The Bilingual Bioprogram: Evidence for Child Bilingualism in the Formation of Creoles

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1. Introduction

Studies concerning the emergence of creole languages are largely based on assumptions related to the monolingual speaker, with little discussion of the role that bilingualism may play in creole formation. For instance, the Language Bioprogram Hypothesis argues that creoles arise within one generation when children create a novel first language as a result of exposure to their immigrant parents' degenerate L2 (pidgin) speech. A contrasting view argues that creole grammar is manifested through a prolonged process carried out by adults whose unsuccessful attempts at second language acquisition converge to a new code over the span of several generations. Until recently, no method existed for reliably testing claims put forth in creole genesis proposals. By designing computer-generated "artificial societies," it becomes possible to reconstruct historical and linguistic contexts, with an eye towards better understanding the complex factors involved in language acquisition. To this end, the current work draws from recent psycholinguistic research on language development. Additionally, we employ historical records of sugarcane plantations in Surinam (Arends 1995, Bruyn 1995, Van den Berg 2000), using the emergence of the creole Sranan Tongo as a case study. Preliminary findings from three computer simulations suggest that under the scenarios tested, bilingual competence is a necessary, and indeed adequate, component for the formation of a creole grammar. Specifically, locally-born bilingual children over time appear to be the primary contributors in the emerging creole.

The rest of the paper is organized as follows: Section 2 provides a brief overview of creole genesis and also sketches the recent theoretical formulations advanced with respect to language acquisition. We then focus on the internal workings of the computational model of the "artificial society" in Section 3, discussing in detail the linguistic and social elements encoded into the simulation. Next we profile the emergence of a real-world creole, using evidence from Sranan as a base. In Section 5, three computer simulations are described, comparing the results to Sranan data and to proposals in well-known accounts where conditions for creole emergence may hinge on a) populations of children in the early plantation setting and b) the degree of language contact required between speakers of different grammars. The final sections of the paper offer some additional implications for bilingualism and ends with concluding remarks.

2. Overview: key assumptions and claims

2.1 Creolist terminologies and definitions

Within the creolist literature, we will provisionally adhere to definitions offered by standard works such as Arends, Muysken and Smith (1995) and Thomason (1997, 2001). For the current paper, a *pidgin* refers to any contact language that is established in order to facilitate communication in a restricted social context. A pidgin language is typically a reduced grammar, deriving its limited lexicon from the *superstrate* (language spoken natively by the ruling class.), while deriving its rudimentary morpho-syntactic structure from the *substrate* (the L1s spoken natively by the less powerful groups).

* This work has benefited from helpful comments and discussion from the participants at the 4th International Symposium on Bilingualism 2003 at Arizona State University. I am grateful for programming support and stimulating discussion from Rick Riolo, Wei Chen, and others at the University of Michigan Center of Study for Complex Systems. All errors are my own.

 ISB4: Proceedings of the 4th International Symposium on Bilingualism, ed. James Cohen, Kara T. McAlister, Kellie Rolstad, and Jeff MacSwan, 2075-2094. Somerville, MA: Cascadilla Press.

It is commonly held that pidgins do not constitute the mother tongue for any of its speakers; as an L2, however, a pidgin possesses structural norms and conventions that must be learned by the speaker.

Pidginization is often characterized as a continuum ranging from periods of highly unstable jargon (linguistically and functionally), to extremely stable phases with expanded pidgins. For the purposes of this study, we assume that if a pidgin becomes a widely accepted code in the speech community, children growing up in this environment may acquire it as a native language. *Nativization* is the process whereby the language obtains L1 speakers. The resultant code is referred to as a *creole*, a stable language possessing expanded forms and structure. [1] In terms of nativization, some creoles appear to arise abruptly as L1s (that is, without prior pidgins), while others seem to develop gradually.

Muysken & Smith (1995:8) observe the strong presupposition in the literature that creole grammars[2] have properties that are readily distinguishable from "conventionally" acquired languages.[3] In terms of structure, certain researchers argue that creoles worldwide maintain a striking typological uniformity, sharing far-reaching structural similarities with respect to SVO word order, preverbal TMA markers, word compounding strategies, and so forth. Creoles (and pidgins), as compared to "normal" grammars, are assumed to lack linguistic material—they are confined to a few *simple* structures, displaying little or no morphological, phonological or syntactic irregularities. From a historical and language change perspective, it is assumed that creoles originate from two or more source languages (superstrate and substrates) rather than from a single source, as do non-creole languages. Moreover, creoles are often viewed as languages whose existence can be accurately pinpointed to a specific time in history. [4,5] Certain creoles are frequently assumed to represent an atypical developmental scenario, brought about due to an abrupt break in the natural transmission of L1 from generation to generation.

Of greatest consideration for the current inquiry will be an assumption that, to a large extent, underlies the creole genesis literature. It is the notion that creoles arise due to a unique combination of 'nature' (biological capacity for humans to acquire language), and 'nurture' (external features shaping human development). In light of the numerous studies carried out under the Principles and Parameters framework (Chomsky 1981, among many other works), the nature-nurture conception in and of itself does not set apart creoles as linguistically distinctive. However, depending on the creole genesis approach adopted, the assumption of a disproportionate amount of either biologically-driven nativism or socially-induced interaction (ignoring for the moment how such amounts might be formally calculated) motivates the acquisition of a creole language as essentially different from that of its non-creole counterpart. Given the especially important implications of "nature and nurture" hypotheses for research in creole acquisition, we focus on these premises in the next section.

2.2 Theoretical background
2.2.1 Nature

While a full review of the literature on L1 and L2 acquisition of syntax is beyond the scope of this paper, it has generally been observed that children attain competence in their language(s) to the fullest degree and with relative ease; on the other hand, adults rarely enjoy similar success in L2 acquisition

[1] Earlier studies often define nativized pidgins strictly as creoles. More recently however, creolists are shifting away from rigid classifications. For instance, Bakker (1995) points out that it is not clear whether creole status can be automatically conferred upon a nativized pidgin. If the pidgin is already elaborated and stabilized, such as the case of Tok Pisin, nativization will not greatly affect its structure.

[2] Here, creole 'grammar' is referred to in the sense of Lightfoot (1999:74), as a finite system of knowledge that is represented in the speaker's mind/brain and manifests the individual's linguistic capability; however there are no doubt theoretical discrepancies in the use of the term 'grammar' as well.

[3] The growing view that creoles cannot be categorized as sharing a *linguistically* unique core of features in contrast to non-creoles has been expressed by Chaudenson 1992, Mufwene 1996, DeGraff (in press), among others.

[4] For example, Sranan Tongo is assumed not to have been in existence before 1650. In contrast to this abrupt rise, "ordinary" natural languages are claimed to unfold over long periods of time, such that their definitive historical point of emergence cannot be established.

[5] See DeGraff 2001b, 2001c for in-depth and dissenting commentary.

even when they possess considerable motivation and resources. Lenneberg (1967) explained such age-related differences in language learning as the Critical Period Hypothesis. The idea is that a developmental window exists in the maturation of humans, such that between two years of age and puberty it is possible to be exposed to primary linguistic input and to acquire any language completely and effortlessly. However, before and after this approximately 10-year window, language acquisition becomes increasingly more difficult.[6] Recent psycholinguistics work in the area of sentence processing using event-related brain potentials (ERPs) also supports this hypothesis. Weber-Fox & Neville (1996) found similarities in the concentration of activity in the left anterior temporal region of the brain for monolinguals and early bilinguals processing specific syntactic structures, whereas late bilinguals (onset of the second language was at 11 years or older) showed considerably less activity. Likewise, Johnson & Newport (1989) report syntactic studies where maturational effects were clearly evident in L1 Chinese and Korean speakers, depending on the age when they were exposed to L2 English. In short, participants who had their first exposure to English at 11-15 years of age exhibited a significant decline in performance from native English speakers and from those participants first exposed to English at 3-7 years, in terms of many syntactic areas including mastery of plural and past tense morphology. Other findings from Johnson & Newport (1991) similarly show that L2 speakers who have their first experience with the L2 between 4-7 years of age do not differ significantly from native speakers with respect to subjacency phenomena, whereas those speakers who are first exposed to the L2 at 8 years or older have a marked decrease in performance. In sum, the work presented above and numerous other studies suggest that children first exposed to an L2 prior to age 8 attain native-like competence in that language, while beyond age 8, L2 speakers perform notably distinctly from native speakers in the target language. For this paper, we will adopt this claim as part of a working hypothesis, albeit with a more generous cut-off point of 11-years. We will further assume, in the spirit of Bhatia & Ritchie (1999:580), that any child with early (for this study, prior to age 11) exposure to the L2 who has also received "sufficient" input to both L1 and L2 qualifies as a bilingual, and possesses bilingual competence.

