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How successful is errorless learning in supporting memory for high and low-level knowledge in dementia?

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Errorless learning has been shown to be very successful in the rehabilitation of memory problems particularly in patients with severe forms of memory impairment. Much of this research has focused on testing knowledge of specific details studied, ignoring any additional, higher-level knowledge that patients may have acquired during the learning process. Hence, it is pertinent to ask whether errorless learning is equally successful in the acquisition of high and low-level knowledge. In this paper, we present results of several studies comparing the effectiveness of errorless and standard trial-and-error methods in acquisition of high and low-level knowledge in people diagnosed with dementia and non-impaired controls. In Study 1, participants were asked to learn novel face–name–occupation associations; and knowledge across a range of levels, from very general (i.e., high-level) to very specific (i.e., low-level), was examined. For patients with probable Alzheimer's disease and controls there was evidence of increased benefit from errorless training in general, but the technique was most beneficial for patients attempting to retrieve specific detail. Study 2 was conducted to address the problem raised by the failure in Study 1 to manipulate learning condition at our highest knowledge level. This novel manipulation was successful, but neither of the patients received the standard benefit from errorless training. Study 3, involving a small group of dementia patients with mixed

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diagnoses, was conducted to replicate findings from Study 1. Results from the group analysis confirmed that the benefit obtained from errorless learning increased as a function of knowledge specificity, but again several patients failed to show a consistent effect of learning condition. Implications for use of the errorless technique are discussed.

INTRODUCTION

One of the most debilitating features of many forms of dementia is a deterioration in memory which eventually hinders an individual's ability to perform everyday tasks and interact socially. Rehabilitation has been reasonably successful in managing memory problems, most notably in Alzheimer's disease (AD), with errorless (EL) learning proving to be one of the better techniques available (Clare et al., 2000, 2001; Clare, Wilson, Breen, & Hodges, 1999; Winter & Hunkin, 1999). Nonetheless, our understanding of the effectiveness of EL techniques, particularly in relation to the nature of information acquired and depth of learning, is relatively poor. Most of the literature focuses on the effectiveness of EL learning in facilitating acquisition of specific details that have been taught but little attention is paid to any additional information, and in particular higher-level knowledge, that may have been acquired in the process. Moreover, we do not know whether EL learning maintains its advantage when acquiring a range of knowledge, from that which is general to that which is more specific. The present research addresses these issues.

When applying EL learning principles, the aim is to prevent, or at least reduce, incorrect responses during learning. The basic premise is that error prevention hinders reinforcement of incorrect responses and in so doing, facilitates memory performance. In traditional trial-and-error, or "errorful" (EF), learning paradigms guessing is encouraged resulting in the production of unintentional errors that, once repeated, strengthen incorrect associations through reinforcement. In the case of EL learning, the correct response is reinforced more often which, in turn, strengthens accurate associations.

The EL technique was originally described by Terrace (1963) for use with pigeons, then adapted for children with learning disabilities (Cullen, 1976; Sidman & Stoddart, 1967). More recently, it has been applied to treat people who present with acquired memory impairment (e.g., Baddeley & Wilson, 1994; Clare et al., 1999, 2000; Hunkin, Squires, Parkin, & Tidy, 1998; Squires, Hunkin, & Parkin, 1997; Wilson & Evans, 1996). Despite variation in pathology (e.g., head injury, encephalitis, cerebrovascular accidents, Alzheimer's disease) and type of task (e.g., word list learning, face–name associations, general knowledge, orientation, novel vocabulary), research findings suggest that EL is effective in facilitating performance in people with memory impairment but, importantly, the amount of improvement is typically less on the whole than that observed in non-impaired controls.

The EL technique has been particularly valuable in offering a direction for treatment in patients with the amnesic syndrome. Using a list-learning paradigm, Baddeley and Wilson (1994) compared the memory performance of amnesic patients against that of younger and older healthy adults. During the study, participants were presented with word fragments and were either encouraged to guess the word (i.e., in the EF condition) or were provided with the correct answer (i.e., in the EL condition). The researchers found that patients performed best when errors were eliminated during training. Wilson and Evans, together with their colleagues (Evans et al., 2000; Wilson, Baddeley, Evans, & Shiel, 1994), applied EL principles in the acquisition of more practical information (e.g., object naming, general knowledge, use of an electronic memory aid, face–name associations). An overall advantage of EL learning was found for the majority of tasks (Evans et al., 2000; Wilson et al., 1994), although interestingly, the findings in the case of face–name learning were inconsistent[1] and no benefit was found when learning a diagrammatic route (Wilson & Evans, 1996). Baddeley and Wilson (1994) argued that memory facilitation in these cases was due primarily to the integrity of implicit memory functioning. Implicit memory is fairly resilient in patients with profound memory impairment and attuned to eliciting production of the strongest response. If errors are eliminated during learning, the correct response is the only one reinforced and hence the only one which increases in representational strength. If errors are repeated during learning, which is common under EF conditions, then the incorrect response is reinforced which increases its strength relative to that of the correct response.

Hunkin and colleagues (1998) offered an alternative explanation for the facilitation observed in memory performance under EL conditions. These researchers investigated list learning using both implicit (word-fragment completion) and explicit (cued recall) tasks to tap these different processes. It was predicted that if EL learning was supported primarily by implicit memory, then performance in cued recall and word-fragment completion under EL conditions should be correlated. Consistent with previous findings, the authors found that performance under EL conditions was superior to EF conditions and this advantage was still apparent 48 hours later. However, there was evidence of a low and non-significant correlation in test performance under EL and EF conditions (i.e., $r = .2$ and .23, respectively). The researchers argued that this, together with the fact that there was no evidence of greater priming for recalled and non-recalled items, suggested that EL learning was not supported by implicit memory. Having found little

[1]Findings from Wilson & Evans (1996) provide clear evidence of the benefits of EL in acquiring face–name associations, while Evans et al. (2000) report only a modest advantage.

support for the role of implicit memory, Hunkin et al. argued that residual explicit processes must support EL learning and, to support their claim, they highlighted the superior performance observed under EL conditions in free recall. Importantly though, Squires et al. (1997) did not discount a third possibility—one involving a combination of implicit and residual explicit memory—but this alternative has yet to be investigated formally.

The EL technique has also been applied to learning novel associations (Squires et al., 1997) with a similar facilitation in memory performance reported. Squires et al. (1997) investigated ability to learn both novel and remotely linked word associations using EL learning. They found that memory performance was best when learning novel associations, particularly at immediate test, although performance declined following delay. Although this result may at first appear surprising, the authors argued that the additional cognitive effort required to learn novel associations facilitated performance in this condition and resulted in the formation of stronger memory representations. This argument is supported by the results of a study conducted by Tailby and Haslam (2003) in which it was found that active participation during learning provided an additional facilitation in memory performance relative to standard EL procedures. In this study, patients studied words under three conditions—a standard EL condition, a self-generated EL condition (in which patients generated their own responses using verbal descriptions to support errorless word retrieval) and an EF condition. As predicted, performance deteriorated as a function of level of participation in learning; with self-generation superior to the standard EL technique and this in turn superior to the EF condition.

While these studies provide confirmation of the effectiveness of EL learning when memory-impairment is stable, one could ask whether the technique is as useful in progressive conditions. In fact, Clare and colleagues (1999, 2000) and Winter and Hunkin (1999) have addressed this question in their investigations of EL learning in patients diagnosed with probable Alzheimer's disease. In Clare et al.'s study (2001), a patient (VJ) was taught the names of people from his social club using a combination of EL learning and vanishing cues (e.g., see Glisky, Schacter, & Tulving, 1986). Eleven people, whom VJ consistently failed to name, were targeted for the intervention. A mnemonic strategy was applied, in which VJ was taught to associate a distinctive physical feature of each person with the first letter of his or her name (e.g., "Caroline with the curl on her forehead"). Vanishing cues simply consisted of a step-by-step reduction in the number of letters provided. At each step, VJ was asked to fill in the letters to complete the person's name and expanded rehearsal was used to facilitate name recall. Using these methods, VJ's accuracy increased from 22% (baseline) to 98% and this remained relatively stable at 9 months. While performance declined somewhat when re-tested two years later, it remained relatively high (i.e., 71%;

Clare et al., 2001). Another patient, ER, was taught the names of 10 famous people using the EL technique (Winter & Hunkin, 1999). More recently, a controlled trial (comparing performance under trained and control learning conditions) conducted with 12 people diagnosed with probable AD provided evidence of the generalisability of the EL technique in relearning face–name associations even after a delay of 6 months (Clare et al., 2002).

