CHAPTER NUMBER (?)

THE LIFE CYCLE OF A REPRESENTATION: THE CASE OF GENDER

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Overview

In this chapter, I will present a processing-based ‘working model’ of the mind based on research findings across a range of disciplines within cognitive science. The inclusion of processing considerations should not obscure the fact that representational and processing explanations are integrated within this model, or more properly, within this theoretical ‘framework’. The makes it an extension of theoretical linguistic explanations for changes in the way a language is represented in the mind of an individual. It also runs counter to the current and, in present terms, entirely misguided tendency to see representations and processing routines as entirely separate phenomena. Where research deals with acquisition or acquisition real time, as is the case with developmental linguistics, only an integrated view makes sense. A representation existing in the mind of a specific individual engaged in language-related activity is a particular combination of structural and processing properties. These can change together over time and in different ways: you cannot consider one without considering the other.

The role of language is interpreted, in line with the generative enterprise, as being dependent on a uniquely human, biologically endowed linguistic ability. Language ability in its broadest sense both depends on this core ability but is actually much more extensive involving many parts of the mind that have other unrelated functions. Any unifying framework that encompasses all these aspects will need incorporate much more than an abstract account of linguistic structure divorced from time and space considerations. The manner in which its theoretical insights are formulated out for internal theoretical purposes will not be a reliable and complete guide when working out the nature of those mechanisms responsible for online processing, storage and development. The underlying aim is, accordingly, to integrate theoretical linguistic accounts with current explanations of how the mind processes and stores mental representations of any kind. This has also to be done in a way that is in tune with and can supplement work in current neuroscience.

A platform like this has arguably not been available to researchers thus far and not surprisingly researchers have become so accustomed to doing without one that they seem to have lost any sense of really needing one in the first place. I would argue strongly that such a conceptual platform, providing as its does a much clearer working model of the mind as a whole than one based on vague assumptions, should not be regarded as a luxury extra or perhaps just something for the future but rather as a dire necessity. It does require the abandonment of more locally-based frameworks for the guidance of research. In fact, it depends on them. At the same time, separate hypotheses and theories developed and tested using terminology and techniques that facilitate empirical work only within one individual research area do little to promote a combined view of what they all mean for our understanding of the mind. The tradition of studying separately linguistic representations on the one hand and on-line language processing on the other provides a prime example of academic apartheid that is not in the long term helpful for those interested in accounting for development which requires both perspectives to be combined.

After very briefly discussing the basic features of this framework, I will go on to show how, in terms of the framework, how language cognition fits with cognition in general. This will include: accounting for how two or more languages can be accommodated within the same mind and providing precise definitions for some crucial
concepts that are often avoided or mentioned imprecisely. As suggested by the chapter subtitle, ‘the life cycle of a representation, the chapter will conclude with a brief implementation. This will look at gender. Implementations of the framework can of course differ: alternative explanations can be proposed so this will just be an example to illustrate how the framework can be exploited. Grammatical gender will in fact form a thread running through the whole discussion.

Nesting frameworks

Every researcher in language acquisition must do necessary work with some mental model of how the mind is organised. The model may be largely implicit although there will explicit, more elaborated parts reflecting just those areas where the researcher in question work and therefore is most expert, an obvious example in the context of this volume being what generative linguistic theory provides including empirical studies in particular aspects of grammar and in particular languages. In addition, there may be other somewhat less elaborated areas which have proved to be of obvious and immediate relevance either in providing methodological tools or theoretical insights or both. What might some of those aspects of mental organisation be that one might expect any researchers to be knowledgeable about, that is apart from the abstract linguistic properties of a given language system? Clearly, they would have to be issues concerning linguistic development in real time. Here is a small rough-and-ready checklist containing just a handful of the fundamental questions that would require coherent and detailed answers:

1. How do you personally imagine the way the mind instantiates and manipulates representations in real time?
2. What is working memory and how does it work?
3. Interface should be a familiar commonly used concept from the generative linguistic literature: how exactly do you think an interface works in real time to shed light on experimental results in studies of
   a. on-line processing?
   b. development over time?

My guess is the few researchers would like to be put on the spot and asked to produce detailed answers to these questions on the spur of the moment. The reason for that is twofold. First, given the current state of our knowledge in the relevant areas of cognitive sciences, there is very little consensus about any of these issues. Secondly, most researchers simply do not have the time available to acquaint themselves with the relevant research fields and review all the available options and will tend to plump for what seems to be the most accessible and long-established approach. One way out of this dilemma is to commit to interdisciplinary research projects, a norm in the hard sciences and increasingly popular now in cognitive science. Another way, especially compatible with the first, is the main focus of this chapter, namely to look for and use a wide-scope framework in which coherent, explicit commitments are made about just the kind of questions listed above.

‘Wide-scope’ here means that in principle a given currently used framework in one or more subdomains can be ‘nested’ within the wide-scope framework. One positive outcome of this nesting of frameworks, apart from its potential to expand and refine explanations of data, should be synergies that enable the refinement of the frameworks themselves. By the end of this chapter there should be answers to each of the question listed above, each of which will be precise and coherent. Whether they are right or even useful is of course an empirical question.

There should be no controversy about the need to take a wider perspective on local theoretical issues. Indeed, it has increasingly been acknowledged in the research literature: wishes for this need to be addressed typically take one or other of two forms:

1. the ‘whole mind’ perspective
2. the ‘mind/brain’ perspective

Expressing the whole mind perspective, Thierry, a neurolinguist, writes as follows: ‘The time has come, perhaps, to go beyond merely acknowledging that language is a core manifestation of the workings of the human mind and that it relates interactively to all aspects of thinking’ (Thierry 2016). The second, mind/brain perspective is expressed by Kroll, a psycholinguist looks in the other direction: ‘Understanding how different aspects of language processing will engage cognitive and neural processes will be crucial’ (Kroll 2015). These sentiments seem to me to implicitly underline the need for a facilitating conceptual framework of some kind. Such a framework should specify with much greater precision than has been customary hitherto the relevant
psychological processes and mechanisms involved. The proviso is only that this should take account of theoretical views and empirical findings in cognitive- and neuro-scientific research.

**The Interactive Modular Mind**

**The framework**

The wider-scope framework to be used in this discussion is the *Modular Cognition Framework* (MCF). A brief comment on this name is appropriate at this juncture. The framework has been known more widely as the MOGUL (Modular Online Growth and Use of Language) framework. Accordingly, in all discussions relating to language cognition as in this chapter, it can still be used interchangeably with MCF: MOGUL happens to be the instantiation of the framework that is used specifically to explain language-related phenomena. In order to situate language within the mind as a whole so as to account for general issues such as perception, memory, cognitive control, attention and consciousness, it had been necessary to widen the scope to take that into account: the MCF name more appropriately reflects that mind-wide perspective which should be equally applicable to research on areas of cognition other than language.

I will now outline briefly the main features of MOGUL (MCF). The mind, like the brain, has a modular architecture. In broad terms this is fairly uncontroversial, the devil being in the detail. In MOGUL, this means that the mind is composed of a network of interacting expert systems each of which has an identical basic design. This basic design is of course neurally instantiated in many different ways but a mind-based account abstracts away from these. The modular system can be seen as a *collaborative network*, coping with a myriad of different tasks in parallel and with the modules connected with other modules by means of *interfaces*. Its neural instantiation will also be a network of interacting systems but will naturally look quite different. Unlike the interfaces posited purely within the context of mainstream generative linguistic literature, the framework versions are processors that operate in real time. They generally mirror the way interfaces are described in Jackendoff’s architecture of the language faculty (see, for example, Jackendoff 1987, 2002). Moreover, these interfaces, as just mentioned, are not limited to just those that connect up the language-specific systems to adjoining systems outside but include all the other connections between modules as well.