Researchers working largely within the generative paradigm (Lightfoot 1998, 1999; DeGraff 1999, among others) make arguments for the ease of L1 acquisition and maturational effects that are claimed to be attested in creoles, based on the notion of human language as genetic endowment, the core of which is claimed to proceed from Universal Grammar (UG), the biological faculty for language acquisition. A number of such studies suggest that instantiations of L1 acquisition, language change, and creole formation are the result of the very same L1 processes, though manifested through distinct external conditions. A well-known L1 acquisition model is the *Language Bioprogram Hypothesis (LBH) (*Bickerton 1981, 1984a, 1992, 1999). The LBH is offered as a universalist proposal formally outlining the deterministic nature of UG properties in the L1 learning of syntax. The guiding notion is that in such instances where the child's primary L1 input is chaotic or dramatically impoverished (e.g., an unstable (pre-)pidgin), UG-based blueprints are programmed to impose the most unmarked, representations on the child's grammar. The predicted outcome, according to the LBH, can be attested in the shared linguistic structures across creole languages (see Section 2.1). To the degree that young L1 learners internalize a radically different grammar than that of the preceding generation of speakers, there is also a basis for the claim that certain creoles emerge abruptly, possibly nativizing within one generation of child speakers. Support for this particular view of abrupt L1 genesis has come mainly from formal linguistic camps. Other creole specialists remain largely critical. As more empirical findings come forth, the LBH is increasingly seen as lacking explanatory merit due to an insufficient grounding in the historical, anthropological, and social conditions of language contact (Thomason 2001:178).

2.2.2 Nurture

Much formal L2 acquisition research has attempted to demonstrate that "nature," manifested as the strong influence of UG, guides adult L2 acquisition well (White 1989, Epstein et al. 1996, among

[6] See also Long (1990), Schachter (1996), O'Grady (1997), and Bhatia & Ritchie (1999) for in-depth overviews on maturational effects in language acquisition.

others.) However, a larger number of creolist studies (e.g., Chaudenson 1995, Singler 1996, Lumsden 1999, Gross 2000, among others) appear to follow the viewpoint that children and adults are intrinsically different types of language learners. Such accounts assert that "nurture" in the form of imperfect adult L2 learning is the more logical agent of creole genesis. In the case of certain historic plantation colonies, Chaudenson (1995) claims that a phase of inconsistent input and too few cues of explicit negative evidence in the target language, in this case vernacular French, caused L2 learners to restructure the superstrate language into increasingly divergent varieties of creoles over time. After a prolonged period, newly arrived adult slaves were not exposed to the original target variety of French, but instead obtained input from the approximate L2 grammars of the already acculturated adult slaves and from the L2 varieties of other recently imported slaves. Migge (1998) among others, concurs with the hypothesis of an L2 acquisition process, yet argues that in the Surinam creoles, the adult slaves' new L2 objective was not initially a European grammar, but rather a previously formed creole whose base structure came from West African languages. In either case, these and a large number of the proponents of similar adult L2 accounts also maintain that creole formation must be characterized as a gradual non-nativized process. Gradual creole development can be understood in such studies as the formation of the creole progressing over multiple generations of L2 speakers. Ironically, in parallel to the LBH L1-grounded studies, researchers advocating imperfect-L2 adults as the agents of creole formation,[7] have received similar criticisms against their analyses on historical, social, and empirical grounds.[8]

To summarize this section, we have attempted to show that a majority of creolists would concur that the language acquisition process of a young child has a quite different character than that of an adult. Even so, it can still be argued that both L1-nature and L2-nurture hypotheses make sound enough cases for the formation of creoles in a plantation setting. As with most complex questions, one argument is not likely to resoundingly cancel out the other.[9] Thomason (2001:188) concludes, "we can be certain that diverse genesis processes have produced [pidgins and] creoles, but these processes usually cannot be distinguished retrospectively, either in principle or in fact." We would maintain that given the lack of evidence due to the complexity of factors involved in language acquisition, not to mention incomplete historical records, absence of data for early and intermediate forms, and so forth, this conclusion is premature. The current study attempts utilize computational modeling to revive the creole genesis debate by providing a new approach for examining the missing links of past accounts.

3. Components of the model

Building on Satterfield (2001)[10], we posit that a historical language contact setting can be translated into a viable *artificial society* that is able to "cultivate" grammars *in silico*. The goal is to then analyze the linguistic structures "acquired" by the inhabitants of the simulated plantation at various intervals to determine if creole formation is possible taking place. To carry out this investigation, a particular form of computational modeling, known as *agent-based models*, will be used. The program implemented, SWARM, is able to analyze aspects of a determined social domain using dynamic entities, or agents, whose initial general behaviors are specified in the computer program (Epstein and Axtell 1996). Since the program "learns" as it goes along, no further programming or instructions are supplied to regulate the evolving society during a simulation. Change occurs in the society as the multi-agent populations interact in various ways. Based on the local

[7] There is a trend in the gradualist-oriented theories to argue against an abrupt model in the formation of Caribbean plantation creoles, even though these were not previously assumed to have arisen from stable pidgins (Singler 1996, among others).

[8] Consult, for example, McWhorter (1998, 2000) for counter-evidence and commentaries against the gradualist hypothesis.

[9] Thus, see more 'moderate' approaches in Holm (2000), Sprouse and Vance (1999) or Mufwene (1999).

[10] See this and also Satterfield (in preparation) for detailed technical explanation of this model and subsequent versions.

individual interactions and the features of the environment, certain characteristics begin to emerge naturally in the overall system. For our purposes, the primary aim is to release an initial population of agents into the simulated environment. The model is then examined at regular intervals to determine if the emergence of particular linguistic structures will be the indirect consequence of rule-governed interaction between multiple agents operating within the communicative context of the plantation, and to ascertain whether those linguistic structures will be identifiable as creolized forms, based on the features of the case study language to be outlined in Section 4. Our methodology involves the explicit encoding of both abstract linguistic properties and socio-historical documentation of a plantation population into the computer program. We include mechanisms representing the internal development of the speaker's knowledge (L1 and L2 grammar(s), language(s) shared by the community at large, and demographic aspects of the plantation space. Along these lines, the next section briefly outlines the three programmable components that comprise the foundation of this agent-based experiment: environment space, agents, and local rules for the environment and for the agent, respectively.

