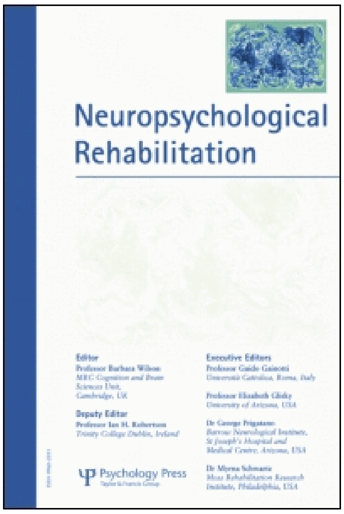

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Predicting the outcome of anomia therapy for people with aphasia post CVA: Both language and cognitive status are key predictors

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The aim of this study was to determine whether it was possible to predict therapy gain from participants' performance on background tests of language and cognitive ability. To do this, we amalgamated the assessment and therapy results from 33 people with aphasia following cerebral vascular accident (CVA), all of whom had received the same anomia therapy (based on progressive phonemic and orthographic cueing). Previous studies with smaller numbers of participants had found a possible relationship between anomia therapy performance and some language and cognitive assessments. Because this study had access to a larger data set than previous studies, we were able to replicate the previous findings and also to verify two overarching factors which were predictive of therapy gain: a cognitive factor and a phonological factor. The status of these two domains was able to predict both immediate and longer-term therapy gain. Pre-treatment naming ability also predicted gain after the anomia therapy. When combined, both cognitive and language (naming or phonological) skills were found to be independent predictors of therapy outcome.

Keywords: Anomia; Therapy; Predictors; Cognition; Language.

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BACKGROUND

Aphasia is a language impairment resulting from acquired brain injury which affects speech, comprehension, reading and writing. It is a common feature of stroke (affecting 1/5 of chronic and 1/3 of acute patients) with around 250,000 people with aphasia at any one time in the UK (Cummings, 2008). One of its most debilitating symptoms is word retrieval failures (anomia) where even simple, everyday words cannot be retrieved easily or quickly. This dramatically reduces people's quality of life and affects all aspects of everyday communication, such as talking to a family member, conversing in social settings, using the telephone, etc. (Laine & Martin, 2006).

There is considerable research on treatments for anomia (see Laine and Martin, 2006; Whitworth, Webster, & Howard, 2005, for useful summaries). However, there is much less research on predicting the outcome of anomia therapy – either in terms of who might benefit or the size of the therapy gain. Yet there would be many benefits to being able to make such predictions. For example, it would allow therapists to target individuals who were likely to respond to treatment and it would provide information to service providers so that they could allocate stroke care and rehabilitation services appropriately. It might also improve the provision of information that speech and language therapists could give to people with aphasia and their relatives about how they might respond to therapy and later why they did (or did not) respond. This would, in turn, assist the therapists in managing the expectations of individuals with aphasia and their families.

The most obvious factor for predicting therapy outcome is the severity of the language impairment, particularly as this has been shown to be a strong predictor of spontaneous recovery (Goldenberg & Spatt, 1994; Liang et al., 2001; Mark, Thomas, & Berndt, 1992; Marshall & Phillips, 1983; Pedersen, Jorgensen, Nakayama, Raaschou, & Olsen, 1995). Importantly, Robey (1998) carried out a detailed meta-analysis which showed that even participants with severe aphasia were able to make progress in therapy. People with aphasia show great variability in their response to anomia therapy even when they are equated for time post-onset and degree of language impairments. Since the early 1990s and the use of case series treatment designs, research on anomia therapy has been able to reflect this variability (Best, Herbert, Hickin, Osborne, & Howard, 2002; Conroy, Sage, & Lambon Ralph, 2009a, 2009b; Fillingham, Sage, & Lambon Ralph, 2006; Hickin, Best, Herbert, Howard, & Osborne, 2002; Martin, Fink, Laine, & Ayala, 2004). For example, Best, Hickin, Herbert, Howard, and Osborne (2000) found that pre-treatment response to phonological and orthographic cueing predicted subsequent improvement on a cueing-based therapy. Unlike the 4/5 participants who demonstrated significant naming improvement, the one participant who did not exhibit a therapy gain had not benefited from the cues in the pre-treatment cueing task.

In a study of seven participants, Conroy et al. (2009a) found that therapy gain was correlated with both pre-treatment language status (measures of naming, comprehension and phonology) and cognitive skills (Rey Complex Figure: Meyers & Meyers, 1995). The possible importance of cognitive as well as language status in predicting therapy outcome was highlighted in a series of studies by Fillingham, Sage, and Lambon Ralph (2005a, 2005b; 2006). Across a series of anomia therapy studies with 10 participants, they found that pre-treatment measures of executive function (Wisconsin Card Sort Task, WCST; Grant & Berg, 1993) and self-monitoring skills predicted participants' response to treatment. In contrast, anomia severity (as measured by the BNT; Goodglass, Kaplan, & Baressi, 2001) was more weakly associated with therapy gain. The only language assessment to correlate significantly with treatment success was the written version of the Pyramids and Palm Trees Test (Howard & Patterson, 1992), which has a considerable problem-solving/executive component. Although the results from the Fillingham et al. and the Conroy et al. studies may appear to be contradictory, the variation is mostly likely to reflect insufficient statistical power. In both studies, the non-significant correlations were high yet there were insufficient cases for these to reach statistical significance. The current study was designed specifically to reduce this problem. Hinckley and Carr (2001) also found that the WCST and the Ravens Coloured Progressive Matrices (Raven, 1962) were good predictors of how quickly and effectively 18 participants were able to learn in the therapy task. Goldenberg, Dettmers, Grothe, and Spatt (1994) found that performance on episodic-recognition memory for words, faces and pictures (Goldenberg et al., 1992), recall of the Rey Complex Figure, and semantic memory tests predicted response to language therapy in 18 participants following CVA. Several measures did not predict performance, including a test for ideomotor apraxia (Goldenberg et al., 1992), Rey Complex Figure, association learning (Goldenberg et al., 1992), card sorting, and working memory tasks (Goldenberg et al., 1992; Lezak, Howieson, & Loring, 2004).

