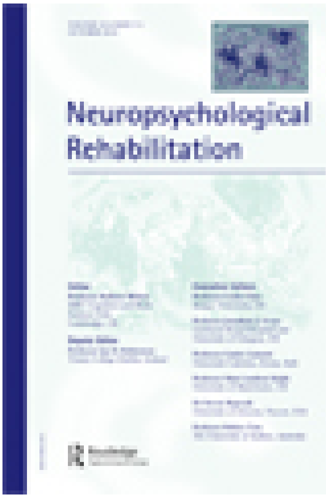

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How to constrain and maintain a lexicon for the treatment of progressive semantic naming deficits: Principles of item selection for formal semantic therapy

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How to constrain and maintain a lexicon for the treatment of progressive semantic naming deficits: Principles of item selection for formal semantic therapy

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The progressive degradation of semantic memory is a common feature of many forms of dementia, including Alzheimer's disease and the semantic variant of primary progressive aphasia (svPPA). One of the most functionally debilitating effects of this semantic impairment is the inability to name common people and objects (i.e., anomia). Clinical management of a progressive, semantically based anomia presents extraordinary challenges for neurorehabilitation. Techniques such as errorless learning and spaced-retrieval training show promise for retraining forgotten words. However, we lack complementary detail about what to train (i.e., item selection) and how to flexibly adapt the training to a declining cognitive system. This position paper weighs the relative merits of several treatment rationales (e.g., restore vs. compensate) and advocates for maintenance of known words over reacquisition of forgotten knowledge in the context of semantic treatment paradigms. I propose a system for generating an item pool and outline a set of core principles for training and sustaining a micro-lexicon consisting of approximately 100 words. These principles are informed by lessons learned over the course of a Phase I treatment study

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targeting language maintenance over a 5-year span in Alzheimer's disease and SvPPA. Finally, I propose a semantic training approach that capitalises on lexical frequency and repeated training on conceptual structure to offset the loss of key vocabulary as disease severity worsens.

Keywords: Dementia; Primary progressive aphasia; Language treatment; Language disorder; Anomia; Item selection.

INTRODUCTION

Language disorders incurred in dementia present an extraordinary challenge for neuropsychological rehabilitation. We currently know little about how to optimise cognitive-linguistic functioning in the dementias. However, the shifting landscape of ageing across much of the industrialised world compels the development of effective language interventions that will promote functional communication and prolong independent living (Dorsey et al., 2007; Hebert, Scherr, Bienias, & Evans, 2001; Schulz & Martire, 2004). Progressive naming impairments are among the most functionally debilitating symptoms of dementia (Reilly, Rodriguez, Lamy, & Neils-Strunjas, 2010), and a number of recent treatment studies have appropriately targeted single word naming as a means of ameliorating language impairment (Henry, Beeson, & Rapcsak, 2008b; Heredia, Sage, Lambon Ralph, & Berthier, 2009; Savage, Ballard, Piguet, & Hodges, 2013).

Successful confrontation naming relies on the orchestration of many dissociable brain regions, and anomia consequently has a variety of root causes. Patients with unique distributions of cortical pathology associated with distinct dementia subtypes often show qualitatively different patterns of naming impairment (Reilly, Peelle, Antonucci, & Grossman, 2011). For example, the presence of frequent phonemic distortions and paraphasias during confrontation naming is a hallmark of nonfluent/agrammatic progressive aphasia (Gorno-Tempini et al., 2011; Reilly, Rodriguez, Peelle, & Grossman, 2011). One of the most ubiquitous causes of naming impairment across dementia subpopulations is degradation of semantic memory, the fundamental substrate for word and object meaning (Hodges, Patterson, Graham, & Dawson, 1996; Lambon Ralph, Patterson, & Hodges, 1997). Benson (1979) has referred to this particular aetiology of naming impairment as semantic anomia. Here I will adopt the term "progressive semantic anomia" in collective reference to a range of neurodegenerative disorders that present with naming deficits of a primary semantic aetiology. This includes, but is not limited to, Alzheimer's disease (AD) and the semantic variant of primary progressive aphasia (svPPA).

My aim in this position paper is to describe a unique approach to item selection and semantic training for progressive semantic anomia. Many of the factors that drive this particular approach were informed by a longitudinal anomia treatment study conducted at the University of Florida from 2007 to 2013 (Troche et al., 2009). The goal of treatment was to promote maintenance of a 100-word lexicon over a two-year span using a combination of error-reduced learning, spaced retrieval and repeated naming. A description of the treatment and its limitations will set the stage for the later discussion of item selection.

METHOD

Participants

Patients who satisfied diagnostic criteria for Alzheimer's disease ($n = 5$) (McKhann et al., 1984) or semantic dementia ($n = 5$) (Neary et al., 1998).[1] Diagnoses were established by an experienced behavioural neurologist and subsequently confirmed via an interdisciplinary consensus review mechanism with the University of Florida Memory Disorders Center. No severity restrictions were imposed, and several patients began the treatment study with severe dementia (e.g., S04). Relevant demographic and neuropsychological data appear in Table 1. Participants with semantic dementia (mean age = 63.8 years) were younger than their counterparts with AD by a margin of approximately six years (AD mean age = 70.6 years). Time to diagnosis for the AD patients was approximately twice that of the semantic dementia patients (see Table 1).

In parallel with our direct clinical intervention, we established an ancillary support group to address emerging problems both in the patients (e.g., sleep, medication, nutrition, pneumonia) and their caregivers (e.g., depression, exhaustion, financial planning). All patients provided written informed consent in conjunction with their caregivers. Despite these efforts at retention, we observed 50% attrition over the two-year treatment period as patients transferred from home to skilled nursing facilities ($n = 3$) or became too severe to take part in the treatment ($n = 2$).

Item assignment

Together with the patient and primary caregiver, we tailored a communication board for each patient. Training stimuli ($n = 100$) included familiar people ($n = 10$), and items from the following semantic categories ($n = 15$ each category): hygiene, activities, places, foods, clothes, household items. We also included exploratory categories consisting of four light

[1]We enrolled all patients prior to more contemporary diagnostic criteria for AD (McKhann et al., 2011) and primary progressive aphasia (Gorno-Tempini et al., 2011) were published.

