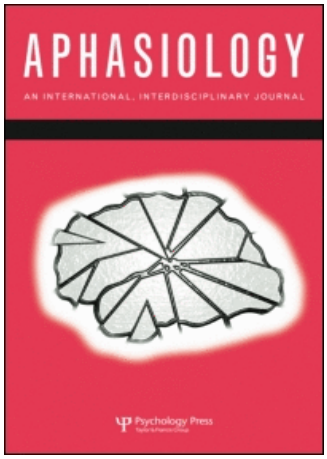

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Further explorations and an overview of errorless and errorful therapy for aphasic word-finding difficulties: The number of naming attempts during therapy affects outcome

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Further explorations and an overview of errorless and errorful therapy for aphasic word-finding difficulties: The number of naming attempts during therapy affects outcome

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Background: Errorless learning continues to be much debated in rehabilitation literature. Emerging data suggest that errorless learning is as effective as errorful learning when applied to the treatment of aphasic word-finding difficulties (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003; Fillingham, Sage, & Lambon Ralph, in press; Fillingham, Sage, & Lambon Ralph, 2005).

Aims: This paper presents a third investigation, which was designed to replicate this result and also to explore and extend other important and interesting findings from the previous empirical studies: (1) that withdrawing feedback during therapy (not giving information about whether a patient's response was correct or not) does not prevent learning; (2) that frontal executive skills are a predictor of therapy outcome but not language skill. We also used this third study to explore whether the number of naming attempts during therapy affects outcome.

Methods & Procedures: Seven of the original eleven participants took part in a multiple baseline, crossover, case-series design.

Outcomes & Results: The previous results were replicated: errorless and errorful therapy produced equivalent results immediately post-therapy and at follow-up. There was no effect of omitting feedback—the participants learned equally well without therapists' feedback. Also, executive/problem-solving skills and monitoring ability again predicted immediate naming improvements not language ability. In addition, we found that increasing the number of naming attempts during therapy affected learning outcome.

Conclusions: The final section of the paper draws together the results of all three studies, and their implications for the treatment of aphasic word-finding difficulties are discussed.

A considerable amount of clinical time is devoted to the amelioration of anomia—one of the most dominant and frustrating aphasic symptoms. It is surprising, perhaps, that errorless learning has not been reported as a technique for the treatment of aphasic word-finding difficulties, given its reported success for the relearning of names and objects in patients with other acquired neurological disorders, predominantly head injury and Alzheimer's disease (Clare, Wilson, Breen, & Hodges, 1999; Clare, Wilson, Carter, Breen, Gosses, & Hodges, 2000; Evans et al., 2000; Hunkin, Squires, Parkin, & Tidy, 1998; O'Carroll, Russell, Lawrie, & Johnstone, 1999; Tailby & Haslam, 2003; Wilson & Evans, 1996; Wilson, Baddeley, Evans, & Shiel, 1994). Fillingham et al. (2003) reviewed the anomia literature in order to investigate previous uses of errorless learning techniques

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for aphasic word-finding difficulties (in the context of stroke). The review found that there have been no studies of people with aphasia that have deliberately investigated errorless learning techniques. However, the treatment methods used in the studies could be categorised into one of the three types: Errorless learning (the attempt to control for errors during training) was split into two subtypes—*error elimination* (no errors are made during training) and *error reduction* (errors are reduced during training)—and the third classification was *errorful learning* (errors are not controlled during training). The review found some limited evidence to suggest that errorless approaches are just as likely as errorful approaches to achieve a positive outcome—in terms of immediate effect, follow-up testing, and generalisation.

The Fillingham et al. (2003) review highlighted the lack of information about the application of errorless learning to the treatment of anomia. To address this, two empirical studies were conducted. Fillingham et al. (in press) compared the efficacy of errorless and errorful learning in a case-series of 11 people with aphasic word-finding difficulties. Language and neuropsychological assessments were completed with each participant and a naming therapy was carried out in a case-series analysis. Errorless therapy consisted of providing the participant with the picture, including its spoken and written name to ensure the correct response was made, and asking them to repeat the name three times. In errorful therapy, the participant was asked to name the picture, and if the response was incorrect they were provided with combined progressive phonemic and orthographic cueing. There were 30 items in each set of therapy and 30 control items. Each picture was seen and attempted three times in each therapy session. Errorless and errorful therapies were completed consecutively and each subject received 10 sessions. Naming performance was assessed at the end of each therapy block and at a 5-week follow-up appointment. As the anomia literature review suggested, errorless learning proved to be as effective as the more traditional, errorful approach in terms of both immediate improvement and at follow-up assessment. There were two participants who did not respond to either treatment and only one participant who demonstrated greater benefit from errorful therapy immediately and in the longer term. The most surprising result was that the status of the participants' language skill did not predict therapy outcome. Instead, immediate naming improvements, irrespective of treatment type, were related to the participants' executive skills, recognition memory, and self-monitoring ability. Over the long term (at follow-up assessment) executive skills and recognition memory continued to predict therapy outcome.

Even though the results from the literature review were replicated by this first study, it seemed surprising that errorless and errorful techniques produced equivalent outcomes, given results from other language-related studies. For example, McCandliss, Fiez, Protopapas, Conway, and McClelland (2002) conducted a phoneme-learning study with normal Japanese adults. They contrasted errorless and errorful learning techniques, with and without feedback, to teach the auditory discrimination of the English liquids [r] and [l], which Japanese adults can be poor at even after years of exposure to English. They found that errorless learning produced better results than errorful learning. However, they also found that feedback was crucial—subjects in the errorful condition who received feedback learned as well as those people in the errorless condition. This suggests that there may be some form of cognitive process that can filter out or inhibit the influence of erroneous responses via feedback (see Fillingham et al., 2003, for further discussion).

The results from this study have implications when the strategies used in the Fillingham et al. (in press) investigation are examined. During errorful therapy the patient had an opportunity to name the picture with increasing phonological and orthographic

cues. As the participants learned the target pictures they needed fewer attempts at naming and, therefore, fewer cues. When the correct word was produced, whether it was after the first, second, or third attempt, no other attempts were made and the participant moved on to the next picture. Because of this procedure, external feedback was given implicitly—the participant knew that the response was correct when they no longer had to attempt it. This raises the possibility that the results of the errorful learning treatment were inflated due to feedback, as suggested by the McCandliss et al. study (2002).

