A network model of lexical organisation in the bilingual brain

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Abstract

In this article a novel approach to modelling the mental lexicon of bilingual speakers is presented. It assumes non-selective, integrated organisation, as supported by much of the recent psycholinguistic evidence, and suggests how a principle of cortical proximity of near-equivalent mediatory 'word columns' in two languages could facilitate the operation of intertwined language-specific networks. Such networks are seen as distinguished by differential phonological anchoring. The model emphasises the level of lexical concepts and the recombination of shared bundles of 'micro-functional' features in processes likely to be involved in expressing the same conceptual content in one language or the other. This is illustrated with examples of the hypothetical production of near-equivalent English and French sentences by a bilingual speaker. It is proposed that fluent bilinguals utilize the micro-functional level more fully than late second language learners, thus largely bypassing the need for lexeme-to-lexeme translation.

Key words: mental lexicon, bilingualism, network model, lexical concepts, translation

1. Introduction

A considerable literature has emerged over the past few decades concerning the nature of the mental lexicon in bilingual speakers, much of it presenting experimental evidence bearing upon whether the lexicons for the two languages concerned are separate or merged (or overlapping). Although this field has not reached the point where one can speak of consensus, there would appear to be dwindling support for the 'separate store' hypothesis. Most of this evidence concerns the perception and recognition of individual words by early and late bilinguals, not the production of whole sentences (words-in-context) by such speakers. Detailed models for the production of near-equivalent sentences in the two languages mastered by a single speaker have to my knowledge not yet been attempted, yet this is surely a prerequisite for

formulating hypotheses as to the relation between the bilingual mental lexicon and sentence production and setting up experiments to test them. This goal requires combining an overall model of sentence production with a theory of the organization of the mental lexicon in the bilingual brain. In the present article I attempt an initial, theoretical stage in such an enterprise, based on the model developed in Fortescue (2009) for the mental lexicon in terms of 'mediatory word columns' and their affordances.[1] The results will be speculative but open in principle to available methods of neurolinguistic testing.

My hypothesis is that the lexical networks in both languages are intertwined and that mediatory word columns for near-equivalent words are located in proximity to each other in the same association areas of the cortex. This ensures, among other things, that rapid, quasi-automatic code-switching from one language to the other can take place. It does so according to my model largely at the level of (paradigmatic) 'micro-functional' affordances in the dominant left hemisphere. This corresponds to the level of 'lexical concepts' in Lexical Concepts and Cognitive Models theory (Evans 2009).[2] The grammatically relevant features at the micro-functional level represent a restricted (quasi-universal) set from which individual languages select and combine in connection with individual word columns (see Fortescue 2010 for a detailed coverage of modelling the mental lexicon within this framework).

My principal assumptions in this area are as follows:

● The mental lexicon (both mono- and multi-lingual) is organized by interrelated networks anchored in 'mediatory word columns'[3] in association cortex that relate phonological forms (in Wernicke's area) with highly distributed perceptual/sensory and conceptual 'affordances'.

● Higher-order affordances are divided into micro-functional (grammar-relevant) ones (i.e. 'lexical concepts', largely confined to the dominant left hemisphere) and macro-functional ones — 'scenarios' or 'frames' (i.e. 'cognitive models', predominantly concentrated in the right hemisphere).[4]

● Mediatory word columns for words of similar — but not necessarily identical —meaning in the two languages are stored in adjacent cortical loci in a given bilingual speaker's brain (the exact position determined by the locus of the word in the earlier learnt or dominant language).

● What distinguishes inter-language translation from single language paraphrasing it is the coherence afforded the intertwined mental lexicons of the individual languages by language-specific phonological anchoring in Wernicke's and Broca's areas.[5]

My proposed model illustrates how the two languages of a bilingual speaker may share the same overall 'mental lexicon' (including combined or converging experiential 'scenarios' associated with individual words) but also contain language-specific 'subsets' in the manner of Paradis (2004). Thus word columns corresponding to French and English lexemes that are near-

equivalents semantically are assumed to be stored in close proximity and/or by strong mutual associations, whereas less direct equivalents – words or constructions with quite different arrays of affordances, only partially overlapping – are related through compatible micro-affordances alone. Recombination of such affordances-in-context rather than direct mutual activation of lexemes is required in the latter case, presumably a more cognitively costly process.

The claim of proximity is based on two considerations: first, the likelihood that L2 near-equivalents will be positioned close to the L1 forms that were first learnt and are most deeply entrenched and to which translational reference may at first be required. Secondly, the evidence that lexical nodes (word columns on my model) are in general situated or anchored close to the sensory or sensorimotor area of the cortex most relevant to the word's semantics (whatever the language).[6] In this way the arrangement would aid the speed and efficiency of switching from one language to the other and focus the spreading of activation from a word in one language primarily to relevant, semantically overlapping words in the other language.