Not surprisingly, all these studies focused on the acquisition and retention of specific information encountered during study. In reality, though, learning is often far from perfect and, under these circumstances, there is a possibility that some knowledge relevant to the original information encountered may still be accessible. A typical example might be meeting the new receptionist in your doctor's surgery and seeing them subsequently out of context, perhaps in the local shops. At the very least, you may recognise the person as being familiar, but be unable to recall any additional information. Another possibility is recognising the person and recalling that they are associated somehow with your doctor's surgery. An ability to retrieve their profession (i.e., receptionist) represents more specific information as would an ability to generate their name. This information represents the possible range of knowledge, from very high (i.e., familiarity) to very low (i.e., name), that may be available simply from being introduced to a new person. However, as we know from everyday experience, we may be unable to access the full range of knowledge (which we will refer to as knowledge levels) represented in this example for various reasons. If we consider the range of information that can potentially be acquired in the context of learning, it is pertinent to ask whether the benefits associated with use of EL principles are the same across a range of knowledge levels.

Along these lines, there is some evidence to suggest that people with memory impairment can retrieve higher-level knowledge despite an inability to access specific information encountered during study. In a study investigating an amnesic patient's ability to acquire novel word meanings, Verfaellie, Croce, and Milberg (1995) showed that such learning was possible but it was restricted to broad category-based, or generic, information about the target items. This was evident in the patient's ability to differentiate correct from incorrect usage of novel target items in sentences assessing the word's general meaning. A somewhat different approach to examination of higher-level learning in amnesia was taken by Verfaellie and Cermak (1994). Participants were asked to learn a series of word lists in which some items were repeated, but all were presented in unique colours. The authors argued that if memory for repeated items was based on knowledge specific to those items, then there should be no difference between item and colour recall. In fact, amnesic patients recalled more repeated words, but their recall of colours for repeated items was worse than that for items only encountered once. On this basis it was concluded that superior performance for repeated words was not supported by particular presentations of words but rather reflected more generic (or higher-level) knowledge about the items. Similar reports of superior acquisition of higher-level category relative to low-level knowledge in amnesia has been reported in the context of artificial grammar learning (e.g., Knowlton, Mangels, & Squire, 1996; Knowlton, Ramus, & Squire, 1992; Knowlton & Squire, 1994, 1996), categorization of dot patterns (Knowlton & Squire, 1993; Squire & Knowlton, 1995) and paintings (Kolodny, 1994; see Haslam, Cook, & McKone, 1998, for a further discussion of these studies).

Haslam et al. (Haslam, Cook, & Coltheart, 2001; Haslam et al., 1998; Haslam, Coltheart, & Cook, 1997) provide additional evidence of higher-level learning in amnesia. In one series of studies (Haslam et al., 1998), two patients were asked to learn a set of face–occupation associations to investigate whether they could acquire and retrieve any novel information at all in this knowledge domain. Occupations were chosen deliberately to allow patients to demonstrate knowledge at two levels: high and low. In the first of four studies, four specific occupations were studied (i.e., teachers, lecturers, electricians, and plumbers). These specific occupations could also be categorised at a higher level; in this case involving the discrimination between educators and tradespeople. From previous research, the authors reasoned that it was unlikely amnesic patients would demonstrate knowledge of the studied occupations presented during study. They were more interested in whether any knowledge at all about studied occupations could be demonstrated and, more specifically, whether patients could distinguish faces at the higher occupational level. As expected, the patients were no better than chance in discriminating between types of educators and types of tradespeople. However, both patients were significantly better than chance in discriminating educators from tradespeople. In other words, the memory representations acquired were not sufficient to support discrimination of the low-level occupations encountered during study, but they were sufficient to support the higher-level judgement requiring educators to be discriminated from tradespeople. Similar findings were reported by Haslam et al. (1997) who found evidence of differential memory performance on tests of categorical and item-specific knowledge in another amnesic patient. In the course of studying specific picture–name associations, the patient only acquired sufficient knowledge to discriminate novel concepts on the basis of their higher-level semantic category. Considered together, this evidence suggests that memory-impaired patients are capable of acquiring and retrieving higher-level knowledge when item-specific information encountered during study is not available.

These findings highlight the importance of attempting to examine the range of knowledge that memory-impaired patients acquire and retrieve—from the general to increasingly specific—as even higher-level knowledge may be sufficient to support some degree of independence in a rehabilitation context. This is the aim of the present research. In particular, it is concerned with the question of the relative benefit of different memory rehabilitation techniques in acquisition of high- and low-level knowledge. Specifically, the research attempts to discover whether the relative benefit of EL learning is the same across all levels of knowledge specificity. Why, might one ask, would differences in the relative benefit of EL over EF learning be predicted at different levels of knowledge specificity? Two factors are pertinent here. First, as discussed above, it has been shown that patients with memory impairment, even those with classic amnesia, can acquire higher-level knowledge despite an inability to retrieve specific details presented during study and demonstrate this knowledge in explicit tests. Accordingly, it could be argued that there may be some resilience or advantage associated with higher-level knowledge and less of an advantage with increasingly specific knowledge. Second, it is clear from the findings of many EL learning studies that patients perform worse than healthy controls and this difference appears to increase as a function of the severity of memory impairment (see Tailby & Haslam, 2003). This suggests that the technique has a limited capacity for facilitation as the performance of memory-impaired patients under EL conditions has never been shown to be equal to that of healthy controls. In light of these points, if there is an added resilience or advantage for higher-level knowledge in the context of a limited capacity for learning, then the amount of improvement possible at higher knowledge levels should be less than that for lower-level knowledge. Accordingly, one might predict that the relative benefit of EL learning will not be the same across the range of knowledge levels.

In this paper we report findings from three studies investigating the relative benefit of EL over EF learning in retrieval of a range of knowledge, from the general to the increasingly specific, in healthy adults (Study 1), patients diagnosed with probable AD (Studies 1 and 2) and a small group of dementia patients with mixed diagnoses (Study 3). A hierarchical knowledge structure, similar to that employed by Haslam et al. (2001), was adopted to examine explicitly the differentiation between high and low-level knowledge and determine the circumstances under which EL learning is most effective.

STUDY 1

The aim of this first study was to determine the relative benefit of EL over EF learning when knowledge encountered during study was tested across a range of levels. To this end, a knowledge hierarchy was devised (based on that reported by Haslam et al., 2001) and comprised four levels. These involved knowledge of specific detail encountered during study (Levels III and IV) in addition to higher-level information not directly encountered during study (Levels I and II). While a differentiation between high and low-level knowledge has been demonstrated in amnesic patients this has not been demonstrated using an EL paradigm nor in patients with AD. Evidence of a relationship (or interaction) between learning condition and knowledge level would suggest that there are differences in the relative advantage of EL over EF learning in the retrieval of high- and low-level knowledge.

Method

Participants

There were 11 participants in this study. Three participants had received a medical diagnosis, from a consultant in old age psychiatry, of probable Alzheimer's disease (CF, TL, and AA) and were recruited through a local memory clinic. An additional eight healthy older adults, matched as closely as possible to these patients in terms of their age and education (see Table 1), also took part and were recruited from the School of Psychology participant pool. Exclusion criteria included a history of either memory difficulties, neurological disease or psychiatric illness.

Neuropsychological assessment. A series of standardised tests were administered to patients and controls. The aim was to obtain a measure of current ability and confirm that controls were indeed healthy older adults with no signs of progressive illness. The following areas were examined: (a) general intellectual ability (i.e., National Adult Reading Test, NART, Nelson & Willison, 1991; Raven's Progressive Matrices, Short Form, RPM, Raven, 1976), Wechsler Adult Intelligence Scale—Revised (WAIS-R; Wechsler, 1981; 2-subtest version; Silverstein, 1982), (b) memory function (using the Wechsler Memory Scale—Revised, WMS-R; Wechsler, 1987 and Ivnik et al.'s, 1992, norms for older adults) and (c) face recognition (using Benton's Facial Recognition Test; Levin et al., 1975). These data are presented in Table 2. Controls performed well within normal limits on all tests administered, indicating that they were appropriately placed in the control group. As expected, this was not the case for patients. Their individual histories and neuropsychological performance are summarized below.