The importance of cognitive ability (as well as age) in predicting general aphasia therapy outcome was underlined by van de Sandt-Koenderman and colleagues (2008). As a part of a large randomised control trial, people with aphasia were assessed on the MAAS (Multi-Axial Aphasia System) which provides severity ratings from a multi-disciplinary team on five clinically-relevant dimensions (language severity, medical-neurological severity, cognitive ability, psychosocial information and socio-economic factors). Patients ($N = 58$) all had a mixture of semantic and phonological impairment and, in the treatment arm of the RCT, received intensive, direct cognitive-linguistic therapy. The outcome measure was the ANELT

(Amsterdam Nijmegen Everyday Language Test: Blomert, Kean, Koster, & Schokker, 1994). Van de Sandt-Koenderman et al. (2008) used the five-factor MAAS ratings to predict performance on this outcome measure and found that the only significant predictors were the rating of the patients' cognitive status and age. The rating of the language impairment did not predict performance on the ANELT – although this might be a reflection of the fact that it is very difficult (if not impossible) to reduce contrasting language profiles (e.g., fluent vs. nonfluent aphasia) to a single, general aphasia severity. The results of this study are important because they show that when enough participants are included in the analyses then (a) it is possible to predict (general) therapy outcome, and (b) that the neuropsychological profile of patients should be taken into account, as suggested by previous studies. In an attempt to improve these predictions, rather than using overall ratings of language and cognitive status, we utilised careful and detailed aphasiological and neuropsychological testing, collected prior to treatment, to make predictions of therapy gain within a specific language domain (aphasic word-finding difficulties) rather than a general language outcome measure.

The importance of cognitive factors has been repeatedly highlighted in other parts of the neurorehabilitation literature (Carod-Artal, Medeiros, Horan, & Braga, 2005; Helm-Estabrooks, 2002; Robertson, Ridgeway, Greenfield, & Parr, 1997; Verschaeve, Boon, Paquier, & Van Harskamp, 1992). In the context of physiotherapy and CVA, attention (measured by the map search subtest of the Test of Everyday Attention: Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994) was found to predict the rate and the degree to which participants were able to acquire new physical skills and to learn to use compensatory strategies independently (Robertson et al., 1997). To date there has been little systematic assessment of attentional deficits in aphasia following CVA and little work examining its role in acquiring new skills in the language domain. Murray (1999) suggested two possible attentional problems for people with aphasia post CVA: an inability to allocate attentional resources correctly or a reduced capacity of attentional resources, and that these two may occur concurrently.

Study aim and method for selecting participant data

The aim of this study was to examine the relationship between gain after anomia therapy and performance on language and cognitive tasks. Although a few studies have explored this before (see above), the strength of the conclusions was limited by the relatively small number of participants. In this study, therefore, we accumulated the data from a relatively large number of participants with aphasia ($N = 33$) who had undergone the same anomia therapy and had the same language and cognitive testing prior to treatment. This was achieved by pooling data from four previous studies (Conroy et al., 2009b; Fillingham et al., 2006; Sage, Snell, & Lambon Ralph, 2009; Snell, Sage, & Lambon Ralph, in press). Two of these studies (Conroy et al., 2009b; Fillingham et al., 2006) had compared "traditional" anomia therapy based on progressive phonemic and orthographic cueing to other types of therapy (errorless learning or reducing cues). The other two studies had investigated factors within therapy: list size (Snell et al., in press) and intensity (Sage et al., 2009). From each study, we extracted the results from the standard cueing-based therapy and the patients' pre-treatment assessment results to permit direct comparisons across patients.

METHOD

Participant selection

In all four studies, participants were selected because they presented with aphasic word-finding difficulties following CVA, were at least six months post-onset and had no other pre-existing neurological problem such as dementia, Parkinson's disease, or severe perceptual or cognitive deficits. All those participants who needed corrective glasses or hearing aids were asked to wear them throughout the assessment and therapy sessions. All participants were native speakers of English and literate prior to their onset.

Therapy method

A very similar therapy design and method was used in the four studies. In order to select items for therapy (and for the control sets), all participants had been asked to name, on three different occasions, a large corpus of pictures. From each participant's corpus, an item was selected only if it had been named on either 0/3 or 1/3 of these naming occasions. Items were divided into therapy and control sets, matched for frequency (Baayen, Piepenbrock, & Rijn, 1993), syllable length, number of phonemes and baseline naming ability. For each group of selected items, we computed the pre-treatment naming accuracy by selecting the highest accuracy scores for each item collected across the three baseline testing sessions. This is a relatively conservative measure, given that it represents the very best performance level achieved by each patient prior to therapy.

