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Research training proposal: **Functional Categories and Clause Structure of Child English: In Search for a Grammatical-Neurocognitive Account**[♣]

I. SPECIFIC AIMS

Modern generative linguistic theory has been recognizing the importance of *interdisciplinary* work between linguistics and natural sciences more and more in the last decade or so (Chomsky 2000; Freidin & Vergnaud 2001; Hauser, Chomsky & Fitch 2002; Jackendoff 2002; Jenkins 2000; Pinker 1994, 1999). Though ever since the cognitive revolution (Miller 1956, 2003) there has always been awareness among generative linguists that their object of study is human psychology, and ultimately human biology, little work has been done in unifying the two fields (Chomsky 1995, 2000). However, thanks to the state-of-the art brain imaging techniques that have developed in the field of cognitive neuroscience and to our better understanding of the functioning of the human brain, linguists have started to bridge their observations and findings with those of evolutionary and cognitive psychologists, biologists, computer scientists, and cognitive neuroscientists.

Scientists have become aware that language is a very intricate system that involves complex computational, psychological, and neurocognitive processes that are crucial for fundamental language capacities, such as the mental storage of words (lexicon) or the computation of mental rules (grammar). 'Dual-system' approaches to language thus assume a distinction between *the mental lexicon* and *the mental grammar*, as opposed to 'single-system' accounts, where a single associate memory system with broad anatomic distribution links both capacities. What the 'right' (and possibly also more 'psychologically real') model of acquisition and processing is still remains a matter of dispute. Many computational and cognitive psychologists have argued that a dual-system can be a much more productive model to explain language acquisition (Kim et al. 1994,

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Marcus 1995, Pinker & Prince 1988), though computer scientists and some psychologists believe some type of connectionist single-system is more likely to be the model of acquisition and processing (Elman et al. 1996; McClelland & Rumelhart 1988). I put this issue aside in the paper, assuming a dual-system for human language perception and generation, though I do not dismiss the possibility of statistical probability (and consistency) playing a role in language acquisition (Newport & Aslin 2000, Saffran et al. 1999).

Furthermore, I believe that language acquisitionists and other researchers in the field of language learnability working in '*linguistic/grammatical competence*' accounts (see O'Grady 1997 and Guasti 2002 for the reviews) should recognize that the likely unproductive theoretical debates about the underpinnings of language should move beyond theoretical analyses and descriptions of grammar and lean towards *empirically focused* and *comparative research program* in language.

I will propose a study that draws conclusions from both *theoretical psycholinguistics* and *cognitive neuroscience*. To my knowledge, extremely little has been done in the field of language learnability in terms of *combining* the two perspectives on acquisition, i.e., the *grammatical/linguistic* perspective and the *neurocognitive* perspective. Though generative accounts on language stress that the study of language should be focused not only on the questions of *what constitutes knowledge of language* and *how it is acquired and put to use*, but also on the question of *what the brain mechanisms for language are* (Chomsky 1986; Jenkins 1997, 2000), no model of language to-date offers a combined perspective on language as a cognitive system. I will propose a specific theoretical (psycholinguistic) model by using the Declarative/Procedural (DP) neurocognitive model (see below).