TABLE 1
Demographic information for patients and controls

Participants	*Age (years)*	*Education (years)*	*Gender*
CF	81	9	F
TL	89	9	F
AA	81	10	F
Controls	77.5 (8.3)	10.8 (1.6)	1M, 7F

TABLE 2
Results of neuropsychological assessment for patients and controls (raw scores followed by scaled scores in brackets)

	CF	*TL*	*AA*	*Controls mean (SD)*
Intellectual ability:				
NART (No. correct/50)	35	40	38	43 (3.1)
Raven's Standard Progressive Matrixes (No. correct/12)	3	3	1	6 (2.1)
WAIS-R (selected tests)[1]				
Vocabulary	58 (14)	56 (12)	43 (9)	63.6 (8.7)
Block	0 (3)	4 (6)	12 (8)	35.2 (7.3)
Estimated Full Scale IQ	104	108	104	—
Memory (WMS-R)[2]				
Information and Orientation	11	6	8	11.63 (1.8)
Mental Control	3 (6)	3 (6)	4 (9)	5.5 (0.5)
Figural Memory	2 (3)	5 (10)	5 (10)	7 (1.3)
Logical Memory I	7 (5)	3 (3)	4 (4)	23.4 (6.7)
Visual Paired Associates I	2 (6)	5 (9)	3 (7)	9.8 (3.5)
Verbal Paired Associates I	13 (9)	7 (3)	4 (8)	17.9 (3.6)
Visual Reproduction I	6 (2)	11 (4)	9 (3)	30.4 (5.5)
Digit Span	13 (11)	12 (10)	6 (4)	16.6 (2.1)
Visual Memory Span	6 (4)	11 (7)	5 (3)	15.6 (2.5)
Logical Memory II	6 (7)	0 (2)	0 (2)	17.3 (8.0)
Visual Paired Associates II	1 (8)	0 (6)	2 (10)	4.4 (1.8)
Verbal Paired Associates II	3 (6)	1 (3)	0 (2)	5.5 (1.9)
Visual Reproduction II	5 (6)	1 (4)	1 (4)	22.4 (8.5)
Verbal Memory Index	70	56	55	102.3 (13.6)
Visual Memory Index	62	74	69	113.4 (14.1)
General Memory Index	58	57	62	107.5 (14.0)
Attention/Concentration Index	75	88	57	113.3 (7.0)
Delayed Recall Index	65	52	55	108.9 (19.9)
Face recognition				
Benton's Test of Facial Recognition (long conversion)	45	45	41	46.6 (5.0)

NART: Nelson Adult reading Test, WAIS-R: Wechsler Adult Intelligence Scale Revised, WMS-R: Wechsler Memory Scale Revised.

[1]Scaled scores from WAIS-R and WMS-R indices were calculated using the oldest age groups norms available from Ivnik et al. (1992). [2]Raw scores are provided for WMS-R Information and Orientation and scaled scores for the remaining subtests.

CF

CF was 81 years of age when she took part in this study. Her occupational history includes work as a telephone exchange operator and dinner lady. She was initially referred to the memory clinic shortly after her husband's death, when her daughter became increasingly concerned about her memory.

However, a formal diagnosis of early dementia with slow onset was only made two years after initial presentation.

Baseline neuropsychological testing (see Table 2) indicated that CF was of average intellectual ability which had not altered substantially at the time of current examination, despite her poor performance on a visuospatial constructional task. Both auditory-verbal and non-verbal memory was impaired. A marked discrepancy was evident in tests of auditory-verbal and visual immediate memory span with performance in the former well within normal limits and that in the latter significantly reduced. A test of face recognition was included, as impairment in this would hinder learning of the face–occupation–name associations used in this study. CF's performance on this task was within the normal range.

TL

TL was a trained hairdresser and prior to retirement had been a sweet shop owner. On presentation to the clinic she reported experiencing memory difficulties for some time and particularly over the past 12 months. This reported deterioration was confirmed by her family who were concerned that TL's memory problems had increased in the last 6 months. Medical and psychological investigations were conducted with clinicians reporting significant memory impairment, poor orientation to time, and naming difficulties. Her initial score on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) was 13/37. At this time, TL's insight into her condition was reported to be fairly good. Results of baseline neuropsychological testing confirmed significant difficulties in both verbal and non-verbal memory with an average immediate memory span for digits. Memory performance was well below premorbid estimates of intelligence, which was found to be above average. Current intellectual ability was within the average range for her age, although slightly below premorbid levels, and face recognition was within normal limits.

AA

AA, employed as a legal secretary prior to retirement, was referred to the clinic following complaints of memory problems. Initially it was felt that her memory difficulties were associated with fluctuations in mood. However, a mild deterioration in MMSE scores (from initial scores of 27/37, to 23/37 three years later and 23/37 the following year) prompted closer monitoring. A brain Computer Tomograpy (CT) scan revealed an area of low density in the right hemisphere together with an old vascular insult. Evidence of poor orientation, word-finding difficulties, impairment in concentration and in retention of information over time was noted in medical reports. Baseline testing revealed deterioration in current estimated intellectual function.

Memory performance was well below average on the whole, with relative strength in learning and retention of visually associated pairs. Both auditory-verbal and non-verbal memory span was poor. Recognition of faces was within normal limits.

In summary, as might be anticipated, there was evidence of variability in the performance of patients on neuropsychological testing. There was a deterioration in general intellectual ability in two patients, and deterioration in memory functioning in all patients. These findings add to the medical evidence supporting a diagnosis of probable AD in these patients. Face recognition performance was within normal limits in all cases and hence unlikely to interfere with memory training. In addition, no evidence of hearing difficulties nor impairment in comprehension was found in any participant.

Materials

Two sets of materials were developed for use in memory training. One set was used in the EL training condition and the other in the EF condition. Each set contained 12 faces. Faces were of non-famous people scanned from magazine advertisements using Adobe Photoshop software to control for factors such as colour, size and background. They were reproduced in black and white and were scaled to a width of 8 cm and height of between 10 and 12 cm. Equal numbers of male and female faces were used. The task for participants was to learn to associate each face with their name and occupation. Only first names (e.g., Evelyn), with an average of 5.5 letters and 2–3 syllables were used. One of four occupations was assigned to each item—primary school teacher, high/secondary school teacher, pianist or violinist. These studied occupations could also be discriminated at a higher level; educators and musicians. Occupations were allocated randomly, with the stipulation that they were divided equally among male and female faces.

Two sets of cards were developed for each set of studied materials in order to test memory for face–occupation–name associations. The first set was used to test familiarity with faces and comprised 24 black and white photographs of people. These included the 12 studied faces with an additional 12 novel faces (6 male, 6 female) created using the same procedure described above. The second set of 12 cards contained only studied faces and these were used to elicit knowledge about occupation and name.

Procedure

Memory training commenced one week following baseline neuropsychological assessment. There were two sessions of one-to-one memory training with a two-week break between sessions. In each session participants were asked to learn information about people under two conditions—an EL and an EF condition. The order of presentation of learning condition was counterbalanced both within and across sessions. The procedure differed for EL and EF learning conditions and thus will be described separately.

Errorful learning. At study participants were told they would be required to learn face–name–occupation associations. Items were presented individually at which time information about the person's name and occupation was provided. In the case of naming, participants were told that the person's first name began with a particular letter (e.g., "This person's name begins with E"). They were then invited to guess the name (i.e., What do you think their name might be?). After at least one incorrect guess (they were encouraged to make a total of three guesses), the participant was told the correct answer. If the correct name was produced on the first trial, participants were told the name was incorrect and another name substituted to ensure that at least one error was produced for each item. The same procedure was used to generate the person's occupation and in this case no substitutes were required. Participants were then asked to make an association judgement (e.g., "Does this person look like someone who might be a violinist called Roger?") to ensure they processed the information together. The same procedure was repeated with the remaining 11 faces in the set, before repeating the entire process twice to make a total of three learning trials.