Fillingham et al., (2005) addressed this potential confound by repeating the previous study and removing feedback during training, so that errorless and errorful learning were directly comparable. The predictive power of non-language skills for therapy outcome was also studied again. There were a few changes made to the original study design (see Table 1 for a comparison of the two studies). Seven of the original eleven participants took part. Errorless and errorful therapies ran concurrently (so that results could not be confounded by order effects). Because running the therapies concurrently would lengthen each therapy session, the number of items in each therapy set was reduced to 20 (as well as a control set of 20 items). Errorless therapy matched the original design—however, participants were only required to repeat the target item once (again to reduce time during therapy sessions). During errorful therapy the first letter and phoneme were given alongside the picture and the participant was required to produce the name. In both therapies no feedback was given to either a correct or incorrect response. Each picture was seen and attempted three times in each therapy session and there were 10 sessions of therapy. Surprisingly, there was no effect of omitting feedback. Errorless and errorful therapies continued to produce equivalent results. Five participants improved in both conditions, two participants did not show a therapy effect, and one participant showed an effect of errorful therapy immediately post-treatment but not at follow-up. The results also replicated the original study results in terms of predicting therapy outcome. Executive/problem-solving skills and monitoring ability, but not language skills, predicted immediate naming improvement.

TABLE 1
Similarities and differences between Study 1 (Fillingham et al., in press) and 2 (2005)

	Study 1	*Study 2*
Participants	HF, FO, RD, EW, RR, JS, RH, ME, HA, GP, SC	HF, RD, RR, JS, ME, HA, SC
No. items per treatment condition	30	20
No. sessions	10	10
Method	Consecutively	Concurrently
No. items per session	30	40
Therapy	EL – read and/or repeat EF – progressive phonological and orthographic cueing	EL – read and/or repeat EF – 1st phoneme and grapheme cue
No. attempts at each item	90 – errorless 120 (potentially) – errorful	30
Feedback given	Yes	No

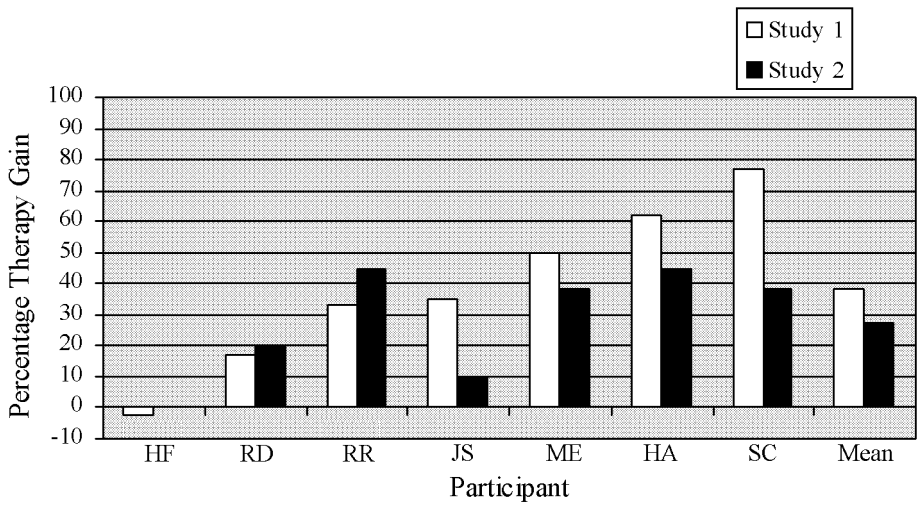

Figure 1. Total percentage therapy gain immediately post-therapy in each study (post-treatment minus baseline)

It is clear from Figure 1 that four (JS, ME, HA, SC) of the five participants who showed a significant therapy effect in Study 2 appeared to learn less than in Study 1. This was statistically significant for three of the four participants—JS: $\chi^2(1) = 16.43$, $p < .0001$; HA: $\chi^2(1) = 5.12$, $p = .02$; SC: $\chi^2(1) = 29.40$, $p < .0001$.

Several factors could have contributed to this reduction in therapy effectiveness. There were more items per session in the second study (40) than in the first study (30), and too many items per session may overload the learning system. Even though feedback did not make a difference to the direct contrast between errorless and errorful therapy, its absence may have contributed to the reduced learning in Study 2. A final reason may relate to the number of attempts at the target items. In Study 1 participants repeated the target items three times in errorless therapy, and in errorful therapy had the potential to attempt the target item four times due to the cueing hierarchy (this reduced over the period of therapy as the participants learned and needed fewer cues). In Study 2 this was reduced to one repetition for errorless learning and one attempt at naming with a cue for errorful learning. Therefore, the number of naming attempts over the therapy period in Study 1 was 90 for errorless learning and potentially 120 for errorful therapy. By comparison, in Study 2 participants had 30 attempts at naming each item for both errorless and errorful therapy over the therapy period. As far as we are aware, there are few or no existing data on the influence of these factors and so this study was designed to explore their effect specifically.

BACKGROUND NEUROPSYCHOLOGY AND APHASIA ASSESSMENTS

Participants

The same participants were used for this investigation as for Study 2 (Fillingham et al., 2005) apart from RD. Participant RH from Study 1 (Fillingham et al., in press) also completed this study. Participants were recruited through local speech and language therapy services. They were selected primarily on the basis that they had word-finding

difficulties due to a central language impairment. Patients who failed to name pictures because they had perceptual deficits (agnosia) or who had significant dyspraxia or speech-motor programming deficits were excluded. They were required to be at least 6 months post-onset, to have an acquired neurological deficit, to have a significant word-finding problem (below 70% on a simple naming assessment: Lambon Ralph, Ellis, & Sage, 1998), and to be able to repeat and/or read with a degree of accuracy (preferably above 70% on PALPA 9 and/or PALPA 31: Kay, Lesser, & Coltheart, 1992). Basic information about the participants is given below.

JS was a 76-year-old man who had a left-sided CVA in 1992 resulting in a severe global aphasia and right hemiparesis. He was a retired electrician and lived with his wife. He presented with a severe global aphasia.

HF was 64-year-old widow and housewife before a left middle cerebral artery infarct and frontal lobe changes in 2001. She had a moderate aphasia characterised by semantic difficulties and reading problems.