The *generative grammatical (GG) framework* in acquisition of syntax relies on the Universal Grammar (UG) Hypothesis, whose central thesis is based on the assumption that there is a genetically given abstract system of grammar in the human brain/mind (i.e., it is encoded in our genes) (Chomsky 1965, 1986). Such UG is *domain-specific* (i.e., unique to human language and dissociated from other cognitive domains) and is subsumed under a "broader" *language faculty* (Hilles 1991; Kirby 1999; see also Rus 2001 for a review), which presumably also includes other cognitive systems, such as *sensory-motor* and *conceptual-intentional systems* (Chomsky 1995; Hauser, Chomsky, & Fitch 2002, Piatelli-Palmarini & Uriagereka in press) though proponents of this approach claim we know very little about other cognitive domains as opposed to language. The "narrow" language faculty (UG) view has been the focus of research in the field of theoretical psycholinguistics for at least 40 years now. The goal of this research program has been to find and describe the *linguistic constraints* that restrict logically/biologically possible grammars (Wexler & Culicover 1980; Lasnik 1990) and to account for the characteristics of the children's linguistic development. Though the model had achieved an extreme amount of *descriptive* power by early 80s, it seemed to have lost the battle with *explanatory* adequacy (i.e., with the explanation of how linguistic knowledge is acquired by the child). Many computationalists concluded that from a purely mathematical point of view, GG was too unconstrained. Furthermore, they claimed that the model was not efficient enough to be implemented as a sentence-processing device (Berwick & Weinberg 1984). It seemed that the rules of GG could not correspond to the mental computations people used during language understanding and language generation (Schank and Colbly 1973; Woods 1970). In the field of psycholinguistic, GG did not seem to fare any better. It was often claimed that GG could not describe early child grammars at all (Fodor, Bever, & Garret 1974). The years to come saw the "make-up" for such a loss. By the late 80s the model culminated in a very elaborated and intricate linguistic model (Principles & Parameters) that achieved a much greater amount of explanatory power. However, it was of little interest to psychologists and neuroscientists because all observations about language development were based on *linguistic description* and intricate linguistic analysis, with occasional speculating about what and where the biological bases of language might be.

In the 90s generative grammarians tried to pursue the explanatory adequacy even further. Postulating that language is a "perfect system", the most recent generative program (the Minimalist Program; henceforth MP) posits "natural" and "elegant" principles such as

Economy (derivations must be optimal, i.e., as economical as possible) or *Procrastinate* (movement should not take place in overt syntax, if possible) (Chomsky 1995). The set of operations in the MP (in the mid 90s model) consists of three processes - *Select* (choosing an item from the lexicon), *Merge* (combining one item with another to form a larger category), and *Move* (displacement of an item or a category, involving both Select and Merge). Most natural language phenomena are described in terms of these operations and a small number of constraints and filters that prevent overgeneration (i.e., that constrain grammar). Though Chomskyan linguists often relate their analyses to the question of what the relevant *brain mechanisms* that play a role in the knowledge of language are, or even how this knowledge *evolved* in the human species (Chomsky 1986; Jenkins 2000), they failed to produce any satisfactory evidence that the language faculty (in the "narrower" sense) is unique among the cognitive systems (or even in the organic world), and that the computational system of the human language is *biologically isolated*. The reason why this has been so is quite simple: all observations about language that have been penned by formal linguists are *theory-internal* (*framework-specific*). Though such an approach can account for the questions of *what constitutes our knowledge of language* and *how it is acquired or put to use*, it certainly fails to account for the *brain mechanisms* of language and to give the *evolutionary account* of language.

On the other hand, neurocognitive models of language have based their observations on the brain *circuits* (i.e., on the functional/neuroanatomical level) and *neural substrates* (i.e., on the cellular/molecular level) subserving different language functions. A great deal of evidence about which circuits play a role in which language function comes from hundreds of imaging studies (see Gazzaniga 1995, 1998, 2000 for reviews). Neurocognitive accounts, such as the Declarative/Procedural Model (DP), usually put forth the hypothesis that specific cognitive domains *share commonalities* with language and that if the systems underlying the target cognitive domains are well-understood, they should yield better and clearer predictions about language, based solely on *non-language accounts*.