On completion of the study phase, participants were given a brief distractor task (the digit span test from the WAIS-R) before memory for the studied materials was tested. Face cues were used to elicit information at four levels of knowledge. The questions presented at these levels were designed to tap knowledge across the entire range: from high (i.e., Level I) to low (i.e., Level IV) and were presented in the following order:

(i) Level I: "Is this person familiar?"

(ii) Level II: "Is this person a teacher or a musician?"

(iii) Level III: "Is this person a primary or high/secondary school teacher?" (for educators) or "Is this person a pianist or violinist?" (for musicians)

(iv) Level IV: "What is this person's name?"

At the first (i.e., highest) level, participants' ability to discriminate studied from non-studied faces was examined. At Level II, knowledge of general occupation was examined, involving discrimination between the occupations of educator and musician. An ability to discriminate faces at Levels I and II would indicate that participants had acquired some information about people even if they were unable to retrieve additional information presented during study. Knowledge of specific occupation was examined at Level III, requiring participants to discriminate between types of educator and types of musician. A two-alternative forced-choice response format was used at these three levels. The last question involving naming, at Level IV, was included to provide a direct comparison with previous EL studies of face–name learning—all of which have focused on free recall. Participants were encouraged to guess if they were not sure of answers and they were not given feedback on the accuracy of their answers. Memory was tested again after a 30-minute delay using the same materials and procedure. The entire procedure was repeated two weeks later in a second memory training session.

The levels in the above knowledge hierarchy were developed according to the principle of "sharedness". At the highest knowledge level, half the target items shared the attribute in question, and this number decreased progressively down the knowledge hierarchy. For instance, at the top of the hierarchy, participants were asked to indicate whether they were familiar with a person's face. In this case all studied items shared the attribute of "familiarity". At the lowest end of the knowledge continuum, participants were asked to provide the name of the person—an attribute that was unique to the person in question. This hierarchy of knowledge levels allows us to test the depth of learning and capacity for retrieval in participants. Thus, although a participant may not be able to recall the specific occupation they encountered during study (e.g., violinist), the procedure allows us to determine whether they could retrieve any information at all about the person in question. For instance, if a participant identifies a target face as familiar, then we know the face has been encoded. If they proceed to correctly identify the same face as that of a musician, then this indicates additional information has been encoded. However, if no further information can be retrieved, then performance at these first two levels suggests that only higher-level information relevant to the original studied materials is accessible.

Errorless learning. At study participants were told they would be required to learn a different set of face–name–occupation associations. Information relevant to each item was presented individually. For each item participants were told that the person's name began with a particular letter and were immediately provided with the correct answer (e.g., "This person's name begins with the letter R and his name is Roger"). The same procedure was used to generate the person's occupation. As in the EF procedure, participants were asked to comment on the association between the face, occupation and name. This procedure was repeated for the remaining 11 faces and the entire process repeated twice to make a total of 3 learning trials.

The same general testing procedure employed in the EF condition was repeated here. Thus, participants were asked the same questions to determine knowledge at each level. The only difference lay in the instruction not to guess if participants were unsure of their answer. This reduced the likelihood of inadvertently introducing errors across sessions (i.e., between sessions 1 and 2) and within sessions (i.e., between immediate and delayed testing).

Results and discussion

In this section control data are reported first, to provide an indication of performance in a non-impaired population. This is followed by presentation of patient data.

Control data

Figure 1 shows accuracy in performance (represented as a proportion of the hit rate from the false alarm rate) in EL and EF conditions at immediate and delayed test for Levels I to III.[2] As a two-alternative forced-choice response format was used at each level, 0.5 represents chance performance. Of note was the discrepancy in performance accuracy between EL and EF conditions which increased as a function of knowledge level. This is illustrated in Figure 1 and shows, in the case of immediate test, a slight EF advantage at Level I, an EL advantage of 10% at Level II and an EL advantage of 18% at Level III. The same pattern emerged on delayed test. Using accuracy scores, A 2 (time: immediate, delayed test) $\times$ 2 (session: 1, 2) $\times$ 3 (knowledge level: I, II and III) ANOVA was conducted with repeated measures on all factors. The analysis revealed a main effect of knowledge level only, $F(2, 14) = 4.62, p < .05$. Tests of within subjects contrasts revealed a significant linear trend for the knowledge level factor, $F(1, 7) = 8.46, p < .05$, indicating that the discrepancy between EL and EF learning performance (i.e., the overall advantage of EL learning) increased as a function of knowledge level. At higher knowledge levels (particularly, Level I) there was little, if any, difference between EL and EF performance, but this difference increased steadily as a function of knowledge specificity indicating that EL learning was most advantageous when retrieving lower-level knowledge.

Naming data are reported separately in Table 3,[3] as the response format differed from that required at the previous levels (i.e., spontaneous response versus two-alternative forced-choice). The expected EL advantage was found, but this was only marginal. A 2 (session)$\times$2 (learning condition)$\times$2 (time) ANOVA with repeated measures on all factors was conducted. Here only a main effect of session emerged $F(1, 7) = 24.7$, $p < .01$, indicating better naming performance in the second session (as would be expected) but no evidence of naming superiority in either learning condition.

[2]The data for session 1 and session 2 have been combined in this figure.

[3]Data presented here have been collapsed across session and time.

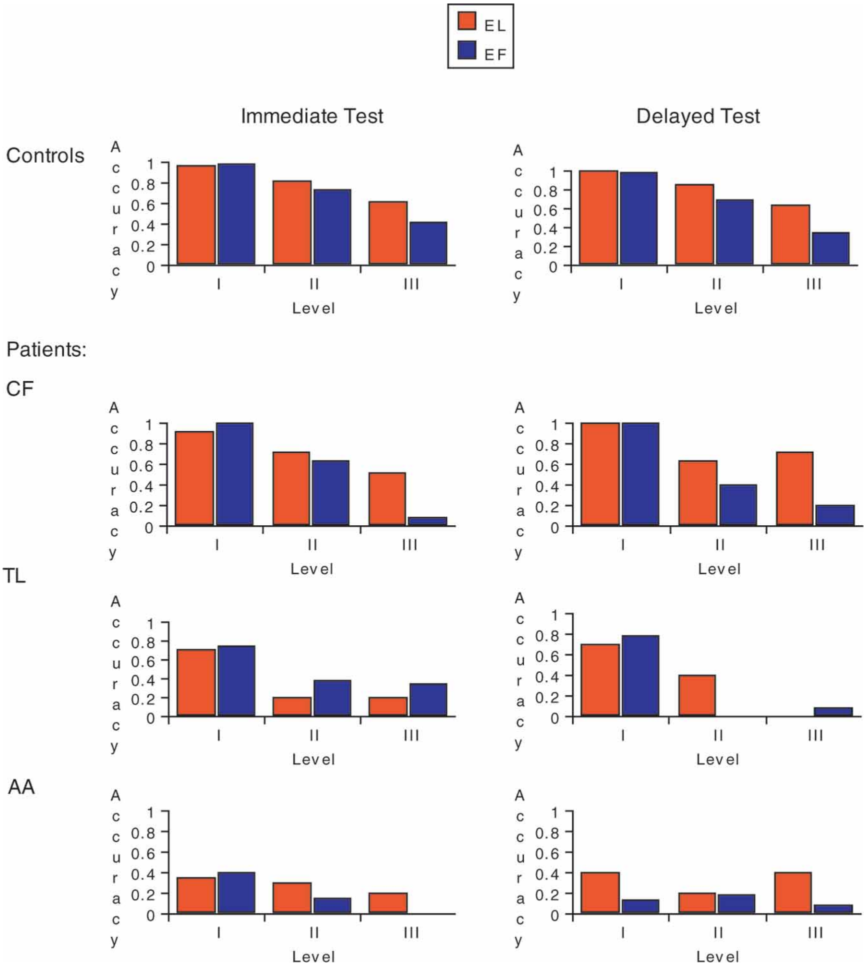

Figure 1. Accuracy (pHR − pFAR) as a function of knowledge level in patients and controls in Study 1.

Patient data

To facilitate comparison with control data, the findings from individual patients are also presented in Figure 1. Of the three patients, CF performed most like controls. In her case, the EL advantage ranged from 8% to 44% at Level II and III, respectively, on immediate test and 0%, 24% and 52% at Levels I, II and III, respectively, on delayed test. Greater variability in performance was observed in the remaining patients, particularly at Levels II and III.