TABLE 1
Demographic and neuropsychological data

						Digits f/b		*WAB-R*		*MOCA*		*PPTp/w*	
ID	*Age*	*Dx*	*Edu*	*Sex*	*Time post*	T_1	T_2	T_1	T_2	T_1	T_2	*T1*	*T2*
S01	54	SD	12	F	24	6/2	4/2	1.0	.80	24	8	46/38	33/28
S02	58	SD	20	F	12	7/5	5/4	1.0	.88	23	U	47/50	U/U
S03	59	SD	16	F	12	6/4	5/U	.97	.77	25	12	45/47	35/28
S04	67	SD	18	F	24	3/U	U/U	.88	U	5	U	29/21	U/U
S05	69	SD	18	F	24-36	5/5	4/U	.88	NT	28	14	47/41	31/21
S06	79	AD	12	M	72	3/2	2/U	.91	.76	18	U	32/37	U/U
S07	58	AD	8	M	36	4/2	4/U	.80	.44	22	6	43/41	U/U
S08	81	AD/VaD	18	M	36-48	5/2	4/U	.87	.67	29	13	nt/38	31/25
S09	77	AD	16	M	12	3/3	3/2	.88	.40	17	12	39/U	28/U
S10	58	AD	12	M	48-60	3/2	3/U	.80	.66	18	2	37/42	24/31

U = Untestable; NT = Not tested; Times (e.g., T1, T2) reflect repeated observations at 8-month intervals; Dx = diagnosis; Edu = Education in years; Time post = Number of months from subjectively reported symptom onset to formal diagnosis and treatment onset; Digits f/b = Digit span forward and backward from the Wechsler digit span subtest (Wechsler, 2008); WAB-R = single word repetition accuracy for the Western Aphasia Battery repetition subtest (Kertesz, 1982) for 45 words (independent of context) with scores converted to proportion correct; MOCA = Montreal Cognitive Assessment (Nasreddine et al., 2005) raw score of 30; PPTp/w = Pyramids and Palm Trees Test picture and word version raw score of 52, two forced choice guessing format where chance guessing equals 26 correct; AD = Alzheimer's disease; SD: semantic dementia; AD/VaD = Alzheimer's disease/vascular dementia.

verbs (i.e., want, feel, go, get) and somatic states (i.e., sad, happy, hot, cold, pain/painful, hungry, thirsty). Patients and their caregivers worked together to select training items from larger fixed lists representing each category (e.g., choose 15 foods from a list of 30). Patients were also permitted to personalise their training lexicon by adding their own categories of interest, and two patients took advantage of this option (e.g., surgical instruments for a nurse and indigenous wild birds for a wildlife biologist).

The selection of target people was carried out with the constraint that all must be highly frequent and familiar. Inappropriate items (e.g., coffee for a non-coffee drinker) were swapped out. Upon completion of item assignment, the patient was visited at home and pictures were taken of the target items. Somatic state categories and activities were depicted using a set of canonical pictures of people undertaking each activity. The target pictures were then physically arrayed on a large white poster board in clusters by semantic category, mirroring the canonical subject-verb-object (S-V-O) structure of English. Target pictures of people were positioned on the left side of the board with the patient and primary caregiver featured in the upper left corner, followed by verbs (orthographic), and the remaining semantic categories dispersed in blocks across the right side of the board.

Patient S04 was enrolled when she was at a very advanced stage of dementia severity. Upon enrolment, she soon became un-testable on most cognitive measures. Her communication board was tailored to reflect a small number of immediate family members ($n = 7$) and a set of high frequency, high utility objects ($n = 16$). The same training procedures (repeat–name) were employed for S04 as were used for all other patients.

Data analyses

There was 50% attrition over the two-year study; patients completed various lengths of treatment ranging from 8–24 months. The greatest attrition occurred for patients at the severe end of the continuum. Dropout and heterogeneity in baseline dementia severity preclude group and trend analyses. Therefore, coarse measures of pre-/post-treatment for each patient were derived using the effect size derivation recommended by Beeson and Robey (2006) [(X_{post}-X_{pre}/SD_{pooled}]. Table 1 reflects these effect sizes for naming of untrained pictures (BNT) relative to naming the patient's own target pictures.

Treatment protocol

Baseline neuropsychological testing and naming ability for the target lexicon and the initiated treatment were obtained. The treatment was composed of an error-reduced learning approach where a clinician or caregiver announced the name of each item and cued it for immediate repetition (e.g., This is a spoon, say the word spoon), followed by generative naming for the same item with no cue (e.g., What is this?). Failure to successfully repeat or name cycled the item back to the repetition phase (e.g., Say the word spoon) until the patient could successfully name the item. A spacing procedure was implemented where each successfully named item was revisited/re-probed after short (3 intervening items) or long delays (15 intervening items). The treatment was administered by caregivers in the home and by clinical staff who visited patients in their homes every 2–3 weeks. Caregivers tracked the progress of their home treatment through checklists and were asked to complete the naming treatment three times a week for approximately 30 minutes each session. During the clinician visits, attempts were made to pair multi-word combinations using verbs and somatic states (e.g., I-feel-hot, I-want-water) by pointing from left-to-right across the board and asking the patient to produce combinations of words mirroring simple S-V-O structure.

Results

Table 2 reflects patterns of performance over the duration of the treatment. The exploratory verb and somatic state manipulations were abandoned after the first patients consistently failed to name physical states or generate

TABLE 2
Naming performance across time

			BNT-Naming				*Picture Board Naming*					
ID	*DX*	*Time in study*	$T_{baseline}$	T_2	T_3	T_4	$T_{baseline}$	T_2	T_3	T_4	*Tx Effect size* (d)	*BNT Effect size* (d)
S01	SD	18	20 (.33)	12 (.20)	8 (.13)	*	.47	.96	.88	*	1.6	−2.0
S02	SD	24	28 (.46)	29 (.48)	14 (.23)	4 (.07)	.73	.92	.78	.62	−1.1	−2.8
S03	SD	18	35 (.58)	28 (.46)	16 (.26)	*	.39	.97	.93	*	1.7	−2.0
*S04	SD	8	18 (.30)	2 (.03)	*	*	.12	.08	*	*	−1.4	−1.4
S05	SD	19	24 (.40)	15 (.25)	4 (.06)	*	.73	.93	.89	*	1.5	−2.0
S06	AD	24	41 (.68)	42 (.70)	29 (.48)	19 (.31)	.48	.67	.78	.57	0.60	−3.0
S07	AD	24	52 (.87)	37 (.61)	12 (.20)	U (.00)	.85	.95	.65	.28	−1.3	−2.0
S08	AD/VaD	24	48 (.80)	39 (.65)	31 (.52)	25 (.42)	.93	.97	.87	.82	−2.2	−2.7
S09	AD	12	19 (.31)	18 (.30)	*	*	.58	.48	*	*	−1.4	−1.4
S10	AD	24	27 (.45)	*	12 (.20)	10 (.17)	.73	*	.82	.68	−0.80	−1.6

Note: * = not observed; U = untestable; BNT-Naming = Raw score correctly named for the Boston Naming Test (Kaplan et al., 1983) 60-item full form and corresponding proportion in parentheses. DX = diagnosis; Time in study = Time spent in the treatment study before dropping out or becoming untestable; Picture Board Naming Accuracy = % accuracy for pictures named at each successive time point not inclusive of the original somatic state and light verb categories; Tx Effect size = Effect sizes derived from the picture board naming accuracy via the formula (T_{final}-$T_{baseline}$/SD_{pooled}) (Beeson & Robey, 2006); BNT Effect size = derived using the Beeson & Robey (2006) criteria but reflecting (BNT_{final}-$BNT_{baseline}$/SD_{pooled}); AD = Alzheimer's disease; SD: semantic dementia; AD/VaD = Alzheimer's disease/vascular dementia.

appropriate verb thematic roles. Treatment effect sizes were larger for trained items (mean = −0.29) relative to untrained BNT items (mean = −2.09), paired $t(9) = 3.55$, $p = .006$. Patients tended to learn their target items rapidly, and performance for the treated items across all patients followed a nonlinear (quadratic) trend characterised by rapid gains followed by a period of plateau that gradually receded with worsening global cognitive impairment.