Another important point is that, within this collaborative network of modular systems, no system can be described as ‘domain-general.’ This term has been frequently used as a convenient way of saying ‘not in the language module’ or ‘not governed by principles of UG’ and so the implications of the existence of a domain general system have not been found relevant. In MOGUL, there are two potential candidates for domain-general status. The first obvious one is the *conceptual system* which in the human mind forms a central hub for many of the mind’s operations and, although its neural underpinning involves a number of different brain systems, the most striking one is the human prefrontal cortex. The second candidate is a temporary phenomenon related to the generation of conscious experience. It is what arises when intense synchronised online activity occurs in the various perceptual memory stores: while in progress, this collaboration produces an effect called *global working memory* (GWM) (Truscott 2017, e.g. Engle 2002). However, both these two candidates fail to fit the idea of a central processor where all mental activity is supervised. The conceptual system, even though it often plays the role of a central hub where connections between different stores intersect, it still cannot be treated as a controlling mind-within-a-mind. In other words, it is no homunculus. Rather, it conforms like any other module to the same basic working principles in the way it works internally and the way it works externally via its interfaces with other modules. Global working memory, the other candidate, does in some measure have the appearance of possessing a supervisory, decision-making capability (which may be illusory; see Libet 1993). However, being exclusively about various degrees of awareness, it excludes by definition the vast majority of mental processes that work below the level of awareness and therefore beyond its direct control: it is an Oval Office with the computers down, the doors locked and very few people available to respond to orders. To sum up, whatever we may think, no one system controls the mind, which is not hierarchical but rather *heterarchical* (without a permanent central executive in place).

**Modules: the basic design**

I will now spell out, for those less familiar with MOGUL, the basic features of any module in the framework although some points will be made that have not been regularly emphasised in earlier publications. The reader is encouraged to keep in mind two things, firstly the fact that in most of the processing (psycho)linguistic literature there is frequent mention of given linguistics constructions being ‘harder to process’ or ‘easier to process’ on the basis of relative response times and/or measures of accuracy and secondly, the absence of any clear account of how the processing mechanisms that produce these particular responses actually work. This may seem an
unjustified or exaggerated claim because frequent references are made to working memory and to particular accounts of what that is. Apart from the fact that working memory research is a dynamic field with much controversy and a variety of theoretical approaches on offer, the details of how processing works and the commitment to one or other of these approaches are not a regular feature of discussion sections of psycholinguistic studies (see Sharwood Smith 2017 and other contributions in the same special issue of Second Language Research).

A modular system contains a processor and a store. The processor is driven by principles unique to that module. For example, the syntactic module is constrained by syntactic principles the nature of which is defined in various ways in syntactic theory. These principles have the effect of ensuring that any syntactic structure or ‘representation’ known or created by an individual conforms to what can be thought of as a syntactic code. A processor works in real time so it activates and assembles representations in response to current processing demands, which will be elaborated shortly. If we can say, using familiar terminology, that any syntactic representation must ‘conform to the principles of UG’, in this case as instantiated in the syntactic processor, then effectively we can say that any module has its own ‘UG’. The special contribution of syntactic theory is precisely to shed light on the properties of the syntactic processor and the syntactic representations it handles. In fact the notion of a module-specific code which is part of our biological endowment can be applied across the board. In this way any visual representation must conform to ‘visual UG’, or in present terms, the visual code and this will reflect innate, universal human principles governing human visual cognition. Note also that visual processing and syntactic processing in the brain, as indeed any other kind of neural processing, are distinguished by unique neural patterns as well. In other words, this modular idea can work in neural terms as well although obviously in quite dissimilar ways as it involves particular brain locations, neural patterns and pathways.

Turning now to the stores, which house the structures of a given module, these structures include primitive elements, structural properties or features from which more complex representations can be assembled and which reside in the system from the start. For example, the visual system will have its own primitives to help build complex representations of visual input over the life time making human vision different from vision in any other species. Theoretical linguists may think of a store as a syntactic lexicon or ‘syntacticon’ (Borer 1984, Emonds 1985, 2000). However, responding to input over the lifetime, these primitive structural elements may be combined in various lawful ways to build new complex (syntactic or other) structures in the appropriate (memory) store. The primitives are already there at birth, ready to be used when required. Hence a store will contain not only the primitives but all these more complex structures that have been created. A psycholinguist will see stores as memories and indeed this is what they are, one for each module. A modular approach to memory is very much in line with current thinking about memory in psychology as well as neuroscience (see for example D’Esposito and Postle, 2015, Erikson et al. 2015 and Oberauer et al. 2016).

**Representations and neurons**

For those who are not classical connectionists, the basic idea of a representation is a familiar term and is defined in various ways according to a given researcher’s theoretical stance. The above description of structures in a store as either basic simple structural items (primitives) or combinations of those items forming more complex items should not be objectionable. Whatever the preferred ways of describing representations in a given theory are, it should be easy for most people to reconceptualise a representation as a network, either as very local networks of features expressing some basic structural category or as a combination of such micro-networks into a larger more complex representation. The designation of the smallest items as ‘primitives’, that is structural items that are provided as part of our biological inheritance, is more controversial but should certainly not be objectionable to those of generative linguistic persuasion. Furthermore, the description of structural items of greater or less complexity as being subject to processes such as storage and (co)activation will not give psycholinguists any cause for complaint provided that they do not hold to the view that the concept of a representation is just a convenient post-hoc description for what is actually a set of interconnected nodes that have no symbolic function.

Interestingly, neuroscientists who may not regularly employ the term ‘representation’ in describing neural phenomena may nevertheless still find the concept attractive, important and potentially very useful. Accordingly, some have felt the need to spell out what a representation might be in neural terms. Antonio Damasio, for example, uses the term dispositional representation which he defines as ‘a potential pattern of neuron activity in small ensembles of neurons’ which “may be distributed over a number of different locations in the cortex” (Damasio 1994, pp. 102-105). Joaquin Fuster uses the term cognit the definition of which seems to fit best with the kind of representation, that involves a set of connections between representations ranging across different systems so not just representations within a single store (Fuster 2006, 2007, 2008). Both see
representations as assemblies of interconnected neurons and Fuster makes clear that it is, for him at least, the neuronal patterns that count: the same cognit may involve different neurons on a subsequent occasion and still be the same cognit. He also assumes that some cognits are innate.

In sum, it seems appropriate to note that if neuroscientists feel the needs to spell out what they think a representation might be for them, then researchers working in linguistics, in this case generative linguistics, should be equally interested in exploring and even developing the intellectual interface between theoretical psychological and linguistic constructs on the one hand and the theoretical concepts used in brain research on the other. For this to work effectively, you need a platform for doing this, which researchers working in these different areas can use, in other words an overarching conceptual framework.