RH was a 68-year-old man who had retired as a foreman and lived with his wife. A CT scan in 1998 revealed an infarct in the region of the left middle cerebral artery territory. RH had a right hemiparesis. He presented with a global aphasia.

SC was a 74-year-old man who lived with his wife and was the owner of a chain of florists. In 1999 he had a large acute haematoma in the left occipito-parietal region and a right fronto-parietal infarction secondary to previous haemorrhage. He had a moderate aphasia characterised by high-level semantic difficulties and reading problems.

RR was a 60-year-old man who took retirement in 1999 after a left middle cerebral artery infarct. After this he was wheelchair bound due to a dense right hemiplegia and lived in a residential home. He presented with a severe-moderate aphasia characterised by general language difficulties in both phonology and semantics.

HA was a 74-year-old man who lived with his wife and, prior to his stroke, worked as a High Court judge. In 1998 he had a cerebral infarction of the left post cerebral artery territory in the left parietal-occipital region. He presented with a mild aphasia with core phonological problems.

ME was a 70-year-old housewife who lived with her husband. She had a left CVA in 1987 resulting in a right hemiparesis. She presented with a mild aphasia characterised by non-lexical phonological difficulties and very high-level semantic difficulties.

Background assessment

A thorough language and neuropsychological assessment battery was completed. All participants were asked to complete the same battery of tests so that direct comparisons between participants could be made and severity of different underlying impairments measured. The assessments took between four to six sessions to complete.

Assessment of the participants' language skills focused mainly on single-word processing (see Table 2). Picture-naming tests were used to measure the degree of word-finding impairment; Boston Naming Test without standard systematic cueing (Kaplan, Goodglass, & Weintraub, 1976), Graded Naming Test (McKenna & Warrington, 1983), and Picture-naming PALPA 53 (Kay et al., 1992). Single-word reading and repetition were used to assess the integrity of phonological representations; reading words (PALPA 31) and nonwords (PALPA 8) (Kay et al., 1992); repeating words (PALPA 9) and nonwords (PALPA 8) (Kay et al., 1992). Impairments of semantic memory/comprehension were assessed using various measures of picture, spoken word, and written

TABLE 2
Initial language assessment results for each participant

Domain	*Assessment*	*Max.*	*JS*	*HF*	*RH*	*SC*	*RR*	*HA*	*ME*	*Norms**
Naming	BNT	60	0	22	4	10	6	15	25	42–60
	GNT	30	0	2	0	0	0	3	6	12
	PON	40	1	14	9	20	25	35	36	39.80
	Total Naming	130	1	56	13	30	31	53	67	n/a
Phonology	Word reading	80	0	63	9	65	16	64	80	79.4
	Nonword reading	30	0	5	0	20	0	17	12	78.81
	Word repetition	80	36	79	67	78	76	65	79	78.81
	Nonword repetition	30	6	28	11	26	23	17	24	n/a
Semantics	PPT (pictures)	52	40	45	47	50	45	52	48	49–52
	PPT (words)	52	32	43	37	51	26	51	50	49–52
	SWPM	100	39	83	97	100	97	100	96	96–100
	WWPM	100	37	79	90	98	81	99	95	96–100
	BPVS – SWPM	168	86	104	150	135	87	156	137	n/a
	BPVS – WWPM	168	44	16	116	114	51	159	143	n/a
	WSJ – Aud/Con	25	N/C	5%ile	1%ile	5%ile	<1%ile	50%ile	50%ile	n/a
	WSJ – Aud/Ab	25	N/C	5%ile	10%ile	<1%ile	10%ile	90%ile	25%ile	n/a
	WSJ – Writ/Con	25	10%ile	1%ile	5%ile	<1%ile	<1%ile	90%ile	25%ile	n/a
	WSJ – Writ/Ab	25	1%ile	10%ile	1%ile	N/C	<1%ile	90%ile	25%ile	n/a

N/C – not able to complete due to memory problems, difficulty understanding task, repeating or refusal; n/a – not available; BNT – Boston Naming Test; GNT – Graded Naming Test; PON – Picture Oral Naming PALPA 53; Total Naming – the total correct for the three naming tests; Word reading – (PALPA 31), Nonword reading – (PALPA 8), Word repetition (PALPA 9) and Nonword repetition (PALPA 8); PPT – Pyramids and Palm Trees picture and written word versions; SWPM and WWPM – a 100-item spoken and written word–picture matching test; BPVS SWPM and WWPM – spoken and written word–picture matching versions of the British Picture Vocabulary Scale; WSJ – Warrington Synonym Judgement (Aud – Auditory version, Writ – Written version, Con – Concrete items and Ab – Abstract items). * – the norms reflect either the range of normal performance or two standard deviations below the mean control performance. A score underlined indicates that it is within the normal range.

word comprehension; word and picture versions of the Pyramids and Palm Trees (Howard & Patterson, 1992); a 100-item spoken word–picture matching test in both spoken (SWPM) and written formats (WWPM: Lambon Ralph et al., 1998). Given that these are relatively insensitive measures for detecting mild semantic impairments we also included two psychometrically graded tests of comprehension, again run twice for auditory and written presentations: British Picture Vocabulary Scale (BPVS: Dunn, Dunn, Whetton, & Burley, 1997) and Concrete and Abstract Synonyms (Warrington, McKenna, & Orpwood, 1998).

Table 2 shows the participants' results on language assessments indicated either by raw score or percentile score. The table indicates a wide range of aphasia presentations. Naming ability is highlighted with the total naming score (the sum of the three naming assessments), which ranged from 1/130 (JS) to 67/130 (ME). When the naming errors were analysed, HF, RH, and RR had an equivalent proportion of semantic and phonological errors in naming. SC and ME's proportions of errors were predominantly semantic and JS and HA showed the reverse—predominantly phonological errors. There was variation in phonological skill, from JS as the most severe overall to ME who was within normal range for both reading and repeating words. HF and SC were also within normal range for word repetition. Again, JS appeared to have the poorest semantic ability overall, while HA was within normal range on all semantic tasks, including the graded Warrington Synonym Judgement test (Warrington et al., 1998). SC also scored within normal range on the easier semantic tests but showed marked difficulties on the more stringent tests.