Interim discussion

Patients learned their target vocabulary and showed good retention of naming ability for trained relative to untrained items as gauged by repeated administration of the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983). The treatment effect size contrasts demonstrate a shallower slope of decline for the trained items, supporting some degree of maintenance. Thus, the overall accuracy results appear promising. However, the accuracy results mask several serious shortcomings with this treatment paradigm. First, several patients showed radical under-generalisation such that their treatment gains were rigidly linked to the target pictures. S04, for example, was unable to generalise from naming of a picture of her spouse on the communication board to her actual spouse sitting beside her. Another common problem related to the ephemeral nature of the observed treatment effects once daily practice was terminated. Several patients took extended vacations of over a month in duration, failed to practise naming, and upon their return were subsequently near floor accuracy (Graham, Patterson, Pratt, & Hodges, 2001; for similar findings see Savage et al., 2013; Snowden, Neary, & Mann, 2002). Finally, as disease severity worsened, patients had great difficulty with several of the core lexical categories that were originally specified for training (i.e., light verbs, emotions, and somatic states).

In some respects the initial intervention was a failure. Yet, a great deal was learned about what not to do in language maintenance therapy. It was apparent that repeated naming alone is insufficient to promote functional language gains. We also formalised criteria for optimising item selection for formal semantic therapies that address progressive naming deficits. In the discussion to follow many of the pitfalls encountered are described, along with lessons learned about how maintenance treatment for progressive semantic anomia might be better targeted.

DISTINCT PHILOSOPHICAL APPROACHES TO DEMENTIA TREATMENT

Several schools of thought govern contemporary rehabilitation for progressive aphasia. Proponents of restorative approaches endorse working directly with a patient to restore a lost or inaccessible cognitive function (see Clare, 2008; Hopper et al., 2013). For example, a clinician steeped in the restorative tradition might retrain a series of forgotten names until the patient achieves mastery. In contrast, compensatory stimulation strategies often forego direct intervention in favour of external memory aids, caregiver communication strategies (e.g., asking yes/no questions rather than open-ended questions), and structured environmental cues (Bourgeois, Dijkstra, Burgio, & Allen-Burge, 2001; Burgio et al., 2001). The restorative and compensatory traditions both have relative merits. Restorative approaches empower patients by placing them at the centre of a treatment hierarchy. Yet, direct restorative approaches can be difficult to justify from the standpoint of long-term efficacy for progressive semantic anomia. Clinicians cannot predict which words will fade from a patient's lexicon next.[2] Consequently, therapists couched in the restorative framework have little choice other than to reactively treat language disorders as they emerge. The well-documented case of semantic dementia patient, D.M., illustrates this conundrum (Graham, Patterson, Pratt, & Hodges, 1999; Graham et al., 2001; Graham, Pratt, & Hodges, 1998). D.M. was a former surgeon who began to experience severe anomia accompanied by comprehension deficits that forced his early retirement. D.M. self-medicated by filling notebooks with forgotten words, and he also drilled on naming via a picture dictionary. Over 2 years, D.M. continued his obsessive practice, but his expressive and receptive language abilities ultimately crumbled (Graham et al., 2001). The futility of D.M.'s approach is apparent when one considers that the number of active words in the English lexicon exceeds 170,000, an impossible target of retention for even the most dedicated clinician.

Restorative interventions can be effective and appropriate for many neurogenic language and cognitive disorders that do not have a progressive component (e.g., stroke aphasia). Restorative approaches are also advantageous for demonstrating the efficacy of a particular intervention in controlled, cross-sectional studies. Many treatment studies for progressive semantic anomia in Alzheimer's disease involve single-shot restorative approaches such as using errorless learning to retrain a set of face–name associations

[2]One might look to an extensive literature on category-specific language impairments to glean insight into global word classes that are differentially vulnerable to the effects of semantic impairment. For example, dissociations of natural kinds vs manufactured artifacts (Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997), nouns vs. verbs (Hillis, Tuffiash, & Caramazza, 2002) and abstract vs. concrete words (Breedin, Saffran, & Coslett, 1994) have all been reported. Most of these dissociations remain controversial, and individual differences add another source of variability. Although global trends might inform treatment (e.g., verbs and abstract words are often difficult for patients), explicit prediction of the sequence of forgetting individual words remains impossible.

(Clare, Wilson, Carter, Roth, & Hodges, 2002; Metzler-Baddeley & Snowden, 2005). In this restorative treatment paradigm, patients are trained to mastery on this particular task and are then passively evaluated at various intervals (3, 6, 12 months) to examine skill retention. Similar models of treatment delivery characterised by a relatively brief period of active treatment followed by an extended period of observation have also been reported for semantic variant primary progressive aphasia (Henry et al., 2008b; Heredia et al., 2009; Jokel & Anderson, 2012; Savage et al., 2013).

Restorative approaches involve direct intervention with the patient to relearn a forgotten skill. In contrast, compensatory approaches are considered indirect forms of treatment in that their gains are realised through optimising a patient's communicative environment. For example, there exist numerous formalised training programmes for nursing home staff to facilitate communicative exchanges for patients with various forms of dementia (McCallion, Toseland, Lacey, & Banks, 1999; Ripich, Wykle, & Niles, 1995; Ripich, Ziol, Fritsch, & Durand, 1999; for evidence-based practice review see Zientz et al., 2007). The FOCUSED programme (F = face-to-face, O = orientation, C = continuity, U = unsticking, S = structure, E = exchange, D = direct) is one prominent example of an indirect approach that trains staff on the unique demands of patients (e.g., maintaining eye contact, frequently re-orientating the patient, maintaining topic or explicitly announcing topic shifts, avoiding open-ended questions in favour of yes/no questions) (Ripich et al., 1999).

Another indirect compensatory approach involves working with caregivers to promote cognitive stimulation. This family of formal memory stimulation techniques has been implemented both for classical memory disorders such as Alzheimer's disease (e.g., group reminiscence therapy) (Bahar-Fuchs, Clare, & Woods, 2013; Clare, 2008), as well as more focally within the domain of language. Quayhagen and colleagues (Quayhagen, Quayhagen, Corbeil, Roth, & Rodgers, 1995; Quayhagen & Quayhagen, 2001), for example, proposed a formal language stimulation programme administered by caregivers using a prescribed schedule of activities. Patients in this stimulation paradigm complete a series of "active" tasks including structured conversational exchanges designed to promote verbal fluency and verbal problem solving scenarios (e.g., What would you do if you discovered a house fire?). Patients in this study were assigned to one of three conditions including an active stimulation condition, placebo condition (passive reading of news stories to patient) or no treat control group. After two months of treatment, patients in the active and placebo conditions showed gains relative to the no-treat control group. Similar transfer advantages have been reported in a variety of other cognitive stimulation programmes (Grandmaison & Simard, 2003), suggesting that targeted cognitive-linguistic stimulation through dyadic interaction produces powerful and lasting effects.[3]

Another form of compensatory treatment involves the use of external aids such as memory books, wallets, planners, calendars, and memory banks (i.e., recorded video or auditory messages from loved ones) (Bourgeois et al., 2001, 2003; Hopper et al., 2013). The most common application of these techniques has occurred in the context of memory disorders and/or executive dysfunction rather than an explicit focus on language disturbance or as a mode of training (but see Bourgeois et al., 2001).