**Module cooperation: interfaces and schemas**

In the mind we can distinguish between the (sensory) perceptual systems on the one hand and the modules involved in deeper level processing on the other. The perpetual systems responsible, respectively, for visual, auditory, gustatory, olfactory and somatosensory representations (seeing, hearing, taste, smell and body sense) together form the portal for the initial cognitive processing of environmental input (the ring of modules in Fig.1). In neural terms, this is already about the different functions of the cortex rather than the initial, peripheral systems responsible for the transduction of environmental stimuli via the various sense organs. The auditory module, to take one example of a perceptual module, receives inputs originating in the ear and builds, processes, stores and activates auditory representations for any kind of sound (linguistic or otherwise). In the MCF, and therefore in MOGUL, these representations are known as auditory structures (AS). We can, in this way, distinguish between the brain’s auditory system which is distributed across the brain as pathways and various cortical locations, and the mind’s auditory system. The latter, at this deeper level of abstraction, can be conceptualised more economically as a single system in one metaphorical location, a module in fact equipped with an auditory processor specialising in auditory structure and an auditory store where the structures are housed, and where they can be activated.

![Figure 1. The perceptual portal featuring five stores](image)

Experience of a bee, say, will require these two modular systems to collaborate. In present terms, this means activating an association between a particular auditory structure (AS) in the auditory store on the one hand and a particular visual structure (VS) in the visual store on the other. This operation is carried out in parallel by means of the existing connection system between the two modules concerned: this is the visual-auditory interface represented thus: AS ↔ VS. Note that interfaces are shown in the figures as bidirectional double arrows connecting the stores. This particular two-way collaboration between two separate modules goes a little of the way towards explaining a particular instantaneous bee experience.
Further collaboration between modules at the second deeper level will enrich the experience: engaging the conceptual module, for example, will provide a meaning in the form of a conceptual structure (CS). The conceptual system will have interfaces with both the visual and the auditory module (CS $\leftrightarrow$ VS and CS $\leftrightarrow$ AS). This provides us with a very simple example of a small representational schema with three nodes, i.e. three representations, each from three separate stores, each encoded in a manner different from any other module (see the three small circles in Fig 2). These three representations, each in a different store, can be activated in parallel, as a schema, but they cannot be merged into a single structural unit because they are mutually incompatible because they are written in different codes, respectively auditory, conceptual and visual. This collaboration without incorporation of representations reflects the key feature of this type of modularity and the parallel processing architecture of the current framework. More will be said later about the conceptual system and its role in giving the instant, complex experience of the bee its unified character.

Before going on to describing language processing, one question needs answering straightaway, namely: how do interfaces actually form associations between representations sitting in different memory stores in the first place? Exactly what mechanisms are involved? Acquisition in terms of the framework can be defined precisely and minimally as a time that an association between representations (structures) is first made. In other words, acquisition thus defined is instant. The moment of acquisition for any representation is also at present difficult to establish empirically but the idea behind it should be quite acceptable. A connection between two representations can be formed within a modular system as well as between systems. In the case of an association between representations in adjoining (interfaced) modules, the representations involved are each given a specific index marking the fact that they are now associated. For convenience we can imagine that this index is a number. The interface(s) involved in a given representational schema or simple chain of two assigns an index to each representation. For example, CS$_{123}$$\leftrightarrow$ VS$_{123}$ shows the assignment of a particular meaning to a particular visual representation using a (here randomly picked) number. In addition to the operation of assigning indices, an interface’s subsequent function is to co-activate structures that have identical index. Next time CS$_{123}$ is activated VS$_{123}$ will be coactivated along with any other representation that has the same index.

To sum up, an interface assigns indices and coactivates co-indexed structures such that when one structure within a store is activated, for whatever reason, all the others are immediately coactivated as well. Once a bee is sighted, all associated representations become active, thanks to the interfaces. Interfaces can be thought of as simple processors that have this function of associating and coin dexing. However, when representations are first associated within a single module thus forming a more complex representation, clearly no interfaces are involved. Rather, it is the processor belonging to that module that binds them together in line with its own unique, internal set of principles. The addition, by the syntactic processor, of a syntactic gender feature like [fem] or [masc] to a pre-existing ‘genderless’ assembly of features would be a case in point. This is the way all modules work, internally and externally. Representations will be associated in various ways within modules and across modules and they may in the course of a lifetime come to have many indices attached to them to reflect their multiple intermodular connections.

**Memory.**

Memory has already been also described as modular: in other words, each module has its own memory. These are the ‘stores’ referred to above and examples can be found, displayed as boxes, in Figs 1-3. However, memory is not internally modular. They do contain representations which can be either simple or a cluster of associated representations as is expressed in the idea of ‘feature assemblies’ (Lardiere 2008). Apart from that a memory store has no subsystems. This means a particular stance is taken on the status of working memory which is not the modular view of working memory pioneered by Baddeley which has proved so popular in psycholinguistic studies (Baddeley 1986, 2012, 2017). By contrast, the MCF adopts the ‘state’ view, namely that representations in working memory are defined as those representations in a store that are currently in an activated state (Cowan 2005). In other words, this means that whenever a processor activates a given representation, that representation is ipso facto ‘in’ working memory, or, in more precise terms ‘in a working memory state’. For
example, at this psycholinguistic level, a minimal MOGUL description of a word currently in working memory will involve the coactivation of three separate representations, each one in a different memory store, each being either simple or complex representations written in the code of their particular module but all sharing the same index, call it ‘456.’ The word with the meaning ‘bee’ would then be a combination of phonological, syntactic and conceptual representations expressed very roughly as PS_{456} \leftrightarrow SS_{456} \leftrightarrow CS_{456} or thus: 
/\text{bi/}_{456} \leftrightarrow \text{N}oun \,[\text{singular}]_{456} \leftrightarrow \text{BEE}_{456}.

The interfaces ensure that when one is activated in its respective module, the other two will be immediately activated in parallel. The specification of the conceptual structure which happens to be in English (CS_{456} in this example) reflects the abstract meaning of the word, not its language identity. The phonological structure in the above example (PS_{456}) is one associated with English but BEE could equally be associated with syntactic and phonological structures that are appropriate for representing equivalent words in other languages like Portuguese “abelha”, Polish “pszczoła” or Dutch “bij.” Also, the complete syntactic representation of SS_{456} may or may not contain a gender feature and the specific gender feature might be [fem] or [masc] or another gender depending on the language and the current state of the individual’s knowledge of that language.

The processing characterisation of this word as a combination of just three different types of structure (PS, SS and CS) is a simplification. In fact, more modules will have been involved than those of primary interest to phonologists and syntacticians or indeed those primarily interested in semantics and pragmatics. The original cause of the co-activation of PS and SS will have been external input into one of these two modules. In speech or written production, it will have been the activation of the conceptual structure already mentioned, namely BEE. In speech comprehension it will have been the AS (auditory structure; see Fig 1). This AS will itself have been activated in response to input generated by raw acoustic stimuli (speech sounds in the immediate environment). In all cases, initial input, wherever it came from, will have triggered the parallel coactivation of all the coindexed structures in the modules involved.

Another point is that, within any of the given modules, clusters of associated representations will have been activated making them more complex than was shown in the above examples. For example, the simple characterisation of N[singular] may, in fact include representations of gender, case, number etc. Different languages will of course have different outcomes. In Portuguese, the same meaning (CS) should have triggered, apart from a different PS corresponding to the sound of the word ‘abelha’, a feminine gender feature [fem] in the syntax module. This gender feature will not have been triggered for the English counterpart, CS BEE, at least in the mind of a monolingual English speaker since English, unlike Portuguese, does not have grammatical gender.