One can take this as another extreme of trying to shed light on language and its computational, representational, psychological and neurological characteristics. Most of these approaches have claimed that cognitive domains other than language are much better understood in many ways since predictions about target cognitive systems can be tested on animals both evasively and non-evasively. Such approaches usually view characteristics of language as shared with other domains, which may have nothing to do with communication. Motor skills, for example, are usually paired with grammar in being dependent on implicit knowledge, involving real-time processing as well as sequencing and hierarchies. The fact that these two domains may share the same characteristics suggests that the two domains may share *the same neural circuits* and even *evolutionary origins* (Ullman et al. 1997, Ullman, 2001a, 2001c, in press). Most of these approaches assume a 'dual-system' organization of language in the brain, i.e., language depends on a memorized 'mental lexicon' and a computational 'mental grammar'. The lexicon as perceived by grammatical (GG) accounts, however, differs considerably from the lexicon viewed by most neurocognitive dual-system accounts, since the MP posits a *strict lexicalist approach*, meaning that all *word computation* (*inflectional and derivational morphology*) is done prior to lexical insertion (into the derivation). Under this view, word-morphology will not be a process separated from the lexicon (i.e., it will not be parallel to syntax or a by-product of syntax) but will happen before the derivation gets even created. The DP neurocognitive model uses the terminology in a slightly different way – it assumes that the computational mental grammar, separated *anatomically* and *functionally* from the mental lexicon will underlie (regular) word morphology by 'pulling' non-compositional words from the mental lexicon (for the intricacies, weaknesses, and strengths of the generative lexicon, see Jackendoff 1997, 2000; Marantz 1997; Pustejovsky 1995; for the nature of a "DP Lexicon", see Ullman in press and below).

The DP Model of Language views the mental lexicon as a *repository of stored information*, including all idiosyncratic word-specific information. Hence it includes at least those words whose phonological forms and meanings cannot be derived from each other (since the sound-meaning pairs are arbitrary). It may also contain other non-compositional forms, smaller or larger than words, such as bound morphemes (e.g., the past tense suffix *–ed* or the present participle/gerund suffix *–ing*). The mental grammar, on the other hand, contains rules, operations, and constraints, underlying the productive sequential and hierarchical combinations of lexical forms and abstract representations into complex abstract representations, words, phrases, clauses, and sentences (Ullman 2001a-c). Grammar thus subserves the computation of linguistic forms whose meanings are *transparently derivable from their structures* (e.g., English gerunds/present participles are derived from the concatenation of a verb stem and an *–ing* suffix; this mental rule allows productive computation of *–ing* forms from any verb, including novel verbs such as 'mick' or 'plunck'). Rule-derived forms can thus be computed in real-time and do not need to be memorized, although even compositional forms (e.g., *played*) could in principle be memorized (Pinker 1994, 1999; Ullman 2001 a-c). The two language capacities, which interact in several ways (e.g., grammar requires lexical items to manipulate, i.e., to combine items into bigger categories), are based on the dichotomy between *declarative* and *procedural memory systems*. These two memory systems have been well studied in humans and in several animal models, including monkeys and rodents (Squire & Knowlton 2000). It has been shown several times that the two systems are independent from each other, though they interact in many ways. The declarative memory system, which has been implicated in the learning, representation, and use of knowledge of facts ("*semantic knowledge*") and events ("*episodic knowledge*"), may be particularly important for the *very quick learning* of arbitrarily-related information, and is believed *not* to be informationally encapsulated (i.e., it is *accessible* to multiple mental systems) (Squire & Knowlton 2000; Ullman in press). It depends mainly on *medial temporal lobe structures*, particular on the hippocampal region, perirhinal cortex, and parahippocampal cortex. The procedural system, on the other hand, plays a role in learning of new, and the execution of the established, sensory-motor and cognitive "habits" or "skills" (procedures), such as skilled game playing or riding a bicycle. This system is especially important for the *learning and processing of real-time linear or hierarchical sequences, or sensory-motor or cognitive*. It is believed to be *informationally encapsulated*, i.e., the mappings the system handles during the computation are rigid, inflexible, and not influenced by other mental systems. It is sometimes referred to as "*implicit memory*" since the learning of knowledge and the knowledge itself are *not* available to conscious access. It depends mainly on *basal ganglia*, a set of sub-cortical structures, including the neostriatum, globus pallidus, sub-thalamic nucleus, and substantia nigra, as well as specific frontal structures, including Broca's area. More recent research has even begun to elucidate the specific anatomical, computational, cellular, and molecular aspects of these two systems across species (Ullman in press).