Maintenance as an alternative to compensation and restoration

An alternative treatment philosophy is gaining traction for progressive language and memory disorders. Maintenance therapies function through preservation of known words rather than restoration of forgotten words (Jokel, Rochon, & Anderson, 2010; Jokel, Rochon, & Leonard, 2006; Reilly, Martin, & Grossman, 2005). A common maintenance paradigm might involve training a particular skillset to mastery and subsequently protecting that skillset against loss as disease severity worsens. Training on known words capitalises on familiarity and preserved lexical-semantic representation. Perhaps the most compelling advantage of the maintenance approach is that it is proactive rather than reactive. That is, the clinician can target a particular skill for retention and then take subsequent action to retain that skill rather than retraining forgotten knowledge ad hoc as deficits unpredictably emerge.

ITEM SELECTION PRINCIPLES FOR LANGUAGE MAINTENANCE

Techniques such as errorless learning, spaced retrieval training, vanishing cues, and memory books all show promise for promoting learning in progressive semantic anomia (Heredia et al., 2009; Hopper et al., 2013; Jokel & Anderson, 2012). Thus, a picture is emerging regarding how best to promote durable skill acquisition. Yet, little is known about how to craft an item pool and adapt training paradigms to the dynamic nature of a neurodegenerative disorder. This is a serious rate-limiting factor for maintenance therapies where item selection is of paramount importance. One logical starting point might involve looking to the more mature state of language rehabilitation in stroke aphasia.

[3]The "dyadic" component involving direct interaction with another sentient being may be especially critical. The data in support of transfer benefits from computer-based brain training paradigms remain limited (Owen et al., 2010).

During the past decade, stroke aphasia research has focused extensively on issues related to treatment dosage (e.g., intensity, duration) (Kleim, 2011; Pulvermüller et al., 2001; Raymer et al., 2008). Snell, Sage, and Lambon Ralph (2010) focused on one dosage-related component with special relevance for item selection. These authors asked the question of how many words should be included in a conventional anomia therapy by conducting both a meta-analysis and empirical study whereby set size was manipulated. The meta-analysis revealed an unexpected bias such that milder patients were more often trained on smaller item sets. When this bias was controlled, no definitive conclusions could be drawn within the extant literature. In their experimental study, Snell and colleagues manipulated set size using a crossover design and found that small and large item pools produced similar results. Snell and colleagues argued that patients could potentially tolerate larger item pools without deleterious effects.

To my knowledge, there exist no comparable set size investigations for progressive semantic anomia. One possible solution is to simply extrapolate from stroke to progressive aphasia. Although this approach seems a sensible starting point, it has substantial shortcomings. Stroke aphasia is not a neurodegenerative process; patients with chronic stroke aphasia are typically either stable or improving (Benjamin et al., 2014; Nickels, 2002). Thus, stroke therapies can realistically work towards mastery of progressively larger item pools as patients regain function. In contrast, the nature of a progressive neurological disorder precludes this strategy. Therefore, it is crucial to sample a smaller subset of items for progressive semantic anomia and to optimise their effectiveness for functional communication over time. The following outlines strategies and considerations for constraining such an item pool.

PRINCIPLES FOR ITEM SELECTION: CRAFTING A MICRO-LEXICON

Consider the following thought exercise. A judge has exiled you to live out the remainder of your days on an isolated desert island accompanied only by a robot. Your robot's memory capacity is limited to 100 words. The judge permits you the one-time opportunity to programme your robot's vocabulary. However, in a cruel twist your jailers also announce that your robot cannot learn new words, nor can it ever be reprogrammed. Which words will you choose?

In some respects, the desert island analogy is not far removed from the daily life of a person with advanced dementia. The most pressing communication needs centre around the immediate living environment, especially for patients who transition to skilled care facilities (e.g., locked memory units).

Despite its apparent silliness, the robot-island exercise suggests several core principles for optimising a lexicon, perhaps the most fundamental of which is that the robot's lexicon should meet immediate survival needs. The robot should accordingly understand basic requests for action (e.g., "get coconut", "get crab", "get water", "get medicine", "start fire"). In addition to survival requests, however, there are other principles and pitfalls to consider when crafting a lexicon for maintenance therapy. The following discusses considerations for item selection: quantity, network architecture, concreteness, familiarity, semantic diversity, variable learning, and information content.

Quantity in item selection

The Goldilocks principle is a term often used in pharmaceutical trials to describe optimal dosage. Similar dosage principles apply to target word selection such that the "just right" number of training items is neither too few, nor too many. A productive lexicon, however small, must capture a minimal set of salient concepts necessary for daily survival. An additional constraint is that cognitive-linguistic function will decline over time. Thus, the decision to pursue a 1000-word training vocabulary in a patient with mild dementia is likely to have deleterious consequences as his or her capacities decline. The "just right" quantity for a progressive language disorder is, therefore, a dynamic construct that presents a moving target for language treatment. A micro-lexicon consisting of approximately 100 words can potentially satisfy both constraints. This set size is sufficient to express many of the most salient concepts a patient with advanced dementia will face in his or her daily life but not overly expansive such that the lexicon will implode as cognitive capacities diminish.

Network structure and the architecture of a small lexicon

When constructed well, a small lexicon can assume rudimentary small-world network architecture similar to larger-scale neural, transportation, and social networks (Bassett & Bullmore, 2006; Sporns, 2012). Small-world architecture offers the advantage of redundancy through multiple pathways to a single node (word). One way of accomplishing this organisation is by aggregating the target words into a series of modules (semantic clusters) linked by broad commonalities (e.g., context, function). Scripts and situation models (e.g., things that appear in a kitchen) are highly salient organising principles in semantic memory (Funnell, 2001). Moreover, a consistent and robust finding in episodic memory research is that semantic relatedness confers significant advantages in recall (Baddeley, 1986; Martin, 2009). Our treatment involves training on semantic clusters as a way of capitalising on the relatedness phenomenon that engages higher-level contextual support from event