**Competition and activation**

Crucial to any account of language processing or indeed cognitive processing of any kind is an account of how input from an external source is responded to, whether that input is a) still somewhere within the collaborative network itself and involves input from one module into another or b) literally external, i.e. physical stimuli originating in the environment in the immediate vicinity. As suggested above, competition is a dominant feature of input processing. This will be very familiar to those working in the psycholinguistics of bilingualism\(^{18}\) processing since there is almost a consensus now maintaining that bi/multilingual processing is ‘non-selective’, in other words all languages are activated to some extent in a bilingual’s mind irrespective of the one currently being used. This means that input will trigger competition between structures irrespective of their linguistic origin before a best-fit is found. Competition is also standard in the monolingual individual since there are often alternative solutions to representing a given meaning even within a language system. This is not confined to accurate representations. For example, on hearing “bee” a monolingual English speaker will have inadvertently activated rival phonological candidates more appropriate to words like “me” and “bay”, so called phonological neighbours. From a MOGUL perspective however, the regular use of ‘selection’ and ‘selective’, in themselves harmless and useful metaphors, requires a strong accompanying cautionary statement to the effect that there is actually no ‘selector’. In other words, the final outcome ‘falls out’ as a best-fit solution and not because there is a procedure involved whereby some kind of subconscious executive ‘chooses’ one solution over the other: the winner in a race has not been selected as the winner but just happens to have run the fastest. The ‘selection’ idea only really makes sense, possibly, when conscious decisions are involved. In fact, as indicated earlier, since Libet’s well-known experiment in 1993, even the status of conscious decisions has been open to question (Libet 1993). It might still seem to some people to be extremely uneconomical to have so much non-selective, competitive activity go on at a subconscious level when only a very small part of that activity is reflected in the final representation of some input. This should not, however, pose a problem if one accepts that the vast amount of subconscious activity that goes on in the mind/brain is actually very resource-friendly and could even be...
considered as virtually resource-free. Conscious processing by contrast requires intense levels of activation and is therefore not at all resource-friendly. It forces processing out of its parallel mode into a serial one. As has been recognised since William James, especially where unfamiliar tasks are concerned, it is also experienced as more or less effortful (James 1890, Dehaene & Changeux, 2011). Puzzling consciously over what the gender of a particular word in Portuguese might be might be quite tiring. Subconscious gender assignment just happens.

Activation lies at the centre of any processing model, also in neural explanations. Competition arises between those representations that have been activated and not those that lie dormant, that is to say at some kind of resting level. A framework of the present kind needs a theory of activation in which the mechanisms that cause a structure to change its state from ‘resting’ to ‘activated’ are described in precise terms. This should also detail the way in which activation increases and decreases in strength under given circumstances. In a framework of this kind and arguably in any approach to language development (acquisition and attrition), it should be possible to have a way of talking about representations that includes both a) the structural linguistic properties and b) their processing profile at the same time. This makes representations more than just ‘present’ or ‘absent’ in a person’s mind: it allows for different degrees of accessibility or robustness.

As is true for working memory and other crucial component of any cognitive processing theory, without some commitment to a view on activation, discussions about how word and constructions are processed should be viewed with an appropriate degree of scepticism. However, with such a commitment we at least have the basis of a proper language processing model to work with until a better one comes around (see for example Paradis 2004, Sharwood Smith and Truscott 2014). Furthermore, along with a theory of activation, we also have in the current framework a transition theory, that is a proper theory of acquisition as well, something arguably most non-connectionist or non-behaviouristic work on language acquisition that does not, and has never had (Gregg 1996).

There are various ways of representing the idea of activation. In MOGUL a vertical height metaphor has been used but it would be equally possible to represent degrees of activation with light so a representation would glow intensely if it was strongly activated, weakly if it was only slightly activated or remain dim if it was at its current resting level of activation (RLA). If we keep in mind that memory is not to be broken down into separate components like long term and short term and working memory and divisions beyond that as in Baddeley’s model of working memory, vertical height nevertheless gives a better idea of how activation works, so imagine a memory store as a tank with structures (representations) suspended at different heights (see Fig 3). This would show structures at their current resting levels the height being determined by how much they had been activated previously. The uppermost layer of the store would then be the place where representations ‘arrive’ at a point in working memory where they are ‘selected’ to participate in on-line processing. Selection, in this metaphorical sense of the term, will therefore depend on the outcome of representations that are currently competing for participation. Let us assume for the moment that gender features are syntactic primitives. A never-activated masculine gender feature, say, in a monolingual whose L1 has no grammatical gender would be resting at the bottom of the syntax module whereas another monolingual whose L1 has grammatical gender, including masculine gender, would have the respective feature floating at a higher level in the store with a better chance of making it to the top of the store and outcompeting any rival candidates. Note in passing that ‘low’ and ‘high’ are used differently in the way Paradis frames his comparable activation threshold hypothesis so that every time an item’s activation threshold is ‘lowered’, it becomes more accessible (Paradis 2004). Here working memory accessibility is increased the more an item’s RLA is ‘raised’.

From this description of activation, two things emerge. Firstly, activation is a relative concept and admits of gradience. Secondly, resting levels of activation (RLAs) depend on previous activation history. This idea is expressed in so-called Activation by Processing Theory (APT) introduced in Truscott & Sharwood Smith (2004). Out of context, APT could describe many frequency-driven theoretical approaches to activation such as emergentism and any version of connectionism. Note, however, that in this modular parallel processing architecture, frequency only really counts with regard to a specific module’s memory and perhaps also the history of its coactivation via its interfaces. RLAs have a very indirect relationship with frequency of input coming from the external environment. As modules participate in building representations, a particular memory
store has to be engaged during this online mental activity for any representations in that store to have their RLAs raised. This will be illustrated later in the life-cycle example below. In other words, module-internal frequency of activation is what counts and not automatically what happens in other modules and especially not what happens in the external environment. In addition, what happens in language attrition is also linked to activation history. A reduction in the frequency of activation is going to impact on a representation’s RLA making it less accessible. This happens not only with a complete cessation of activation but also with continued weak activation, that is when, say, a gender feature is activated on a given occasion, since activation is non-selective and does not depend on which language is being used, but regularly fails to participate fully in online representation cutting off its activation time. So, in other words such a feature is still activated as a matter of course along with other representations but is nevertheless regularly outcompeted by rival representations associated with another now more dominant language, e.g. an ‘L2’-specific. This ‘loser’ will be deactivated before it has a chance to participate in the representation of current input thus reducing the time and intensity of its activation compared with the ‘winners. Selection and participation in the representation of current input gives a representation its best chance of remaining competitive. Continuing failure will, over a period of time, cause a cumulative decline in a structure’s RLA.