The therapy method was based on picture naming with progressive phonemic and orthographic cues (up to four progressively longer cues were provided for each picture) provided by the therapist. Cueing continued until the target name was produced or until the whole target word had been presented in spoken and written format by the therapist. If the whole word was provided via cueing then the participant was encouraged to repeat/read the target name. The next picture was then presented. Each item was treated three times per session. Each session lasted between 20 and 40 minutes. Each therapy consisted of 10 sessions (participants were seen twice a week over a period of 5 weeks) with an assessment immediately after therapy (within one week) and five weeks later during which time no therapy or maintenance programme took place. Control (untreated) sets were only seen at the immediate and five week assessments.

In order to compare results directly across the individuals (given variation in baseline naming score and the total numbers of items in each therapy set), the proportion of the potential maximal gain for each participant was calculated, (post-therapy naming accuracy – baseline naming)/(number of items included in therapy – baseline naming). For example, if there were 20 items to be treated and the individual correctly named 4 at baseline and 15 correctly after treatment, the calculation would be: $(15-4)/(20-4) = 11/16 = 0.69$. These computed values are reported in Table 2 below for each individual. This gives a measure of the proportion of possible items that each patient had been able to gain during therapy.

Pre-treatment performance on language and cognitive assessment

Method. Each study carried out language and cognitive assessments prior to treatment. The common assessments were extracted from each of these studies and are described briefly below. For all assessments, performance was judged to be impaired if the score fell two standard deviations below the mean or below the published cut-off score.

Naming. All 33 participants had undergone pre-treatment naming of the 60 items in the Boston Naming Test (BNT; Goodglass, Kaplan, & Barresi, 2001). The BNT contains 60 black and white line drawings of decreasing familiarity. This test was used as the measure of anomia severity. All patient results (see Tables 2 and 3 below) are ordered by their BNT score.

Reading. All 33 participants completed the PALPA 31 imageability × frequency (Kay, Lesser, & Coltheart, 1992) test of reading aloud. This test contains 80 words of which 20 are highly imageable and high frequency, such as “church” and “letter”; 20 are highly imageable and low frequency, such as “axe” and “tractor”, 20 are low imageable and high frequency, such as “attitude” and “thought”, and 20 are low imageable and low frequency, such as “dogma” and “mercy”. The normative cut-off score is 79/80.

Repetition. All participants had completed PALPA 9 imageability × frequency word repetition (Kay et al., 1992) which contains the same 80 words used in the reading test (PALPA 31), described above. A score below 78 was impaired.

Semantic memory and comprehension. All 33 participants undertook the three picture version of the Pyramids and Palm Trees Test. This test assesses semantic knowledge by requiring participants to match one picture to another (from a choice of two) on the basis of semantic association. For example, for a *pyramid*, the participant chooses between a *palm tree* and a *fir tree*. The published cut-off score for this test is 49/52. It should be noted, perhaps, that this test also demands good problem-solving skills and thus also assesses the status of executive abilities.

Attention. All 33 participants were assessed on two auditory subtests of the Test of Everyday Attention. The first easier subtest (Elevator Counting) assesses sustained attention. Participants hear a series of beeps at random time intervals (representing floors in a lift). They are asked to count the number of beeps (range 3–14) in order to track which floor the lift has arrived at. A table of written numbers was provided to enable responses from patients with number naming difficulties. Use of their own fingers to indicate the number was also accepted. Impaired performance on this test is 5 and below. The second, more demanding subtest (Elevator Counting with Distraction) assesses divided attention. Participants hear a series of high and low beeps. They are asked to count only the low beeps, while ignoring the high beeps. Beeps are presented in a random order at random time intervals (range 2–14). Impaired performance on this test is 4 and below.

Visuospatial memory. All participants carried out the full version of the Complex Figure of Rey. This test assesses participants' visuospatial ability by requiring them to copy a complex, abstract geometric figure. They are asked to reproduce it immediately from memory and again 30 minutes later, providing information about their visuospatial memory. Impaired performance on this test is dependent on participants' age (see Table 3).

Executive functioning. All participants were assessed with the Wisconsin Card Sort Task (WCST). This test uses 128 cards varying three features – colour (red, yellow, blue, green), shape (circle, triangle, square, cross) and number (one, two, three, four). Participants have four reference cards laid out in front of them, are given the pack of cards and asked to sort the cards using the reference cards to work out a sorting rule (e.g., sort by colour). Participants are given feedback on whether their sorting mechanism is right or wrong. Once 10 consecutive cards have been placed correctly, the tester changes the sorting rule (e.g., sort by number) without explicitly informing the participants of the rule change (although the feedback now changes). Rule changes are based on colour, shape or number. We report the number of categories completed (maximum = 6) to provide an indication of how many rule changes the participants were able to detect. Participants are impaired on this test if they fail to complete one category.

RESULTS

Table 1 sets out the biographical details of the 33 participants. Participants are displayed in order of BNT severity (most severe top to least severe bottom in all tables). Further participant details have been reported in the following papers; 10 cases (FO, RD, EW, RR, JS, RH, ME, HA, GP, SC) in Fillingham et al. (2006), nine cases (KP, PM, RP, PO, JT, RH, MD, DR, WE) in Conroy et al. (2009b), 13 cases (RR, FT, SM, DB, ER, JM, SS, LC, PG, JA, IH, FL, SB,) in Snell et al. (in press) and one case (PR) from Sage et al. (2009). The current cohort of participants ($n = 33$) ranged in age from 40 to 84 years (mean age = 65.45, $SD = 10.77$). All were right handed and presented with aphasia following left-hemisphere lesions, 32 as a result of CVA and one following a haematoma secondary to haemorrhage (SC). Time post-onset ranged from 7 to 192 months (mean = 53.39, $SD = 41.62$). The range of anomia scores pre-therapy as measured by the BNT, was between 0/60 and 43/60, covering severe to mild naming difficulties.