Of particular interest was whether EL learning maintained its advantage at all levels—or, put in another way, whether performance under EL conditions

TABLE 3
Name recall as a function of learning condition

	EL	*EF*
CF	7.8 (1.9)	4.5 (1.5)
TL	1.3 (1.3)	0.3 (0.4)
AA	2.5 (0.5)	1.0 (1.0)
Controls	8.3 (0.7)	7.1 (1.1)

was always better than that under EF (i.e., whether EL $>$ EF). A finding to the contrary is represented by the two other possible outcomes involving these conditions. That is, whether performance under EL conditions is either equal to, or worse than, that under EF conditions (i.e., EL $\leq$ EF). To address our question, we can compare the frequency with which these outcomes occur for patients at each level. This is shown in Table 4 with the frequencies at each level collapsed over session and time. Looking at these data, it is clear that EL is rarely better than EF at Level I. However, this relationship changed from Level II onwards, where performance under EL conditions was better than EF on the majority of occasions and especially so at Level III. A chi-square goodness-of-fit test was conducted to determine whether there was a relationship between outcome and knowledge level. Because the frequency of outcomes (not the response format) was critical in this analysis, all four knowledge levels, including naming, were included. A significant relationship was found between these variables indicating that the "EL $>$ EF" outcome occurred with greater frequency, $\chi^2(2) = 8.92$, $p < .05$, to the extent that more detailed information about studied people was requested. In other words, EL learning appeared to be more beneficial in situations that required low-level information to be retrieved.

Further analysis was conducted with the data from CF—the one patient who showed clear evidence of learning (i.e., better than chance performance in at least one learning condition). Separate chi-square analyses were conducted comparing EL and EF performance on immediate and delayed test across each of the knowledge levels. Performance under EL conditions was

TABLE 4
Frequency of outcomes as a function of knowledge level in patients

	Level			
Outcome	*I*	*II*	*III*	*IV*
EL $>$ EF	3	8	10	8
EL $\leq$ EF	9	4	2	4

found to be significantly better than EF at Level III (lower-level, studied occupation) on delayed test, $\chi^2(1) = 5.2$, $p < .05$, in session 1 and Level IV (studied name) at both immediate and delayed test, $\chi^2(1)_{\text{immediate}} = 6.76$, $p < .05$; $\chi^2(1)_{\text{delay}} = 7.1$, $p < .05$, in the second session. Thus, performance under EL conditions was not significantly better than that under EF at higher knowledge levels (i.e., Levels I and II). However, at lower levels—those requiring retrieval of more specific detail—performance under EL conditions was significantly better than that under EF.

Re-analysis of patient and control group data

While the above findings suggest that EL learning is more beneficial in retrieval of low-level knowledge, it could be argued that learning method was not strictly manipulated at Level I. Specifically, non-studied faces used to test knowledge at Level I were not presented during study and hence could not be subject to error. Thus, it is likely that our EF condition was in fact a replication of the EL at this level and this could account for the lack of difference observed in analysis of the group data. Given this, we re-analysed the patient and control group data with Level I excluded in an attempt to provide a more accurate indication of the impact of learning method at different knowledge levels. For controls this involved a 2 (session: 1, 2) $\times$ 2 (time: immediate test, delayed test) $\times$ 2 (knowledge level: II and III) ANOVA with repeated measures on all factors. No main effects emerged from this analysis suggesting that for controls EL learning is equally effective in facilitating retrieval of high- (Level II) and low-level (Level III) occupational information in healthy older adults, $F(1, 7) = 0.907$, *ns*. Although the advantage of EL learning increased from an average of 10% and 18% at Level II to 18% and 24% at Level III on immediate test and delayed test, respectively, with knowledge level showing a medium to large effect in control performance (i.e., $\eta^2 = 0.12$), power was low (i.e., 0.13) and this is likely to have influenced the outcome of this analysis.

Re-analysis of the patient data with Level I removed involved binomial testing. As Table 4 shows, an EL advantage was observed more frequently than EF at both high (Level II) and low (Level III) knowledge levels, but the ratio of $\text{EL} > \text{EF} : \text{EL} \leq \text{EF}$ outcomes was 2 : 1 at Level II and 5 : 1 at Level III. Results of binomial testing indicated that this ratio of outcomes was only significantly greater than chance at Level III, $p = .27$, $p = .02$, for Levels II and III, respectively. Therefore, as predicted, the EL advantage was only significantly better than chance at the lower knowledge level (i.e., Level III) where it was predicted that it would be most beneficial.

The above re-analysis of control data was inconclusive to the extent that low power is likely to have influenced results of the analysis. However, re-analysis of the patient data showed a clear difference in the frequency with which EL learning facilitated retrieval of high- and low-level knowledge. In this case, the EL advantage was only significantly better than chance in retrieval of studied (but not higher-level) occupation. Together with the data from CF (in which the original analysis showed that EL performance was only significantly better at the lower Levels of III and IV), the evidence suggests that for patients, EL learning may be more beneficial in retrieval of specific detail encountered during study. Unfortunately, given the exclusion of data from Level I, we are not in a position to comment on the relative advantage of EL over EF learning at the most general knowledge level—that required in making familiarity-based judgements. The aim of Study 2 was to determine whether a paradigm could be developed to examine the effectiveness of EL training at this highest knowledge level.

STUDY 2

Haslam et al.'s (2001) procedure, used to examine residual remote knowledge in a patient with retrograde amnesia (patient TG), offered a potential way of manipulating learning condition when seeking a familiarity-based judgement. In this study all knowledge levels were examined using a two-alternative forced-choice format. At the most specific knowledge level, Level V, the intention was to examine knowledge of face–name associations. At this level, for example, the face of the actor Mel Gibson was presented together with the question, "Is this person's name Mel Gibson or Mel Gibbons". TG performed significantly above chance on this task which was unexpected as patients with amnesia have repeatedly shown an inability to learn such a specific association. It was argued, and subsequently shown, that the patient's judgements at this level were based on a lack of familiarity with the distractor names. In other words, the name Mel Gibbons was sufficiently novel for TG to judge that it could not be correct. It was felt that this approach could be adopted to determine whether a familiarity-based judgement was possible while allowing errors to be made in the EF condition. Hence, we had two aims in this study: the first, to determine whether familiarity-based judgements were possible in an EL paradigm and, if successful, our second aim was to evaluate the effectiveness of EL over EF learning at this highest knowledge level.

Method

Participants

Two participants, recruited through the same local memory clinic, took part in this study. Neither had participated in Study 1. Both participants, one female (MP) and the other male (HG), had received a medical diagnosis of probable Alzheimer's disease by the same consultant who recruited participants for the first study. Both had been referred to the memory clinic with complaints of a deterioration in memory. MP was 84 years of age at the time she took part in this study. She had worked as an artist for the majority of her life, and for some time by a Fine Arts Council. HG was 78 years of age at the time of testing and had been employed in various occupations including work as a salesman and ground staff for the air force before retiring at the age of 65. Results of baseline neuropsychological testing[4] are presented in Table 5 and, consistent with the patients who took part Study 1, they revealed evidence of a general cognitive decline most prominent in the area of memory. The composite scores for both MP and HG are either within, or just over, 1 standard deviation of those obtained from a sample of people with Alzheimer's disease (see Table 2.16 in Wechsler, 1997). Face recognition was within normal limits.

Materials and procedure

Apart from introducing a two alternative forced-choice task to test familiarity with names (our previous Level IV), the general procedure was the same as that employed in Study 1. In addition, we changed the profession violinist to saxophonist to increase the probability of making errors at this level in the EF condition (because potential confusion can arise between saxophonist and secondary school teacher when provided with the letter S). Given the intention of this study was to examine familiarity in the context of naming at Level IV, it was no longer sensible to classify it as such on a knowledge hierarchy. Hence, it was included within Level I and, in line with this, our revised hierarchy with questions was as follows:

(i) Level Ia: "Is this person familiar?"

(ii) Level Ib: "Is this person's name ___ or ___?"

(iii) Level II: "Is this person a teacher or a musician?"

(iv) Level III: "Is this person a primary or high/secondary school teacher?" (for educators) or "Is this person a pianist or saxophonist?" (for musicians).