2. Theoretical background for the organisation of the bilingual mental lexicon

Dong *et al.* (2005) give an account of various theories of the organization of the bilingual mental lexicon (for both shared and separate storage) that have been proposed in the past. They opt themselves for a model not incompatible with my own, although its workings are not spelled out in detail. Experimental evidence is presented indicating that there is a shared (distributed) conceptual system for the bilingual speaker's two languages, with asymmetrical links to L1 and L2 (the former priming elements of the latter more strongly than the reverse). They argue, further, that conceptual representations may contain both L1- and L2-specific information (converging).

Paradis (2004) proposes a 'Three Store' model with separate lexical sub-systems for each of the bilingual individual's languages within the same broader cortical areas involved. In terms of my own model, this would mean that for bilinguals the same overall areas for functional, sensory and phonological affordances would be involved as for monolingual speakers, but that there would be separate sub-systems within each of these for the individual languages. These would constitute coherent language-specific networks or sub-sets intimately intertwined but separately activateable or inhibitable as wholes (Paradis 2004: 196-198) and would not be limited just to the classical language centres. The distinction between fluent/balanced bilinguals and those who learn their second language late in life is, according to Paradis, a matter of the greater on-line reliance on consciously accessible 'declarative' memory in the case of the latter, who also draw more heavily on pragmatics and context than on automatic 'procedural' memory.[7] Early, fluent

bilingualism may, he suggests, result in a more integrated network in frontal grammar cortex for the two languages concerned (not a matter of lexicon as such). Late or less fluent bilingualism, involving second language learning after the full acquisition of the dominant one, may on the other hand require more widespread cerebral activation. What L2 lacks for most speakers may be the deep limbic (i.e. emotional) anchoring of L1, on which the learning of a second language must piggyback (Paradis 2004: 24-25).

Pulvermüller and Schumann (1994: 717-718) cite evidence that content word meanings acquired late by second language learners may be located closer to higher order association areas than for early learners, for whom neural assemblies for such meanings lie closer to the perisylvian language areas. The reason, they argue, is that the latter areas myelinate (maturate) earlier than the former and thus become less plastic after childhood. This is not incompatible with the hypothesis of proximity advocated in the present paper for relatively early or fluent bilingualism but does raise questions as regards its application to late second language learners. Ding *et al.* (2003) present evidence that there is increased right hemisphere activity (especially in the right frontal and parietal lobes) involved when late bilinguals use their second language as opposed to their first language in a semantic categorization task. The more widespread cortical activity associated with late rather than early bilingualism in processing L2 may, however, have more to do with the extra processing burden faced by late learners and may not directly reflect the localization of L2 lexical representations as such.

Although relevant neuroimaging findings are still somewhat limited in scope, van Heuven and Dijkstra (2010) summarize the general state of play pertaining. Their own BIA+ (Bilingual Interactive Activation Plus) model assumes an integrated lexicon and parallel access to word candidates from different languages, coupled with a separate task/decision system. My model is compatible with this and other recent dynamic models of bilingual language processing that assume structural overlap between first and second language representations. Démonet et al. (2005: 72-73) indicate that studies of language comprehension by bilinguals give clearer results than the few that focus on production, though some studies of the latter type suggest larger cerebral activation for a less frequently used language than one regularly used. Most recent neuroimaging investigations support the idea that a single common neural network is involved in the processing of both languages for proficient bilinguals, late as well as early. For evidence that the same neural tissue may actually be involved in supporting the two languages of a bilingual's mental lexicon (with differences a matter of control rather than representation) see Abutalabi and Green (2007).

More radically distributed models of the bilingual lexicon have been proposed, for instance de Groot's (1992) Distributed Feature Model in which translation from one language to the other is bi-directionally via the shared feature-based conceptual system. This is taken to account for the relative ease of translating concrete words (sharing many as opposed to few semantic features) as

opposed to abstract ones. It allows for any degree of semantic overlap between words. This can be contrasted with the Revised Hierarchical Model (cf. Kroll and Stewart 1994), which sees a privileged link between L1 and the conceptual system, and thus at least partially separate lexicons. This may, however, reflect a later age of acquisition and/or a stage of lesser proficiency.