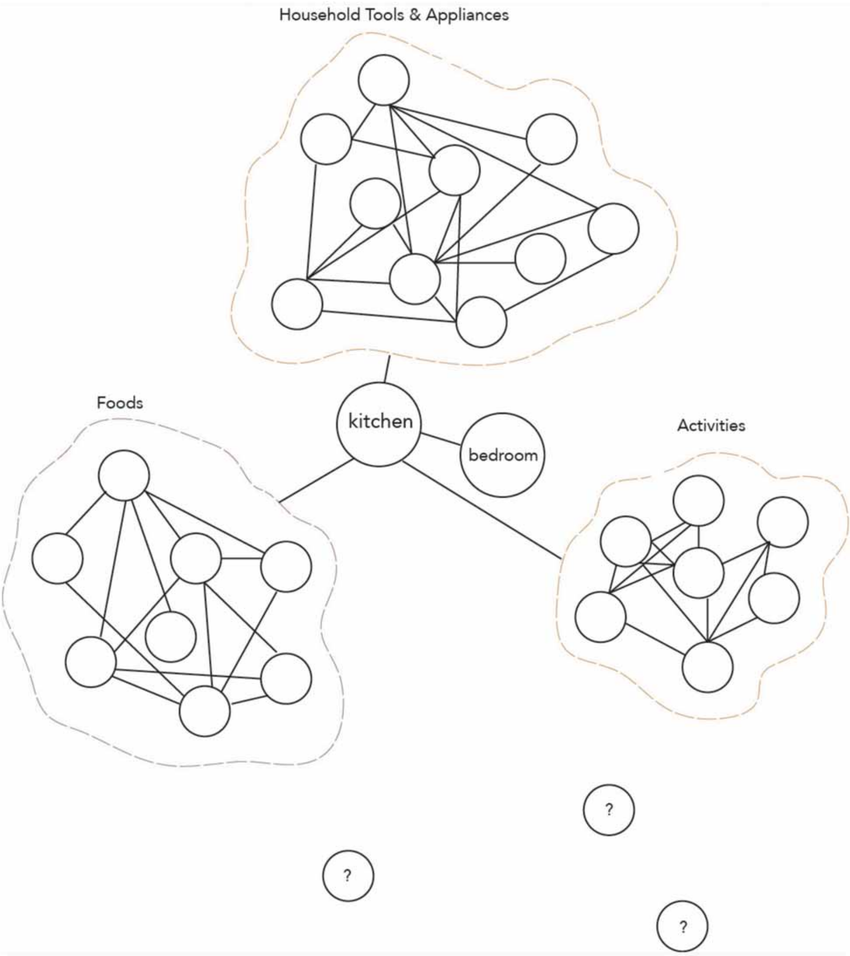

Figure 1. A simple associative semantic network architecture. The figure is represented using a node and edge structure that is standard in graph theory (West, 2001). Each word represents a circular node in the network with bi-directional connections to other words within their own clusters. The large free-form bounding shapes define hypothetical modules that correspond to semantic clusters. The modules are joined by words that act as global connector hubs. Each word has higher local connectivity (degree) within its respective cluster than between clusters.

schemas.[4] Figure 1 represents just such a simple architecture characterised by high local connectivity and short path lengths within three hypothetical modules (e.g., foods, tools, activities) in addition to hublike nodes linking

[4]Of note, we did not conduct a parallel longitudinal study using random picture presentation. Thus, this semantic clustering hypothesis remains tentative and is an open empirical question.

the various clusters. Isolated word nodes (represented by question marks) represent dead ends within such a network.

Imageability and concreteness in item selection

Cognitive abstraction grows difficult for patients during the advanced stages of dementia. During the initial stages of our intervention, we attempted to train and maintain categories such as light verbs (e.g., get, go), somatic states (e.g., tired, hungry), and emotions (e.g., angry, happy). This was done by using a variety of abstract pictorial representations of these states (e.g., pain scale faces, videos of people executing ?get" actions). Abstract words and verbs were amenable to training in mild-stage dementia. However, patients later struggled mightily with the abstract pictorial depiction of pain, love, or anger. In lieu of an effective verb and abstract word intervention, the training items should be highly imageable and amenable to multi-modal presentation (e.g., pictures, sounds, odours) (Hirsh & Funnell, 1995; see also Robinson, Druks, Hodges, & Garrard, 2009).

Target items should nominally be presented as pictures due to the prevalence of reading disorders such as surface dyslexia in dementia and progressive aphasia (Blazely, Coltheart, & Casey, 2005; Caine, Breen, & Patterson, 2009; Gorno-Tempini et al., 2011; McKhann et al., 1984, 2011; Wilson et al., 2009; Woollams, Lambon Ralph, Plaut, & Patterson, 2007). Another compelling reason to present target words via pictures or video arises from the picture superiority effect found in healthy adults. This advantage for pictures over words across numerous domains of memory and language has been attributed to privileged access of veridical perceptual information to the semantic system (Caramazza, Hillis, Rapp, & Romani, 1990; Winograd, Smith, & Simon, 1982). That is, the relationship between the phonological or orthographic forms of a word and its referent is arbitrarily symbolic (Reilly, Westbury, Kean, & Peelle, 2012; Saussure, 1916). In contrast, pictures can potentially bypass many vulnerable stages of input lexical access to gain direct access to object concepts. The picture superiority effect is typically maintained in healthy ageing (Winograd et al., 1982), and its dominance is also evident in mild cognitive impairment and Alzheimer's disease (Ally, Gold, & Budson, 2009).

Familiarity and frequency in item selection

Subjective frequency and personal familiarity are correlated variables that constitute the most active ingredients of maintenance therapy. Frequency typically reflects the number of instances (per million) that a particular word appears in a given corpus (e.g., hypertext, newspapers, television broadcasts) (Brysbaert & New, 2009; Jescheniak & Levelt, 1994). In contrast, familiarity captures a person's subjective awareness/knowledge of a given concept. Frequency and familiarity are both powerful predictors of lexical retention in progressive aphasia. Low-frequency, low-familiarity words (including proper nouns and face–name associations) are especially vulnerable to the effects of neurodegeneration, particularly for spelling and naming (Lambon Ralph et al., 1997; Patterson & Behrmann, 1997; Reilly et al., 2005).

One powerful way of promoting language maintenance for progressive aphasia is to capitalise on the advantages bestowed by repeated exposure to familiar words (Reilly et al., 2005; Reilly, Troche, & Grossman, 2011). In our own treatment work, patients are requested to generate a list of 15 people they wish to preserve across time with the caveat that these target names should reflect people that the patient encounters very frequently (e.g., at least once a week). In contrast, rarely encountered names are more vulnerable to forgetting and have limited use in daily conversation. The benefit of including less frequent names (e.g., a great grandchild seen once a year) should be weighed against the cost of utilising scarce resources.

Semantic diversity versus semantic relevance in item selection

One way of optimising lexical network structure is through clustering the stimuli by their semantic relatedness. This grouping procedure does, however, invoke several methodological questions, such as:

- Which semantic clusters should be trained, and at what level of specificity (e.g., animals, tools)?
- How many semantic clusters should be trained?
- How many items should be trained within each cluster?

The nascent state of neurorehabilitation for progressive semantic anomia yields no definitive answers to these questions. Our training lexicon employs seven semantic categories, each with 15 nested exemplars. These categories include functional domains such as foods, places, clothes, people, and activities. In the early stages of our intervention, we experimented with categories that ultimately proved difficult to train and maintain (e.g., emotions, somatic states, verbs). We also pursued a variable category selection procedure, tailoring the clusters to the unique interests of each patient. This decision had unforeseen consequences for several patients. For example, we tailored a micro-lexicon for a wildlife biologist who specialised in wild turkeys. This particular patient was emphatic about including a semantic cluster of local fowl so that he could maintain authorship of a newsletter. His request was honoured, and although he was initially motivated to retain turkey names, their frequency and functional use was limited. The patient's family reported that he never used the bird species names in daily conversation. Ultimately, the patient produced the term "bird" for all 15 species in the cluster. This example demonstrates the complexity of weighing personal relevance with long-term functional usefulness of the target items. This is not to say, however, that instilling items with personal relevance is not an essential component of treatment effectiveness. A number of successful treatment studies have employed elaboration strategies cueing patients to describe personal associations with the target items (Henry et al., 2008b; Jokel et al., 2006; Snowden & Neary, 2002). The effectiveness of this strategy has clear empirical footing from more than a half century of research in the self-reference effect*,* a phenomenon characterised by superior encoding (and retrieval) for information that is encoded with reference to the self (Symons & Johnson, 1997).

