The bilingual lexicon, Hebbian learning, and vocabulary teaching: tentative theory in daily practice

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INTRODUCTION
This paper raises four of the important questions, not as yet definitively answered, about words in the language learner's mind, giving something of the background. I shall see some features of a pedagogically-situated preliminary model of the bilingual mental lexicon that seem to be consistent with theory and observation. Finally, I shall make certain concrete suggestions, not necessarily innovative, for vocabulary teaching.

First, though, we need to define some terms from the title. I use "bilingual" in the wider sense of "knowing and using two languages", not in the restricted sense of "knowing two languages equally or perfectly". Then, "Hebbian learning" has to do with Donald Hebb's seminal idea over 50 years ago, that when the mind processes information, links between the neurons involved are created or strengthened, making it easier or more likely for the same things to happen in the future - that is, learning is accounted for as a physiological process (Hebb 1949). I also use the interchangeable terms "L2" and "second language" to refer to any language that is at an earlier stage of learning than the L1.

QUESTIONS ABOUT THE L2 MENTAL LEXICON
For the last twenty years or so, second language vocabulary acquisition has attracted increasing attention from researchers. Twenty years or so ago, it was possible to describe it as "neglected" (Meara 1980). More recently, it has been accorded more importance, and we find statements such as "the bedrock of L2 is its vocabulary" (Ellis 1994a). Though vocabulary is getting at least some of the research and pedagogic attention it deserves, there are important questions still unanswered.

Minds contain words. Bilingual minds contain words that are explicitly assigned, in consciousness and following arbitrary convention, to different languages. Clearly some kind of implicit process is also at work in separating the words of different languages in a bilingual's productions, or even the term "code-mixing" would be inadequate to describe the confusion that would result in unmonitored production. However, the nature of this implicit code separation process remains controversial (for reviews see Green 1993, Poulisse 1997). So the first of our questions is:
How do bilingual speakers keep their languages apart as well as they do?

Minds also contain entities that are not words. Though I think we can take that much as given, from this point, we enter into controversy. In this paper, I shall adopt the term "concept" in its widest possible sense for non-word entities, to include images (visual memories), drives, schemata and episodic memories as well as verbalisable symbolic representations that do not necessarily map onto single words or even onto formulae. I regard verbalisable concepts as verbally-derived, as distinct from images, episodic memories and so on. I do not follow those such as Pinker (1994) who postulate a "mentalese" onto which a particular language is mapped by experience. Neither do I see a need to postulate a "conceptualiser" module (Levelt 1989), separate from the lexicon, that produces verbalisable output to the language modules, though at the same time there must be processes of non-verbal cognition that contribute to the contents of messages. So while my answer to the question

What is the relationship between words and the other contents of the mind?

is necessarily uncertain, it is in the camp of those who would see language as playing a determining role in peculiarly human cognition (e.g. Bickerton 1990 "secondary representational system", Karmiloff-Smith 1992 "re-representations", Vygostsky 1937/1986 "inner speech"). From our present concern, the question may be taken as that of form/meaning mapping. Kroll and de Groot (1997) review some of the research here that has produced contradictory results in answer to the question of whether the bilingual has a double or a shared conceptual system.

There is a further question of interest, related to the above questions.

In the bilingual, is the lexicon a single or a dual system?

As Schreuder and Welten's (1993) point out, this question is posed simplistically, as information could be stored separately or integrally (shared) at different syntactic, semantic and formal levels. The task of research is to tease out these strands.

Research using a number of methodologies has addressed the question

Is the L2 lexicon similar to, or different from, the L1 lexicon?

This controversy too continues. For instance, for recent work supporting the "difference" claim, see Forster and Jiang (2001).