Table 2 summarises the language test results. Eighteen participants showed impaired performance on all the language tests while 15 exhibited scores in the normal range for at least one of the assessments. Seven participants scored 49 or above on the three-picture version of the Pyramids and Palm Trees Test. Seven participants showed excellent repetition skills and five participants were within 2 standard deviations of control mean for the word reading assessment (PALPA 31).

Table 3 sets out the cognitive skills of each participant. There was generally good performance on the sustained attention task of the TEA with 26/33 participants scoring within normal limits. This is to be expected given the relative ease of sustained attention when compared to divided attention. The divided attention task from the TEA showed much greater variation in ability across the participants and probably reflects the greater task difficulty. The WSCT and the Rey Figure Test also revealed a range of cognitive skills across the participants.

The relationship between therapy gain and the pre-treatment assessments

To establish whether there was a relationship between therapy gain and the pre-treatment assessments, initially Pearson's correlations were applied to

TABLE 1
Background information for each participant

Participant	*Age*	*Gender*	*TPO*	*Scan result*	*Occupation*
JS	76	M	132	n/a	Electrician
KP	75	F	48	n/a	n/a
EW	73	M	24	L p	Builder
FO	80	M	72	n/a	Company secretary
PM	42	F	60	n/a	n/a
RH1	68	M	60	L MCA	Foreman
RD	40	M	24	L	Company director
RR1	60	M	48	LMCA	n/a
RR2	74	F	72	L t-p	n/a
FT	75	F	13	L f-p	Wages clerk
RP	71	M	36	n/a	n/a
SM	48	M	16	L t-p	Radio sports commentator
SC	74	M	48	L o-p R. f-p	Florist
GP	73	M	60	n/a	Policeman
DB	78	F	12	n/a	Accountant
HA	74	M	60	L p-o	Judge
ER	69	M	55	L o-p	Metal worker
PO	60	M	12	n/a	Businessman
ME	70	F	192	n/a	Housewife
JM	58	M	67	L f-p	Computer worker
JT	84	F	24	n/a	n/a
SS	65	F	132	n/a	School secretary
RH3	62	F	18	n/a	n/a
LC	54	M	7	L p-t	Railway maintenance
MD	48	F	108	n/a	n/a
DR	65	M	36	n/a	Engineer
PR	69	M	84	L t-p	Undertaker
PG	62	M	87	SAH	Architect
JA	59	M	60	n/a	Bricklayer
IH	69	M	11	subcortical	Processing manager
FL	67	M	7	L f	Lorry driver
WE	65	F	48	n/a	n/a
SB	53	F	29	n/a	Shop worker

MCA = middle cerebral artery, f = frontal, t = temporal, p = parietal, o = occipital, SAH = subarachnoid haemorrhage, n/a = not available. TPO = time post-onset (months), L = left, R = right

the data. Six of the pre-treatment assessments (three language and three cognitive) were significantly correlated with therapy gain both immediately and at follow up (see Table 4). The three language tests were the Boston Naming Test, three-picture Pyramids and Palm Trees Test and PALPA 31 imageabilty × frequency word reading. The three cognitive tests were Test of Everyday Attention elevator counting with distraction, the Rey Figure copy, and the Rey Figure delayed recall.

TABLE 2
Pre-treatment language assessment results for each participant

Participant	*Study*	*BNT (max = 60)*	*PPT (max = 52)*	*PALPA Repetition (max = 80)*	*PALPA Reading (max = 80)*	*Proportion gain: post- therapy*	*Proportion gain: follow up*
JS	1	0	40	36	0	.33	.33
KP	3	0	42	55	28	.43	.43
EW	1	2	45	76	36	.39	.32
FO	1	3	31	63	16	.04	.04
PM	3	3	39	79	9	.30	.23
RH	1	4	47	67	9	.46	.21
RD	1	5	44	75	51	.15	.22
RR	1	6	45	76	16	.44	.30
RR	2	7	**49**	56	11	.37	.16
FT	2	8	48	46	31	.38	.41
RP	3	8	42	67	20	.58	.58
SM	2	9	33	77	36	.38	.43
SC	1	10	**50**	**78**	65	.79	.38
GP	1	12	47	**79**	**80**	.93	.46
DB	2	15	37	**80**	63	.51	.39
HA	1	15	**52**	65	64	.63	.56
ER	2	23	47	47	46	.79	.64
PO	3	24	47	**78**	63	.83	.80
ME	1	25	48	**79**	**80**	.58	.23
JM	2	28	46	75	**79**	.98	.81
JT	3	28	40	74	46	.70	.50
SS	2	29	42	**79**	75	.78	.57
RH	3	29	**52**	76	71	.78	.75
LC	2	34	**50**	75	**79**	.89	.68
MD	3	34	48	75	57	.85	.65
DR	3	35	**52**	66	74	.95	.88
PR	4	36	47	72	61	.70	.53
PG	2	37	38	73	**79**	.52	.48
JA	2	38	46	69	74	.94	.67
IH	2	39	42	75	78	.57	.43
FL	2	39	44	63	55	.48	.32
WE	3	40	46	**80**	77	.85	.53
SB	2	43	**50**	66	59	.86	.63

1 = from Fillingham et al. (2006); 2 = from Snell et al. (in press); 3 = from Conroy et al. (2009b); 4 = from Sage et al., (2009).