Within a connectionist framework, Jacquet and French (2002) have illustrated the possibility at least of purely bottom-up, self-organizing word learning from mixed input in two theoretical languages. This is closely related to the non-localizationalist 'correlated feature' theory of the mental lexicon as such (Caramazza et al. 1990). Recently, Dynamic System approaches to linguistic processing and the mental lexicon have been proposed, as in Lowie and Verspoor (2011). They argue for a 'fuzzy set' as opposed to a modular approach to the bilingual lexicon, which seems to obscure the distinction between the 'digital' (symbolic, discrete, top-down) nature of the language system and the 'analog' (distributed, 'fuzzy', bottom-up) conceptual system to which it provides access. Though both are subject to continual adjustment and extension according to context and experience, lexical concepts as I understand them (micro-functional features) are quasi-universal and therefore hardly 'fuzzy'. Their core meanings are precisely part of a system, and are at least partially decomposable and re-composable via common features, anchored in pre-linguistic sensory and sensorimotor experience but overlaid by culturally mediated 'definitions' — this is what allows inter-language translatability to take place at all. My model is more in keeping with de Bot's (2004) multiple processing model, which contains language-specific sub-sets in each of three stores, conceptual, syntactic and formal (phonological). His model adds a 'language node' switch to Levelt's revised (1993) model — which now includes a level of 'lexical concepts' between communicative intentions and lexical lemmas.

What I propose is precisely a dynamic and distributed process scenario for sentence production by bilingual speakers. It maintains, nevertheless, an element of localizationalism (as in Warrington and Shallice's 1984 'sensory/functional theory'), in so far as the 'mediatory word column' is assumed — as a privileged, hierarchically superior node in the word network — to be located in an at least approximately determinate region of association cortex, according to its dominant (most concrete or early) associations. Through time, with increasing proficiency, L2 words learnt by late bilinguals, even if initially 'piggybacking' on spatially adjacent translation equivalents in L1 as my model suggests, could develop far-flung semantic associations of their own, eventually attaining a degree of entrenchment supporting direct access to the conceptual system, largely independent of their L1 near-equivalents.[8]

3.   Prerequisites for a bilingual mental lexicon capable of producing English/French near-equivalent sentences

Consider the following two alternative sentences, one in English and one in French, that could have been produced by one and the same speaker fluent in both languages to describe the same event:

(1a)   The robber dropped the gun and ran.

(1b)   *Le voleur a laissé tomber son pistolet et a décampé.*

The sentences in both languages can be taken as reflecting the same core mental/cognitive model event in both cases, namely one displaying a propositional structure 'X (Pred$_1$(Y) + Pred$_2$)', where X is a person, Y a thing and the two predicates the successive actions of X. Although the exact information and inferences activated by the sentences for any given speaker may differ, the content of the 'robbery' scenario for both French and English speakers must surely include the person of the robber (with typical attributes of behaviour and attire), his victim(s), a weapon with which he threatens the victim, the money or goods he is demanding, the place (typically a bank or shop), and the sequence of actions: entering, threatening, demanding money/goods, and escaping from the premises with his booty – or being apprehended by a representative of the law.[9] The structural differences between the two sentences are not great (word order and 'equi deletion' conditions are the same in both grammars, for example). The mediatory word columns for 'robber' and 'voleur' are assumed to stand physically close (participating in inter-related but language-specific lexical networks) for the bilingual speaker; likewise as regards 'gun' and 'pistolet'.

Some further points to bear in mind: the verbal form 'ran' in English has a special 'run away' sense, close to that of 'décamper' (both containing a spatial lexical feature AWAY). The choice of 'son' (i.e. 'his') in French by the hypothetical speaker here rather than the definite article could be due to the fact that 'le pistolet' is not such a highly expected component of the robbery scenario as 'the gun' is in English (where the scene itself evokes a gun, which need not have been mentioned before in order to take the definite article). The most interesting point of difference between (1a) and (1b) is the French expression 'laisser tomber' ('let' plus 'fall') corresponding to English simplex 'drop' (in its causative sense), both of which invite the same inferences (e.g. that the gun is now left on the ground).

In Figure 1 I present a simplified view of the organization of the relevant word columns and their crucial connections needed to produce the two sentences in (1) above.[10] In the following section we shall see how this can be interpreted in actual production terms. The conventions are the same as those used in Fortescue (2010), that is, with sensory affordances represented by the crossed axes at the bottom of the vertical lines (the individual columns) and functional