The underpinnings of the declarative memory system (and thus the mental lexicon) will not be of my interest in the study, though it will of course play an important role in syntax and all other language functions. I will also put aside the issue of innateness in the psycholinguistics/neuropsychology/learnability literature, i.e., whether some of the brain circuits that subserve grammar (language) are genetically given (i.e., innate) or whether they have evolved from structures subserving other cognitive functions. Though the DP Model relies heavily on the notion of *domain-generality*, separate structures within the procedural (or declarative) system brain circuitry may be designed for language-specific tasks (and are part of a bigger system, i.e. "the language faculty/organ" in the sense of Anderson & Lightfoot 2002).

In my study I will *test the DP model against the existing theoretical psycholinguistic assumptions of child language development in terms of the acquisition of functional categories* (e.g., Tense or Agreement). I will concentrate on the role of *Merge* as the operation in syntax and test *my hypothesis that the DP model can be viewed as a supplement to the UG-based theoretical/grammatical models*. I will test this hypothesis with both a *behavioral (psycholinguistic)* study and an imaging study, using *ERP*. I will argue that for a better understanding of child language development, one needs to combine the tools of theoretical (psycho)linguistics and cognitive neuroscience, since the psycholinguistic accounts provide specifications at the level of representation, computation, and processing, whereas the DP model provides further specifications of the underlying brain structures and their functions.

II. BACKGROUND AND SIGNIFICANCE

1. Psycholinguistic Evidence and Psycholinguistic Accounts.

A. Functional Categories (FCs) in Generative Linguistic Theory.

In terms of FCs the study will focus on the Principles & Parameters framework, including its recent extensions (MP) (Chomsky 1995, 1998). Within this framework categories are taken from the lexicon as input to the computational system of the human language (C_{HL}) in our brain. C_{HL} then generates *structured representations* (that serve as input to the articulatory-perceptual (A-I) and conceptual-intentional systems (C-I). For example, in order to compute the V(erb) P(hrase) *drink beer*, an abstract node corresponding to the V is combined (merged) with the abstract category corresponding to the N(oun). The abstract category is determined on the basis of the *obligatory head* (V in VP, N in NP, etc.). GG in early days made a classic sort of distinction between *lexical categories* (i. e., those headed by *lexical* (*open-class*) vocabulary items, such as Ns, Vs, and A(djectives)). More recent work in GG has focused particularly on *functional categories* (i.e., phrases which are headed by *closed-class* items, such as Det(erminer), C(omplementizer), and I(nflection) (the last being later split into two functional projections, Agr(eement) P(hrase) and T(ense) P(hrase)). (Pollock 1989; Chomsky 1991 in Chomsky 1995 *inter alia*). The functional layers (the CP domain and the IP domain) of a sentence structure have exploded into several FCs, some of which are more or less justifiable (Cinque 1999; Rizzi 1997; Ouhalla 1991). For the purpose of our study (i.e., functional categories that play a role in verb morphology) such a fine distinction of the left periphery is of no importance. I will assume the 'classic' functional projections for English, i.e., AgrP, TP, and CP.

B. Functional Categories & Language Development: Psycholinguistic Accounts.

There is an increasing awareness among psycholinguists that the developmental facts must be accounted for, either by addressing them in terms of a linguistic theory or by explaining precisely how the acquisition facts would follow from any *non-linguistic* factors. Several theoretical and experimental psycholinguistic accounts of child language development exist in the field of acquisition, but two of them have been dominant in the (generative) psycholinguistic literature: the *Continuity* theory (splitting into *Strong Continuity* and *Weak Continuity*) and the *Maturational* theory. A common view among the proponents of the continuity hypothesis account for the children's developmental delays is that children fail to process and produce certain linguistic information due to *extragrammatical factors* (Pinker 1984; Bloom 1990; Valian 1991). I term this approach as the "*Processing Continuity Account*". This approach is sometimes combined with approaches that take into account *perceptual considerations*, such as *phonological salience* (Demuth 1994) or *semantic considerations* (Pinker 1984).