Limiting the scope of generalisation

Progressive aphasia is often characterised by rigid learning with limited generalisation. For example, a patient might successfully name his own red toothbrush but fail to name a new toothbrush or use it appropriately. One way of potentially promoting generalisation is through a variable learning strategy such as category induction. This might involve training the concept "hammer" by asking the patient to name many different exemplars, spanning the semantic field of hammers. The ideal outcome is for the learner to establish a cohesive semantic network and category prototype for hammers. Once a stable network has been established, he should then theoretically generalise naming to any hammer rather than restricting his accuracy to a single exemplar. The problem with this assumption is that patients with dementia often have great difficulties with category induction, retaining only the most prototypical exemplars of a particular category (Bozeat et al., 2003; Garrard, Lambon Ralph, Hodges, & Patterson, 2001; Koenig, Smith, & Grossman, 2006; Koenig, Smith, Moore, Glosser, & Grossman, 2007; Reilly, Peelle, et al., 2011). In the few novel implicit category-learning studies to date, patients with progressive semantic deficits tend to show limited generalisation abilities, particularly for explicit rule-based categorisation processes (e.g., *Crutters* have long necks and sharp claws) (Koenig et al., 2006, 2007).

An alternative approach to variable learning involves extensive training on the patient's own implements and family/friends. This item selection constraint capitalises on frequency and familiarity to boost functional language skills. The choice to train on specific exemplars is not without controversy, however. Training on a single exemplar has the potential to promote undergeneralisation (for reviews of generalisation in svPPA see Carthery-Goulart et al., 2013; Jokel, Graham, Rochon, & Leonard, 2014). One way to counteract such effects is through multi-modal training on high-level conceptual attributes of the target items rather than exclusive reliance on repeated naming (see Suárez-González et al., 2014). This point is revisited during the description of the intervention using semantic feature analysis.

Information content and basic level terminology

The aim of maintenance is to plan for scarce cognitive resources as disease severity worsens. Each training item occupies a slot in what will ultimately devolve into a limited communication repertoire. Therefore, it is prudent to select target words with high-information content. Expressive language in advanced dementia is peppered with vague superordinate terms, unclear pronominal references (e.g., you know ... it's that thing ...) and overlearned phrases (e.g., I'm fine, how are you?). Graceful degradation accounts of language dissolution in dementia hold that such superordinate terms reflect the bottom-up erosion of lexical-semantic knowledge that supports more specific conceptual distinctions (Reilly, Rodriguez, et al., 2011; Tyler, Moss, Patterson, & Hodges, 1997).

Most concrete objects are nested within a hierarchical taxonomy ordered from the most general superordinate distinctions (e.g., ANIMAL), through basic-level categories (e.g., DOG), extending to subordinate (e.g., LABRADOR) and terminating with specific proper nouns (e.g., FLUFFY) (Rosch, 1973). The Gricean maxim of *quantity* holds that speakers should provide the "just right" amount of information in the context of a particular conversational demand (Grice, 1975). Naming at the superordinate level (e.g., My son wants an *animal* for Christmas.) violates the quantity maxim. Conversely, subordinate terms (e.g., Oh look at the *chrysanthemum*) often yield too much detail. The "just right" level of object naming appears to be at the basic level (Lakoff, 1990; Rogers & Patterson, 2007). Item pools should be constructed with attention to the maxim of quantity, and basic-level terms typically satisfy this constraint.

PUTTING THE PIECES TOGETHER: A SYSTEM FOR ITEM SELECTION IN MAINTENANCE THERAPY

Figure 2 represents a schematic of the picture system we currently employ for structuring a maintenance lexicon. Target words ($n = 105$) span seven semantic categories, each with 15 exemplars. Categories include familiar people, clothes, hygiene, places, activities, foods, and household tools.

In the first iteration of the intervention all of the exemplars were arrayed as photos on a single poster-sized communication board. Familiar people were positioned on the left side of the board and objects/activities on the right side of the board. The patient himself or herself was pictured prominently in the left upper corner of the picture board. This physical arrangement mirrors the canonical thematic and syntactic structures of English, a right-branching language where the subject (head) typically appears at the

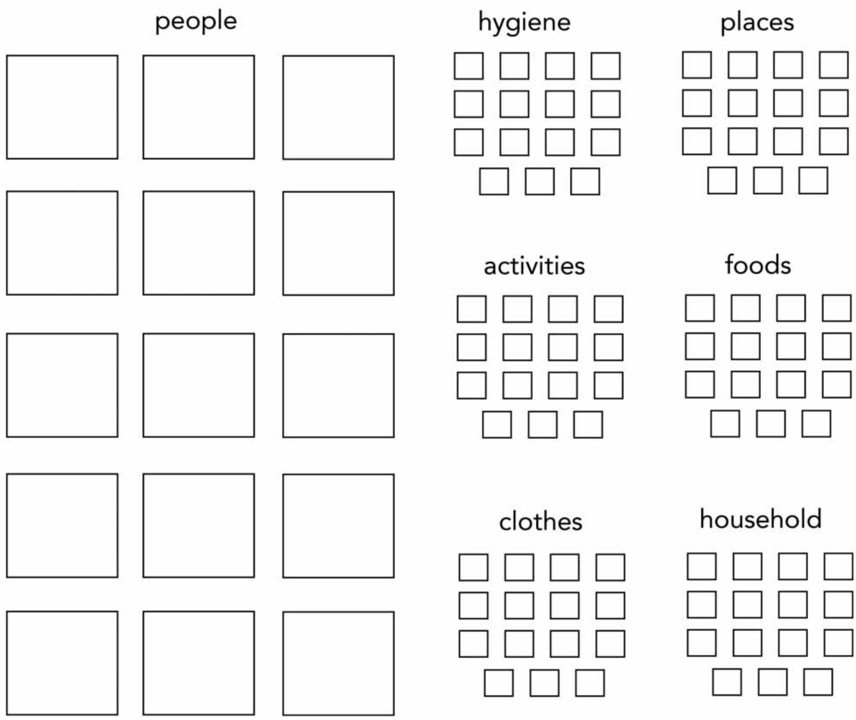

Figure 2. Structure of a training lexicon for language maintenance.

beginning of a sentence. In S-V-O transitive syntax, the subject of a sentence is also likely to serve the thematic role of agent, whereas the direct object (theme) acts as the recipient of an action (Edmonds & Babb, 2011; McRae, Ferretti, & Amyote, 1997; Saffran, Schwartz, & Linebarger, 1998). If patients visually scan the board from left to right, the physical arrangement of target people and objects will mirror simple transitive S-V-O syntax. This physical arrangement also has the advantage of facilitating people–object conceptual combinations (e.g., “Mary watch TV”, “John drink coffee”).