ones at the top. In actual neural terms the bottom of the columns would lie closer to the cortical surface than the top of them (see Mountcastle 1998 for the detailed structure of cortical columns). The two crossing functional axes indicate respectively the paradigmatic and syntagmatic affordances of the word – the former a matter of grammar-relevant semantic features/categories whose combination represent a unique 'lexical concept', and the latter is a matter of the linear ordering of elements (other words or abstract syntactic categories) into which the word is expected to fit. The double-headed arrows can be regarded as content associations between the columns concerned, all relevant to the 'robbery' scenario. The scenario itself (hypothetically anchored in contralateral frontal cortex) is also represented by a cortical column with diffuse sensory affordances (the ring around its lower extent) and more constrained functional affordances (here limited to its association with the word 'rob') – it would be misleading to call it a mediatory word column as opposed to a mediatory scenario or frame column, though its organization is assumed to be analogous to that of a left hemisphere word column.
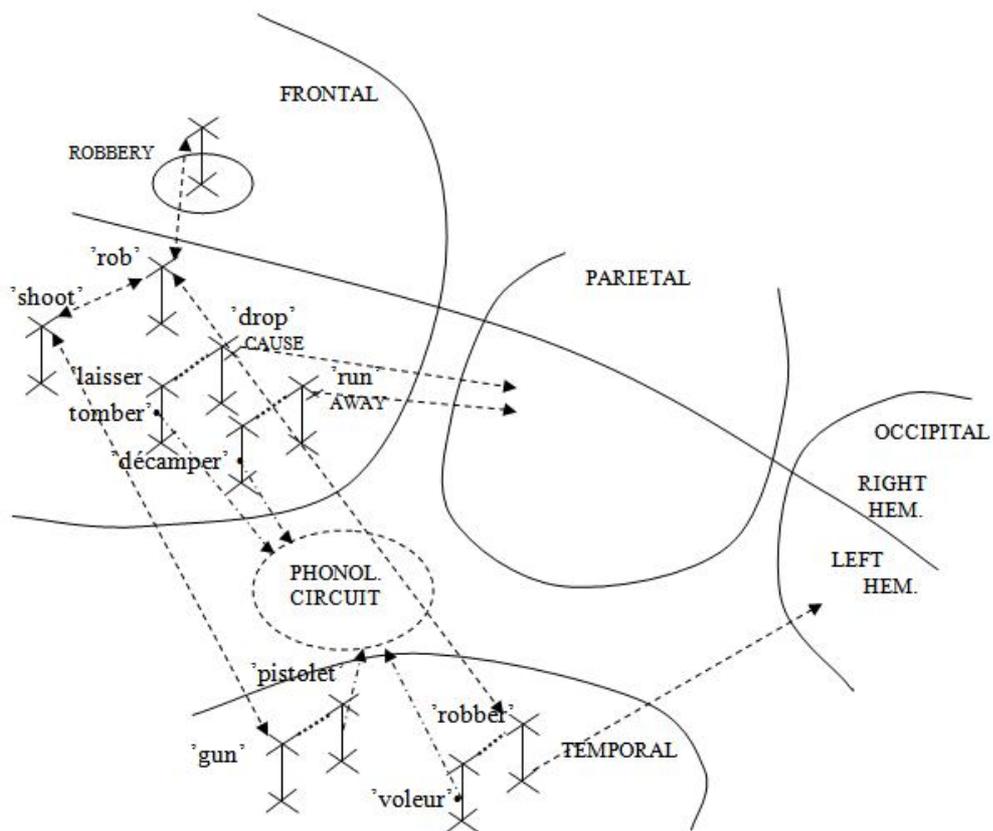

Figure 1. The robber dropped the gun and ran/ Le voleur a laissé tomber son pistolet et a décampé

Note the short dotted lines connecting the paradigmatic micro-functional axes of equivalent words in French and English. The relationship of a word to its nearest equivalent(s) in another language is, precisely, 'paradigmatic', a matter of possible (approximate) replacement of the one word by the other in a suitable verbal context. The alternating dotted and dashed lines from mid-column of the French words link them to the phonological circuit (between

Broca's and Wernicke's areas); similar links could of course be added for the English lexemes. The short cross-bar marked CAUSE on the paradigmatic axis of the word column for 'drop' indicates its activation state (*'eigenstate'* in Fortescue 2009) as a transitive verb. This lexical content feature, considered universal, is also relevant to the content of 'laisser' in French, but to simplify the picture I have treated 'laisser tomber' as a unit, a causative version of 'tomber' alone – it should perhaps better be represented by the association of two distinct word columns. Similarly, the paradigmatic feature AWAY indicated on the column for 'run' is activated in the relevant sense of the verb here. It is also part and parcel of the meaning of 'décamper' – both words produce the entailment that the subject is no longer in the vicinity, that there is (rapid) movement elsewhere (hence the arrow pointing back into the parietal lobe, which according to the model handles the spatial consequences of telic action words). All specific sensory affordances have been omitted (except the arrow from the bottom of the 'robber' word column, which points towards relevant visual affordances), as have macro-affordances of the words concerned pointing to scenarios other than the 'robbery' one. It should be understood that the figure represents a minimal mental lexicon organization necessary to produce the two sentences and is by no means meant to reflect the actual neural architecture in any detail. It is nevertheless compatible with what neurolinguistic evidence is available to date as to that organization.

In Figure 2 is shown in greater detail just two of the word columns from Figure 1, the closely associated words 'gun' and 'pistolet' in the mental lexicon of a bilingual speaker. They are orientated the same way as the templates in Fortescue (2009). The word column on the left is for the English word 'gun', as can be seen by the phonemic form in square brackets labelling the input arrow at mid-column (from the thalamic relay station). Sensory features associated with the word (primarily visual)[11] are indicated on the lower half of the column. There are also functional affordances associated with the word since it refers to an instrument used for a particular purpose (aiming and firing at a target, especially in order to harm/kill) – this is represented on the word column partly by association with the macro-functional scenario SHOOTING, partly by the micro-functional (syntagmatic) link to the verb 'shoot' (in italics), which has its own 'motion' (i.e. kinaesthetic, motor) affordances, in turn associated with the same SHOOTING scenario.