BNT = Boston Naming Test; PPT = Pyramids and Palm Trees; PALPA = Psycholinguistic Assessments of Language Processing in Aphasia. Underlined and **emboldened** scores were within the normal range

It is possible that these raw correlations reflected the impact of one or more underlying common neuropsychological or aphasiological factors. We explored this possibility by using a principal component analysis (PCA) to group the pre-treatment measures. This type of data analysis and approach has been used previously to explore cognitive and language results from CVA-related aphasia (Lambon Ralph, Moriarty, & Sage, 2002), semantic dementia (Woollams, Lambon Ralph, Plaut, & Patterson, 2007) and Alzheimer's disease (Lambon Ralph, Patterson, Graham, Dawson, & Hodges, 2003). In the Lambon Ralph et al. (2002) study, for example, it was possible

TABLE 3
Pre-treatment cognitive assessment results for each participant

Participant	*Study*	*TEA (max = 7)*	*TEA/D (max = 10)*	*WCST (max = 6)*	*Rey Copy (max = 36)*	*Rey Imm (max = 36)*	*Rey Delay (max = 36)*
JS	1	**6**	3	0	9.5	5	5
KP	3	**7**	2	**2**	23	3	6
EW	1	**7**	2	**1**	24	2	0.5
FO	1	**7**	0	0	24	1.5	1
PM	3	4	0	**1**	26	5	7
RH	1	**6**	3	**3**	29.5	6.5	3
RD	1	5	2	**4**	32	**10.5**	**10.5**
RR	1	**6**	3	**5**	15	9	4
RR	2	**6**	1	**5**	**31**	**17**	**18**
FT	2	**6**	4	**3**	26	6.5	6.5
RP	3	**6**	1	**2**	**36**	**11**	7
SM	2	4	0	n/a	25	0	0
SC	1	**7**	1	**6**	27.5	0	0
GP	1	**7**	5	**3**	**36**	**12**	**14**
DB	2	3	1	0	19	0	0
HA	1	**7**	5	**6**	**34.5**	**21**	**17**
ER	2	**6**	n/a	**2**	15.5	4	3.5
PO	3	5	**7**	**5**	**34**	11	11
ME	1	**7**	3	**4**	28	**14**	**11.5**
JM	2	**7**	**6**	**4**	**32**	**24**	**21**
JT	3	4	3	**3**	18	6	4
SS	2	**7**	**6**	**6**	22	2	1
RH	3	5	1	**1**	**35**	**22**	**22**
LC	2	**7**	**5**	**5**	32	6	5
MD	3	**6**	4	**4**	**34**	**19**	**16**
DR	3	**7**	**5**	**5**	**36**	**20**	**21**
PR	4	**7**	4	**4**	27	19	15
PG	2	**7**	**5**	**5**	28	4.5	7
JA	2	**7**	2	**2**	22	**15**	11
IH	2	**7**	2	**2**	19	5	6.5
FL	2	**7**	**6**	**6**	n/a	n/a	n/a
WE	3	**7**	2	**2**	28	7	7
SB	2	**6**	4	**4**	**30**	11	5.5

1 = from Fillingham et al. (2006); 2 = from Snell et al. (in press) 3 = from Conroy et al. (2009b); 4 = from Sage et al., (2009).

TEA = Test of Everyday Attention (elevator counting subtest); TEA/D = Test of Everyday Attention with distraction (elevator counting with distraction subtest); WCST = Wisconsin Card Sort Task; Rey Copy = Complex Figure of Rey – Copy trial; Rey Imm = Rey immediate recall; Rey Delay = Complex Figure of Rey – Delayed recall; N/A = not available. Underlined and **emboldened** scores were within the normal range

to predict aphasic naming performance by reducing the pre-treatment aphasiological assessments to two underlying factors (which corresponded to semantic and phonological status). A crucial aspect of such analyses is that

TABLE 4
Correlation results for therapy gain and background assessments

	Gain at:	
	Immediately post-therapy	*Follow up testing*
Test		
BNT	0.68**	0.62**
PPT	0.61**	0.46**
Word repetition (PALPA 9)	0.26 *ns*	0.12 *ns*
Word reading (PALPA 31)	0.71**	0.60**
Elevator counting task	0.26 *ns*	0.10 *ns*
Elevator counting with distraction	0.48**	0.47**
WCST	0.30 +	0.17 *ns*
Rey Figure copy	0.33*	0.34*
Rey Figure immediate recall	−0.03 *ns*	−0.02 *ns*
Rey Figure delayed recall	0.41*	0.46**
Factor 1: Cognitive	0.48**	0.46*
Factor 2: Phonological	0.47**	0.37*

+ = p = .1; * = $p < .05$; ** = $p < .01$; = not significant. BNT = Boston Naming Test; PPT = Pyramids and Palm Trees; PALPA = Psycholinguistic Assessments of Language Processing in Aphasia; TEA = Test of Everyday Attention – elevator counting subtest; TEA/D Test of Everyday Attention – elevator counting with distraction subtest; WCST = Wisconsin Card Sort Task; Rey Figure copy = Complex Figure of Rey – Copy trial; Rey Figure delay = Complex Figure of Rey – delayed recall.

PCA is used to group the pre-treatment data in an unconstrained fashion that is independent of the measure being predicted. So, in the previous study, the background tests were grouped according to their shared variance and then were used to predict naming ability (which was not included in the underlying PCA).