I am assuming that the *nativist linguistic description* (or at least some "*nativist-flavor"* account such as O'Grady 1997, 1999 is needed to obtain a descriptively and explanatorily satisfying theoretical model of acquisition. I believe other theoretical approaches, such as a *Construction Grammar* approach and other "*functional approaches*" (Tomasello & Brooks 1999; Tomasello 2003; for a review see Ritchie & Bhatia 1999) fall short to explain several language phenomena observed in children's speech.

B1: Continuity.

This approach views the language acquisition process as being "continuous" in the sense that the language acquisition device (LAD) analyzes experience in terms of the same notions and relations at all stages of development. It is often associated with UG-based accounts, where it is taken to entail that the entire system of UG is available to the child from the very beginning of the acquisition process (Pinker 1984; Poeppel & Wexler 1993; Lust 1995). Poeppel & Wexler 1993 terms such view as the *Full Hypothesis*. The strong continuity assumes that children are capable of forming a fully-fledged sentence structure (with both lexical and functional projections) from the earliest stages of language development. Hence a typical biclausal sentence such as *Think Mommy gone home* is believed to include one null functional head in the matrix clause, null matrix C, specified matrix INFL (Agr/T: Present), each of them projecting into phrasal categories (CP and IP respectively). The embedded clause will have a null C, specified INFL (Past) and a fully-fledged VP (V and its NP complement). In brief, the sentence representation under this approach is viewed as an adult speaker's representation.

In contrast, the weak continuity hypothesis holds that though children have access to the full set of functional categories and operations from the onset of the acquisition process, they may not make use of them in their representations right away (Pinker 1984) (e.g., children who have not heard Cs yet might not have a CP representation in their grammars) (Vainikka 1993/94). Both the strong and the weak hypotheses limit the domain of syntactic development to two phenomena, *parameter setting* and *lexical acquisition*, where the LAD (which makes the parameters themselves and their options available) must determine on the basis of the linguistic input which parameter setting to choose (e.g., a) subject drop is permitted or b) subject drop is not permitted), and where lexical acquisition may involve the discovery of special properties of lexical items (e.g., what categorical and selectional complements each verb takes).

B2: Maturational Accounts.

There is a general agreement (at least to some extent) among acquisitionists that *maturation* plays an important role in the earliest stages of cognitive and linguistic development. The more controversial question, however, is whether maturational factors are responsible for later features of syntactic development (i.e., from the one-word stage onward). It has been claimed many times in the literature that syntactic development (viewed as progression through several stages of development) is relatively independent of experience (Gleitman 1981). Language development under this approach is believed not to be associated with physical growth, but it is driven by a *biologically determined timetable*. Several nativists believe that this is a much more likely scenario of language development than the Full Hypothesis. Certain components of UG under this approach are believed to emerge and become operative in a very specific, maturationally given order (Borer & Wexler 1987, Felix 1987, 1992; Bickerton 1991). Gleitman 1981 proposes different stages of syntactic development, the first three being a) *the one-word stage* (approx. age of onset: 12 months), b) *the two- and three-word stage* (approx. 24 months), and c) *simple fully grammatical constructions* (approx. 36 months). Based on longitudinal studies of three children, Bickerton 1991 suggests that Gleitman's third stage involves the emergence of the X-bar component of UG (which entails the emergence of functional projections). Felix 1987 & 1992 conclude that only the maturational theory can explain the well-known facts about child language (e.g., the lack of the X-bar schema of the UG results in omission of obligatory heads (as in *Mommy bathroom* or the non-adult utterances consisting of a 'relation word' such as *there high* or *bye bye man*).

Radford's "Small Clause" Hypothesis.