In addition to providing important clinical data, neuropsychological assessments were given to test various non-language, cognitive processes that may underpin feedback and control mechanisms (see Table 3). These included assessments of episodic memory for verbal and nonverbal materials including recognition for faces, pictures, words, and landscapes; Camden Memory Test (Warrington, 1996), Rey Complex Figure Test (Meyers & Meyers, 1995); working memory, digit span, and the PALPA Auditory Digit Matching Span (Bachrach & Mintz, 1974; Kay et al., 1992); nonverbal problem solving and reasoning, Wisconsin Card Sorting (Grant & Berg, 1993); and attention, both vigilance and divided attention—elevator counting with and without distraction from the Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994). The errorless learning literature suggests that patients' ability to monitor the accuracy of their own responses/behaviour may also be critical (O'Carroll et al., 1999). It may also be a critical factor that determines the usefulness of feedback (Fillingham et al., 2003). Accordingly, we assessed the participants' ability to judge the accuracy of their own naming. This was achieved by using the PALPA 53 picture-naming assessment (Kay et al., 1992). After the participant had named the picture they were asked if they thought their response was correct or incorrect.

Table 3 shows the results of the neuropsychological testing for each participant (raw score, percent correct, or percentile score is shown). HA was the only participant who was able to correctly monitor his naming attempts (100%). The weakest, JS, scored 26%. There is a great deal of variation in all memory assessments and all participants showed a deficit in at least one of the memory tests. HF and JS were all poor at problem solving whereas the remaining four participants scored well. It was surprising to find that all participants had a mild to moderate deficit when requested to divide their attention (in a nonverbal task). Also, all participants had some degree of difficulty with either visuospatial skills and/or visuospatial memory.

TABLE 3
Neuropsychological assessment results for each participant

Domain	*Assessment*	*JS*	*HF*	*RH*	*SC*	*RR*	*HA*	*ME*
Monitoring	Self-rating	26%	49%	62%	91%	93%	100%	92%
Episodic Memory	CMTpic	100%ile	100%ile	10%ile	100%ile	10%ile	100%ile	10%ile
	CMTtop	75%ile	<5%ile	25%ile	95%ile	50%ile	75%ile	25%ile
	CMTword	10%ile	<5%ile	<5%ile	100%ile	25%ile	100%ile	25%ile
	CMface	>5%ile	25%ile	10%ile	50%ile	>5%ile	75%ile	25%ile
Working Memory	WDSf	N/C	5	1	3	3	3	5
	WDSb	N/C	2	1	2	1	4	2
	PADMS	N/C	7	N/A	N/C	2	7	7
Non-verbal Problem Solving	WCS – No.cat	6–10%ile*	<1%ile*	>16%ile	>16%ile	>16%ile	>16%ile	>16%ile
	WCS – FMS	16%ile	6–10%ile	11–16%ile	16%ile	16%ile	16%ile	16%ile
Attention	TEA – elevator	6/7	7/7	6/7	7/7	6/7	7/7	7/7
	TEA – with dis	6.7–12.2%ile	12.2–20.2%ile	6.7–12.2%ile	3.3–6.7%ile	3.3–6.7%ile	12.2–20.2%ile	6.7–12.2%ile
Visuospatial Ability and Memory	Rey – copy	<1%ile	<1%ile	11-16%ile	11–16%ile	<1%ile	>16%ile	6–10%ile
	Rey – Imm Recall	5%ile	<1%ile	4%ile	<1%ile	5%ile	99%ile	54%ile
	Rey – Del Recall	4%ile	<1%ile	<1%ile	<1%ile	<1%ile	90%ile	34%ile
	Rey – Rec Total	14%ile	<1%ile	12%ile	4%ile	10%ile	14%ile	4%ile

N/C – not able to complete due to memory problems, difficulty understanding task, repeating or refusal; * denotes that the patient did not complete the whole task and so scores are based on the cards that were sorted; Self-rating – ability of patient to rate their own naming attempt using PALPA 53 picture naming assessment; CMT – Camden Memory Test (pic – pictographical, top – topographical, word – written word, face – faces); WDS – Wechsler Digit Span (f – forward, b – backward); PADMS – PALPA Auditory Digit Matching Span; WCS – Wisconsin Card Sorting (No. cat – Number of categories score, FMS – Failure to Maintain Set score); TEA – Test of Everyday Attention (elevator – elevator counting, with dis – elevator counting with distraction); Rey – Rey Complex Figure Test (copy – copying score, Imm Recall – immediate recall score, Del Recall – delayed recall score, Rec Total – recognition total correct score).

THERAPY

A multiple baseline, crossover study was carried out to contrast errorless and errorful therapies for word-finding difficulties. The 260 pictures from the Snodgrass and Vanderwart (1980) picture-naming test were used for all participants for a baseline measure, with the exception of HA for whom this test did not yield sufficient unnamed items for therapy. For HA, therefore, items from the more challenging Category Specific Naming Test (CSNT), (McKenna, 1997) were used. Three baseline measures were taken and the items were split into three groups of 20 matched for accuracy, frequency, number of phonemes, and number of syllables. One set was treated using errorless learning, one using an errorful technique, and the third acted as a control set. The only change made to the method from Fillingham et al., (2005) study was the number of times each item was attempted per session. This was increased from one to three attempts during each trial, bringing the method back in line with Study 1 (Fillingham et al., in press).

Phonemic and orthographic cues were presented together with the picture so that all modalities were being used. Errorless therapy consisted of providing the participant with the picture along with its spoken and written name to ensure the correct response was made. The participant repeated and/or read the name three times (in the previous study this was once). In errorful therapy the participant was given the picture along with the first phoneme and grapheme and asked to name the picture. This was conducted three times (in the previous study this was done once). In both therapies, whether the response was correct or not, no feedback was given and the next item was attempted. The 40 items (20 for errorless treatment and 20 for errorful treatment) were cycled through three times in each therapy session, which lasted between 25 and 40 minutes. Ten sessions of each therapy were given. The 20 items in the control set were not seen during therapy.

Baseline measures were taken in the first 2 weeks. In the next 5 weeks both therapies ran concurrently (rather than interleaved as per a standard multiple baseline therapy design), counterbalanced across sessions. There were 10 sessions of therapy, given twice weekly for 5 weeks (with breaks for unavoidable events, e.g., illness, holidays, etc.). Assessment was carried out after therapy (within the next week) to measure the immediate effect to treated and untreated items (generalisation to the control set). A follow-up assessment was carried out after an additional period of time (on average 5 weeks post-therapy). The efficacy of each therapy was compared and also related back to each participant's background language and neuropsychological measures in order to see if some of the critical, underlying cognitive predictors of therapy that were found in the previous study could be replicated.