3.1 Methodology

3.1.1 Specification of environment space

Any developments hypothesized in the creolist literature can potentially unfold in the artificial society, merely based on a small quantity of over-arching variables that initialize the language contact setting. Real-world features of this environment include a landscape, or search space where physical limited are incorporated. The space is made up of a level of grids arranged on a 50 x 50 square lattice which holds 2500 slots. Agents appear as color-coded squares representing different African and European populations, as shown in Figure 1:

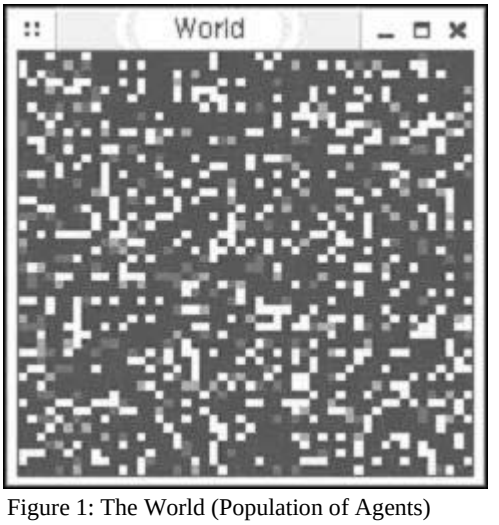

Figure 1: The World (Population of Agents)

The number of inhabitants initially settling the space is 750. The total population will never go beyond a 2500-person carrying capacity (specified as the *population limit rule*) in this particular model. The local rules, specifications used for replicating the Surinam scenario, are shown in Figure 2. For example, population control mechanisms include the *newborn survival rate*, which regulates the number of live births in the plantation.[11] To parallel historical data, no live births occur during the first year of the artificial society's existence, as seen under *delay Years*. Certain parameters control population makeup based on historical statistics and on social affiliations, for instance: *master-to-slave* ratio in the plantation society, *high-status slave (i.e., houseslaves)* ratio *to low-status slave (fieldslaves)*

[11] In keeping with Surinam's demographic records, the *newborn survival rate* divides along racial lines: infants born of European parents have a higher survival rate than the newborns of slaves.

ratio, *male-to-female slave* ratio, *child-to-adult* ratio in total society, and the *percentage of fertile adults* in the general population.[12]

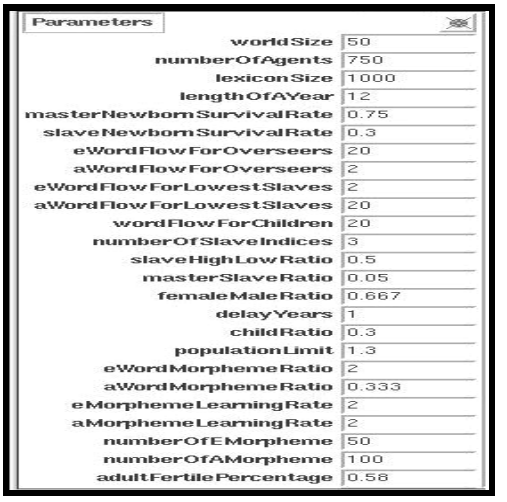

Figure 2: World Parameters

Real-world chronological conditions are also approximated. For each cycle of the model's interaction cycle, one "month" of time elapses. A year is signaled by the *Length of a* Year parameter, which is set at 12 iterations of the interaction cycle. While these time steps are abstractions of actual chronology, they play an important part in identifying language contact benchmarks over a period of time.

Aspects designated as bounded linguistic resources are also encoded as part of the speakers' (mental) environment. Each speaker's capacity for generating and analyzing structure is encoded as the individual's language faculty (FL), drawing on recent syntactic formulations (Chomsky 1995) and psycholinguistic studies (Jackendoff 1997, 2002). The architecture of the FL, as represented in the computational model, is briefly summarized. We assume without further discussion, that the FL is comprised of modular components that interface with one another at various points. We will thus assume that the principal modules of the FL are the cognitive and performance units. Information assembled in the cognitive unit, based on principles of UG and economy must be interpreted for sound and meaning at interface of the performance module. Within the cognitive module, we posit two sub-modules, the lexicon and the computational system. For adult speakers, the lexicon is represented as a list classifying each native and non-native (L2) word stored by the agent. In the case of child agents, we assume that the lexicon[13] is the repository for language-specific information in the form of lexical items (stems and affixes) and rules of word formation for each language encountered. The lexicon is further delimited by two storage compartments: a morphology unit which houses inflectional morphemes or preverbal TMA markers and as a function of the speaker's L1, and a second unit for storage of word stems. Once the speaker has formed words in the lexicon, the computational system applies syntactic operations, which are conceptualized in this model as links "merging" strings of words together based on the grammar specified. As an example in Figure 2, specifications are made under *lexicon Size* concerning the quantity of words that can be housed in the L1 lexical storage of an adult agent entering into the artificial society.[14] As stated, the lexicon is the storage space for lexical items, specifically stems and affixes, and is delimited for both child and adult agents based on several

[12] Slaves receive a hierarchical sociolinguistic index, as detailed in the upcoming pages.

[13] For each lexical item, I will assume that there is an entry itemizing the morpho-syntactic, semantic, phonological information that corresponds to that lexical item, although these distinctions will not be relevant for the current paper.

[14] The model assumes a simplified language contact scenario that is activated only in this new plantation environment. In other words, each adult brings only a previously developed L1 and no other lexical influence to the language contact setting.

features. *Word flow*, a constraint specific to the performance module, denotes the maximum number of merged strings of lexical items in European (*eWordFflow*) languages words and African (*aWordFlow*) languages words that can be transmitted and/or acquired (i.e., permanently stored in the lexicon) in a single exchange by a given agent. An exchange is defined as the transmission and receipt of an utterance (merged strings of words). We also distinguish between higher status slaves' word flow, such as overseers, and the lower status slaves' word flow capacity. The rational for this distinction is that higher status inhabitants will speak more and have proportionally longer utterances than will lower status agents. We further distinguish between adult and child capacity for parameters such as *Word flow*, whereby adult agents may ultimately transmit a larger quantity of their L1 items, but they are more constrained in terms of transmitting and acquiring L2 items than children. Since child agents exposed to multiple languages from birth are not programmed to immediately distinguish *E*-class or *A*-class languages (Deuchar and Quay 2000, Satterfield and Peréz-Bazán, in preparation), the youngest inhabitants are merely specified for a quantity that caps the overall word flow possible. In this respect, we follow one point of the Critical Period Hypothesis that children have a greater capacity for acquiring lexical items during certain periods of their development. Similarly, *eWordmorpheme* and *aWordmorpheme* ratios constitute the maximum number of affixes that can be present along with the transmitted stem of the European-language or African-language(s) word. That is, an E-class stem can be linked to maximally two affixes, while the A-class word can be transmitted with up to three preverbal markers. Simplistically, African (A-class) languages are mapped three preverbal markers to every one lexical item generated, based on general typological properties of Gbe dialects, such as Fon (Fabb 1992, DeGraff 2002). European (E-class) languages are represented as two inflectional morpheme per word, based on average morphosyntactic properties assumed for Early Modern English. On analogy with the studies involving maturational effects and acquisition of inflectional morphology, the M*orpheme Learning Rates* regulate the number of morphemes that the child can obtain for storage during any given exchange with an interlocutor. It is important to understand for this model that the acquisition of L2 morphology is not built into the adult learning capacity for L2, based on the maturational accounts already discussed. The *number of Morphemes* provides an upper bound on the initial quantity of European–morphemes and African preverbal particles that will be available to be unified with stems and words in each respective grammar.

3.1.2 Specification of agents

As with the initial environmental specifications, over-arching variables characterize the initial population of agents. All agents are uniquely endowed with internal states and behavioral rules. An agent's genetic profile designating age, race, sex, death, and so forth, is fixed for life; while its cultural identity and social status may vary over time, in keeping with the demographics to be presented in Section 4. Figure 3 shows the complete inventory of agent properties in the current simulation:

As a dynamic model, a basic component of the SWARM model is the movement rule. Agents are in constant movement throughout the plantation during their lifespans. Each agent is located in a specific slot, identifiable by ordered pairs of x-y (*x=33, y=4)* coordinates of the lattice, as shown in Figure 3. Two inhabitants are never allowed to occupy the same position in the world. For our purposes, the movement rule instructs the agents to relocate to the closest unoccupied cell that also contains adjacent neighbors. This rule sets the stage for the ensuing linguistic and reproductive interactions in which every agent can potentially be selected for participation.