Three levels of description
To sum up so far, cognitive representations, including those associated with language cognition, can be studied at three distinct levels of description. Firstly, at the top, there is the theoretical linguistic level. Here spatio-temporal aspects can be safely ignored even where the theoretical linguistic framework used is intended as a contribution to psychology and/or biology as is the case with the biolinguistic perspective strongly associated with those working with the Minimalist Program (see Sciullo & Jenkins 2016). Staying strictly within theoretical linguistics, theorising permits the free use of metaphors of space and time without any necessary suggestion that the mechanisms used actually related directly to real time and real space. You might, for example have a ‘merge’ or ‘feature-checking ‘stage’ (a temporal metaphor) in the derivation of a particular construction. This may be a very effective and economical way of describing the architecture of, in this case, syntax. The architecture designed at this highest level of abstraction cannot however be imported without further ado into a description of how the language system works at the next, lower level of description which is the psychological level or even beyond that to describe operations in the brain at the neural level where real space is involved as well as time. Psycholinguistically speaking, a representation has to be at least situated in time since we need to know its psychological characteristics, particularly its current RLA or the RLAs of its component parts and perhaps its likely competitors. This we find out using various instruments including those that measure response times. We may also incorporate measures that deliver neural data, in other words, brain imaging and ERP (event related potential) measures. This strategy somewhat fudges the distinction between the second and third, least abstract level of description namely the neural level, the one referred to above when Damasio’s and Fuster’s notions of representation was discussed. ERP data will include not only the timing of particular responses when investigating participants’ current knowledge but also the presumed brain locations involved, something that is actually best identified using fMRI scans. This means, for a psycholinguist, that a representation should be a combination of the properties derived from theoretical accounts at the highest, most abstract level of description plus their real time processing characteristics which are described theoretically at the second, psychological level of description: at this point you have a solid basis for empirical psycholinguistic investigation. A given Spanish noun phrase in psycholinguistic terms will therefore look different and behave differently in a Spanish L1 user and a Spanish L2 user and any other kind of Spanish user. In all of these individuals there may well be a gender feature associated with that NP but the gender representation that forms part of the complex representation (the NP as a whole) may well have a different RLA making the overt behaviour of each speaker different just for that NP. A complex representation’s overall profile can only be assessed by looking at the performance characteristics of each of its component parts. N(oun), for example will have a very high RLA but various features bundled with it may include some with low RLAs because these particular features have only recently been acquired (in the minimal sense used here. At the third level of description, the neural level, this selfsame NP in a given individual will be described as a particular pattern of neurons whose spatial characteristics with regard to approximate locations in the relevant areas of the cortex and pathways cross different systems. Something that will only really be possible in the future. Here again we may hope that given characteristics of representations at the psychological level of description will be relatable to, for example, synaptic strengths and resting potentials at this neural level. The neural plausibility of psychological architecture cannot be taken for granted, and vice-versa so interdisciplinary cooperation is needed to maintain plausible relationships between these two levels.
Modules and the language faculty

Turning now to the overall MCF architecture, the set of modules in the current version of the framework contain what is represented in Figure 3 except for two modules not yet added. Here, in Fig 4., we see the outer circle of perceptual structures to which three more modules have been added (displayed as grey boxes, again without the accompanying processors). These three are involved in a second ‘deeper’ level of cognitive processing. Each is connected with all the others via interfaces. Although in Fig. 4. there is no real relationship between size and importance, the central module, the conceptual system, is in fact one that is strikingly different in the human species being enormously elaborated and complex, even begging the interesting question as to what extent it has parallels in other species. If it does, then the human conceptual system still stands out by virtue of its immense complexity as one obvious way of differentiating us from our evolutionary cousins (see extended discussions in Truscott and Sharwood Smith, in prep).

If emergentists and cognitive linguists were to have their way, Fig. 4. might already for them represent an acceptable model of the human mind. Let us pursue this possibility for a moment. As has been shown above, it is definitely possible to form sound-meaning connections between the auditory representation (AS) of a spoken word like “bee” with a meaning representation (CS). To a limited extent this kind of connection would work in animal cognition, for some animals at least, as long as the existence of a simpler conceptual system for them makes sense (Truscott and Sharwood Smith 2014, p. XXX, Sharwood Smith 2017 p.XX). Given the complexity of the human conceptual system would it not be possible to assemble not only a vast lexicon in this way but also relate the resulting set of words and their component parts to a grammar without recourse to innate linguistic properties? If so we could dispense with the notion of an innate language faculty.

In terms of the framework, the answer to this challenging question is both ‘yes’ and ‘no’. The conceptual store is a repository of representations that together constitute the core of our understanding of the world we live in and so contains the basis for our encyclopaedic knowledge and episodic knowledge reflecting our person experience. This includes the explicit ‘declarative’ grammatical knowledge that we can reflect upon and analyse consciously, in other words metalinguistic knowledge about grammar, what might therefore be termed our conceptual grammatical knowledge (Sharwood Smith XXX). As a place where meaning is stored and processed, it also includes anything falling under the rubric of lexical, semantic, pragmatic and discourse knowledge, all potentially amenable to conscious introspection. Much if not all of language cognition is already accounted for, it seems. This explains the ‘yes’ The ‘no’ has to do with the two missing modules which together constitute the core language system that lies at the centre of human linguistic ability, namely (in line with a version of Jackendoff’s parallel architecture: Jackendoff 2002). These are, respectively, the phonological and (morpho) syntactic modules. Irrespective of difference in the generative linguistic world about the precise nature of the narrow language faculty, shared arguments about learnability and the basic rationale for a human-specific language faculty are the basis of this framework’s characterisation of language in its broadest, most inclusive sense. More will be said about the framework’s bimodular core language system shortly.

The other two non-sensory perception modules in Fig.4. are the affective and motor systems. The affective system is very much work in progress; at least as it is currently presented in discussions of the MOGUL framework, it relates to the way representations of different kinds generally may be valued, that is, in positive and negative terms and with various degrees of strength. This gives it a powerful position influencing processing and storage of all kinds. The assignment of a given value is determined by interface connections between the affective store and the relevant representations in the stores of other modules to which the affective system is
connected. The ways in which the representations RLA can be given an extra boost or otherwise inhibited under varying circumstances can be attributed to the influence of affect. This idea has been recently applied to the explanation of code-switching (Truscott & Sharwood Smith 2016; see also Sharwood Smith 2017b).

Following APT, a very recently acquired structure such as [masc] newly co-activated with [N]oun for the Spanish word “problema” (problem), should sit at the metaphorical floor level of the memory store, i.e. with a very low RLA, making it minimally accessible. At this early stage, the learner may well have [fem] associated with this word by analogy with many other words in Spanish ending in -a. [fem] will have a higher RLSA that [masc] and so for a time may compete successfully leading the learner to persist in producing, for example, non-native determiner-Noun agreement (*la problema). For a time [masc] will be activated only very weakly, awaiting the time when frequent exposure to input such as “el problema” will have gradually raised the RLA of [fem] to a point where it too can regularly participate in the speaker’s spontaneous speech and outcompete [fem]. At the same time, the learner may have become metalinguistically aware of the incorrectness of “la problema” which means his or her conceptual grammar will reflect the native norms while at the same time spontaneous production driven by the syntax module will still be reflecting the dominant [fem].

The third ‘movement’ module in Fig.4, i.e. the motor system, is responsible for the cognitive control of the body’s motor responses. It is as it were the software part of motor control and its interfaces with other cognitive systems ensure that for example meanings (conceptual representations) can be realised as movements of the speech organs and the production of appropriate sound wave patterns. A complete schema corresponding even to the production in speech of the word “bee” will be a much more complex network than the one suggested by Fig 1 and would certainly include motor structures and auditory structures as well since speakers will always, subconsciously or otherwise, be monitoring their production of the word by activating the related auditory representations that match the acoustic processing of the selfsame word. In other words, when we talk in psycholinguistic terms about the ‘representation’ of the word “bee” we are actually talking about a complex set of interrelated representations involving interfaces and modules across the system as a whole. Two of the implicated modules will be the ones that make up the core linguistic system mentioned above and which were left out of Fig 4. These are the phonological system specialising in the processing of speech structures and the syntactic system which deals with (morpho)syntactic structures. There is one interface that links these two systems: the phonological module associates speech representations (PS) with syntactic ones (SS). Reaching outside the core linguistic modules to mental systems that are not specifically linguistic, the SS ⇔ CS interface associates syntactic structures (SS) with conceptual ones (CS). Similarly, the AS ⇔ PS interface will associate generic sound (auditory) structures with phonological ones. This means that both the auditory and the conceptual systems being non-language-specific, also store and process structures that are not language-related.