Figure 2. The relationship between 'gun' and 'pistolet'

The micro-functional affordances (the crossing paradigmatic and syntagmatic lines above the small parallel lines that) are grammar-relevant features. The relevant paradigmatic ones here are 'count' (count noun) and 'weapon' – the latter category is grammar-relevant in the sense that the word can be deployed in association with verbs and adjectives requiring a weapon as argument or phrasal head ('grammar' in this sense includes semantic as well as syntactic selection restrictions); 'shoot' is such a verb. On the syntagmatic axis the frequent association of the word 'gun' as object of the verb 'shoot' is indicated.

The general macro-functional scenario for 'shooting' (in the circle immediately above the word column) is separated by another pair of parallel double lines indicating distal, contralateral connectivity. It contains (pointers to) a relevant 'cast', 'setting' and 'action sequence'. One ingredient of the latter is a weapon (here bolded). SHOOTING in turn overlaps with a more specific scenario, the ROBBERY one above it, which has its own internal structure.[12] Specifically, 'shooting' is the threat involved in that scenario (that is if the weapon is a gun). The slanting broken line from the paradigmatic feature 'weapon' on the word column for 'gun' maps that feature onto the same feature bolded inside the scenario circle.

The word column for French 'pistolet' is organized in precisely the same way (though the verb associated syntagmatically with it is 'tirer', which has its own micro-functional features, not indicated here). But there are slight differences – in particular, the relationship of 'pistolet' to the word 'fusil', which is also associated with 'gun' for the bilingual speaker. It would not have been incorrect for the bilingual to have translated 'gun' as 'fusil' here, but the connotations – the potential image evoked – would have been somewhat different. In this instance 'fusil' has been primed by the feature 'weapon' of the English word 'gun' but not activated for production. 'Pointers' to the specific words 'pistolet' and 'gun' could have been added to the scenario itself (as realizations of the lexical concept 'weapon') in the combined scenario I am assuming for the bilingual brain.

Now consider a second pair of sentences that could be uttered by the same person in appropriate circumstances:

(2a) I see I'll have to go there myself.

(2b) *Évidemment il faut que j'y aille moi-même.*

Here there is a greater difference in structure and more complex pragmatic/discourse factors lie behind the production of the two sentences. Note in particular that although there are two clauses involved in the English sentence, 'I see' can be analysed as a kind of evidential phrase modifying the main clause, which is a single sentence containing a modal auxiliary. In French on the other hand the evidential element is adverbial ('évidemment') and there is a complex clause (with embedded predicate) corresponding to the second simplex clause in English. Moreover, the deontic expression in French ('il faut') has an impersonal subject (as opposed to the personal subject of the embedded subjunctive clause). The main clause predicate 'aller' is the direct equivalent of 'go' (though there are some differences in syntagmatic affordances and, of course, inflectional potential). The future tense is required in English but not in French (the present subjunctive covers the hypothetical/irrealis situation referred to). Adverbial 'there' in English corresponds to clitic 'y' in French.

Despite these differences in expression, the propositional structure in both languages can be analysed as: 'EVID(DEONTIC (1SG$_{Foc}$ – Pred))', where predicate Pred contains a future time specification and a deictic spatial goal. DEONTIC is a micro-functional feature at the semantic core of both the 'have to' and 'il faut que' constructions. Note that this structure is assumed to be layered but not temporarily ordered.

The shared propositional structure behind the English and the French sentences is not reducible to the inherent sensory structure of a corresponding perceptual scene, nor is it just a matter of rolling out completely fixed verbal 'chunks' in either language. In particular, the evidential feature (EVID) expresses speaker attitude to the content of the proposition expressed by the rest of the utterance in both languages, a matter of evidential/epistemic assessment in the pertaining discourse context. The individual expression elements of the target language activated by this conceptual structure will predispose the production apparatus to certain morphosyntactic expectations, e.g. of the subjunctive mood following the choice of 'il faut que'. Although there may be cultural and stylistic differences *en route* from conceptual intention to lexical expression, these do not directly affect the organisation of the bilingual speaker's mental lexicon, as opposed to its contextual deployment in discourse. So for a pair of sentences such as (2a) and (2b), given identical situations, the same overall propositional intention can be assumed.

4.   The translation of English sentence (1a) to French sentence (1b)

Consider again sentence (1b), repeated below, as it might actually be translated into French from (1a) by a native speaker of English, a late learner reasonably fluent in that language. I break the process down into two phases, the activation of the relevant lexical units, then the top-down and bottom-up integration of the target sentence, though they can be understood as largely taking place in parallel.