The four questions italicised in the above text have been researched, but not answered to the extent of having theories that are both testable and well-tested.
RESEARCH AND THE TEACHER
A teacher who is a consumer, so to speak, of linguistics and second language acquisition theory and research, remains at the same time a practitioner who has to act, but, being a reader and thinker needs a rationale for action. At the same time, we are faced with the theoretical and empirical uncertainties briefly described above. When teaching vocabulary, some sort of answer to these questions is needed. If not a theory, with all that that implies, then at least some characteristics of any eventual model of the mental lexicon that can account for lexical acquisition processes in a manner that can consistently inform pedagogy. So, the word "theory" in my title may reasonably be regarded as misleading, even as a non-count noun preceded by "tentative". What we really have below is the outline of a model: something variably based on imagination, as well as theory and observation, and so not inconsistent with received knowledge, but also situated, and so suitable for a purpose.

LEARNING ONE WORD
Before presenting the model and further expounding upon its underpinnings, here is what may appear to be a digression. It is only apparently so, as it is intended to illustrate an obvious but often overlooked point to which reference will be made in subsequent discussion.

Imagine that you are in a classroom, beginning a new language. The teacher presents a word - "ystaffell" (for pronunciation see endnote¹). The presentation is direct method, by pointing and/or drawing. Translation is not used. You, the learner, achieve a phonological form representation and come to understand the word, if the direct method presentation is successful. But in what way do you understand the word, in this very early stage of a new language? Do you form a new concept? Do you link it to an existing concept outside language? Or do you link it to a translational equivalent or equivalents, such as "room", "ethousa" or "pièce", for speakers of English, Hellenic and French respectively? I dare to suggest that the last of these three possibilities is actually the rule. Years of observation in my own and others' classrooms have shown that learners are rarely content until they can assign an L1 equivalent to a new word. Early L2 learning at least is parasitic upon the L1. (This applies to lexis, for our present purposes: the probable ways in which it applies to syntax, phonology and pragmatics are not our direct concern here.) It is not just that there are "subordinate bilinguals" (Weinreich 1953/1974): it is that there are subordinate words.

¹ ystaffell. Approximate pronunciation: y as u in fun, st unvoiced as in steak, a as in sat, f as v in van, e as in bet, ll is an unvoiced lateral fricative. Stress penultimate.
BRAINS AND CONNECTIONS
What seems to fit the needs of vocabulary teaching, at least, is a connectionist or network model of the lexicon. First, however, a word is in order on what is known about the brain, and how this has inspired connectionist theory. Neurons (cells of the central nervous system) receive stimulation through the dendrites from a large number of other neurons until at some point they discharge, sending a current spike down the axon to stimulate a number of other neurons through the axon's branches. Furthermore, these axons to dendrite pathways are far from fixed. New connections are established, used ones strengthened, and disused ones weakened, throughout life, though never to the same extent as in infancy, while the brain is still growing in size. (In early life, in particular, whole groups of nerves may be re-directed to parts of the brain that would not normally serve the function that that nerve group usually serves, as in the case of those born blind, whose visual cortex appears to be re-connected to serve hearing.) Some areas receive input from the systems of sensory neurons, such as the visual cortex, while others are more closely connected to the motor neurons, i.e. to output. Most interestingly for those who wish to understand complex phenomena such as language some parts of the brain have no I/O (input/output) connections. Some of the neurons here are connected to I/O indirectly, while most are interconnected in excitatory or inhibitory loops. The human brain, to put it simply, has proportionately more such non-I/O brain tissue than that of any other species.

Connectionist models take the node as the building block. A node is taken as potentially corresponding, for purposes of modelling or simulation, to a part of the real brain, be this a single neuron (rarely), or a grouping of neurons, or even a pattern of activation that shifts but persists independent of any particular physical brain location (Calvin 1996). It is assumed that cognition is a process in which nodes are subject to different degrees of activation, or readiness to "fire". Reaching a threshold level, a node fires and activates other nodes. A variable network of connections links the nodes: these may be established, strengthened, weakened or possibly extinguished altogether. The network of connections is, then, subject to alteration (learning), while its present state represents a potential for a large number of patterns and levels of activation.