Radford 1990 develops a comprehensive and detailed maturational theory of syntactic development. His stages of development are very similar to those of Gleitman's (see also Vainikka 1993/94). The initial stage for Radford is '*pregrammatical*', meaning that the utterances at this stage consist of single words that have not been categorized syntactically (as Ns, Vs, etc.). This entails that there is *no true syntactic structure* in these utterances. Radford reports that at around 20 months of age two striking changes in child English occur, (1) a sharp increase in the size of the child's vocabulary (esp. lexical categories, Ns, Vs, As, and Ps), and (2) a wide range of combinatorial patterns (conforming to the X-bar schema) appear. Radford refers to this stage as the "*lexical stage*", where *no* functional categories are present yet (only the VP). These, he believes, emerge in the third/final ("*functional*") stage, at around 25 months of age. He provides a lot of empirical evidence for his claims, assuming the maturational view of language development (i.e., components of UG are genetically programmed to come into operation at different biologically determined stages of development).

2. Neurolinguistic Evidence and the DP Neurocognitive Account.

A. The DP Model and Neuroimaging Studies.

The computational role of the procedural system is likely to be similar across all language domains, i.e., phonology, morphology, syntax, and lexical (compositional) semantics, though each of these subdomains (or systems within these subdoamins) might have a certain degree of independence (or might even be language-specific; see above).

A great number of studies have shown ventro-lateral pre-frontal cortex, including Broca's area activation in tasks related to both procedural memory and syntactic processing (Martin et al. in Gazzaniga 2000, see also Ullman in press for more studies) in both receptive and expressive language (Caplan et al. 1998; see also Ullman 2003 for more studies).

ERPs reflect the real-time electrophysiological brain activity of cognitive processing. Difficulties in lexical (or non-linguistic conceptual semantic) processing elicit central/posterior bilateral negativities that peak about 400 milliseconds (ms) post-stimulus (N400). Difficulties in rule-governed syntactic, morphological, or phonological processing, on the other hand, yield relatively early (150-500 ms) *left anterior negativities* (LAN). These LANs have been claimed to be linked to *rule-based automatic computations* and correspond to procedural memory processes on the DP model we are assuming here (Ullman 2001a, 2001c, in press).

B. Functional Categories & the DP Model: Evidence from Agrammatism.

Several studies in agrammatic aphasia have focused on the dichotomy between closed-class and open-class categories or even on the differences within closed-class items (Leonard 1998; Ullman in press). Caplan 1987 reported that not all closed-class items were uniformly impaired. A number of subsequent proposals have implicated the *hierarchy* of functional categories of agrammatic impairment, providing evidence that computations dependent on higher functional categories are more impaired than those dependent on lower categories. Pancheva and Ullman in press reviews several studies that showed lower functional categories (such as TP and Neg(ation)P) being more resistant to damage than higher C-domain phrasal projections (e.g., $Agr_{(S)}P$ or CP). Several studies also implicated *between-subject* differences in severity rather than an *all-or-nothing pattern* of performance. Friedman & Grodzinsky 1994 report a 'tree-pruning' pattern, where the patients' impairments resulted in sentence structures allowing functional projections bellow TP (thus excluding CP and TP on Pollock's 1989 hierarchy of CP>TP>AgrP>NegP>VP). They believe that the greater the deficit, the higher up tree pruning will occur. Izvorski & Ullman's 2000 *Hierarchy Complex Hypothesis* (HCH), on the other hand, posits that it is the *relative* height of a given category in the hierarchy that predicts the severity of impairment (i.e., the greater complexity of hierarchical structures means the larger number of categories below them). In line with the MP linguistic framework, they conclude that the brain deficit resulting in agrammatic aphasia will affect the operation that combines elements into larger structures (i.e., Merge).

This analysis is predicted by neuropsychological and neurolinguistic theories, including the DP neurocognitive model. Anterior aphasia is associated with damage to left frontal structures (particularly Broca's area and the nearby cortex), the basal ganglia, and parietal regions (see above). In addition to agrammatism, anterior aphasia is also linked to impairments of motor skills (ideomotor apraxia) (Goodglass 1993).