The agent also has certain genetic states encoded in a binary (no = 0 and yes = 1) alphabet. The inhabitant #1018 profiled in Figure 3 is a male, non-fertile (given his age of 3 years) and, at this point in the simulation, apparently still alive based on the specification of *dead* = 0. Each individual in the plantation setting receives a social class marker, 1= slave, 0 = planter. From the *momClass* and the *dadClass* we can trace the child's parentage as well. For more complex social categories that change over time, each agent can be tracked through his/her *slave Index*, a tag that represents specific attributes of various ingroups. The tag links the agent in a more fine-grained manner with agents who share certain features that the researcher may wish to track. In this study, a 3-bit string of 0's and 1's characterizes the traits, as in the individual's string consisting of *1-0-0* in Figure 3. In the first bit-position of the string, the general social categorization, or class, of the agent is re-specified. European planters have the highest social standing and receive 0, whereas all slaves receive a marker of 1. In the second bit, a status index is assigned, where planters and children receive a 0 index and adult slaves

are classified with an index between 1 and 4, based on their function in the plantation. Overseers have high status (=1) among slaves, house slaves receive the index 2, as can be observed for the father of agent #1018, in the *dadIndex*. Field hands and infirm slaves receive progressively lower indices. Upon reaching age 12, the child's status is assigned through random 'inheritance' of either the mother or the father's class-marker (*momIndex*, *dadIndex*). The final position in the string corresponds to the agent's ethnolinguistic group. Europeans again receive the index 0, and slaves are categorized by indices 1-4 according to their cultural heritage, as will be discussed shortly.

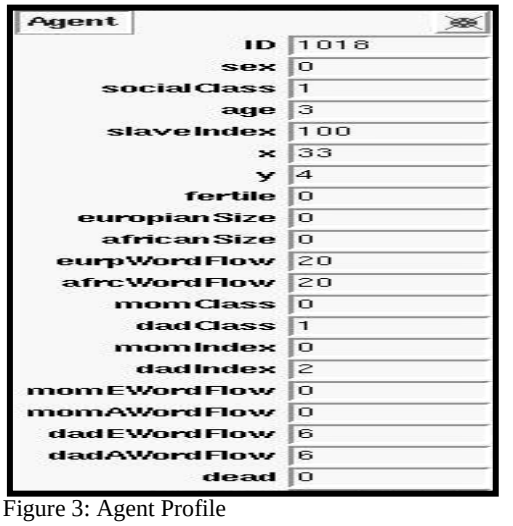

Figure 3: Agent Profile

The exact size of the agent's particular lexicon (for both Euro- and Afro-languages) is specified at all times under the categories *european Size* and *african Size*. In this example, the quantity of data that the 3-year old child can maximally process in a given encounter are shown in the European and African *WordFlow* categories. What is interesting in this case is that in Figure 3, the child's father is transmitting a small amount of both A-class language words and E-class language words to the child in equal quantities, which would lead us to assume that the father is to some extent bilingual, given his status as a house slave. The child's mother is not involved in this instance in providing linguistic input for the child.

Again, the psycholinguistic literature (i.e., Goldin-Meadow and Mylander 1990, Wexler 1998, 1999, Hudson and Newport 1999) is replete with studies supporting the hypothesis that children and adults possess different computational limitations for acquisition and storage of lexical and grammatical information. For this model, a t*emporary memory buffer* constrains child learners, and to a larger extent, adult learners from acquiring an unchecked amount of vocabulary for long term memory, on analogy with the restricted computational resources of learners posited in much of the language acquisition literature (i.e., Johnson & Newport 1991, Strozer 1994, among others.). Only after a specific number of interactions when a lexical item has been encountered repeatedly will the learners store the information in the lexicon; thus in Figure 3, we see that the size of the child's lexicon (long term memory) still reads 0. Child-agents enter the environment with no linguistic affiliation, but given the presence of UG in the child's language faculty, they possess an inherent ability to acquire and to generate any language. Children in this model use the temporary memory buffer to store both words and inflectional morphemes/TMA markers from all input sources (E-class and A-class languages) at slightly higher rates than adults.

The language learning algorithm functions in the following manner: to begin the simulation, the demographics and environmental properties are specified, and adults (agents over 12 years of age) are initialized with an agent profile. The next step is to induce language contact. Contact occurs through the movement rule, where agents must move within the world to the unoccupied slot closest to them that also contains adjacent neighbors. During the initial linguistic exchange, agent1 transmits an utterance (a string of words) to his/her adult neighbor(s). The number of neighbors that can be involved in the communication is adjustable in the model. If a lexical item in agent1's sentence is not found in the current lexicon of adult agent2, agent2 will then add the element to his/her temporary

memory buffer, contingent on social and linguistic constraints discussed throughout this section. If agent2 then receives an utterance from adult agent3 and encounters the same lexical item again, agent2 will add the new word to his/her lexicon (long term memory). Thus, it is important to note that frequency plays a crucial rule in the language learning process utilized in the model. If agent2 and agent 3 are interlocutors of the opposite sex and both are fertile, they may also engage in reproductive activities. In the following learning cycle, suppose that children are now appearing in the environment. Language contact is induced via the movement rule. The child, agent4, can enter into a linguistic exchange with any agent who is older than 5 years old. Agent4 receives an utterance from Agent5. Child agent4 does not possess any items in his lexicon and thus, stores the words from the utterance as separate parts, each as a stem and an affix, in the lexicon (long term memory) during the exchange. The language learning cycle is completed and can be repeated for any number of iterations.

4. Case study: Sranan Tongo

The ethnolinguistic and demographic criteria utilized for the current computational model derive from a compilation of historical archives and linguistic accounts on Sranan Tongo, an English-based creole (Arends 1992, 1995; Winford 2000; Adamson and Smith 1995; Bruyn 1995; Migge 1998, 2000; and van den Berg 2000).[15] The aim is to compare the computer simulation to the development of Sranan over time, to determine whether the inhabitants of the artificial society come to have grammars that reflect the properties found in the Sranan creole.

4.1 Linguistic features

The general typology outlined in this sub-section concerns the distributional facts of Sranan's syntax and morphology. Sranan exhibits several properties that appear to be shared by other creoles: reduced inflection, the marking of tense, mood, aspect (TMA) by means of pre-verbal particles, reduplication, and a canonical SVO word order in declarative and interrogative constructions. Given the mechanisms of the language faculty specified in the model for adult and child speakers in the contact situation, a possible outcome of their interactions over time might produce strings that share the features of the following sentences:

1. a. I e skrifi waN brifi.
"You are writing a letter."

b. I e skrifi waN brifi?
"Are you writing a letter?" Adamson and Smith (1995:226)

The SVO order is largely invariant in Sranan, as in (1) there is no lexical material used to distinguish the declarative form from the interrogative in the two sentences. Inflectional morphology is not prevalent as a paradigm. While not uncontroversial as an analysis, the overt inflection of the preverbal tense/mood/aspect, *e* for progressive and *o* for future/irrealis (per Adamson and Smith 1995) can plausibly be identified as inflection, as arguably they rigidly precede the verb and allow no intervention from other items. The use of oblique forms as subject pronouns (*mi ,i, a, den, etc.*) is attested in the Sranan pronominal system. There is a distinction between singular and plural pronouns, with plural items diverging more from their English source (Baker and Huber 2000).

As regards the lexicon, Bickerton (1984a) claims that Sranan's lexifier language is essentially Early Modern English, on the view that it represents an abrupt creole. If it is the case that all English planters (and presumably their slaves with them) left Surinam around 1680, then the likelihood of gradual development seems more remote. The major superstrate influence thus may have taken place

[15] These studies have been further informed by data in Seigel (1987).

abruptly, from possibly 30 years of English; whereas Sranan speakers have been exposed to Dutch and various African language varieties for over 300 years.[16] Note examples in (2):

2. a. Mi no ben si en.
"I did not see him."

b. Pas te unu kaba nanga skoro dan wi o meki pikin nanaga den sani dati.
"Only when we finish with school, then we'll have kids and all those things."

c. Ma yu nelde yu mama dati wi e go pley bal?
"But have you told your mom that we're going to play basketball?"

d. Dan te mi miti en mi sa aski en.
"Then when I see him I will ask him." Winford 2001 (pc)

McWhorter (1998) claims that the initial input to Sranan was a West African Pidgin, perhaps used in addition to regional dialects of languages spoken natively by Europeans. However, compelling evidence, especially from the early part of the 18th century (Arends 1992), pinpoints English as the main lexifical source for Sranan.