Fig 5 accordingly shows gives the completed model of the mind with the core linguistic systems added in. The thicker interface arrows represent the direct connections within and beyond the two core language systems. A direct link between phonology and vision is included in line with sign language theorising that suggests just such a connection and even uses the term sign language ‘phonology’ despite the fact that no sound is involved (Sandler 2012).

**Activation and consciousness**

No mind-wide framework should exclude some account of consciousness reflecting current thinking on this thorny issue. Despite continuing, inevitable controversy, a picture is building in neuroscience that conscious awareness is generated by means of high levels of activation in different brain locations in synchrony with one another (see, for example, Crick and Koch 2007, Baars 2007, Dehaene 2011). Also common is the idea that consciousness is intimately linked with perception.
Consciousness plays a very important role in understanding language. For instance, experimental techniques used to access language knowledge and ability typically involve participants’ conscious participation: at the very least they are conscious of what they are expected to do before and as they perform tasks and they will have conscious thoughts concerning what they know or suspect the experiment is about. But related questions touch on more general issues such as the nature of metalinguistic knowledge and metalinguistic processing and what terms like explicit and declarative mean in terms of this framework. What, for example, is the status of my understanding of how gender works in Spanish and the difference between grammatical and biological gender? Briefly, the MOGUL/MCF take on this is as follows. Conscious awareness is generated in the perceptual systems (the outer circle of systems in Figs 4 and 5). To create a unified experience, the representations in the working memory of these systems have to be very highly activated and synchronised. This gives us and at least our fellow mammals basic awareness that is the global sense of our surroundings at any given moment. When some aspect of this global awareness gets focused on, processing of this particular area in focus is intensified. This is normally referred to as attention. Humans and many other species need this ability for survival, for example to deal with potential threats.

Attention has proved notoriously difficult to distinguish from awareness (see for example Boxtel et al 2010). The framework approach at least permits a basic definition of attention as having to do with different degrees of (sensory) perceptual awareness, in humans and other species as well. However, this does not explain the explicit knowledge of, and focused reflection on the Spanish gender system. For this, as mentioned earlier, we need the complex human conceptual system. The framework account goes as follows. We have developed the ability to project the content of conceptual representations into global perceptual awareness. Provided I have conceptual representations of the Spanish system that are sufficiently well established (with high RLAs), I can project the meaning content into the perceptual systems. There I can perform what (it might seem) only humans and can perform namely the thought operations we know as introspection, conscious analysis, planning and imagining. I can think about different theoretical approaches to the acquisition or attrition of Spanish gender and I can even dream about Spanish gender. The downside is only that this requires such high levels of activation that it can become effortful and the speed with which I can operate in this mode is hampered by the probably related fact that thinking has to be serial: in other words, it cannot benefit from the speed and efficiency associated with parallel processing.

These perceptually-based accounts of the conscious awareness of language structure would certainly be compatible with various views expressed in cognitive and neuroscience. What we cannot project into conscious awareness or even be minimally aware of is the structure and processing activity of the conceptual representations themselves only their content projected into the perceptual systems. This limitation goes for any module and any interface in the system as a whole. Moreover, in line with the notion that phonological and syntactic structures are also completely inaccessible to awareness in any sense, grammatical knowledge representations and grammatical processing in the core language system are quite different from the representations involved in, for example, our explicit, declarative knowledge of Spanish gender. This is projected from knowledge residing in the conceptual system. This allows for the possibility that one can be very knowledgeable about gender in Spanish in the explicit, metalinguistic sense but have little or no ability to use grammatical gender when spontaneously producing or comprehending Spanish utterances. Perhaps reading Latin and Ancient Greek offer better examples of this difference since it is likely to be more pronounced especially in those less expert in classical languages (Sharwood Smith 1996)

**A developmental perspective**

A theory of acquisition and attrition, in brief.
Turning now to how the framework might be used as a tool for understanding cognitive development, a mind-wide perspective should clearly involve dealing with both language acquisition and language attrition phenomena. Acquisition has already been given a precise definition in the framework both for language as well as cognition in general. There have been various definitions of acquisition in the research literature. In the nineteen seventies, the creative construction school adopted the criterion used in contemporary L1 (‘child language’) acquisition studies namely one based on frequency of occurrence in spontaneous production and using adult norms as the target. The usual criterion was 80% or 90% suppliance of the target (native) form, or at least something sufficiently recognisable as the target form, in obligatory contexts (Brown 1973, Dulay et al. 1975). Some studies still use this frequency measure. One problem with this handy definition for experimental researchers was that it conflated what many would call acquisition in the sense of the initial reanalysis of given input signalling a change in the learner’s current mental grammar with what many would call full mastery or native-like fluency. Pienemann came up with a better approach to defining acquisition called an emergence criterion that seemed to have resolved this problem (Pienemann 1998) This briefly places the moment of acquisition at the first appearance or, to be on the safe side, the first four or five appearances of the given form in spontaneous production. After this point, the rest was a matter of building up mastery so that the form was produced regularly. Pienemann’s definition was also better in that it was not uniquely focused on the presumed endpoint, native-like production. In other words, it could be applied equally well to a non-native form, one that marked a recognised stage in a stage-by-stage developmental sequence. To a limited extent this could have been applied in some of the creative construction studies since they also included in their investigations a few of the stages originally noted in child language acquisition, particularly stages in the acquisition of negation and wh-questions (Klima & Bellugi 1966, Bellugi 1965). Pienemann’s Processability theory is, however, deliberately aimed at explaining production data and not the point at which the mental grammar changes. This means that the timing of acquisition is established once forms have actually appeared in the learner’s overt performance and not at some currently indeterminate time when something covert occurs.

The MOGUL definition of acquisition, although it is not focused the native-like mastery, is at least in one sense in line with the creative construction approach. That is to say it is not based on production but on input. It defines acquisition as happening the very first time an association is made that results in a different analysis of the input, this is defined as the point of acquisition. It may either be the first binding of representations within a store, for example when a syntactic feature like [fem] becomes part of a complex N(oun) representation (Lardiere 2008). It may also be the first time an interface coactivates and coindexes representations sitting in adjoining modules as, for instance, when a given auditory structure (the sound of the word “bee”) is associated with a phonological structure /bi/ or when this PS is associated with a syntactic representation (Noun). Clearly establishing the moment of acquisition poses an empirical problem so, at the moment, it awaits advances in neuroscience to assist in pinpointing the initial formation of a new representation. This need not hinder the establishment of a theoretical definition in advance.