This hierarchy also included the original Level I used in Study 1 (now referred to as Level Ia), to allow comparison with Level Ib.[5] As noted

[4]In this study, abbreviated versions of the Wechsler intelligence (Wechsler, 1999) and memory (Wechsler, 2002) scales were used.

[5]Although the question at Level Ib is shown after Level Ia to facilitate comparison, it was the final question in the hierarchy presented to participants.

TABLE 5
Results of neuropsychological testing for participants in Study 2, MP and HG (raw scores followed by scaled scores in brackets)

	MP	*HG*
Intellectual ability		
NART (No. correct/50)	45	19
WASI (2 subtest version)		
Vocabulary	61 (12)	56 (11)
Matrix Reasoning	5 (6)	8 (7)
Estimated Full Scale IQ	96	93
Memory:		
(a) WMS-III Abbreviated		
Logical Memory I	16 (6)	20 (6)
Family Pictures I	15 (7)	11 (4)
Logical Memory II	0 (4)	0 (2)
Family Pictures II	13 (5)	8 (5)
Composite scores:		
Immediate Memory	80	71
Delayed memory	70	65
Total Memory	73	66
(b) Additional tests from WMS-III		
Information and Orientation	8	9
Letter-Number Sequencing	—	6 (8)
Spatial Span (scaled; forwards & backwards)	—	8 (5; 5, 4)
Digit Span (scaled; forwards & backwards)	18 (13; 7, 5)	12 (8; 6, 4)
Face recognition[1] (correct/48)	42	39

NART: Nelson Adult Reading Test, WASI: Wechsler Abbreviated Scale of Intelligence, WMS-III Abbreviated: Wechsler Memory Scale—Third Edition Abbreviated.

[1]The Unfamiliar Face Matching Test developed by Flude and Young and cited in Young et al. (1985). The mean for normal performance is 43.8 ($SD = 2.6$).

earlier, the test procedure at all levels apart from Level Ib was identical to Study 1. At Level Ib, participants were presented with a face and asked to choose between two names—the correct studied name and an incorrect name, of similar length to, and beginning with the same letter as, the studied name.

Results and discussion

Results for the patients are presented separately in Figure 2. As expected, overall performance declined between Levels I to III at immediate and delayed test for MP and HG, which is not surprising given the increasingly specific detail requested. Consistent with Haslam et al.'s (2001) findings, overall accuracy at Level Ib was reasonably high for both patients, with performance most similar on the whole to that at Level Ia (mean difference in

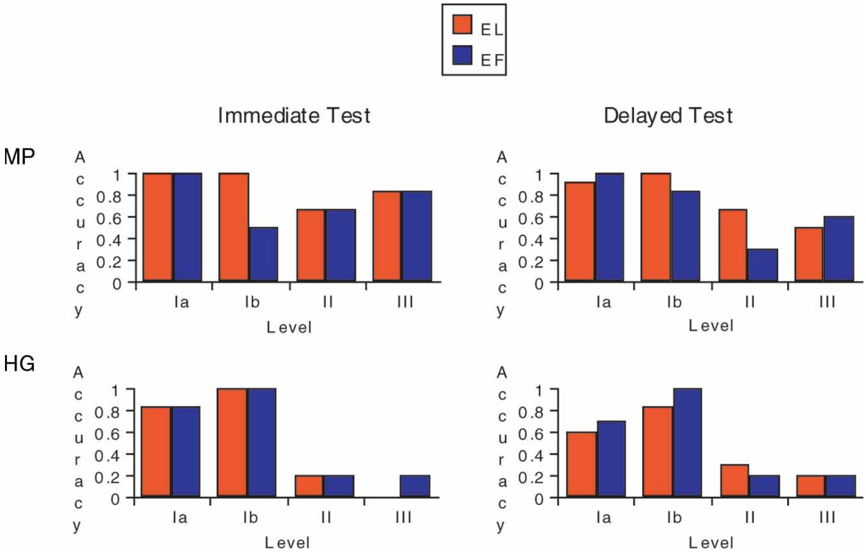

Figure 2. Accuracy (pHR − pFAR) as a function of knowledge level for MP and HG.

performance accuracy at Levels Ia and Ib was 0.04 and 0.25 for MP and 0.17 and 0.27 for HG) and better than that obtained at Levels II and III (mean difference in performance accuracy at Levels Ia, II and III ranged from 0.08 to 0.44 for MP and from 0.67 to 0.9 for HG). Anecdotal reports from both participants indicated that at this level judgements were largely guided by familiarity-based criteria. For instance, MP often stated that she was not familiar with the distractor name, having not seen it in the context of this study, and thus judged that the other must be correct. Together, this suggests that performance at Level Ib may have been supported by higher-level knowledge (in this case a lack of familiarity with the distractor name), while being subject to error in the EF condition.

Having shown that performance at Level Ib could be supported by higher-level knowledge, we proceeded with our second aim to compare the effectiveness of EL and EF learning in the context of familiarity-based judgements. Analysis of errors in learning names under EF conditions, showed that both patients made frequent errors in naming (41 out of a possible 108 errors in the case of MP and 64 out of a possible 108 errors for HG; ranging from 1 to 9 per item). Looking at Figure 2, it can be seen that there was some evidence that the difference between EL and EF conditions increased as a function of specificity in the expected direction, but only for MP at delayed test (i.e., performance under EL conditions 17%, 36% and 12% better than EF at Levels Ib, II and III, respectively). MP showed a clear advantage in favour of EL learning at the level of interest (i.e., an EL advantage of 50%

at Level Ib) on immediate test, but this was not significant, $\chi^2(1) = 3.4$, *ns*. nor was it maintained after delay as the difference was substantially reduced at this stage (i.e., EL advantage of 17%). For HG, performance at Level Ib was identical under EL and EF conditions at immediate test and showed an EF advantage (i.e., of 17%) on delayed test. Performance at the remaining levels was virtually at floor, which makes differences in performance accuracy between EL and EF conditions difficult to interpret.

In sum, while this study was successful in developing a paradigm to examine higher-level judgements of the familiarity-based kind in an errorless paradigm, findings relevant to the effectiveness of EL learning at different knowledge levels were less conclusive. In fact, the difference in performance accuracy between EL and EF conditions was not significant at any level which suggests that learning method was not a significant factor for either patient. This is unusual given both the performance of our controls (in Study 1), who showed an advantage of EL learning from Level II onwards, and in the context of previous reports in which such patients have been shown repeatedly to benefit from the EL technique in learning information about people (Clare et al., 1999, 2000, 2001, 2002). For HG, this might reflect his very poor performance at Levels II and III where differences are not particularly meaningful. The same explanation cannot be used in the case of MP whose performance at Levels II and III was reasonable but varied as a function of both level and learning condition (i.e., EL = EF at Levels II and III on immediate test; EL $>$ EF at Level III on delayed test and EL $<$ EF at Level III on delayed test).

STUDY 3

While Study 1 showed that EL learning was more effective in facilitating retrieval of studied occupations in patients, this effect was not replicated in Study 2. In fact, both patients in the latter study did not even show the well-established advantage of EL over EF learning. The aim of this study was to determine whether the predicted advantage of EL training as a function of knowledge specificity would hold in a mixed group of patients diagnosed with dementia, for purposes of replication.

Method

Participants

Seven new participants (A1 to A7) took part in this study, all recruited through the same local memory clinic as patients in our earlier studies. Demographic information, diagnosis and results of baseline neuropsychological testing are presented in Table 6. As indicated in this table, patients were

TABLE 6
Medical diagnosis, age and results of neuropsychological testing for participants in Study 3, A1 to A7 (raw scores followed by scaled/standard scores in brackets).