Discussion concerning the classification of the African language substrate influences continues. Working from a detailed history of the Dutch Atlantic slave trade, Arends (1995) links the formation of Sranan (and perhaps additional Surinam creoles) to a variety of language families on the western African coast. A primary substrate appears to have been formed stemming from early arrivals (1650-1720) with 50% of these imported slaves speaking languages of the Gbe-cluster (Fon, Ewe), and 40% from particular Bantu languages (e.g., Kikongo) which figured as a strong secondary influence. Between 1720-1740, the main body of slaves imported spoke Gbe-languages and Kwa-languages from the Nyo-branch, such as Akan and Ga. The relevant African languages most likely contributing to Sranan post-1740 are Fon (along with the other closely related Gbe-languages), Kikongo, and, to a smaller degree, Twi. Based on geographic and demographic data, the substrate influences appear to be subject to frequent fluctuations, depending on the quantity and regional origins of slaves in the population in any given period. This said, the linguistic environment may have gradually moved to a more homogeneous state, as within a 75-to-90-year time period, the three post-1740 language groups mentioned above emerged as the most prominent in Surinam. Bruyn (1995) observes that remnants of Fon, Kikongo, and Twi are still discernible today in certain creole communities' rituals.

To summarize up to this point, we will assume that a grammar resembling Sranan will exhibit similar properties, or characteristics, that we will term "creole effects." Creole effects observed as the output of the computer model should include the following: SVO word order, English superstrate of lexical items with African language substrates, in the form of morphology, primarily as preverbal markers.

4.2 Documented demographics

General archival documents indicate that Sranan's earliest history began with mid-17th century English settlers who set up small farms. By 1665, there were roughly 1500 British planters in the region and close to 3000 African-born slaves. A subsequent Dutch invasion occurred which virtually drove out the English by 1680. Until 1690, the new colony experienced accelerated growth as Dutch planters expanded farms into large-scale sugar plantations, importing increasing numbers of African slaves. By 1750, every planter-master owned approximately 45 to 60 slaves. Plantation numbers were routinely decimated from the slaves' short life expectancy, low birth rates, and escape. Records speculate that male slaves outnumbered female slaves 2 to1. Children were at most 15% of the total

[16] While the Sranan lexicon is primarily English-based, Portuguese, and a plethora of Dutch words also contribute to the vocabulary. A number of lexical items are also taken from Javanese and America Indian.

slave cohort; and approximately 45% of these infants died before age 5. Due to these circumstances, the population was sustained through the constant influx of new slave labor rather than from natural growth.

5.2.1 Language contact

Plantations typically functioned as strict hierarchical organizations. In 17th and 18th century Surinam, a large social distance existed between different groups on the plantation, causing a considerable restriction in social networks. Social stratification occurred along the following boundaries: European versus African; adult versus child; elite slaves, including overseers and house slaves, versus field hands; and to a lesser extent, slave elite with diminished manual tasks versus highly skilled African craftsmen. These divisions created differences of social status within the slave community, but also had consequences for the quality and quantity of linguistic interaction among different groups of speakers.[17]

If African languages were maintained on the basis of certain tasks, a wide, yet rather simplistic, spectrum of creole (basilects to acrolects) and non-creole speech forms circulating throughout the plantation can be conjectured. Field slaves could be assumed to preserve more (elements of) African languages, speaking a type of basilect, known in 18th century Surinam as *nengretongo* (literally, "Black man's tongue") that was farthest removed from the English superstrate. The creole variety assumed to be spoken by house slaves would be the acrolect, (e.g., *bakkratongo*, or "White man's tongue") conforming more to the superstrate. Slaves of intermediate status would thus be predicted to speak a mesolect, or intermediate creole.[18] Based on these conditions, Arends (1995:21) predicts that, "the model for the acquisition of the creole as a second language by the African-born slaves would be a second, not a first language version of that creole."

5. Research program

The basic object is now to record the growth or lack thereof of the speakers' linguistic knowledge across the experimental variables. To this end, three tests will be carried out in the present study.
In the first test, a population of European and African adults are activated to begin the simulation. The primary variable under scrutiny is that of the young child and his/her linguistic capacities with respect to L1 development and nativized creoles. Since the initial surviving children appear only after twelve time steps of interacting adult agents, there are no live births in the first year of the plantation. Demographic conditions over time consist of a 15% minimum of children, a regular influx of imported slaves, and extensive contact (per appropriate social hierarchies) between all neighbor-agents. Biologically endowed linguistic mechanisms for L1 acquisition are maximally operative. If creole effects are visible only when a sufficient mass of locally-born children make up the general population, then the result may suggest that nativization is a predictor of creole formation.

The second test attempts to recreate a language learning scenario that isolates non-native adults as the community of language learners. Linguistic and social variables are incorporated to bring about a context suitable for imperfect adult L2 acquisition. Defective L2 learning conditions include: widely diverse input in the linguistic setting, bounded resources in terms of both processing and the acquisition of morphology, regular influxes of new adult slaves, and a dearth of children.[19] A rigid

[17] Valdman (2000:155) points out from historical records that plantation owners were instructed by colonial officials to separate slaves from the same ethnic group in order to avoid uprisings. However, this policy was not strictly implemented by plantation managers, since laborers who worked in teams in the sugar mills or in the cultivation of crops needed to be able to communicate efficiently. It was likely that work forces consisted of homogeneous slave groups from the same "nation."

[18] If such strict linguistic divisions were in place, they would have easily been instantiated by the social practice of *seasoning*; entrusting older, acculturated slaves in a plantation to acquaint recently arrived slaves with life in the colony, in a shared African language, as outlined in Valdman (2000:156).

[19] To compensate for the non-growth of the population, slave importation occurs randomly at twenty to twenty-five-year intervals (once at about every 240-300 time-steps).

social hierarchy limits African access to Europeans and to the standard superstrate targets for the slave populations. If creole effects are visible only when non-locally born adults make up the population, then the result may suggest that nativization is not a strong predictor of creole formation.

In the third simulation, social variables are isolated in order to study the effects of general limited social activities on creole formation. Test III builds a scenario comprised of children and adults; however, instead of 'normal' access to linguistic information from all surrounding neighbors of the appropriate status, agents are restricted to interactions with one neighbor at most per learning cycle. If biological factors are the central motivators of creole development, this scenario may result in the emergence of a creole. However, if social factors as embedded in the communicative context are the primary impetus for creole genesis, then the prediction is that a creole grammar should not result under the hypothesized conditions of very limited interaction.

5.1 Results

5.1.1 Test 1: full instantiations of the LBH and social contact

The results for Test I are found in Figures 4 through 7. These figures represent the lexicon. Figure 4 examines the actual lexical acquisition (stems) activity among the total population, adults and children, at each time-step, over the same 80-year period. At the end of 1000 learning cycles, European-based items are by far the most frequent vocabulary words acquired in the population, with more than twice the number of European lexical items being accumulated than African-language words, even including the most statistically prominent language of the plantation, Fon (where the topmost line represents Fon as *A-words*, the second is Kikongo, or *B-words*, *C-words* as the third line from the top refers to Twi.).

Figure 5 depicts the mental representation of words (stems) in the lexicon for the average adult in the plantation society, spanning a period of approximately 80 years.[20] This information is doubly useful in that it also provides an indicator of the type of lexical input that L1 children and incoming L2 adult learners should encounter from the average adult of the plantation at any given period of time. In short, we see that the slave's lexical inventory is in the process of being transformed from a small quantity of knowledge that is purely African-based. This knowledge doubles over time to a strong, though still yet unstable, amalgam of European and African items. Specifically at the onset of the simulation, an adult on average possessed a small group of lexical items from the main African- From about t_{250}, the trajectory for the adult's average European-based lexical inventory rises steadily, overtaking the line that was initially fourth from the top, categorized as *D*-words, or "lexical items in other African-languages."