While some nodes are associated with output and input, others are not directly so associated. In constructing electronic simulations of neural networks, connectionists call this a "hidden layer". This corresponds in very broad terms with the non I/O brain tissue mentioned above.

The above exposition draws on Deacon (1997) on the brain, on connectionist models of language (tutorial in McMurray 2000), and on
writings on connectionism in second language acquisition (e.g. Broeder and Plunkett 1994, Sokolik 1990).

**BEGINNING A MODEL**

In Figure 1, the diamonds are word nodes; the boxes are non-verbal concepts (say, visual memories). The lines are the connections. Nothing is done here to show the weights (strengths) of the connections, or the possibility that some may be unidirectional. Of course, to represent a whole L1 lexicon and non-verbal memory, we would need to multiply our diagram by $10^4$ or $10^5$. The point is that we take words as nodes in a network, with various connections by which nodes/words can activate each other. The single word in L2 Welsh is shown with a single connection to an L1 word: it may or may not also be connected to a non-verbal representation.

We note in passing that far more complex connectionist models, including syntax in their scope, are possible. For instance, there is the competition model, functional, driven by lexis and input, and connectionist in its mechanism. MacWhinney (1997) reviews over ten years of work here. Then there is the idea that a network is able to build sentence syntax by merging the argument structures of verbs sharing semantic features (Morris, Cotterell and Elman 2000). The idea that the emergence of just about the whole of language is lexically-driven is fascinating but beyond the scope of this paper.

The status of connectionist models of cognitive processes remains controversial. But then, it is also controversial how a rule and symbol system for language might actually be implemented in the brain, while a hypothesised system in which apparent rules emerge from a network of connection strengths is more consistent with neurophysiology. It may well turn out in the end that the language mind is a hybrid system: obviously, nervous systems are capable of some kinds of innate, apparently rule-governed behaviour, such as homeostasis and nest-building. Maybe syntax is on that list. We may wish to leave open the possibility of a hybrid system in which rules handle syntax and the lexicon is a network. Nevertheless, the
idea that network models are better at explaining the lexicon is one to which I am committed.

The other basis of the model is the idea that the clearest internal difference between L1 and L2 acquisition is that in the latter case there is already in situ a lexicon and a set of concepts. This holds whatever the precise relation between these last two might be.

The first question was whether there is one system or two in the bilingual. It seems to me to make no sense at all to speak of a separate L2 lexicon when only one word is known. This is the rather practical point that L2 learning has to start somewhere. If you knew no Welsh before, you now have one word, but that is not a lexicon. Equally clearly, and at the same time, an aim of L2 learning is that we hope that the L2 lexicon will eventually function in ways similar, if not identical, to the functioning of the L1 lexicon. Starting from one word, over a period of years in the usual case, the learner builds up a system of 2000 to 5000 words, maybe 10000 words, or even more in the case of what we would call a highly successful learner, and this system functions autonomously. It might conceivably be possible to learn 5000 or more words in an L2 without building them into an autonomously functioning lexical system, perhaps by memorising lists. I would venture to say that rather few learners could, or would, actually do this, and that the resulting knowledge would be of little immediate utility. (Except, perhaps, in reading.) Speaking and listening are severely hampered by constant reference to the L1, while even reading and writing are often carried out under internally or externally imposed time constraints. The point is to build a system, a lexicon, that does function autonomously, in "real time".

So the answer to the one-system-or-two question seems to me to be "both". There is clearly one system to start with, but something that is at least functionally a dual system develops, if learning is successful.

METAPHORS FOR THE WORD STORE

To say "mental lexicon" is to use a metaphor. Now I would like to extend the metaphor and make another distinction, which I call the mental lexicon vs. the mental dictionary (ML and MD).

Let us say the ML is implicit, the MD explicit. A major feature of the MD is the translational pair, but may also include the L2 word-synonym or word-paraphrase pair, as learning advances. It also necessarily includes form information. Basically, the bilingual mental dictionary is a mental bilingual dictionary.