RESULTS

The research aims were as follows: (1) to compare errorless and errorful learning approaches without feedback, with an increase in number of attempts at each item; (2) to identify which aspects of the participants' language and cognitive skills predict therapy effect; (3) to compare error rates during each treatment type to ensure they were significantly different; (4) to explore the effect of self-generation vs examiner-generated responses by looking at error rates during treatment. These basic results are reported below. The final section of the paper will then address the main question of Study 3 by comparing the results of all three studies: was the reduction in learning found in Study 2 due to the number of items during the therapy session, no feedback or number of attempts at naming during therapy?

Basic results

Figure 2 shows the results of both treatments for each participant. Each box contains results for one participant. The x-axis indicates the time of assessment: at baseline (Baseline), immediately post-treatment (PostTx), and at follow-up (Followup). The unfilled bars show the accuracy for the items treated with an errorless approach while the corresponding data for the items in the errorful treatment are shown as black-filled bars.

The results of the control items are not shown as there was no significant generalisation for any of the participants. No participant showed a significant difference in favour of errorless or errorful therapy at post-treatment or at follow-up assessment.

The graphs are ordered according to the overall therapy effect immediately post-treatment. There were no participants who showed a significant advantage for either therapy technique immediately post-treatment. JS and HF exhibited a change in errorless items only (McNemar $p = .01$, McNemar $p = .004$, one-tailed). RH showed a significant change for errorful items only (McNemar $p = .0005$). The remaining four participants (SC, RR, HA, and ME) all showed a significant effect of both errorless (McNemar $p = .008$ to $p = .001$, one-tailed) and errorful (McNemar $p = .008$ to $p = .0005$, one-tailed) therapy immediately post-treatment.

At follow-up assessment, the participants exhibited differing ability to retain treated items—i.e., comparing performance immediately post-treatment with scores at follow-up. JS exhibited significant change for errorless items (McNemar $p = .03$, two-tailed) indicating a significant loss of those items learnt. HF showed no significant change, indicating retention of the errorless items. RH also showed no significant change, which indicated retention of errorful items. SC, RR, and HA showed no significant change, indicating retention of errorless and errorful items learnt. ME exhibited a significant change for both errorless (McNemar, $p = .004$, two-tailed) and errorful (McNemar, $p = .008$, two-tailed) items, indicating a loss of items learnt.

Comparing the results at follow-up against baseline accuracy reveals the long-term effect of each therapy. JS exhibited no significant change as a result of either therapy. HF, RH, SC, RR, and HA all showed a significant long-term benefit from both errorless (McNemar $p = .01$ to $p = .003$, one-tailed) and errorful (McNemar $p = .03$ to $p = .004$, one-tailed) therapy. ME showed long-term benefit for errorful therapy only (McNemar $p = .03$, one-tailed).

Which aspects of the participants' language and cognitive profiles predicted therapy outcome?

The overall therapy effect varied across participants. JS and HF exhibited a therapy effect for errorless items, RH a therapy effect for errorful items, and the remaining four participants demonstrated differing success rates for both treatments immediately after therapy. JS was the only participant who showed no long-term retention for either therapy. Five participants (HF, RH, SC, RR, HA) showed long-term retention for both therapies and one participant (ME) showed long-term retention for errorful items. One aim of this study was to see if the results from the Fillingham et al. studies (in press, 2005)—indicating that recognition memory, executive/problem-solving skills, and monitoring ability predict therapy outcome—could be replicated. The case-series design (in which each and every participant is assessed across the same battery of tests) means that a direct comparison between the size of the therapy effect and the participants' scores on the background assessments could be made. Two comparisons were made: (a) which background assessments correlate with the size of the immediate therapy effect (i.e., the