Figure 6 reports the acquisition activity for morphological affixes among the population of children, at each time-step. Over the course of 1000 cycles, the African-language inflectional markers are learned at a slightly higher rate than the European forms. However, the overall high frequency of morpheme learning does not vary among African and European grammars over time. Figure 7 highlights the average adult's knowledge state with respect to inflectional morphemes and TMA markers. The topmost line signals the inventory of African-languages affixes, shown initially to be abundant, as one would predict for the slave adult's L1 grammar. While strong knowledge of African-based markers is retained over time, the number of European inflectional morphemes in the average adult's lexicon increases incrementally to a near maximal level. As an indicator of the adult knowledge state in the population at any given period, the information in Figure 7 can also provide some insight into the type of morphological input that L1 children and incoming L2 adult learners encounter on average from the adults in the plantation setting. However, another important point is that from a learnability perspective, Figure 7 predicts that the adult would be potentially transmitting ambiguous data given complete and consistent knowledge of both African-language-based and European-based morphological paradigms.

[20] The average adult speaker in this setting is statistically most likely to be a field slave of 15 years or older.

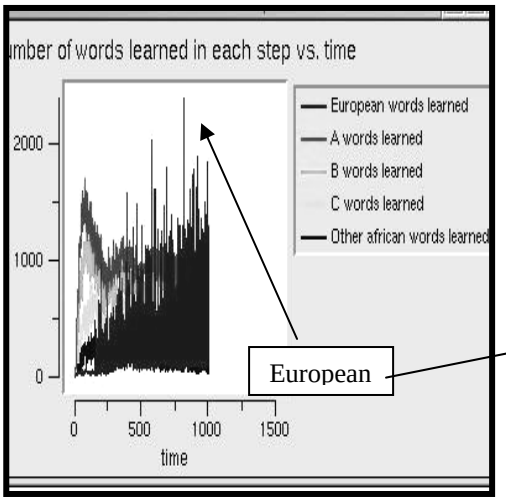

Figure 4: Lexical Acquisition in Population

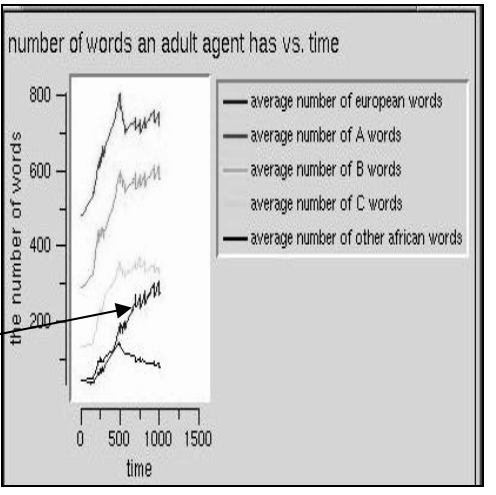

Figure 5: Lexical items of Average Speaker

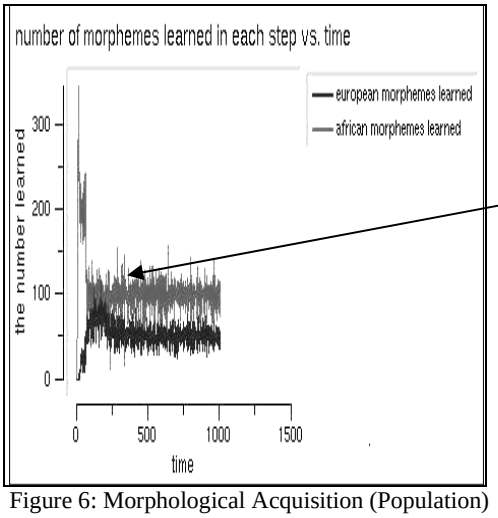

Figure 6: Morphological Acquisition (Population)

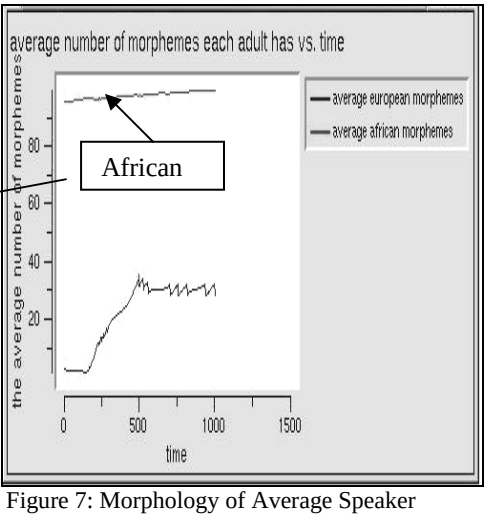

Figure 7: Morphology of Average Speaker

5.1.2 Test II: Strong social contact, absence of children (no LBH)

Test II findings shown in Figures 8 through 11 demonstrate that, after 1000 learning cycles, the childless scenario translates to a condition in which neither the most recent L2 speakers, nor the more established adult slaves acquire new inflectional morphology. Although speakers maintain the L1 African-language morphological structures that they initially possessed, a new mixture of lexical items, albeit of small magnitude, is attained by the average adult speaker in the plantation. From the topmost line in Figure 8, moving down from *A*-words to *B*-words, *C*-words, and other African-words as *D*-words, respectively, an adult speaker possesses exclusively African vocabulary. There are slight increases in the small adult lexical inventory shortly after t_{250}, t_{500}, and t_{750}, corresponding to growth of the average lexicon due to incoming slaves at those points. Kikongo shows the most expansion within the average adult's storage of lexical items. Crucially, the lowest line of the graph illustrates that the adult population decreases in the already small stores of European-language lexical items on average.

Along the same vein, the inflectional morpheme values for African- and European-languages in the average adult's lexicon are extremely skewed, according to Figure 9.[21] If Figures 8 and 9 represent

[21] The intent to remain faithful to as many demographic points as possible and to endow adult learners with realistic linguistic resources leads to an invariant bias in the model. For instance, it is tempting to argue that the elite house slaves and overseers would acquire European language features, due to their necessary interactions with the European population. Repeatedly in Test II, the absence of genetic reproduction produced a situation of

the type of data transmitted to incoming populations of L2 adult learners at any given time, Figures 10 and 11 show the resultant linguistic structures. At the final time-step, the acquisition of European lexical items has decreased to nearly zero. Figure 10 displays no activity whatsoever for either the acquisition of African or European inflection.

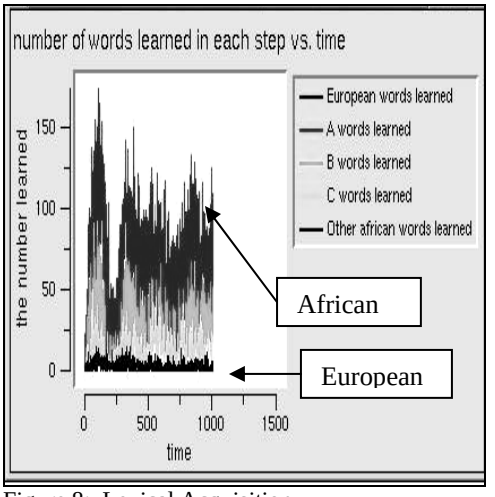

Figure 8: Lexical Acquisition

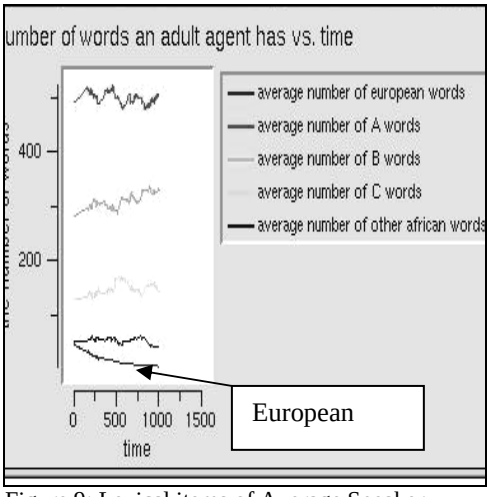

Figure 9: Lexical items of Average Speaker

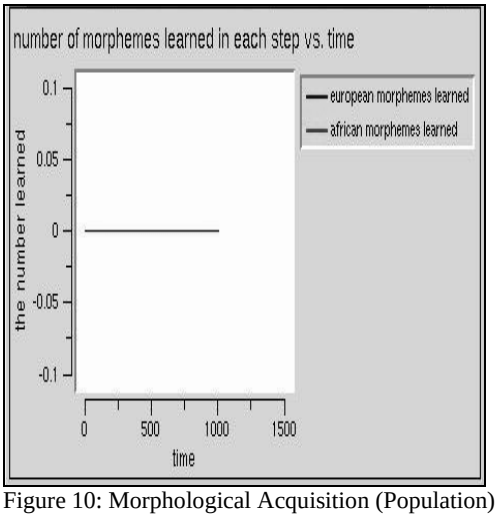

Figure 10: Morphological Acquisition (Population)