	A1	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*
Medical diagnosis[1]	AD	VD	VD	VD	VD	AD	VD
Age	78	74	77	79	67	86	87
Neuropsychological assessment:							
Intellectual ability:							
NART (No. correct/50)	35	47	44	33	35	33	33
WASI (2 subtest version)							
Vocabulary	23 (20)	76 (70)	70 (70)	54 (59)	65 (59)	54 (51)	49 (48)
Matrix Reasoning	20 (59)	30 (73)	27 (70)	11 (45)	17 (49)	12 (53)	23 (70)
Estimated Full Scale IQ	79	140	137	103	107	103	116
Memory:							
(a) WMS-III Abbreviated							
Logical Memory I	2 (1)	16 (3)	49 (15)	8 (1)	9 (2)	28 (10)	25 (10)
Family Pictures I	3 (2)	16 (3)	50 (16)	11 (3)	6 (2)	23 (9)	3 (3)
Logical Memory II	0 (2)	0 (1)	28 (15)	0 (1)	0 (1)	11 (10)	5 (7)
Family Pictures II	1 (2)	5 (2)	43 (13)	1 (1)	6 (2)	4 (5)	0 (4)
(b) Additional tests from WMS-III							
Information and Orientation	8	13	12	8	11	10	12
Letter-Number Sequencing	4 (5)	11 (13)	10 (13)	3 (4)	5 (5)	3 (7)	14 (18)
Spatial Span (scaled; forwards & backwards)	11 (8, 4, 4)	19 (16; 6, 6)	14 (11; 5; 5)	13 (10; 4; 4)	13 (10; 5; 4)	6 (5; 3; 3)	11 (10; 4; 4)
Digit Span (scaled; forwards & backwards)	13 (9, 5, 4)	15 (10; 5, 5)	21 (15; 7; 6)	10 (6; 5; 4)	16 (10; 6; 4)	12 (8; 5; 4)	19 (15; 8; 4)
Face recognition[2] (correct/48)	43	43	46	40	44	47	43

NART: Nelson Adult Reading Test, WASI: Wechsler Abbreviated Scale of Intelligence, WMS-III Abbreviated: Wechsler Memory Scale—Third Edition Abbreviated.

[1]AD = Alzheimer's Disease, VD = vascular dementia. [2]The Unfamiliar Face Matching Test developed by Flude and Young and cited in Young et al. (1985).

diagnosed with either probable Alzheimer's disease ($n = 2$) or vascular dementia ($n = 5$). In all except for one patient (A3), there was evidence of a general cognitive decline and severe memory impairment. All patients showed normal face recognition abilities.

Materials and procedure

As the primary aim was to replicate the patient findings from our earlier experiment, the materials and procedure were identical to those used to examine knowledge at Levels I, II and III in Study 1. As in the previous study, memory rehabilitation commenced a week after baseline neuropsychological testing[6] and comprised two training sessions with at least a two-week break between sessions. Each training session involved presentation of materials for study and immediate test, followed by delayed testing 30 minutes later. According to prediction, the relative advantage of EL over EF learning (i.e., the difference in performance between EL and EF learning) should increase with each knowledge level.

Results and discussion

Accuracy in performance (i.e., proportion of hits from false alarms) for the group of patients is shown in Figure 3. In this figure, the data for session and time is collapsed given no main effects for these variables were found. A 2 (learning method: EL, EF) × 3 (knowledge level: I, II, III) ANOVA with repeated measures revealed significant main effects for both factors, respectively, $F(1, 6) = 8.11$; $p < .05$; $\eta^2 = 0.6$; $F(2, 12) = 39.3$; $p < .01$; $\eta^2 = 0.9$. Performance under EL conditions (overall $\text{mean}_{EL} = 0.48$, $SD = 0.23$) was better than that under EF conditions (overall $\text{mean}_{EF} = 0.38$, $SD = 0.35$). Post-hoc planned comparisons indicated that overall performance at Level I was significantly better than that at Levels II, $t(1, 6) = 6.0$, $p < .01$, and III, $t(1, 6) = 7.12$, $p < .001$. The difference between Levels II and III was not significant, $t(1, 6) = 1.57$, *ns.* At level I, there was no difference in performance under EL and EF conditions, $t(1, 6) = 0.46$, *ns*, but performance under EL conditions was significantly better than EF at levels II, $t(1, 6) = 3.98$, $p < .01$, and III, $t(1, 6) = 4.0$, $p < .01$. Most important for our prediction was evidence of a significant knowledge level by learning method interaction, $F(2, 12) = 15.6$, $p < .01$; $\eta^2 = 0.7$. To explore this further, the difference in memory performance under EL and EF conditions was compared across the three knowledge levels using one-way ANOVA. This revealed a main effect of knowledge level, $F(2, 12) = 14.15$, $p = .001$ and a significant linear trend, $F(1, 6) = 29.34$,

[6]In this study, abbreviated versions of the Wechlser intelligence and memory scales were used.

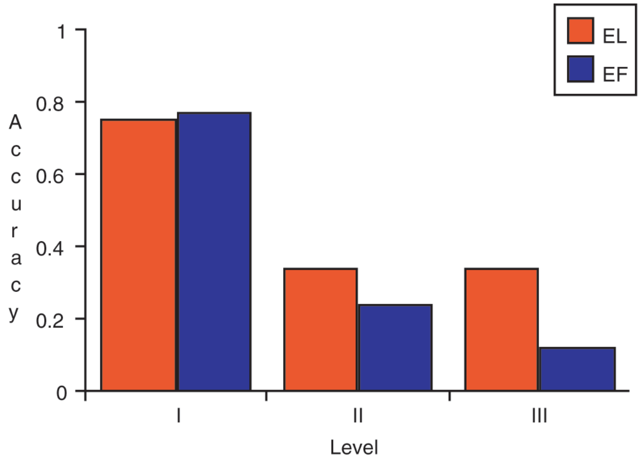

Figure 3. Accuracy (pHR − pFAR) as a function of knowledge level for patients in Study 3.

$p < .01$ indicating, as predicted, that the advantage observed under EL conditions increased as a function of knowledge level. At Level I there was essentially no difference in performance between EL and EF conditions (i.e., 0.02); a finding consistent with that reported in Studies 1 and 2. At Levels II and III the difference increased to 0.10 and 0.22 respectively.

The previous studies showed some variability in patient performance and particularly in the capacity to benefit from EL learning procedures. Similar variability emerged in the present study. Several patients (A2, A3, A6) ether benefited equally from EL and EF strategies or performed better under EF conditions but this was inconsistent across sessions and time delay. Implications for the variability in the effectiveness of the EL technique will be addressed in the general discussion.

GENERAL DISCUSSION

In this paper we investigated the contribution of EL learning in the acquisition of knowledge across a range of levels; from high to low. Previous research has shown that EL learning is effective in facilitating retrieval of low-level knowledge or specific information presented at study. The purpose of this investigation was to determine whether the EL technique maintained its superiority over standard trial-and-error learning in retrieval of higher-level knowledge. Face–name–occupation associations were used for this purpose. Study 1 tested knowledge at four levels—examining ability to discriminate studied faces on the basis of familiarity, general occupation, specific occupation and name—in three patients and a group of controls.

Initial analysis suggested that EL learning was no better than standard trial-and-error learning at the highest knowledge level. Re-analysis of control data indicated that this was supported primarily by performance at Level I where learning condition was not strictly manipulated. At the remaining levels there was evidence of an increasing advantage of EL training; although, as a result of low power, the difference relative to EF training was not significant. However, the patient data were more conclusive, with EL learning considerably more effective in facilitating retrieval of low-level occupational information. This pattern was most consistent for patient CF for whom EL learning was only significantly better than EF in retrieval of the studied occupation and name (i.e., at Levels III and IV) presented at study. For this patient, performance under EL conditions was no better than EF at the general occupational level.

A follow-up study was conducted with two additional patients, first, to determine whether familiarity-based judgements could be used in an EL paradigm and, second, to include this level in re-examination of our prediction that EL learning would be more advantageous with increasing knowledge level. While the novel manipulation of learning condition in the context of familiarity judgements proved successful and the predicted advantage of EL training as a function of specificity was shown in part for one patient, it was neither consistent nor evident in the second patient. Importantly, the typical finding of an EL facilitation (irrespective of knowledge level) was not observed for either patient and this in turn has implications for the application of this technique in a condition such as AD where the presentation can vary considerably from patient to patient. Given this, a third study was conducted, with a mixed group of dementia patients, in an attempt to replicate the findings from Study 1. Results were consistent with prediction and showed that EL learning was most beneficial when patients were required to retrieve detailed information from memory.