It was discovered that a communication board worked well for patients with mild dementia but that more cognitively impaired patients struggled with the physical arrangement. Over time, executive demands outweighed the benefits of arraying all target concepts within a single space. The task demands imposed by this board format unintentionally devolved into an inhibitory control paradigm, forcing patients to sustain attention on one item while inhibiting 104 competing alternatives. In turn, patients with more advanced disease severity spent much of their sessions visually scanning the board and jumping between picture stimuli in search of their target items. The communication board structure was abandoned in favour of smaller sets of photo stimuli. Each patient is now issued with a photo binder with an array of five photos per page, clustered by semantic category and ordered sequentially (people–objects). This arrangement offers flexibility to remove and position individual photo pages up to the full size of the training lexicon.

The maintenance lexicon is personalised by visiting patients' homes and acquiring digital photographs of the training items. All photos are cropped and sized to a uniform dimension and resolution.

Methods of assessing change: Control stimuli

The goal of a maintenance intervention is to impede further loss of a particular function (Heredia et al., 2009; Jokel et al., 2006). Thus, a positive treatment effect should result in a more shallow slope of decline than would otherwise be evident without treatment.

The most substantive challenge for demonstrating efficacy of a maintenance therapy lies in the latent nature of the treatment effect. Assume that patient A and patient B are roughly equivalent in dementia severity at baseline. In the framework of a randomised control trial (RCT), patient A is assigned to a treatment, whereas patient B is assigned to a placebo control condition. Treatment effects are ostensibly measured via group subtraction (A − B). The validity of this procedure hinges on several assumptions, including the law of large numbers and baseline group equivalence (i.e., randomly distributed individual differences). The RCT, although the gold standard in clinical trials, is not yet plausible within the context of contemporary rehabilitation for progressive semantic anomia (but see Bahar-Fuchs et al., 2013; Jelcic et al., 2012). First, there exist no viable, treatment-as-usual options similar to those employed in drug trials. Second, it is unethical to withhold a potentially beneficial treatment. Finally, crossover designs are unrealistic over an extended period because patients with neurodegenerative conditions experience declining baselines (for an exception using a brief waitlist control interval see Davis, Massman, & Doody, 2001). Thus, the issue of appropriate controls looms over anomia maintenance therapy.

In lieu of complete random assignment, one plausible alternative involves item-level controls. Each patient can potentially serve as his or her own control by providing accuracy for treated relative to untreated words across time. In our own language maintenance study, several item-level controls are currently employed, all involving repeated assessment of naming accuracy, as well as more sensitive eyetracking measures (e.g., number of fixations, number of backtracks, saccade amplitude, visual scan paths to areas of interest) collected at multiple timepoints over a 2-year span (Reilly, Troche, Paris, Hung, & Garcia, 2013). The following item-level controls are assessed:

(1) Trained relative to untrained exemplars within each of the semantic categories that are explicitly targeted for maintenance (e.g., an untrained article of clothing).
(2) Trained relative to untrained exemplars from various semantic categories that are *not* explicitly targeted for maintenance (e.g., a school supply).
(3) Trained relative to unique exemplars of the target items (e.g., a random photo of an untrained toothbrush in place of the patient's own toothbrush).
(4) Trained relative to a normed neuropsychological measure of visual confrontation naming (e.g., Boston Naming Test; Kaplan et al., 1983).

Crafting item pools

It is necessary dynamically to assess maintenance effects to adapt treatment delivery (intensity, duration). However, it is impossible to assess treatment effects unless the treatment and control conditions show baseline equivalency. Item equivalence is ensured by constructing balanced stimulus pools that are twice as large as a patient's target lexicon. Each semantic category in the item pool has 30 exemplars. Half of the items are randomly assigned at baseline, whereas unassigned items serve as controls across time. Categories are balanced for frequency and familiarity, and in the event of unbalanced item assignment, the item pool is reshuffled until a balanced training/control set is attained.[5]

Patients must have the flexibility to train on naming and semantic attributes of the people who are most meaningful to them, untethered by psycholinguistic constraints (e.g., word length). Thus, random item assignment is impossible for the familiar face category. Instead patients and caregivers are instructed to select 15 of the most familiar, personally relevant, and highly frequently encountered people they would like to retain. Digital photographs of these people ($n = 15$) are taken and arrayed in the patient's communication binder with the patient and caregiver positioned prominently on the first page. At numerous points across time, familiar people are contrasted to a set of 15 randomly assigned famous faces (e.g., President Barack Obama).

OPTIONS FOR MAINTENANCE TRAINING

This discussion has, thus far, addressed principles and pitfalls for item selection in maintenance therapy. Yet, an optimised item set is of little use unless paired with an effective training paradigm. Progressive semantic anomia therapy has evolved to a state where clinicians have several options

[5]Item lists are freely available for download and use at www.reilly-coglab.com/train-lex.

(e.g., memory books, errorless learning, spaced retrieval training, vanishing cues). It is beyond the scope of this discussion to evaluate the merits of these respective approaches (for reviews see Bahar-Fuchs et al., 2013; Clare, 2008; Hopper et al., 2013). Instead, the focus here is on our current treatment paradigm using a modified version of semantic feature analysis (SFA) (Antonucci, 2009; Boyle, 2004; Dressel et al., 2010).

During the initial years of our training, an error-reduced learning approach was used to boost naming. The rationale of errorless and error-reduced learning paradigms is that the learner is prevented from encoding erroneous detail and associated noise into long-term memory (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003; Gonzalez Rothi et al., 2009; Jokel, Cupit, Rochon, & Graham, 2007; Noonan, Pryer, Jones, Burns, & Lambon Ralph, 2012; Wilson, Baddeley, Evans, & Shiel, 1994). On a given trial, the name of each target item was announced (e.g., "This is Mary") followed by an immediate repetition cue (e.g., "Say the word *Mary*"), culminating in a cue to name that item (e.g., "Who is this?"). Patients showed rapid learning and quickly mastered their communication boards using this technique. In addition, even the most severe patients could successfully name most of their target items after several sessions of practice. However, treatment gains failed to generalise beyond the communication board, and rapid forgetting occurred when practice was terminated. It was ultimately concluded that repeated naming alone was insufficient to promote functional language maintenance. Snowden and Neary (2002) reported comparable results in their study of repeated naming accompanied by rapid post-treatment forgetting in semantic dementia. These converging findings suggest that a better hope for maintenance lies with interventions that promote deeper semantic encoding.

TRAINING ON SEMANTIC DEEP STRUCTURE

Most contemporary theories of semantic memory assume that the brain represents object knowledge in a highly distributed cortical network through a process of semantic feature decomposition (Allport, 1985; Lambon Ralph, Pobric, & Jefferies, 2009; Martin, 2007; Patterson, Nestor, & Rogers, 2007; Reilly et al., 2014). That is, the brain decomposes objects into discrete sets of features, stored in anatomically remote regions. Conceptual retrieval, in turn, relies on integrative processes that glue the many bits and pieces of word and object concepts into coherent wholes. Semantic feature analysis (SFA) is a rehabilitation technique wherein patients generate attributes for a set of given objects (for application of SFA or related treatment variants to PPA see Frattali, 2004; Henry et al., 2008b; Jokel, Rochon, & Leonard, 2002; Savage et al., 2013). Boyle and Coelho's (1995) extensively cited method of SFA involves displaying a photograph of a target object within an empty box with spokes radiating outward to a series of feature cues. Patients are first cued to name the target concept with clinician feedback and modelling as necessary. Patients are then cued to produce corresponding semantic attributes, including:

- GROUP (is a . . .)
- USE (is used for/to . . .)
- ACTION (does what . . .)
- PROPERTIES (is/has a . . .)
- LOCATION (is found . . .)
- ASSOCIATION (reminds me of . . .).