Defined in this precise but minimal way, acquisition can be ephemeral. No sooner is an association gained it may be lost. This rapid type of attrition is displayed on the right in Fig. 5 following the topmost arrow through acquisition and then down and to the right ending up as attrition. This we could call ‘Attrition I’ as opposed to ‘Attrition II’ (see bottom-left in Fig 5) that may occur later on in, or after the consolidation stage. Attrition II is a slower process, even in children who can lose a language relatively quickly. Hence, acquisition in the minimal sense is to be distinguished from what might be called acquisition as growth (the ‘G’ in MOGUL) but here the preferred equivalent term is consolidation. After a representation has become firmly consolidated, it will have built up a high RLA and, unless inhibited, for some reason, becomes very accessible and competitive during online processing. If, however, there is an extended period during which it is either not frequently or never selected due to lack of use or as a result of the presence of a stronger rival representation, e.g. from a newly dominant L2, then the formerly robust representation begins to undergo a longer period of attrition (Attrition II) quite unlike the rapid, ephemeral Attrition I and is the reverse of consolidation although the form in which it takes will be influenced by many factors which are the objects of current research.

The life of [fem]

Let us now, finally, focus on syntax and imagine just one possible life cycle for a syntactic gender feature in individuals who only have one language, English, which has no grammatical gender\textsuperscript{13} so only biological gender.
In other words, we will ignore the growth of conceptual knowledge of gender, what can be classified as FEMALE, MALE etc., and deal only with core language syntax where grammatical gender is assigned and processed. We will also make some theoretical assumptions for this illustration regarding the nature of syntactic features and gender. So, for example, in English (L1), which does not have grammatical gender any more, pronouns referring to a female person will be marked using a conceptual gender structure, not a syntactic structure, the CS [FEMALE]. In other words, when deciding what pronouns to select to refer to Suzanne, the speaker needs to know that she is a woman: that particular knowledge is available in the speaker’s conceptual system. Hence, we can contrast syntactically-driven gender assignment and conceptually-driven gender assignment. For example, processing Portuguese “mãe” should involve the parallel coactivation of various associated coindexed representations in parallel including the conceptual structure CS [MOTHER] and the syntactic structure SS[fem]. Portuguese “abelha” (“bee”) will similarly require [fem] alongside [BEE] to allow gender agreement to operate. In English, however, [fem] is not needed. “Mother” and “bee”, which will also trigger the conceptual representations, CS [MOTHER] and CS [BEE] respectively, requires only the parallel coactivation of CS[FEMALE] to operate pronominal selection and agreement. Languages like Portuguese and French have both gender systems whereas English only has conceptual gender (sometimes called ‘lexical’ gender). In English, it is a CS that triggers the ‘she’ and the ‘her’ in: “Suzanne said she prefers her own chair”: gender agreement in this case is conceptually driven across the SS⇒CS interface.

In languages with both systems, we have to assume that the crucial determiner of gender agreement is processed in the syntax module. Any accompanying coactivation of a conceptual representation identifying Suzanne’s biological (or sociological) gender is not relevant far as syntactic gender assignment and agreement is concerned. The conceptual gender will affect conceptual processing alone although acquirers will learn early on that there are some reliable regular correspondences between, say, female human animate individuals and syntactic [fem]. This should, in advance of any direct syntactic input evidence, already permit syntactic [fem] assignment for any nouns that denotes an unfamiliar individual who can be independently identified with the conceptual representation [FEMALE]. The regular parallel triggering of syntactic gender representations like [fem] and conceptual structures like [FEMALE] in languages with both gender systems may have consequences for how gender is acquired and attrited in certain bilingual scenarios as will be mentioned below.

The following illustration offers one possible explanation for the life cycle of a syntactic gender feature exploiting the framework architecture. It is mainly intended to show the potential of the framework. For this particular account to become a hard and fast claim it would naturally require empirical confirmation as already pointed out. This might well include resorting to supporting neurolinguistic evidence from imaging and ERP data; research by Osterhout and his colleagues shows evidence of very early learning that could not have been detected in behavioural data provides examples of such techniques (McLaughlin et al. 2005). The successful upshot of such interdisciplinary cooperation would produce accounts that are plausible at all three levels of description.

**Input stage**

Beginning with the first stage shown in Fig. 5, environmental stimuli begin to regularly provide perceptual (visual and auditory) systems with highly robust evidence of grammatical (syntactic) gender. This may count as evidence for outside observers, but in the mind of the individual concerned it can only become syntactic evidence once processing has gone through the perceptual portal to a deeper level and triggered a particular response in the syntactic system: this is when the syntactic processor has (as it were) recognised the input it is receiving from auditory and/or visual input specifically as evidence for grammatical gender. Learners may already be able, when processing L2 utterances to create some sort of phonological structure from the auditory structure input (i.e. PS from AS) using easily accessible PS associated with their L1. They may also be able to associate these PS with some kind of syntactic and conceptual structure without responding appropriately to the specific phonological structures that actually reflect the presence of syntactic gender. The core language modules will always, as it were, do their best to represent their input: the grammar does not crash easily and straightforwardly as it would in a theoretical linguistic account. So, one thing that does not happen while in this initial stage in our illustration is acquisition in the syntax module. In other words, [fem] is never triggered and gender is marked either randomly or by selecting a default marker corresponding to [masc], for example.

Alternatively, the learner may proceed item-by-item producing superficially correct pronouns on familiar feminine nouns but without using [fem]. Possibly, in such cases, the highly accessible CSs [FEMALE] and [male] are recruited for this purpose, treating some inanimate and non-human nouns as if they were male or female: in other words, the conceptually-driven gender system of the L1 is recruited to manage the assignment of given pronouns and adjective forms to given L2 nouns. Using this L1 procedure may have the effect of prolonging the input stage in the syntax module.
Acquisition stage

The input stage can be interrupted by a sudden new association. This launches the acquisition stage. Now, for the first time the PS input triggers a response in the adjoining syntax module that has the effect of activating the gender feature, i.e. the syntactic structure \[\text{[fem]}\]. In dealing incrementally with the flow of input created originally by the utterances the individual is exposed to, the syntactic processor responds by matching given phonological input with syntactic structure containing \[\text{[fem]}\]. At this point, \[\text{[fem]}\] has been acquired instantaneously, according to the definition mentioned above. It is hardly likely, however, that learners will be able to immediately make full use of an L2 syntactic gender system at this point since they will be faced with the competition of more established L1-based routines described above. From now on, unless the absence of further input brings about early attrition (Attrition I), the relevant feature assemblies (complexes) of component syntactic representations) when activated online will include struggling new gender features with low, uncompetitive RLAs.

Growth (consolidation) stage

Whereas the acquisition stage is instant, this growth stage never is. As consolidation proceeds, \[\text{[fem]}\] is activated with increasing frequency and begins to accumulate higher RLA’s allowing it to show up in behavioural tests for the existence of syntactic gender. On further exposure to more and more L2 nouns, the resulting phonological input coming across the PS\leftrightarrow SS interface will be accordingly coindexed with gender features. As this gender assignment gradually approximates to native-norm, L2 speakers will accordingly become more native-like in their overt use of L2 gender, that is in their production as well as in their comprehension. Initially and maybe, as current research suggests, until quite advanced stages of overall proficiency, conceptually-driven gender agreement or item-by-item learning may continue to prove difficult to dislodge in spontaneous speech. This may be true even where the individual can show evidence of covert syntactic gender activation under experimental conditions indicating that what has been acquired is still have difficulty with competing influences that have the effect of keeping its RLA relatively low. This problematice surrounding gender acquisition has made it a popular topic for research (see, for example, Parafita Couto et al 2016; Bobb et al 2015; Rodina & Westergaard 2012, Foucart & French-Mestre 2012 and Sagarra & Herschensohn 2011).