For non-impaired controls in Study 1, the difference in performance between EL and EF conditions became apparent from Level II where participants were asked to discriminate studied faces on the basis of their general occupation (information not presented directly during study). This difference increased when knowledge of the specific studied occupation was requested. These findings suggest that the use of EL principles was more critical in retrieval of low-level knowledge, although these differences were not significant. Neither was the difference in accuracy under EL and EF conditions significant for naming which, while contrary to prediction, may also reflect differences in task type (i.e., forced choice was used to test knowledge at Levels I to III and recall at Level IV). It is also important to note that improvement can be more marked in patients than healthy controls, and this may have been a contributing factor in our control data (e.g., Wilson et al., 1994).

The data from patients were more conclusive, particularly in the case of CF, with EL training proving more advantageous as the information to be retrieved increased in specificity. Even with the exclusion of Level I data, results of binomial tests indicated that the EL advantage observed at Levels II (i.e., superior EL performance observed twice as often as superior EF performance at this level) and III (i.e., superior EL performance observed five times as often as superior EF performance at this level) was only significantly better than chance in retrieval of low-level occupational information. Further support for this conclusion is provided by patient CF whose performance under EL conditions was only significantly better than EF at the two levels testing knowledge of specific detail—Level III, involving studied low-level occupation, and Level IV, involving names.

Given the exclusion of Level I in the first study, we conducted a second study in an attempt to determine the relative advantage of EL over EF training when familiarity-based judgements were required. We found that application of this paradigm was successful, indicating that learning condition can be manipulated in making familiarity-based judgements. However, somewhat unexpectedly in light of previous findings, we found that for both patients there was little if any advantage of EL learning at any level. MP was the only patient who gained more from EL training as information retrieved increased in specificity (i.e., from Level Ia to II), but this was only on delayed test with no evidence of a significant difference at any level. At one level, the failure to find a consistent advantage of learning condition means that no firm conclusions can be drawn from these data concerning the relative advantage of EL learning as a function of knowledge level. On its own this does not challenge our prediction concerning the greater effectiveness of EL learning at low knowledge levels, as a difference in performance between learning conditions is critical to test the hypothesis.

With limited support for the differential effectiveness of EL learning as a function of knowledge level, a third study was conducted with a mixed group of dementia patients in an attempt to replicate findings from Study 1. Not surprisingly, no difference emerged in performance between learning conditions at Level I. This is consistent with earlier findings and can be explained by the fact that learning condition was not manipulated at this level. Importantly, the EL advantage was evident at Level II when general occupational judgements were required and this advantage was greater at Level III when specific occupational judgements were required. This result replicates the findings from Study 1 but this time in a small group of dementia patients and supports our prediction that EL training is most beneficial when retrieving low-level knowledge.

Although we were able to replicate findings, data from the two patients in Study 2 (MP and HG) and several patients in Study 3 (A2, A3 and A6) indicated that EL training did not always produce a facilitation in memory performance as previous research seems to suggest. This raises an important question—why do some patients benefit from EL training and others not? Given this was not the focus of the present paper, our answers to this question can only be speculative. In the case of HG, it is possible that differences in learning condition were masked by a floor effect; it may be that EL training was more beneficial than EF but that performance in both conditions was so poor that these differences could not be detected. This is certainly not the case for MP, who showed evidence of learning and at least some benefit, albeit inconsistent, from EL training. Similarly, the patients who either did not benefit consistently from EL learning or performed better under EL conditions in Study 3, showed evidence of learning. Looking at the neuropsychological profiles, there is evidence of a difference between HG and the remaining patients (apart from A6) with evidence of better general performance in the latter cases. This raises the possibility that some baseline level of cognitive function, with the exception of memory, may be required to benefit from an EL paradigm.

Relevant to the above discussion is the fact that the performance of patients in the studies varied. In Study 1 CF performed better than the remaining patients, and received greater benefit from application of EL principles during learning. A similar differentiation was observed in Study 2 with MP's performance being generally superior to that of HG. The data from the group of patients in Study 3 were more mixed and may reflect the variability in their diagnoses. Importantly, differences in actual benefit from EL training cannot be explained by differences in severity of memory impairment alone, as patients with the most profound form of memory impairment (i.e., classic amnesia) have shown they can benefit from EL training (Squires et al., 1997; Tailby & Haslam, 2003; Baddeley & Wilson, 1994). If we look at the data from patients who took part in Studies 1 and 2, it is possible that attentional problems, which are more likely in patients with AD, may influence an individual's capacity to benefit from EL training. For the patients who took part in Study 1, CF and TL were consistently better than AA in all subtests contributing to the attention/concentration index (i.e., mental control, digit span and visual memory span). Furthermore, on no occasion did CF perform at floor on any of these tests—a finding that was observed in the case of visual memory span for TL. In Study 2, there is also evidence of attentional problems, albeit limited, on the digit span test in which MP performed relatively better than HG. Thus, reduced attentional problems may offer a potential explanation for the superior performance of CF and MP under EL conditions. If this is the case, then attentional fluctuation is another feature that should be considered when planning to adopt EL principles in rehabilitation. In a condition such as AD, attentional fluctuation is likely to have the least impact in the early stages of the disease process. Hence, the greatest benefit from use of such principles may be gained in these early stages. The literature seems to support this, with much of the existing data showing the benefits of EL principles in the early stages of dementia (e.g., Clare et al., 1999; 2000; 2001). It remains true, of course, that because this analysis is based on a few single cases with probable Alzheimer's Disease it requires further exploration.

It could be argued that differences in the effectiveness of learning observed across the range of knowledge levels reflect differences in the amount of exposure to high- and low-level information during the study. In fact, this is only pertinent at test where participants were asked to make judgements of familiarity, general occupation, specific occupation and name. Hence, through questioning, participants may have been exposed to high-level information more often than low-level. The critical question, however, is whether participants were exposed to high-level information more often than low-level information in each learning condition. The answer is no. The amount of exposure to information at all knowledge levels was the same in each learning condition. Another potential criticism concerns the presence of floor and ceiling effects. Clearly, no meaningful differences can emerge between EF and EL conditions if, for example, performance is at ceiling, as was the case at the lowest level investigated (although not for all patients). However, this was not the case at the remaining levels (i.e., Levels II to IV) and if we consider CF's data and that for the mixed group of dementia patients in Study 3, we still find the predicted pattern—that EL learning was no better than EF at Level II, but significantly better at the more specific knowledge levels examined.

Previous studies provide clear evidence of facilitation in memory performance under EL conditions (e.g., Clare et al., 2000, 2002; Evans et al., 2000; Hunkin et al., 1998; Wilson et al., 1994), although no studies have explored the role of EL learning relative to standard trial-and-error learning in retrieval of high- and low-level knowledge. The reason probably lies in the traditional approaches we use to test memory. It is common to ask people to recall specific information encountered during study (e.g., the fact that "Roger" is a pianist), but rare to examine higher-level knowledge (e.g., their status as a musician). Perhaps this reflects our general belief that learning specific detail alone is important. Having said this, there are many occasions when high-level knowledge can be just as helpful. As a practical example, consider the number of home visits made by health professionals to a patient with memory difficulties. In an ideal situation, the patient will know each visitor. However, it is more likely that they can access only a limited amount of information about some visitors (e.g., that they are familiar and somehow associated with the health service), particularly if they have only been introduced recently. Most would agree that such information can be just as important if a visitor is to maximise their time with a patient and not be refused entry.

Conclusion

The present investigation makes several novel contributions to the EL learning literature. First, while our findings show that the EL technique can produce a general facilitation in memory performance in both patients and controls, the technique proves most beneficial for patients attempting to retrieve low-level knowledge or specific detail. This was initially demonstrated in Study 1 and then replicated in Study 3. Second, given problems with our initial paradigm, we applied a novel method which allowed us to manipulate learning condition in retrieval of knowledge at our highest knowledge level (i.e., familiarity). While this manipulation was successful, neither patient who took part in this study showed a consistent effect of learning condition. The latter is an important finding in the context of exploring the parameters of the technique because it raises the possibility that not all patients may benefit from EL learning and this has yet to be addressed in the literature.

The implications for rehabilitation are clear. Most importantly, we should explore the entire range of knowledge our patients can acquire in memory rehabilitation as we cannot expect the EL procedure to produce the same benefit in retrieval of high- and low-level knowledge. Whether this is relevant to other rehabilitation techniques has yet to be explored. Finally, irrespective of knowledge level, the question relevant to who benefits from the technique requires interrogation as our findings indicate that not everyone with memory impairment demonstrates the facilitation commonly reported under EL conditions.

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