(1a)   The robber dropped the gun and ran.

(1b)   *Le voleur a laissé tomber son pistolet et a décampé.*

First, let us take it that the speaker has been presented the fully-fledged sentence for direct translation. The English words will activate associated lexical units in French, i.e. 'voleur', 'pistolet', 'laisser tomber' and 'décamper', plus the syntagmatic affordances of these items (the syntactic contexts they evoke/require). At the same time, the intention to produce a well-formed sentence in French will, I assume, activate a particular top-down syntactic template in the 'grammatical' area of the speaker's frontal cortex corresponding to the propositional structure behind both the English and the

French sentences. Such constructional templates (linking a content with a form) are associated either with individual words or phrases or with whole syntactic structures displaying more abstract meanings. Here the relevant clause patterns evoked in French are: one expressing a (transitive) causative act and one expressing the (deliberate) motion of a subject. In this case there would not be much difference in syntactic expectations from those of similar content words in English and their syntagmatic affordances.

Although 'voleur' almost exactly corresponds to 'robber', the choice of 'pistolet' as the correlate of English 'gun' is a little more complex — it is the one most relevant to the robbery scenario. Furthermore, as mentioned, the equivalent to English 'drop' in it transitive sense is a causative construction 'laisser tomber' (which has its own morphosyntactic affordances). Like the English expression, it is underdetermined as to whether the action was done on purpose or not. Finally, 'décamper' is not the nearest equivalent to 'run' in general contexts, but here the English word is used in the special sense of 'run away', and it is that that corresponds to the French verb — 'to V and run' has the status of a formulaic construction.

Activation of the relevant French words (and the phonological network connections specific to that language) will presumably 'outweigh' (if not entirely inhibit) the associated English ones and from here on the usual process for the integration of a purely French utterance will proceed. The activated words will feed their micro-functional requirements into 'grammatical' cortex, which will integrate them with the top-down template for a coordinated bi-propositional structure, as already set up from the propositional input evoked by the English sentence, constraining its further ramifications. The kernel element in this will be the causative verb complex 'laisser tomber' (corresponding to $Pred_1$), which requires all inflection to be applied to the first verb, and which takes its object ('son pistolet') after the verbal complex. As mentioned, French grammar prefers the possessive determiner here (rather than the article as in English), but has similar 'equi deletion' conditions as in English (no overt shared subject in the second conjoined sentence). The choice of the perfect tense for simple past in spoken French will bring with it the correct templatic ordering of the auxiliary before the past participle of both verbs.

5.   The translation of (2a) to (2b)

Now consider the more complicated case of sentence (2b), repeated here, whose production in translating (2a) can be hypothesized to proceed in the following manner.

(2a)   I see I'll have to go there myself.

(2b)   *Évidemment il faut que j'y aille moi-même.*

The way from the English sentence to the French equivalent is more complex than in the previous case, since it involves higher level differences of organisation. Recall the common propositional structure assumed: 'EVID(DEONTIC (1SG$_{Foc}$ −Pred))'. The relationship of the micro-functional feature DEONTIC to pre-linguistic sensorimotor image schemas or the like is very diffuse and indirect, even though it reflects a diachronic pathway from physical to more abstract Force Dynamic conceptualisations of modality. In fact its cognitive reality surely presupposes a linguistic vessel. Something similar could be said of EVID (evidentiality). A strategy of direct word-by-word translation between the two languages would clearly be less than useful. Reference to the underlying propositional structure is essential. The attitudinally infused element EVID with scope over the rest of the structure directly activates a corresponding sentential adverbial in French, although it corresponds to a syntactically superordinate matrix clause 'I see −' in the English sentence. This has similar extra-propositional scope to the French equivalent, but requires its object, the kernel proposition, to be realized as a subordinate object clause with the normal dropping of subordinating conjunction 'that', so there is in fact no overt structural marking of this except by word order.

The kernel proposition is itself complex, with deontic modality having scope over the subject-predicate propositional core. This is realized in both languages by constructions involving words that have no immediate sensory affordances. The essential difference between the two cases is that the French construction is impersonal, with dummy subject 'il' and the deontic verb taking a subordinate clause – which includes the personal subject of the action concerned – within its scope, while the English verb 'have to' takes a personal subject (that of the main predicate), and can be modulated for future tense where relevant, as it is here. Tense is less relevant in the French construction, where it is critical on the other hand that the subordinate clause be in the subjunctive mood. The two internal predicate modifiers or 'satellites' are realized as adverbials in both languages, the only significant difference lying in the status of French 'y' as a proclitic to the main verb, a matter taken care of by the relevant morpho-syntactic template for complex verbal phrases. The only lexical content word (with full sets of affordances) activated in French is the verb of motion 'aller', corresponding to 'go'. These are, according to my model, located in close proximity to one another in the bilingual lexicon, but, as with all French/English near-equivalents, they are anchored in different phonological networks.