In the present study, therefore, we entered the background language and cognitive tests (summarised in Tables 2 and 3) into a principal component analysis with varimax rotation. The background tests included in the analysis were: Pyramids and Palm Trees (three-picture version), PALPA 9 word repetition, PALPA 31 word reading, TEA – elevator counting subtest, TEA/D – elevator counting with distraction subtest, WCST, Rey Figure copy, and Rey Figure delayed recall. These tests covered the possible factors of interest, i.e., they were measures of semantics, phonology and cognition. Given that we wanted to predict improvement in *naming* therapy independently from any factors produced by the PCA, we did not include the BNT scores. Indeed, performance on the BNT was highly correlated to therapy gain both immediately after therapy ($r = .68$, $p < .001$) and at follow-up ($r = .62$, $p < .001$).

The PCA generated two principal components with an eigenvalue above 1. Factor 1 had an eigenvalue of 2.8 and accounted for 34.5% of the variance. Factor 2 had an eigenvalue of 1.9 and accounted for 23.1% of the variance.

TABLE 5
Factor loadings from the principal component analysis following varimax rotation

Assessment	*Factor 1: Cognitive*	*Factor 2: Phonological*
PPT	0.842	0.082
TEA	0.482	−0.011
TEA/D	0.488	0.412
WSCT	0.723	0.119
Rey copy	0.638	0.419
Rey delay	0.742	0.151
PALPA 9 repetition	−0.105	0.910
PALPA 31 reading	0.293	0.796

PPT = Pyramids and Palm Trees; PALPA = Psycholinguistic Assessments of Language Processing in Aphasia; TEA = Test of Everyday Attention – elevator counting subtest; TEA/D Test of Everyday Attention – elevator counting with distraction subtest; WCST = Wisconsin Card Sort Task; Rey copy = Complex Figure of Rey – Copy trial; Rey delay = Complex Figure of Rey – delayed recall.

Thus together the two factors accounted for 58% of the variation in the background measures. The component loadings on each factor are summarised in Table 5. Factor 1 primarily reflected variation in performance on the cognitive tests; for this "cognitive" factor the component loadings were high on the TEA, TEA/D, WCST, Rey Figure copy, Rey Figure delayed recall, and the PPT. The picture PPT was the only language-semantic test to load on this cognitive factor and may well reflect the strong problem-solving component of this assessment (Jefferies & Lambon Ralph, 2006). Factor 2 was identified as a "phonological" factor: both word repetition and reading loaded highly on this factor whereas the remaining background assessments did not.

Both factors (cognitive and phonological) correlated with therapy gain, at both the immediate and follow up assessments (see Table 4). The BNT did not correlate with the cognitive factor (Pearson's $r = .24$, $p = .2$) but it did correlate with the phonology factor (Pearson's $r = .56$, $p < .001$). Given the relationship between the BNT and the phonological factor, we tested the relative predictive power by placing all three measures in a simultaneous linear regression in order to predict immediate and longer-term therapy gain. The cognitive factor continued to predict therapy outcome (immediate therapy gain, $t = 2.9$, $p = .007$; follow-up therapy gain, $t = 2.26$, $p < .05$) as did variation in BNT scores (immediate therapy gain, $t = 3.67$, $p = .001$; follow-up therapy gain, $t = 3.42$, $p < .005$) but the phonological factor added no additional predictive power to the model (immediate therapy gain, $t = 1.24$, $p = .23$; follow-up therapy gain, $t = 1.28$, $p = .23$). Together the results suggested that therapy outcome is best predicted by variation in both cognitive and language severity (as measured by naming or other language assessments).

DISCUSSION

The aim of this investigation was to determine whether it is possible to predict therapy outcome from background measures of language and cognitive ability. Previous studies have suggested that one or other factor can predict therapy outcome but the conclusions were somewhat limited by the small number of participants included in those studies, or the measures used to predict therapy gain. We achieved the study aim by combining detailed background assessment results from 33 participants with varying severities of aphasia, who had all received the same therapy for anomia (Conroy et al., 2009b; Fillingham et al., 2006; Sage et al., 2009; Snell et al., in press).

Many of the individual background assessments correlated with the therapy gain (as measured both immediately after therapy and after a follow-up period). These included three of the four language tasks used (BNT, PPT, word reading) and three of the six cognitive tasks (Elevator Counting with distraction, Rey Figure copy, Rey Figure delayed recall). A principal component analysis (PCA) with varimax rotation indicated that there were two main underlying factors in this neuropsychological database. These reflected variation in cognitive skill (TEA; TEA/D; WCST; Rey Figure copy; Rey Figure delayed recall and PPT all loaded highly on this factor) and in language performance (word reading and repetition loaded highly on this second factor). Both factors correlated with therapy outcome. Perhaps unsurprisingly, the BNT and the extracted language factor were strongly correlated (there was no correlation with the cognitive factor). When pitted against each other, we found that the best predictors of therapy outcome were the cognitive factor and the BNT. The specific phonological factor did not add any additional predictive power to the model. The assessment of phonological skills here (measured by reading and repetition) are only two measures out of a wider range which might have been considered (such as rhyme judgement, delayed repetition, meta-phonological tasks, etc.). Future studies might consider whether inclusion of more phonological measures might provide a finer grain of phonological skill which in turn might allow more of the variance to be explained.