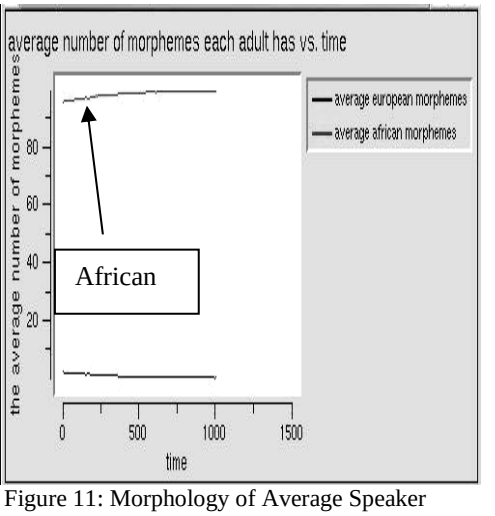

Figure 11: Morphology of Average Speaker

5.1.3 Test III: Limiting social contact and maintaining the LBH constant

If we again suppose that the adult's lexical makeup constitutes the input for L1 and L2 learners in the population, Figure 12 denotes the lexical acquisition across the total population, over each time-step. At the end of 1000 learning cycles, the frequency of words acquired is highest for European items. Thus, one observes that at the end of this simulation, the lexical contributors in decline are the African-languages, Kikongo, Twi, and the class of "other African-languages", respectively. A notable point found in Figure 13 is that the average adult's knowledge of European-based lexical items

early "extinction" for the slave owners. New influxes of Europeans were not periodically introduced into the community, as was the case for the continually replenished slave population. This general paucity of any European language input over time, coupled with stable and growing African groups, naturally resulted in the survival of African languages across the community.

becomes gradually more pervasive, as we see from the represented storage of words in the lexicon. This development occurs in spite of limited inter-agent contact that should equate to minimal European contact for the slaves. The rugged landscape in Figure 14 depicts the instability involved in the acquisition task for the inflectional morphemes. The results show that after an initial peak, African-language inflections drop significantly in the rate that they are acquired across the population; however European-language morphemes increase to an amount nearly equivalent to the African-languages morpheme value. The average adult's inventory of inflectional morphemes as a function of time is charted in Figure 15. The topmost line signals a consistently superlative knowledge of African-language morphemes; while the number of European morphemes maintained by an average adult tends to increase incrementally.

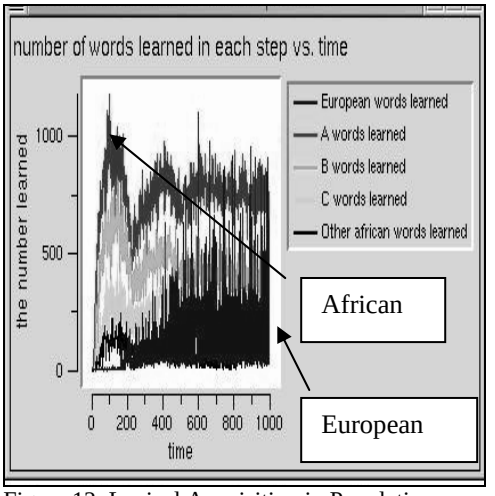

Figure 12: Lexical Acquisition in Population

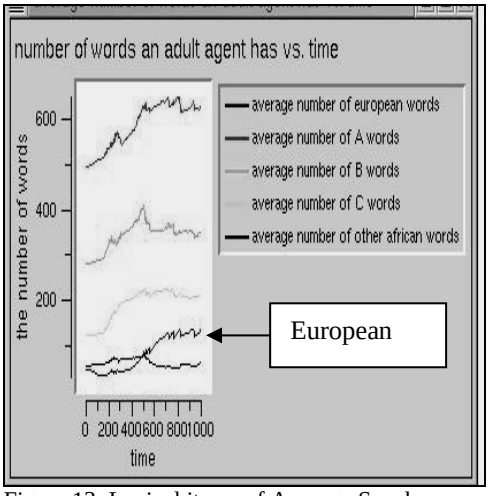

Figure 13: Lexical items of Average Speaker

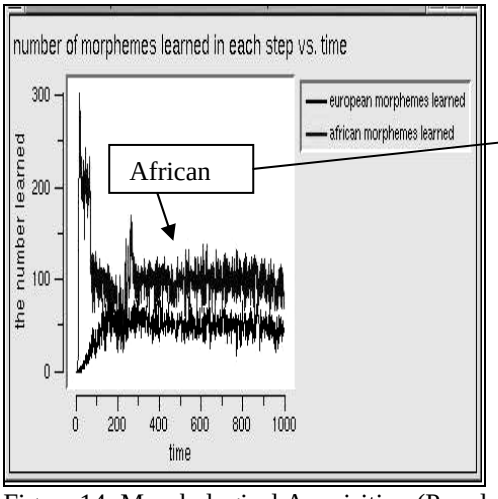

Figure 14: Morphological Acquisition (Population)

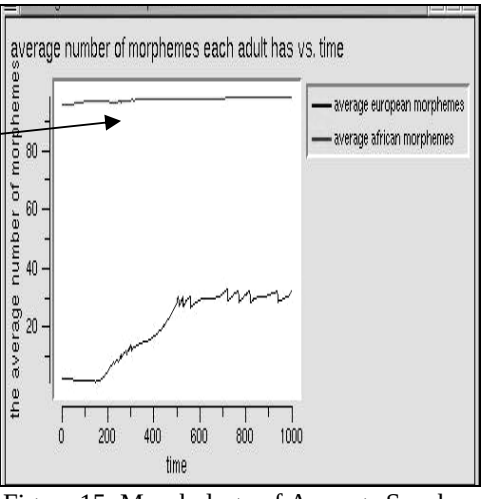

Figure 15: Morphology of Average Speaker

6. Discussion

Preliminary conclusions suggest that based on the presence of local children in the population, linguistic change progressing toward a creole grammar (a European superstrate with an African substrate) does occur, and creole genesis seems imminent. Test I demonstrates that lexical acquisition is exhibiting an ever-growing European inventory over the previous mixture of African lexical items. Further evidence for this conclusion is that the earliest signs of creole formation are never attested in

the first year of the plantation's existence, when adults are the sole inhabitants. Rather, the language change process begins taking place at a point when the oldest locally-born children of the plantation reach about nine years of age (t_{120}), and as a critical mass of younger agents is also taking root. Importantly, given the child agent's innate and relatively powerful linguistic resources, the process of creole genesis is shown to occur gradually, rather than within one generation of child speakers. Likewise, if creole formation occurs under this scenario, it not only must span more than "eighty years" of steady development within the nativizing population, it must be coupled with robust social and linguistic interactions among the neighboring agents.

Test II builds on this conclusion. Abstracting away from the population of child agents, findings show that the non-native adult speakers do not attempt L2 acquisition, imperfect or otherwise, of the superstrate language. In fact, the adults have extremely stable grammars that are the least influenced by European contact or by the minor "other African-languages" in the community. Additional confirmation can be seen by the punctuated accrual of a mixed group of African-language lexical items in the absence of children. This circumstance, however, does not seem to signal a step towards creole formation: first of all, the word inventory that the average adult stores is surprisingly scant considering the continuous influx of new slaves. Secondly, virtually no radical shift in the overall pattern of lexical storage occurs, unlike what occurs with the children's presence. Furthermore, without L1 learners, the acquisition of novel morphological forms or feature expansion does not occur in one instance during 1000 learning cycles. It is relevant that the model encodes a strong bias such that adults do not acquire L2 morphological paradigms. In future versions of the simulation, it would be interesting to endow adults in the environment with a range of abilities for learning new morphology, to determine if this feature also triggers more abrupt creole formation and creole genesis in populations lacking a critical mass of children.