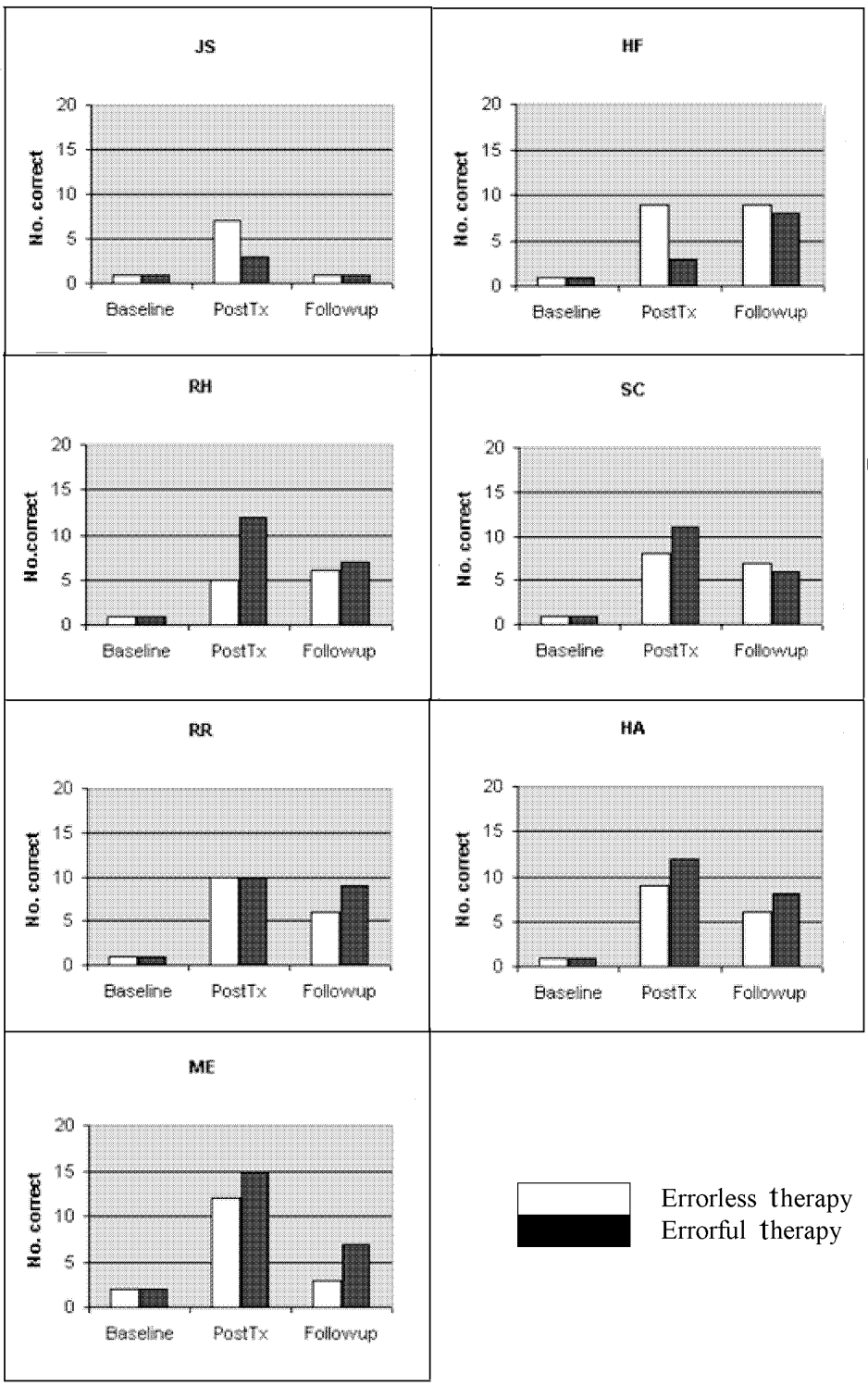

Figure 2. Results of errorless and errorful therapy without feedback.

difference in scores at baseline and immediately post-therapy); (b) which background assessments correlate with the long-term effect (baseline vs follow-up accuracies).

Given the results of our two previous therapy studies, we targeted a limited number of correlations, a priori. Specifically, we investigated the relationship between therapy outcome and executive/monitoring skills. We replicated the results for the immediate therapy effect. Again, it was aspects of the participants' remaining non-language, cognitive skills that predicted therapy outcome not language ability. As noted in Fillingham et al. (in press) these are cognitive factors that are identified as being critical in the rehabilitation literature (executive skills and monitoring: Robertson & Murre, 1999). Specifically, the neuropsychological tests that significantly correlated with immediate therapy effect were the test of self-rating ($\rho = 0.85$, $p = .003$) and the immediate recall score for the Rey Complex Figure Test and Recognition Trial ($\rho = 0.757$, $p = .049$). The number of categories completed on the Wisconsin Card Sorting Test ($\rho = 0.709$, $p = .074$) approached significance. This indicates that the participants who responded well to both therapies immediately post-treatment had better monitoring skills, recall and recognition memory, and executive problem-solving skills. This is also the case when errorless and errorful results are considered separately. In addition, three semantic tasks correlated with immediate therapy effect (the British Picture Vocabulary Scale, written word to picture match, and the auditory version of the Warrington Synonym Judgement test, abstract items) and one of the naming tests (PALPA Oral Naming). Given that these all require problem solving and decision making for accurate performance, it is possible that these correlations reflected the participants' varying executive skills. When scores on the executive and memory tasks were partialled out there was no remaining association between the semantic tasks and therapy outcome (partial between $\rho = 0.18$–0.29, $p = .6$–$.8$). Fillingham et al., (in press) also showed a relationship between immediate therapy effect and subtests scores of the Camden Memory Test (Warrington, 1996), indicating recognition memory as a predictor of therapy outcome. This was not replicated in this study although there was a significant relationship with recall/recognition of the Rey figure.

Comparison of error rates for errorless and errorful techniques

Often error rates during therapy are either not monitored or are not reported. Monitoring of error rates is important to confirm that the errorless technique does actually result in significantly fewer errors than the corresponding errorful treatment. It is important to note that we did not give a naming assessment in each of the therapy sessions as this could contaminate the errorless therapy with a series of errors made by the participant in the naming assessment. Instead, the participants' accuracy was measured in terms of their actual responses during therapy.

Figure 3 shows the participants' accuracy during each therapy session (i.e., the proportion of therapy trials on which the correct name was produced by the participant). Again each box shows the results for one participant and the graphs are ordered according to overall therapy effect, immediately post-treatment. Again, the unfilled bars show the results for errorless therapy and the filled bars for the errorful therapy. The results show that there was a significant difference between the two therapies with errorless therapy being the more accurate for each and every participant, $t(9)$ between 6.9 and 44.1, $p < .001$.