The cognitive factor comprised tests of reasoning and problem-solving (PPT and WCST), attention (Elevator counting) and visual recall (Rey Figure copy and recall). Previous studies have implicated all these cognitive domains in therapy outcome. Conroy et al. (2009b) found that visual memory (Rey Figure immediate recall), in additional to anomia severity, was an important predictor of therapy gain in object and action naming. Fillingham et al. (2005a, 2005b; 2006) and Hinckley and Carr (2001) found performance on WCST predicted therapy outcome for gains in noun naming and a context based approach (catalogue ordering). Interestingly, perhaps because of greater statistical power, the cognitive factor identified in the current study comprised aspects of all three cognitive elements (attention, executive functioning and visuo-spatial memory) and this combined factor reliably predicted aphasia therapy outcome. Although taking a different approach to measuring cognitive and language status, this study aligns closely with the result from van de Sandt-Koenderman et al. (2008). Both studies suggest that neuropsychological abilities need to be taken into account when predicting therapy-related improvement either directly within the targeted domain (i.e., improvements of word-finding skill – the present study) or when predicting the generalised improvement on an outcome measure (van de Sandt-Koenderman et al., 2008).

The present results also mirror findings from the more general neuroreh-abiliation literature. This literature contains repeated demonstrations of the relationship between cognitive status of patients and both their spontaneous recovery (Goldenberg & Spatt, 1994; Mark et al., 1992; Pedersen et al., 1995) and response to specific interventions (Carod-Artal et al., 2005; Helm-Estabrooks, 2002; Robertson et al., 1997). The current study indicates that very similar factors are implicated in stroke-related aphasia.

Previous studies with more limited participant numbers have indicated that either language ability (Best et al., 2000; Conroy et al., 2009a) or cognitive status (Fillingham et al., 2005b; Goldenberg et al., 1994; Hinckley & Carr, 2001) are important predictors of anomia therapy. This larger scale study suggests that *both* factors are independent and important predictors. These results would seem to fit with the clinical observation (see Introduction) that even when patients are equated for the type and degree of language impairment, their response to therapy can be quite different.

In conclusion, there are two obvious clinical implications of these findings: (1) In evaluating candidates for aphasia therapy, assessment of non-language cognitive domains would significantly improve predictions of therapy outcome (Fillingham et al., 2005b; van de Sandt-Koenderman et al., 2008) and (2) therapy materials and methods need to be fashioned to take into account not only the language but also the cognitive abilities of each client. This latter aspect is relatively novel for aphasiological practice and, as such, is typically not explicitly considered in therapy planning. Thus, future research is needed to explore how therapy outcome for patients with co-occurring cognitive impairment can be improved by adopting different methods and approaches to therapy.

REFERENCES

Baayen, R. H., Piepenbrock, R., & Rijn, V. (1993). *The CELEX lexical database* [CD-ROM], Philadelphia: University of Pennsylvania, Linguistic Data Consortium.

Best, W., Herbert, R., Hickin, J., Osborne, F., & Howard, D. (2002). Phonological and orthographic facilitation of word-retrieval in aphasia: Immediate and delayed effects. *Aphasiology*, *16,* 151–168.

Best, W., Hickin, J., Herbert, R., Howard, D., & Osborne, F. (2000). Phonological facilitation of aphasic naming and predicting the outcome of treatment for anomia. *Brain and Language*, *74,* 435–438.

Blomert, L., Kean, M. L., Koster, C., & Schokker, J. (1994). Amsterdam-Nijmegen Everyday Language Test – Construction, Reliability and Validity. *Aphasiology*, *8,* 381–407.

Carod-Artal, F. J., Medeiros, M. S. M., Horan, T. A., & Braga, L. W. (2005). Predictive factors of functional gain in long-term stroke survivors admitted to a rehabilitation programme. *Brain Injury*, *19,* 667–673.

Conroy, P., Sage, K., & Lambon Ralph, M. A. (2009a). The effects of decreasing and increasing cue therapy on improving naming speed and accuracy for verbs and nouns in aphasia. *Aphasiology*, *23,* 707–730.

Conroy, P., Sage, K., & Lambon Ralph, M. A. (2009b). Errorless and errorful therapy for verb and noun naming in aphasia. *Aphasiology*, *23,* 1311–1337.

Cummings, L. (2008). *Clinical Linguistics*. Edinburgh: Edinburgh University Press.

Fillingham, J. K., Sage, K., & Lambon Ralph, M. A. (2005a). Further explorations and an overview of errorless and errorful therapy for aphasic word-finding difficulties: The number of naming attempts during therapy affects outcome. *Aphasiology*, *19,* 597–614.

Fillingham, J. K., Sage, K., & Lambon Ralph, M. A. (2005b). Treatment of anomia using errorless versus errorful learning: Are frontal executive skills and feedback important? *International Journal of Language & Communication Disorders*, *40,* 505–523.

Fillingham, J. K., Sage, K., & Lambon Ralph, M. A. (2006). The treatment of anomia using errorless learning. *Neuropsychological Rehabilitation*, *16,* 129–154.

Goldenberg, G., Dettmers, H., Grothe, C., & Spatt, J. (1994). Influence of linguistic and nonlinguistic capacities on spontaneous recovery of aphasia and on success of language therapy. *Aphasiology*, *8,* 443–456.

Goldenberg, G., Oder, W., Spatt, J., & Podreka, I. (1992). Cerebral correlates of disturbed executive function and memory in survivors of severe closed head-injury: A SPECT study. *Journal of Neurology Neurosurgery and Psychiatry*, *55,* 362–368.

Goldenberg, G., & Spatt, J. (1994). Influence of size and site of cerebral lesions on spontaneous recovery of aphasia and on success of language therapy. *Brain and Language*, *47,* 684–698.