SFA manifests a clear advantage over repeated naming alone in that it engages multi-modal semantic features that support the meaning of the target word. If one particular attribute is selectively disturbed, the patient might theoretically compensate for the loss of one attribute through preserved knowledge of other domains (e.g., form, action, use) (see also Henry, Beeson, & Rapcsak, 2008a). SFA as employed by Boyle and Coelho (1995) is best described as an errorful learning technique. That is, patients generate their own features and receive feedback on their responses. We instead use a modified version of SFA incorporating error-reduced learning. Figure 3 represents the SFA matrix paired with an item from the maintenance lexicon.

In this modified SFA technique, patients learn about blocks of five target items guided by a teacher/clinician who announces the name of each target word followed by an explicit description of its semantic features. Each trial concludes with generation of a novel sentence containing the target word. After the patient learns about the block of five items, he or she is cued to name each object, self-generate its features, and generate a sentence containing the target object/person. We proceed iteratively through blocks of five items until the maintenance lexicon ($n = 105$) is exhausted. The entire list is then recycled, and training begins anew in different block/cluster order.

FUTURE DIRECTIONS AND UNANSWERED QUESTIONS

Here a maintenance therapy designed to buffer a core set of words against loss has been described. Also described is a concrete method for optimising a maintenance lexicon. The following considerations and future directions are germane to honing this approach.

Models of service delivery

Caregivers administer the majority of our maintenance intervention with the intermittent aid of skilled speech-language clinicians. This hybrid mode of

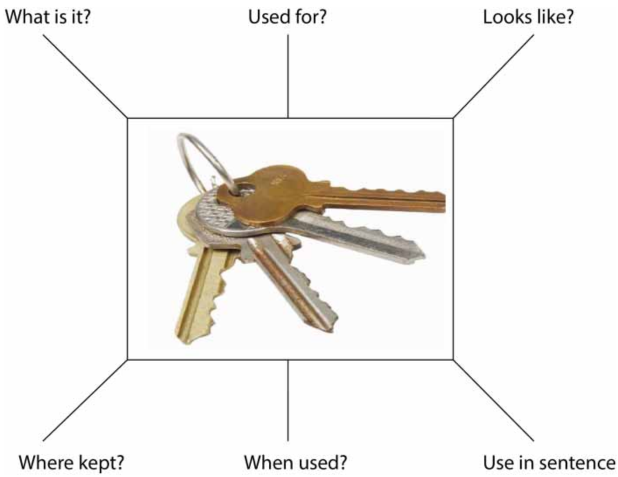

Figure 3. A modified semantic feature analysis matrix.

treatment delivery offers a cost-effective alternative to a standard outpatient speech-language therapy model. Another advantage conferred by this treatment model is the potential for shorter and more frequent training sessions in the home, where the patient is in close proximity to his or her target items. Although trained caregivers can administer much of the intervention, issues of treatment fidelity persist. A clinician must periodically evaluate whether the treatment is being administered as intended, and intermittent checks should also ensure that the patient is not experiencing undesirable side effects (e.g., compulsive/excessive training). We currently conduct fidelity checks and assist in direct treatment. Future treatment delivery options might include teletherapy (e.g., online video conferencing) and dedicated Apple/Android applications with voice and video recording capability for remote data collection and scoring.

Optimising dose parameters

Rehabilitation researchers are engaged in a longstanding debate about how best to optimise frequency and intensity of behavioural and physiological interventions. Of particular relevance are questions such as when to intervene after an acute brain injury and whether to pursue constraint-induced approaches that counteract learned disuse (e.g., binding a functional limb to force the use of a paretic limb) (Kleim, 2011; Pulvermüller et al., 2001). The literature on dose specificity in aphasia has roots in both cognitive learning theory and also more recently in animal models of neuroplasticity and brain injury recovery. It is unlikely, however, that this body of neuroplasticity research extends in a linear fashion to progressive semantic anomia. Massed practice with a high intensity and duration schedule (e.g., 5 days/wk x 3 hrs/day) may be unreasonable for dementia. In our own work, we have found that patients show visible fatigue and tend to experience diminishing returns after 30–45 minutes of treatment. Progressive semantic anomia, therefore, likely calls for its own tailored set of dose parameters. One potentially fruitful strategy derived from applied learning theory is that of a distributed practice routine composed of numerous short sessions that are administered by different "teachers". We currently ask patients to train on their maintenance lexicon using SFA three times a week for 30 minutes each session. The question of whether this is an optimal treatment schedule awaits empirical confirmation.

Training abstract words and verbs and invoking combinatorial semantics

The micro-lexicon technique is powerful in that it can potentially train multi-word conceptual combinations. We initially used light verbs (e.g., want, go, feel) to bridge combinations of subjects and objects arrayed left to right on the board (e.g., I-*want*-sandwich). However, light verbs are not imageable and are accordingly difficult to train/retain in patients with advanced semantic impairments. We experienced the same difficulties with emotions and somatic states (e.g., pain, hunger). Each of these lexical categories is important for connected language, but it remains unclear how verbs, somatic states, and conceptual combinations might best be trained in the context of a maintenance programme for progressive semantic anomia. A more ecological approach to language intervention will involve embedding gains in single word naming with semantic-syntactic training of verb thematic roles (for one viable option see discussions of VNeST by Edmonds & Babb, 2011; Edmonds & Mizrahi, 2011; Edmonds, Nadeau, & Kiran, 2009).

Delineating subject-level predictors of treatment responsiveness

Progressive semantic anomia is not a unitary entity. Many neurodegenerative populations experience progressive naming deficits, and qualitative differences suggest heterogeneity across the clinical subpopulations (Reilly, Peelle, et al., 2011). This begs the question of whether a one-size-fits-all approach to maintenance therapy is justifiable. We are currently addressing this question using a combination of longitudinal neuroimaging, neuropsychological assessment, eyetracking, and clinicopathological diagnoses. These predictors are essential for discerning who might benefit from maintenance by illustrating whether treatment benefits are moderated by phenotype (e.g., score on a test of global cognition) or by diagnostic classification (e.g., Alzheimer's disease vs. frontotemporal degeneration).

Concluding remarks

Biomedical research is entering a new era of optimism for developing drug targets that may slow or halt the progression of several dementia variants. In lieu of a protein panacea, there remains a compelling need to develop effective behavioural interventions. The treatment of progressive semantic anomia represents a new frontier for neurorehabilitation, and the disorder thwarts most traditional restorative language intervention approaches. Techniques that may work well for stroke aphasia have limited efficacy for dementia. Thus, the nature of a progressive language disorder calls for a dynamic, aetiology-specific approach. Maintenance interventions offer a flexible and proactive treatment option for offsetting progressive naming impairments. Furthermore, these approaches are amenable to pairing with other adjuvants (e.g., pharmacology, neurostimulation) to optimise functioning as disease severity worsens.

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