I make the same prediction about the DP Model and the emergence of the functional categories in child speech, namely the more computation (Merge) C_{HL} has to perform, the harder it will be for the child to produce a highly elaborated structure with C-domain FCs. I argue that the development of FCs (and clause-structure in general) follows some sort of HCH, i.e., hierarchical structures with higher projections (such as CP) will be rare in early English and will emerge only gradually. Note that this leaves open the question whether functional projections are part of the LAD from the onset (and not initially accessed, presumably due to processing difficulties and/or memory-limitations) or emerge maturationally (see C bellow).

C. The DP Model as a Supplement to any Theoretical Psycholinguistic Model of Acquisition.

I would like to argue specifically that for a good linguistic theory that aims at the explanation of what brain mechanisms underlie what linguistic knowledge and not only at what knowledge of language is and what its source and use are, we need to combine psycholinguistic studies with neurocognitive studies. Chomsky 2000 refers to this question as "*the unification problem*", namely, *how can we integrate answers to the questions from above within the existing natural sciences, perhaps by modifying them*?

I would like to argue that the DP Model could be viewed as a *supplement to any UG-based psycholinguistic model of acquisition (of FCs)*. First, it is a dual-system assuming that the mental lexicon and a symbol-manipulating mental grammar are subserved by distinct brain regions. Second, it allows the possibility that certain brain circuits within the two broadly-defined memory systems are innate and genetically given (leaving the evolutionary question aside). These may contain representations, procedures, and rules specific to language (and subsumed under UG or a more broadly defined LAD). Third, it is compatible with continuity accounts as viewed by UG-based strong and weak continuity theories in the field of learnability which both predict that the lexical categories will phonetically emerge before the functional categories, whether they are part of the biological program from the onset or not. Furthermore, the DP model fits nicely into the 'continuity processing account' by positing that the greater the structure (i.e., the more functional categories are merged), the more working memory capacity is required. The procedural memory system will thus result in a deficit that can be linguistically described as the *initial lack of functional categories* (due to 'impoverished' Merge, either due to biological program that is not fully developed yet or due to processing constraints) or the deficit in the movement operation ('impoverished' Move; again, due to the same reasons as for Merge). The last view is more theory-internal, though, i.e., framework-specific, but it has a prominent place in the GG literature, where it is widely-assumed that heads need to move in order to either get their functional material (e.g., Agr, T) assigned or checked (if they enter the derivation clothed with functional features already) (leaving the question aside of which approach is more accurate/better or what is the real interplay between syntax and morphology).

III. EXPERIMENTAL DESIGN AND METHODS

A. Overview.

In my study I would like to combine purely behavioral (psycholinguistic) evidence with the DP neurocognitive model to explain the emergence and knowledge of functional categories (and clause structure) in early English, one of the current 'hot' topics in the field of language acquisition. Since most theoretical psycholinguists work with the existing data of child language (CHILDES; see MacWhinney 1991), citing the very same examples from natural production studies such as Brown's "Harvard children" (Brown 1973) (see Valian 1991 for the same point), I would like to build *my own corpus* of early English. I will take *three groups* of *three* children whose age will roughly correspond to

Gleitman's 1981 and Radford's 1990 *three stages* of development and record *natural speech* in the home environment twice a week for a year (Experiment 1, Part I). I will continue observing and recording the first group longitudinally until they reach the fully-grammatical stage (Radford's "functional stage") (Experiment 1, Part II).

B. Predictions.

Since Merge is a process that involves computations that rely heavily on the working memory, we would expect some kind of a hierarchy in terms of functional categories. If we adopt a widely assumed *bottom-up* approach of structure building (Chomsky 1995), where the lexical projections are most deeply embedded (i.e., lowest) in the syntactic hierarchy, I hypothesize that the VP (lexical) periphery will be the first one acquired and the easiest to acquire (see **Prediction 1**). Top-down compositions of hierarchical syntactic structures have also been proposed within the MP (Phillips 1996), but these too assume that the lexical projections are most deeply embedded and are dominate by the same number of functional projections arranged in the same order.

In my study, I will focus solely on production (generation) since it is extremely hard to test the presence/absence of functional material in small children's perception (due to several factors such as test-design, phonological salience, motivation; including grammatical considerations in terms of the syntax/morphology interface, see above).

