

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