A major feature of the L2 mental lexicon is that it is desirable that it should function without reference to the L1 lexicon. In highly fluent L2 users it clearly does just that. Items from MD become items in ML, ideally. This
may be compared with the transformation of explicit into implicit postulated by Ellis (1994b). But what is happening in the brain when that happens?

ADDING WORDS
Let us return to the Welsh lesson that began earlier in this paper. Perhaps these are your second and third Welsh words.
gwely = bed  bwyta = food.
Let’s add these to our figure, together with a phrase (Figure 2),
ystafell wely = bedroom.

The phrase, and the use in class of a sentence such as "Mae gwelu yn yr ystafell" (There's a bed in the room), start to make links along the syntagmatic dimension, starting to build the lexicon towards the same kind of internal structure that a fully-developed L1 lexicon has. (The syntagma here also provides an exemplar of a fact about Welsh morphology, that the onsets of words may change in a principled way. However, the morpho-syntactic analysability or otherwise of learnt wholes is not our concern here.)

PEDAGOGY
Two insights are drawn from the above about how the status of words may be changed as learning progresses. Firstly, the explicit mental dictionary is a necessary starting point but needs to be transformed into a fully functioning L2 mental lexicon by building its internal links. At the same time, and as far as possible, pedagogy should work on connecting items to the L2 mental lexicon straight away. To build these links a two-pronged pedagogic strategy is required. Teachers teach the links, and teachers provide the conditions for learners to make their own, and to make them their own.

The surface form of many of these links is the phrase, the idiom, the collocation, and so on: the various kinds of co-occurrence of words along the syntagmatic dimension. Further support for the importance of this is found in a linguistic tradition going back to Firth and before, and also in some philosophers' concept of holistic semantics. If we accept that a large part of
the meaning of a word is the company it keeps in a text, then the meaning potential of a word is the company it keeps in a language system, L1 or L2.

TEACHERS MAKING CONNECTIONS

As is implied above, the syntagmatic dimension is important from the start of learning. A number of further points may be marshalled in support of this.

1) The fact that we say ystafell wely or ystafell fwyta (room bed = bedroom, room eat = dining room) is just as much an important fact about ystafell as that it means room, ethousa, dhomatio, piece, chambre or whatever.

2) When longer learnt wholes are available, fluency is facilitated (Pawley and Syder 1983). Furthermore, pragmatic functions may often best be realised by holistic utterances - "lexical phrases", as Nattinger and De Carrico (1992) term them.

3) Activation of the L2 lexicon is maintained by continuous stimulation by L2 items. This point is taken further below.

Apart from these points, though, I would like to argue for the importance of common collocations, lexical phrases, formulaic sequences, and so on, as strings that consist of potential word nodes and thus may contribute to network construction. As a teacher, I have come to the conclusion that the teaching of longer strings is important right from the start of learning, from the beginners' class, and that this should not be confined to the pragmatically-oriented exponents of language functions that do appear in materials. A paradigmatic set of words, such as colour adjectives or weather predicates, is less likely to be helpful because we don't usually need to activate more then one of them at a time, while words linked syntagmatically are, necessarily, co-activated. There's a testable prediction here, that, say, a rainy day, a snowman, the north wind, ice on the roads should lead to better retention than rain / wind / snow / ice, as well being as more useful for production. Beginners' and elementary materials tend to present words in paradigmatic sets, but I think we should be questioning this. Look at this set:

beach / coast / sea / seashore / waterfront / promenade / seaside

Learners of English of Hellenic MT, and others, have some difficulties with these. The translational equivalents do not map between languages in any straightforward way. For instance, the Hellenic paralia might be variously translated or mistranslated as beach, waterfront, or promenade. Rote learning of prescriptions and restrictions concerning words might be possible, though there is likely to be great variation between learners in their ability to carry out this kind of explicit learning task. It is much more likely that correct production, when it occurs, derives from exemplars such as these, either used as wholes, or, potentially, analysed.