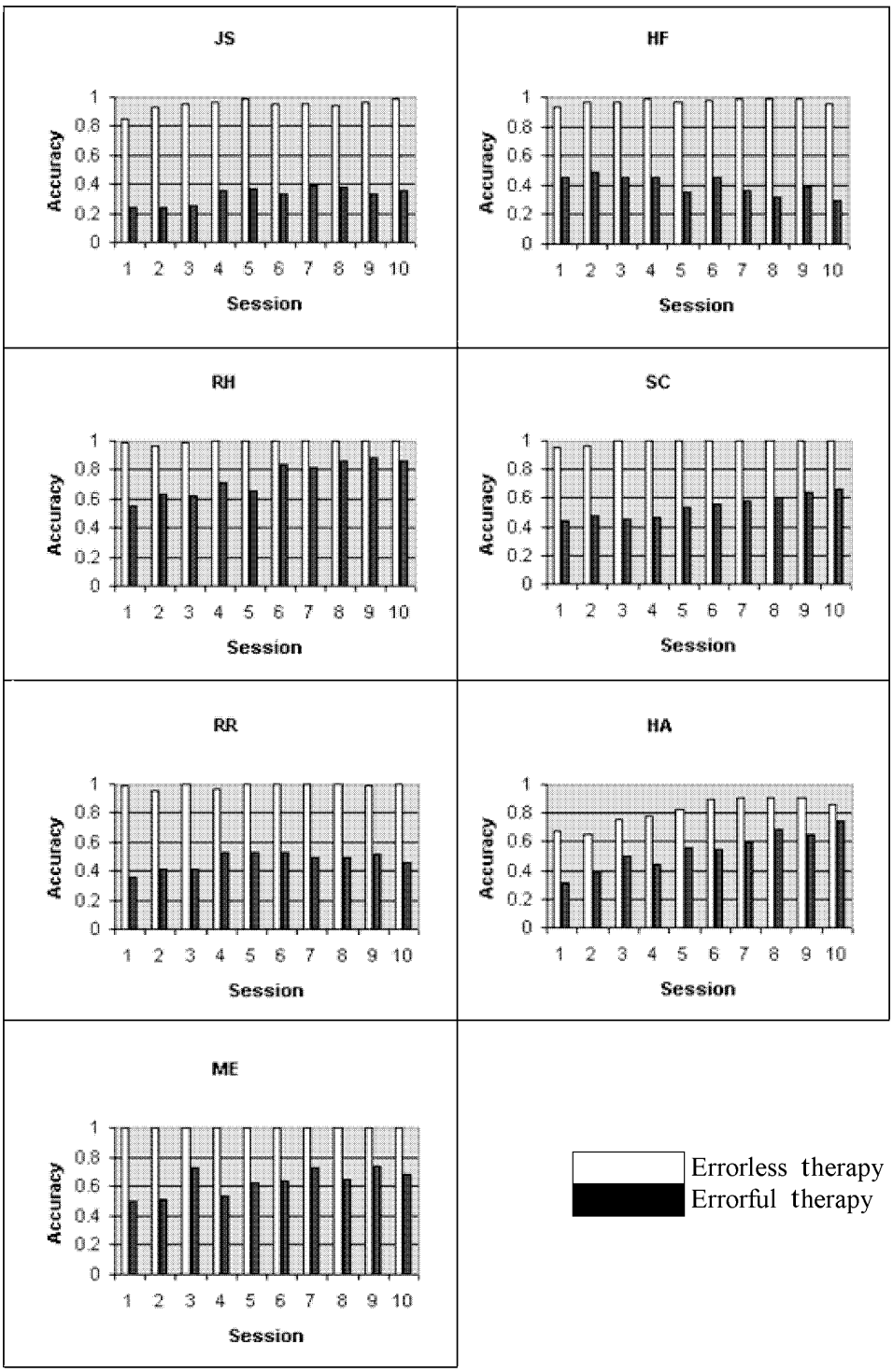

Figure 3. Accuracy during errorless and errorful therapies.

Summary of therapy study

Errorless and errorful learning without feedback was used to treat word-finding difficulties across a case-series of seven people with aphasia. Four of the participants exhibited equivalent, significant improvements for both techniques. Five participants retained a significant number of items at follow-up assessment and two participants lost a significant number of the items learnt. There were no participants who showed a significant advantage for either technique and there was no generalisation for any participant.

The results mirror the review of the anomia literature (Fillingham et al., 2003) and the previous results (Fillingham et al., in press, 2005). Errorless and errorful therapy produced equivalent results, immediately post-treatment and at follow-up assessment. The results also mirror those from Study 2 (Fillingham et al., 2005)—even when feedback is omitted, the two conditions, errorless and errorful learning, produce equivalent effects.

The results of the previous studies of Fillingham et al. (in press, 2005) showed that the status of the participants' language skills did not predict immediate therapy outcome. Instead, immediate naming improvements, irrespective of treatment type, were related to the participants' executive skills and recognition memory. Those participants who responded better overall had better recognition memory, executive/problem-solving skills, and monitoring ability. In this study, monitoring ability, recall memory, and problem-solving skills were again predictors of therapy outcome whereas the status of the participants' language skills was not.

Robertson and Murre (1999) argue that, from a rehabilitation perspective, self-awareness of deficits is critically important in recovery. If self-awareness is impaired then it seems very likely that attending to stimulation, experience, or activity (forms of self-monitoring) will also be impaired. At the neural level, Robertson and Murre argue that attention is important because it modulates synaptic connectivity and so influences repair and reconnection in damaged circuits. Helm-Estabrooks (2002) noted the growing evidence that the neuropsychological (cognitive) status of people with aphasia is important for the development of treatment plans and approaches, and to expectations of positive outcomes. Despite this, speech and language therapists are guided solely by the results of language assessments. While understanding of the nature of the deficit is necessary (Howard, 1999), it is not a sufficient condition for the development of effective and efficient treatments (Helm-Estabrooks, 2002). Helm-Estabrooks (2002) argues that the goal of rehabilitation is to understand the nature of adaptive change (i.e., plasticity) and how best to harness its benefits through interventions.

COMPARISON ACROSS ALL THREE STUDIES: WHICH FACTORS AFFECT THERAPY OUTCOME?

Results from the non-aphasia, rehabilitation literature suggest that errorless learning should produce superior results to errorful learning when relearning names (Evans et al., 2000; Wilson et al., 1994). The first study (Fillingham et al., in press) tested this possibility by directly comparing errorless and errorful learning in a case-series of people with aphasic word-finding difficulties. Contrary to expectations, errorful and errorless techniques produced equivalent results for the majority of participants. However, the study did not control for examiner feedback, which can have a significant positive effect on errorful learning (McCandliss et al., 2002). Therefore, a second study was conducted (Fillingham et al., 2005) as a replica of the original study but with feedback omitted during therapy sessions. Remarkably, the results of the first study were replicated. All of

the participants produced equivalent results for errorless and errorful therapy. However, participants did not learn as well overall in Study 2 as in Study 1. One possibility was that withdrawing feedback reduced learning potential in both the errorless and the errorful conditions. However, there were other methodological differences, which may have contributed to this reduced learning. Table 4 summarises the methodology of each of the three studies.

The differences between Study 1 and Study 2, which could have accounted for the reduction in learning, were the number of items per session (this had increased in the second study even though the number of items per condition were less because the therapies were run concurrently), the number of attempts at naming over the course of the therapy block or omitting feedback. To address these possibilities, the third study was a direct replication of the second with the exception of an increase in the number of attempts at naming each item during the therapy session, bringing it back in line with Study 1, i.e., three times per item.

Figure 4 shows the mean therapy outcome immediately post-treatment (accuracy immediately post-therapy minus baseline) and at follow-up (accuracy at follow-up assessment minus baseline) for all three studies. The figure shows an increase in the number of items learnt in Study 3 over Study 2, which perfectly matches the percentage of items learnt in Study 1. A Wilcoxon signed ranks test showed this increase, from Study 2 to Study 3, was significant ($Z = -2.023$, $p = .043$). These results suggest that the number of naming attempts during therapy had a clear effect on outcome.