Goodglass, H., Kaplan, E., & Barresi, B. (2001). *Boston Diagnostic Aphasia Examination* (3rd ed.). Philadelphia: Lippincott, Williams and Wilkins.

Grant, D. A., & Berg, E. A. (1993). *The Wisconsin Card Sort Task*. San Antonio, TX: Psychological Assessment Resources, Inc.

Helm-Estabrooks, N. (2002). Cognition and aphasia: A discussion and a study. *Journal of Communication Disorders*, *35,* 171–186.

Hickin, J., Best, W., Herbert, R., Howard, D., & Osborne, F. (2002). Phonological therapy for word-finding difficulties: A re-evaluation. *Aphasiology*, *16,* 981–999.

Hinckley, J. J., & Carr, T. H. (2001). Differential contributions of cognitive abilities to success in skill-based versus context-based aphasia treatment. *Brain and Language*, *79,* 3–6.

Howard, D., & Patterson, K. (1992). *Three Picture Version: Pyramids and Palm Trees: A Test of Semantic Access from Pictures and Words*. Bury St Edmunds, UK: Thames Valley Test Company.

Jefferies, E., & Lambon Ralph, M. A. (2006). Semantic impairment in stroke aphasia versus semantic dementia: A case-series comparison. *Brain*, *129,* 2132–2147.

Kay, J., Lesser, R., & Coltheart, M. (1992). *Psycholinguistic Assessments of Language Processing in Aphasia*. Hove: Psychology Press.

Laine, M., & Martin, N. (2006). *Anomia: Theoretical and Clinical Aspects*. Hove, UK: Psychology Press.

Lambon Ralph, M. A., Moriarty, L., & Sage, K. (2002). Anomia is simply a reflection of semantic and phonological impairments: Evidence from a case-series study. *Aphasiology*, *16,* 56–82.

Lambon Ralph, M. A., Patterson, K., Graham, N., Dawson, K., & Hodges, J. R. (2003). Homogeneity and heterogeneity in mild cognitive impairment and Alzheimer's disease: A cross-sectional and longitudinal study of 55 cases. *Brain*, *126,* 2350–2362.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological Assessment* (4th ed.). Oxford: Oxford University Press.

Liang, C. L., Chang, H. W., Lu, K., Lee, T. C., Liliang, P. C., Lu, C. H., et al. (2001). Early prediction of aphasia outcome in left basal ganglia hemorrhage. *Acta Neurologica Scandinavica*, *103,* 148–152.

Mark, V. W., Thomas, B. E., & Berndt, R. S. (1992). Factors associated with improvement in global aphasia. *Aphasiology*, *6,* 121–134.

Marshall, R. C., & Phillips, D. S. (1983). Prognosis for improved verbal communication in aphasic stroke patients. *Archives of Physical Medicine and Rehabilitation*, *64,* 597–600.

Martin, N., Fink, R., Laine, M., & Ayala, J. (2004). Immediate and short-term effects of contextual priming on word retrieval in aphasia. *Aphasiology*, *18,* 867–898.

Meyers, J. E., & Meyers, K. R. (1995). *Rey Complex Figure Test and Recognition Trial*. Odessa, FL: Psychological Assessment Resources, Inc.

Murray, L. L. (1999). Attention and aphasia: Theory, research and clinical implications. *Aphasiology*, *13,* 91–111.

Pedersen, P. M., Jorgensen, H. S., Nakayama, H., Raaschou, H. O., & Olsen, T. S. (1995). Aphasia in acute stroke – Incidence, determinants, and recovery. *Annals of Neurology*, *38,* 659–666.

Raven, J. C. (1962). *Coloured Progressive Matrices*. London: H. K. Lewis.

Robertson, I. H., Ridgeway, V., Greenfield, E., & Parr, A. (1997). Motor recovery after stroke depends on intact sustained attention: A 2-year follow-up study. *Neuropsychology*, *11,* 290–295.

Robertson, I. H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1994). *The Test of Everyday Attention (TEA)*. Bury St Edmunds, UK: Thames Valley Test Company.

Robey, R. R. (1998). A meta-analysis of clinical outcomes in the treatment of aphasia. *Journal of Speech, Language and Hearing Research*, *41,* 172–187.

Sage, K., Snell, C., & Lambon Ralph, M. A. (2009). How intensive does aphasia therapy need to be? *Neuropsychological Rehabiliation*.

Snell, C., Sage, K., & Lambon Ralph, M. A. (in press). How many words should we provide in anomia therapy? A meta-analysis and a case series study. *Aphasiology*.

van de Sandt-Koenderman, W. M. E., van Harskamp, F., Duivenvoorden, H. J., Remerie, S. C., van der Voort-Klees, Y. A., Wielaert, S. M., et al. (2008). MAAS (Multi-Axial Aphasia System): Realistic goal setting in aphasia rehabilitation. *International Journal of Rehabilitation Research*, *31,* 314–320.

Verschaeve, M., Boon, P., Paquier, P., & Van Harskamp, F. (1992). Cognition in global aphasia: Indicators for therapy. *Aphasiology*, *5,* 491–499.

Whitworth, A., Webster, J., & Howard, D. (2005). *A Cognitive Neuropsychological Approach to Assessment and Intervention in Aphasia*. Hove, UK: Psychology Press.

Woollams, A. M., Lambon Ralph, M. A., Plaut, D. C., & Patterson, K. (2007). SD-squared: On the association between semantic dementia and surface dyslexia. *Psychological Review*, *114,* 316–339.

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