Attrition stage II

During this stage, lack of continuing exposure to the L2, the growth process in the bi/multilingual ceases and \[\text{[fem]}\] a) loses its high RLA and b) faces growing competition from relevant representations which are associated with other increasingly dominant languages with the precise results dependent upon the particular gender characteristics of those particular languages. In the worst case scenario, the associations and hence the L1 coindexations formed during the acquisition and consolidation stages are ultimately lost. Even if this never literally happens, the relevant RLAs fall to a point where syntactic gender as instantiated in the L2 is lost to all intents and purposes. This is when there are no indications at all of its existence in observable performance including grammaticality judgements tests. On re-exposure to the L1, it is an open question as to whether the relevant gender properties are ‘re-acquired’, i.e. as in stage 2, or whether the connections that form the L1 representations have not been completely extinguished so that their RLAs are gradually built up again to a point where they become competitive again. In this case it would be a case of re-consolidation rather than re-acquisition.

Alternative life cycle scenarios for \[\text{[fem]}\]

A lot will depend on the interaction of different language systems in the mind of the developing bilingual. How, for example, might one characterise the life cycle of \[\text{[fem]}\] in an L1 speaker of a language which already has grammatical gender acquisition and is acquiring an L2 like English where \[\text{[fem]}\] is irrelevant. And how would it be if that same L1 speakers is acquiring an L2 that also has grammatical gender but with different gender assignments? “Chaise”, a word in French meaning “chair” for example requires \[\text{[fem]}\] but a translation equivalent in German “Stuhl” requires \[\text{[mas]}\]. One might imagine, in the first L1=>L2 scenario, that a French acquirer of English, for example, would have no problem with gender. The learner already has conceptual gender activated when nouns referring to human animate beings, and some animals as well and this system can be used to acquire pronoun-antecedent agreement. The only obvious crosslinguistic influence we might expect is that due to the already formed association between conceptual and syntactic gender due to coactivation when talking about humans might overgeneralise such that English ‘chair’ might trigger the use of ‘she’ and ‘her’ in the French L1 speaker or ‘he’ and ‘him’ in the German L1 speaker. Anecdotal evidence suggests this is more likely in the case of animate beings but the present writer is unaware of any experimental evidence to confirm this. For example, again anecdotally, a Polish speaker regularly refers to ‘fly’ and indeed Polish ’mucha’ using “she” and “her”, suggesting influence from the association between \[\text{[fem]}\] and [FEMALE] in the L1 although
she never refers to a chair (which is feminine in Polish) using ‘her’. One would imagine that crosslinguistic influence is unlikely to be a serious impediment for the grammatical gender L1 learner given the abundant evidence of a non-alternating morphology in the L2 adjective and determiner systems (“the black chair”, “the black fly”, “the black lamp”) etc and the regular use of the pronoun “it” to refer to the vast majority of non-animate nouns.

In the second L1=>L2 scenario, a French learner acquiring L2 German activates syntactic gender but may initially coactivate [fem] with CS [CHAIR] and produce feminine determiners as in “*die Stuhl” (“the chair”) instead of masculine “der Stuhl”. Generally, the empirical evidence seems to point to both these alternative scenarios posing considerably less of a challenge to the learner that the one used in our main example where, on encountering the L2, [fem] has to be activated for the first time (see, for example, Parafita Couto et al 2016, Bobb et al 2015, Saggar & Herschensohn, J. 2010).

Conclusion
To sum up, this chapter has focused the notion of a mental representation. The way in which this has been done is one which is compatible with a generative linguistic perspective. However, representations were reinterpreted to suit two other different theoretical levels of description, crucial for any research in areas like language acquisition and attrition that deal with events and states in real time. A modular cognitive architecture was adopted for this purpose, one broadly based on current cognitive science and another aim of this chapter was to demonstrate its usefulness. The MCF, more generally known as MOGUL, provides the necessary explanatory framework for studying the growth, online processing and attrition of representations. It is an ongoing research program, open to anybody who wishes to make use of it, and still under development. By considering them from a psychological and neurological point of view as well viewing them in abstracto as purely theoretical linguistic entities, various advantages stand out. In particular, a clear line is drawn between these three levels of description avoiding potential confusion caused by importing descriptions unchanged from to another. This still allows for, indeed facilitates exploiting insights from all three of them. The example of grammatical gender was chosen to illustrate how representations derived from theoretical linguistics can be treated as entities that are, figuratively speaking, born, develop and die, hence the metaphor of a life cycle. For the purposes of illustration, one simple and straightforward scenario was focused on in particular, namely the situation where a learner with an L1 having only conceptual (lexical) gender is exposed to a language which has syntactic gender as well. In conclusion, a leitmotiv throughout the chapter was the need for, and advantages of an overarching framework such as the one used here which provided four new benefits, especially for those of a generative persuasion:

1. An integrated account of representation and processing while keeping the two distinct.
2. A developmental theory (APT).
3. A set of clearly defined mechanisms for both a) module-internal operations and b) module external, interface operations across the whole system
4. A crossdisciplinary embedding for local theories and hypotheses and the empirical findings that have flowed from them

References


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1 The ramifications of this are much more fully discussed in Truscott and Sharwood Smith (in prep.).
2 In other words, also in terms of the framework, all modules are equal: there is no master module (McCulloch, 1945, Sharwood Smith & Truscott 2014, p.21).
3 ‘This characterisation of human mental modules in general stands in stark contrast to statements by those who would like to see the whole notion of ‘UG’; i.e. innate grammatical principles, however minimally defined, as a dead duck. In other words, it puts specifically linguistic properties (N, V, Agr. *sonorant, syllable* etc.) into a ‘mind-wide’ context, as examples of what is actually characteristic of cognition as a whole.
4 Alternatively, primitives may be thought of as belonging to the processor and only deployed in the store when needed.
5 The cover term for these representations created in each of the five modules in response to sensory input is POpS which stands for *perceptual output structures*.
6 This term is used to include multilinguals.
7 Alternatively, unused primitive features may only appear in a store when the processor puts them there in response to input. In this case location at the bottom level would imply ‘activated only once’ or ‘scarcely activated’.
8 L2 in the sense of any language currently known to some degree by the given individual, so also an L3, an L4, an L5 etc.
9 What are traditionally ‘phonetic structures’ are in fact AS which have proved compatible with the phonological system so they are *speech-related* or *language-related* representations rather than speech representations themselves. The same indirect relationship with language applies to CS. In other words, ‘semantic structures’ and ‘pragmatic structures’ are *language-related* representations that written in the same code and processed in the same was as any meaning structure that happens to be associated with other types of representation and not currently expressible in language.
10 It is appropriate to mention here the Cambridge Declaration on Consciousness signed by a group of neuroscientists that cast doubt on the exclusivity of humans in this domain. The declaration includes the sentence “Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness” (see the *Francis Crick Memorial Conference* website at http://fccmconference.org/).
11 The assumption here is that historical traces of the original gender system are now handled, in modern English, by the conceptual system.
12 The conceptual system may be recruited to assign gender in other contexts for example where the phonological shape of the human animate noun is strongly correlated with another, inappropriate gender. Rodina & Westergaard discuss the case of Russian where, for example, nouns like “papa” have a morphology that is typically feminine. In such cases, now using the current framework, the regular SS [masculine] CS MALE association appears in Russian L1 children to win over the first type of correlation, that is the one existing between the PS form in papa-nouns and SS [fem]. This suggests that in such cases children proceed conservatively. In doing so, they are able to master various subclasses of noun avoiding massive overgeneralisations (Rodina & Westergaard, 2012).