Furthermore, the DP neurocognitive model, based on the two well-studied memory systems, would predict that Merge would be subserved under the procedural system (see **Prediction 2**).

Thus, I predict the following two hypotheses:

→ **PREDICTION 1:** the language data obtained in the behavioral psycholinguistic study will show the acquisition of FCs is gradual and that there exists a hierarchy of acquired functional categories, presumably in accordance with Radford's 1990 psycholinguistic account and Pancheva & Ullman's 2003 HCH neurolinguistic account (Experiments 1 & 3; see bellow).

→ **PREDICTION 2:** Merge as a syntactic process is subserved by the procedural memory system. Thus I hypothesize that ERPs in elicited-production tasks that will involve merging two or more categories will yield relatively early (150-500 ms) left anterior negativities (LAN) (Experiments 2 & 4; see bellow).

C. Study

The study will address the following questions:

(a) Are FCs present in early English, as proposed by the proponents of the strong continuity theory, or are they absent initially, as proposed by maturationalists and proponents of the processing deficit continuity accounts?

(b) Which FCs get acquired first, i.e., is there any hierarchy of acquired FCs? Do the production data suggest that higher C-domain categories will be acquired later than lower left periphery categories? Does this correspond to the *truncation model* or the *relative height model*? Is the hierarchy compatible with studies of agrammatic patients and is it related to the working memory deficits?

(c) Is Merge really dependent on the procedural memory system, i.e., will ERPs yield relatively early (150-500ms) left anterior negativities (LAN)?

(d) How valid are synchronic investigations of syntactic phenomena in the course of language development as opposed to diachronic (longitudinal) studies?

(e) How successful can an account of syntactic development drawing from theoretical linguistics and cognitive neuroscience be? Are we closer to the question of the 'unification problem'?

Experiments:

Experiment 1: behavioral psycholinguistic study; 3 groups of 3 children

Experiment 2: ERP study; the same children as in Experiment 1

Experiment 3 (Control for 1): longitudinal behavioral psycholinguistic study with Group 1 from Experiment 1

Experiment 4: (Control for 2): longitudinal ERP study with Group 1 from Experiment 1

D. Participants.

For all experiments: right-handed monolingual English-speaking children

Age: 3 children at Stage I: 10-12 months; 3 children at Stage II: 20-22 months; 3 children at Stage III: 22-24 months

(see above for the description of specific groups for specific experiments)

E. Methods & Materials.

Experiment 1: behavioral psycholinguistic study; 3 groups of 3 children

Method: recording of natural production in the child's home environment while the children are playing with their parents/caretakers (story-telling, pictures, playing with toys, etc.)

Experiment 2: ERP study; the same children as in Experiment 1

Method: *elicited-production task; measuring brain activation with ERPs*:

Part I: *talking about a picture/sequence of pictures and story-telling* (e.g., the experimenter will show a sequence of three or four pictures that follow some story and will ask the child *what a certain character did*, *where he went*, *what he said*, *what he didn't do/say*, etc., trying to elicit FCs such as TP, AgrP, AspP, or CP).

<u>Alternatively</u>: an experimenter can act out a story with puppets or other characters and then ask the same questions (Crain & Thornton 1999).

Part II (for Groups II and III only): *imitation* (the presenter will ask the child to repeat the sentences that will differ in complexity, i.e., some will contain only the VP projection, some will add the TP/AgrP, some NegP, with the most-elaborate structure containing all FCs up to CP.

NOTE that the data obtained from elicited-production ERP studies could be potentially used also as psycholinguistics behavioral data and included in the corpus (under Experiments 1 & 3).

Experiment 3 (Control for 1): longitudinal behavioral psycholinguistic study with Group 1 from Experiment 1; the same method as in Experiment 1.

Experiment 4: (Control for 2): longitudinal ERP study with Group 1 from Experiment 1; the same tasks as in Experiment 2.

F. Future Directions.

See **C. Study**, particularly points d) and e)

G. Timeline.

See section **A**. above

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