beach ... swim, beach ... sunbathe

costguard, a town on the coast
a walk along the promenade
on the waterfront
go to the seaside

There is a caveat here. As Wray (2000) points out, we need to take very seriously the possibility that learnt wholes may never in fact be analysed into elements (words, morphemes) such that these become available for independent use. It would certainly not do to take it for granted that such a process occurs automatically in adult L2 learners, who may well try to get by as language users by depending on single words and fossilised, pragmatically useful lexical phrases (see, e.g. Schmidt's 1983 case study). In our current connectionist terms, a phrase may form a node of its own, and unfortunately remain so. This does not mean, however, that learners will not analyse phrases under any conditions, and the contributions of explicit and implicit processes to this analysis deserve further investigation.

ACTIVATION

The concept of activation, as applied to network models, has considerable explanatory power. We asked earlier how it might be that bilingual speakers are frequently able to keep their languages apart in fluent production. Grosjean (2001) explicates "language mode", essentially the notion that at a given point in time a bilingual's languages are in different states of activation. The most activated contributes most to production, and thus may appear to be "switched on". An advantage of such a model is its economy in that it does not need any "language switch" in implicit cognition outside the system of language items. This activation of a particular language can be related to Meara's (1999) explanation of what he calls "the Boulogne ferry effect". This refers to the way in which, after a time lapse in regular use of a known language, re-exposure to quite a small amount of known input brings back a lot of language that is not present in that input, as in the familiar experience of a Briton who knows French, shortly after getting off the ferry in Boulogne. This can be explained by a model in which the activation of a few nodes in a network - or of a few words in a lexicon - activates, by spreading, a large part of the network/lexicon.

Now, taking our simple network model and considering the concept of activation, we may draw a lesson for pedagogy. When L2 word follows L2 word, L2 intra-activation is kept high, while whenever recourse is made to L1, then L1 activation is increased at expense of L2. This suggests that, while there may be reasons why we may not wish or be able to exclude the L1 from the classroom, we should be circumspect in its use, and make every effort to keep the L2 in use, so keeping it activated in the learner's mind and available for the formation of new connections.
This further supports a view, derived from the above idea of the importance of the syntagmatic, that when introducing new vocabulary, an L1/L2 translational pair is never enough. The teacher must see to it that new items are always extended sideways, as it were, into the lexical network.

LEARNERS MAKING CONNECTIONS
It will not have escaped the attention of the reader that my MD/ML distinction is reminiscent of the procedural/declarative memory distinction. There was once an influential theory that language learning is somehow different, and that consciously learnt, declarative knowledge just doesn't become acquired knowledge - in fact doesn't become procedural. The author with whose name this view is most associated was still defending a version of this position only seven years ago (Krashen 1994). The view was certainly influential once, and indeed had value in pedagogy in prompting us to realise that what we teach is not always what is actually learnt, and that comprehensible input at a level just beyond what learners presently know is probably useful. However, when declarative knowledge - including the MD items - is consciously assembled by explicit processes into larger units - phrases, sentences, utterances, whatever, - then those units are available for "acquisition". There's no better input than your own output. Then again, explicit knowledge, such as that in the MD, enables better processing of input from reading. "To those that have shall be given." I don't think we need to take compartmentalised learning vs. acquisition seriously. Communicative activities in which explicitly learnt material is brought into action, so to speak, are likely to lead to the making of more connections, making items more potentially active.

AFTERWARD
If it seems that I have made a journey just to return having found support for some of the by-now-conventional procedures of CLT (communicative language teaching), then so be it. This is related to the point made earlier, that teachers who think need a rationale for what they do. Sometimes seeking a rationale can lead to the justification of practice, as well as to its modification, to new questions and to new tentative answers.

REFERENCES