GENERAL DISCUSSION

This investigation was conducted as a follow-up to the Fillingham et al. (in press, 2005) studies to compare errorless and errorful therapy. Results from the non-aphasia rehabilitation literature suggest that errorless learning should produce superior results to

TABLE 4
Summary of methodology for the three studies

	Study 1 (Fillingham et al. in press)	*Study 2 (Fillingham et al., 2005)*	*Study 3 (this paper)*
Participants	HF, FO, RD, EW, RR, JS, RH, ME, HA, GP, SC	HF, RD, RR, JS, ME, HA, SC	HF, RR, JS, RH, ME, HA, SC
No. items per condition	30	20	20
No. sessions	10	10	10
Method	Consecutively	Concurrently	Concurrently
No. items per session	30	40	40
Therapy	EL – read and/or repeat EF – progressive phonological and othographic cueing	EL – read and/or repeat EF – 1st phoneme and grapheme cue	EL – read and/or repeat EF – 1st phoneme and grapheme cue
No. attempts at each item during therapy	90 – errorless 120 (potentially) – errorful	30	90
Feedback	Yes	No	No

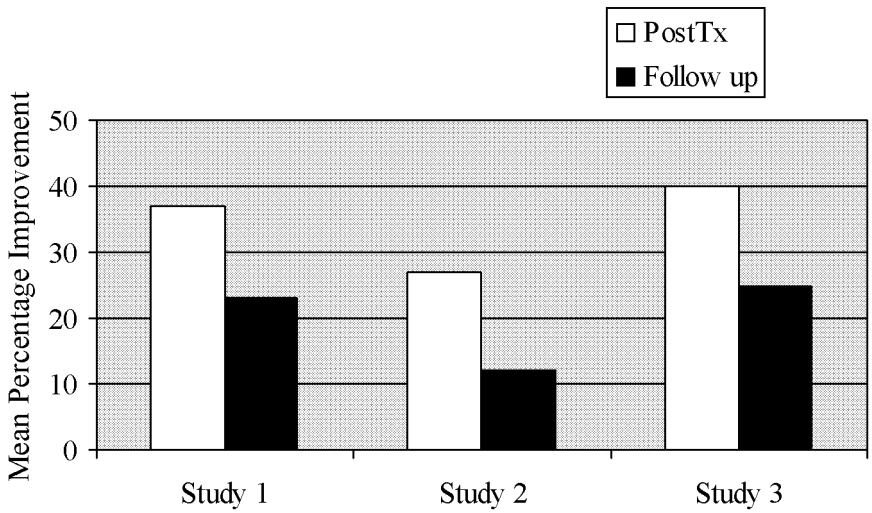

Figure 4. The mean percentage improvement for all participants, for each study, immediately post-treatment and at follow-up.

errorful learning. However, in both previous studies errorless and errorful therapy produced equivalent results. In the original study (Fillingham et al., in press) feedback may have benefited the errorful condition, thus reducing any underlying differences between the two methods (see McCandliss et al., 2002). In the second study (Fillingham et al., 2005) therapist feedback was removed, yet errorless and errorful therapy produced equivalent results. However, there was a general reduction in learning (see Figure 1). This could have been due to withdrawing feedback or other methodological differences between the two studies (see Table 1). The third study presented in this paper addressed this issue and was also carried out to provide further replication of the previous findings.

All three studies have produced consistent findings. Errorless and errorful learning therapy for word-finding impairments produces equivalent results. Therapy outcome can be predicted from the status of the participants' non-language, cognitive skills (executive/problem-solving and monitoring tasks) but not their language skills per se. By comparing the results of this study and the two previous investigations, important findings emerge: The greater the number of attempts at an item during therapy, the greater the success at learning the item; and giving or withdrawing feedback makes no difference to therapy outcome.

The difference between the findings for aphasic and other neurological patients poses important questions. Previous research has shown errorless learning to be superior to errorful learning in a number of areas. It is in the area of amnesia where the relearning of words and names using errorless learning has been studied the most (Baddeley & Wilson, 1994; Clare et al., 1999, 2000; Evans et al., 2000; Wilson et al., 1994). There are two major differences between this research and the results described here. The obvious difference is the diagnosis of the participants involved. The aphasia and amnesia literatures are such that it is difficult to make direct comparisons and theoretical predictions about the role of cognitive processes in language recovery/rehabilitation. This is because aphasia studies rarely assess cognition while language testing is generally very limited, or non-existent, in investigations of people with amnesia (Hinckley, 2002). The extensive language and neuropsychological testing in the three studies in this paper has added to the

growing evidence that people with aphasia do have secondary cognitive difficulties and that these—particularly executive/problem-solving and monitoring ability—influence therapy outcome. While it is becoming more widely acknowledged that assessment of cognition is crucial for rehabilitation (Robertson & Murre, 1999), assessment of language skill in other areas of rehabilitation has largely been ignored, even with growing evidence that semantic and other language impairments are major characteristics of other neurological disorders, e.g., Alzheimer's disease (Lambon Ralph, Patterson, Graham, Dawson, & Hodges, 2003). It may be that each field of work is missing crucial factors that could contribute to an overall theory of rehabilitation.

The second difference between the amnesia literature and the anomia studies presented in this paper, is the way in which learning/therapy is carried out. In the amnesia literature, studies that address learning of words and names tend to fall into one of two categories. The first are those studies that compare errorless and errorful learning techniques in learning novel associations via tasks such as stem completion or paired associate learning (Baddeley & Wilson, 1994; Evans et al., 2000; Wilson et al., 1994). This type of study is impossible to replicate with people with word-finding impairments because of their predominant language difficulties. The second are those studies that address the relearning of words or names using errorless learning techniques for rehabilitation (Clare et al., 1999, 2000; Wilson et al., 1994). These investigations match the techniques used in the rehabilitation of anomia. However, there have been no studies of teaching people with amnesia to relearn words and/or names that have directly compared errorless and errorful techniques. These investigations are based solely on errorless learning and often vary greatly in amount of intervention given, number of items to be learned, number of attempts at learning, and there is often no mention of whether feedback has been given.

Future research needs to address this issue by recruiting people with amnesia and replicating the study presented in this paper. In this way a direct comparison could be made between the two disorders (amnesia and aphasia) and the two techniques (errorless and errorful). Language and neuropsychological assessment using the same tests would also enable direct comparisons and thereby reveal the role of cognitive processes in language recovery/rehabilitation across the two disorders.

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