The production of French sentence (2b), once all lexical items are selected/activated, is unlikely to proceed according to exactly the same stages of production as for sentence (1b) since its core is not constituted by the main predicate/verb around which the whole utterance can be built up. The syntactic core is constituted rather by the deontic construction containing the proposition as such ('il faut que' + Subj-V). Once that is activated the core predicate can be expanded according to the integration of its valency/case frame and the general template for complex declarative utterances in the usual manner. If it were the other way round (core predicate first), there

would be nothing to block the expansion of the verb in the (future) indicative rather than the present subjunctive required by the matrix deontic construction (although the personal subject would be in the right position from the start). The English construction could not be built up directly from the internal verb either, but for another reason – the order of constituents is that required by the presence of the modal verb representing the deontic framing element (and the future tense of the predication is integrated with the modal verb rather than the main predicate to which it adheres semantically).

Both cases suggest that the production process starts 'from the outside' of the propositional structure and works inwards to the inner predication. Putting aside the question of how the evidential element is realized for the moment, it is only by starting at the abstract DEONTIC level of the structure that a French equivalent to the English sentence could be rapidly produced. Starting directly from the concrete English expression 'have to' (which forms a unitary verbal complex with subject shared with the main verb) in order to get to the impersonal French construction with embedded personal subject would require a major change in the top-down template (mono-clausal rather than bi-clausal), i.e. an extra (costly) stage.

That the production of the outermost evidential layer is initiated even before the DEONTIC one is suggested by the constraints the former places on the further accretion of the utterance in the case of the English sentence (notably the possibility of inserting the conjunction 'that' after 'I see') and the influence it has on its overall prosodic contour. In the case of the French this same abstract element will produce an adverb – in the same initial position as the English equivalent but presupposing integration with a following simplex clause (whereas directly translating the first two English words – 'I see' – would presuppose a following subordinate clause). Once the choice of evidential expression is made there is no need to back up and change the top-down pattern (NP + VP) pertaining to the internal predicate.

Sentences like this would presumably be more difficult for a late learner to translate than (1a), since the morphosyntactic structure of the English sentence (and the syntagmatic expectations adhering to the individual words) has to be suppressed. The process needs to take its starting point in underlying propositional structure rather than in the surface syntactical construction of the English sentence.

6.   Conclusion

Given a common pool of experiential 'scenarios', the production of a sentence corresponding to a unitary communicative intention by a multilingual speaker in any of his/her languages can, I have argued, be carried out almost entirely at the level of the micro-functional affordances that adhere to the individual lexical morphemes of the particular language chosen. The initial choice of

language will, according to my model, preferentially activate a language-specific sub-set of 'word columns' in the intertwined mental lexicon in the dominant (left) hemisphere of the speaker. Translation of a sentence in one language to another by such a speaker (amongst other tasks) can be carried out by dint of the proximity in his/her mental lexicon of near-equivalent lexemes (or derivational morphemes) that share the same or overlapping paradigmatic micro-functional features. This, I claim, is so regardless of the degree of structural similarity between the languages concerned, since the micro-functional features (however bundled by individual languages) belong to a quasi-universal stock.

Here a caveat must be added, however: if semantically near-equivalent constructions in the two languages do not share similar top-down templates (with a broadly parallel breakdown into nominal arguments and verbal predicates), then the micro-functional affordances associated with the words of the construction in the one language cannot simply be utilized in order to activate those of the other — at least not without considerable additional processing effort. In such cases 'backing up' to a higher-order semantic starting point is surely required, namely to the level of propositional structure. Fluent speakers must have mastered these higher-level cross-constructional relationships sufficiently to be able to utilize them automatically. In fact that may be the principal distinction between fluent early and late bilinguals. Early fluent bilinguals are able, I would suggest, to operate much more consistently at this micro-functional level, which may be activated directly by conceptual intentions without necessitating much (if any) direct lexeme-to-lexeme or construction-to-construction translation at all.

Some of the abstract elements at this level — such as DEONTIC — correspond to and mutually determine language-specific constructions and should not be understood as constituting independent, purely 'nonverbal' concepts. They depend on word-forms and constructions like 'have to' as their mental vehicle, deployable in suitable types of context. It is not at the level of purely perceptual (e.g. kinaesthetic) imagery that one needs to assign their content, even if they are diachronically related — for instance by metaphor — to more basic schemas. It is doubtful whether such imagery is necessarily evoked when these expressions are produced on line, where the usual 'as if' mode of human discourse and description prevails. Rather, it is by virtue of the whole network of associations between the verbal expression (e.g. the French construction 'il faut que –') and its macro-functional, socio-cultural affordances that the construction takes on its specific meaning. So DEONTIC, for example, is the communicative value borne by constructions like 'have to' and 'il faut que' used in the macro-functional situation types associated with them. If these are similar enough then rapid translation back and forth between their expression in the different languages is possible via the lexical concepts they share, without having to draw upon entirely non-verbal 'concepts'. In the case of the skilled bilingual the constructions as such are presumably already primed for mutual interchangeability.

I should reiterate here that the fluent production of utterances by early bilinguals does not necessarily involve any translation from his/her dominant or first language at all. Moreover, late L2 learners may well not have as compact and unified a mental lexicon as fluent bilinguals, as Paradis and others have suggested. Nevertheless, I hope to have illustrated that even for late L2 learners some version of the proximity hypothesis – at least for basic vocabulary – is necessary to ensure rapid transition between (potential) expression of the same conceptual content in one or the other of his/her languages with or without the involvement of lexeme-by-lexeme translation. One might argue that even greater proximity between near-equivalent lexical items must apply to the mental lexicon of the early fluent bilingual, since these items would have been laid down before myelination of the relevant cortical areas had proceeded very far and when the proximity to the relevant sensory/sensorimotor region would have been paramount in the acquisition of basic vocabulary in either language. The prior entrenchment of a near-equivalent word (typically but not necessarily in the dominant language) would have maximally facilitated the entrenchment of the second one, primed by the same conceptual input. This assumes only a faculty for proto-translation associating near-equivalent terms even in early bilinguals, a faculty that for them may eventually wither away and become redundant in actual speech production, to be replaced by increasing skill at recombining lexical features at the micro-functional level of lexical concepts. In this way direct translation could be avoided altogether when switching between expression in one or the other of their languages. Clearly, much more empirical evidence is needed to confirm such assumptions.

Notes

[1] I use the term 'affordance' in a broader sense than Gibson's (1979) original formulation, that is, not just for reaction to perceptual features but also to functional properties of words, both grammar-relevant semantic features and socio-cultural scenarios.

[2] 'Lexical concepts' are bundles of essential semantic features ingredient in individual lexemes, the vehicles of expression (words and morphological morphemes) which allow access to broader cognitive simulations as required. They build on just those perceptual and conceptual patterns of experience that are potentially highlighted for 'thinking for speaking' by the speaker's inherited language (cf. Slobin 1991).

[3] These 'columns', corresponding to Mountcastle's (1998) cortical columns, are schematized as highly simplified templates in Fortescue (2009) and should be conceived of as 'nodes', clusters of individual cortical columns around a core attuned to the semantically contrastive and grammatically relevant features of the word within a distributed network.

[4] I do not wish to suggest complete separation of function between the two hemispheres – it is a matter of relative dominance. As Jung-Beeman (2005) argues, input words may activate parallel semantic fields in both hemispheres, with those in the more coarsely grained right hemisphere being more diffuse and overlapping (thus well suited to representing the scenarios in my Figure 2).

[5] See Démonet et al. (2005: 73) for evidence of the role of phonological processing in rapid translation/lexical access by proficient bilinguals.

[6] cf. for example Damasio et al. (1996) and Perani et al. (1999).

[7] This distinction was introduced by Ullman (2001), who describes the declarative system (the mental lexicon) as an associational memory of distributed representations localized in the temporal and

parietal lobes and perhaps simulateable by connectionist models. This is distinct from the procedural system (involving the sequencing of items, mental grammar), localized in the frontal cortex and basal ganglia and perhaps best modelled by symbol-manipulation.

[8] I say 'largely', since there is evidence that even relatively proficient bilingual speakers unconsciously translate words in the one language into equivalents in the other when asked to state whether two words in the same language are equivalent or not – cf. Thierry and Wu (2007).

[9] For a case where there is a greater difference between the macro-functional scenarios (or 'frames') associated with near-equivalent lexemes in English and French see Fortescue (2009: 56-57), where the relationship between the general English word 'holiday' and a number of specific words corresponding to it in French are discussed.

[10] Each column (or macro-column) should be understood as having numerous connections to other columns in a distributed but locally anchored architecture. Only the most definitional ones are indicated – and these are assumed to be the most heavily 'weighted' in connectionist terms.

[11] The other three dimensions for nouns are auditory, spatial – including tactile – and '(perceptual) object integration' (cf. Fortescue 2009: 14-16). The latter is replaced by '(kinaesthetic) motion' on verb columns, reflecting their extension into frontal (pre-central) as opposed to temporal cortex (cf. Perani *et al.* 1999).

[12] For experimental evidence of the 'skeletal' contents of this scenario see Fortescue (2007). Here it is a type species of 'mental model' (not a token built up in on-going episodic memory). By 'mental model' jn general I mean a structured multi-modal network that simulates actual experience when activated and is in large part perceptually, emotionally and kinesthetically based (though it may also contain reference to specific word-forms). They are decidedly not to be taken as representations in a modally neutral 'Mentalese'

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