Test III results suggest that social contact or the "nurture" component of creole genesis is a relevant factor in L1 lexical development, having most significant bearing on the accumulation of superstrate vocabulary. Across all speakers, adults and children, the level of interaction between agents in the environment dramatically affects the quantity of lexical items acquired and stored. However, the degree of contact does not appear to influence L1 morphological acquisition. Even with minimal language interaction, children in the plantation setting still acquired inflectional morphology at exactly the same rate and frequency as did children in the richly interactive setting of Test I; and adults consistently maintain their own L1 forms. Manipulation of the interaction variable also factors in on language change effects. As one might expect, less interaction triggers more pronounced gradualness in the language shift away from African words. Due to the prolonged process of development under these conditions, there is no way to predict whether creole grammar will be the definite outcome in the case of extremely limited social contact between agents.

There are some interesting twists in the test results that merit further scrutiny. For instance, when locally-born children are a presence, the average adult's lexicon after 1000 cycles contains a dynamic mix of African and European lexical items. This condition is readily explained if one speculates that historically, slave children actually had more consistent and prolonged contact with European linguistic input. Blassingame (1972:96) relates the fact that until age ten, slave children on plantations were freer to interact with whites and often were raised alongside the white children by a black "mammy." To the degree that the model parallels this activity, European lexical items acquired by slave-owner children could be easily transmitted to African children, and vice versa. The circumstance may also account for the stabilized mixture of African and European affix elements found in the average adult lexicon. However, since there is no overlap or impending loss of either morphological paradigm, this state can be argued to resemble the bilingual acquisition scenario (Hamers and Blanc 2001). To the extent that, over time, the average adult has a bilingual-like competence in both African and European codes, child bilingualism may well be a necessary precursor to nativized creole formation, as noted by Roberts (2000) in her study of Hawaiian Creole. Our preliminary results are consistent with Roberts' empirical evidence: locally-born older children with bilingual competence, rather than non-native adults, trigger creole formation over time. We hasten to add that the class of input in the simulation, although quite diverse, may not have been "deficient" enough for the child to do anything but acquire complete grammars. This matter merits further investigation.

Motivated by further theoretical and practical concerns, modifications are presently being considered, with an eye to providing more explanatory models of language contact. For example, a word formation rule involving fixed templates of *X* words to*Y* morpheme affixes is not exclusively suggested by current cognitive formulations (i.e., Jackendoff 2002), although this strategy efficiently eliminates extensive searches for L1 and L2 language family tags. As previously mentioned, rigid constraints were posited on adult acquisition of non-native words and morphology; whereas the youngest children had less restrictions for storing any morphological or lexical item. It is clear that such stipulations, along with issues of linguistic input, must be coordinated with recent findings in first and second language acquisition theory. Similarly, the nature of the African languages TMA markers and lexical items were not clearly defined among each of the African languages represented in the study. Lastly, demographic factors should be fine-tuned to better include facts of the European populations involved and to also pinpoint those "critical mass" conditions necessary for triggering individual and population-wide creole formation over time.

7. Concluding remarks

This study has demonstrated that it is possible to implement new technologies that begin to reconstruct historical and social contexts for examining premises of linguistic theory and creole development. Of the various hypotheses that have been offered for how creole grammars emerged in historical language contact settings, our preliminary findings have several implications that will be followed up in future research. First, it appears that maturationally specified capacities indeed play a crucial role in allowing children to organize disparate input in such a way that this information can be subsequently accessed to create novel and complex structures, in computations that adults do not seem to utilize. Similar findings were shown in the experiments of Hudson and Newport (1999) that suggest that adult learners exposed to variable input do not generally develop consistent and obligatory rules which they then imposed on the language. When the adults in their study did apply rules to the input, the rules were typically based on omitting structure from the language. Furthermore, striking similarities in the morphological acquisition patterns of Tests I and III in Section 5 strongly favor the LBH claim that extra-linguistic factors and the environment do not greatly influence the child in grammatical (inflectional) acquisition. Along with this, our results also suggest that to the extent that a creole is comprised of a superstrate lexical source and a system of inflectional elements, an optimal level of social interaction is necessary to acquire the lexical inventories, in contrast with minimal interaction needed for the inflections. This situation might imply that creole formation does not obtain unless a certain quantity of lexical morphemes or stems are acquired, where quantity seems linked to specific types of social contact. With further investigation, the acquisition and storage of disparate lexical elements may be found to trigger creole formation and to be the feature that most distinguishes the process of creole genesis from other types of L1 acqusition .

Furthermore, no experiment validated the LBH claim that creole languages develop within a single generation of child speakers, however the results illustrate a representation of knowledge states that we interpret as bilingualism, which did hold fairly constant at minimal levels of social interaction between children and adult speakers. Given these tentative findings, we suggest that, within the 70-plus years of time allotted for our experiments, bilingualism appears to be the precursor to developing a creole language. If this is the case, then the child's capacity for bilingualism may actually play the pivotal role in creole genesis. This model also opens the door for in-depth research on important questions of the very young child's inherent capacity to acquire two or more languages with relative ease. If indeed a language bioprogram exists, it may well be in the form of an expansive blueprint toward bilingualism, instead of its present conceptualization as a reduction to a default monolingual grammar.

References

Adamson, L. & Smith, N. (1995). Sketches of individual languages: Sranan. In Arends, J., Muysken, P., & Smith N. (Eds.). *Pidgins and creoles: an introduction* (pp. 219-232). Amsterdam: John Benjamins.

Arends, J. (1995). Demographic factors in the formation of Sranan. In J. Arends (Ed.), *The early stages of*

creolization (pp.233-285). Amsterdam: John Benjamins.
Arends, J. (1995). General aspects: the socio-historical background of creoles. In Arends, J., Muysken, P., & Smith N. (Eds.). *Pidgins and creoles: an introduc*tion (pp. 15-24).Amsterdam: John Benjamins.
Baker, P. & Huber, M. (2000). Constructing new pronominal systems from the Atlantic to the Pacific. *Linguistics*, 38(5), 833-866.
Bakker, P. (1995). General aspects: pidgins. In Arends, J., Muysken, P., & Smith N. (Eds.). *Pidgins and creoles: an introduction* (pp. 25-39). Amsterdam: John Benjamins.
Bhatia, T. & Ritchie, W. (1999). The bilingual child. In Ritchie, W. & Bhatia, T. (Eds.) *Handbook of child language acquisition*. San Diego: Academic Press.
Bickerton, D. (1981). *Roots of language*. Ann Arbor: Karoma.
Bickerton, D. (1984a). The language bioprogram hypothesis. *Behavioral and Brain Sciences*,7, 212-218.
Bickerton, D. (1988). Creole languages and the bioprogram. In Newmeyer, F. (Ed.), Linguistics: *The Cambridge survey* (pp.267-284). Cambridge: Cambridge University Press.
Bickerton, D. (1992). The sociohistorical matrix of creolization. *Journal of Pidgin and Creole Languages*, 7, 307-318.
Bickerton, D. (1999). How to acquire language without positive evidence: what acquisitionists can learn from creoles. In DeGraff, M. (Ed.), *Language creation and language change* (pp.49-74). Cambridge, MA: MIT Press.
Blassingame, J. (1972). *The Slave Community*. New York: Oxford University Press.
Briscoe, T. (2000). Grammatical acquisition: Inductive bias and coevolution of language and the language acquisition device. *Language*, 76(2), 245-296.
Bruyn, A. (1995). Grammatical features: noun phrases. In Arends, J., Muysken, P., & Smith N. (Eds.). *Pidgins and creoles: an introduction* (pp. 259-288). Amsterdam: John Benjamins.
Bruyn, A., Muysken, P., & Verrips, M. (1999). Double-object constructions in the creole languages: development and acquisition. In DeGraff, M. (Ed*.), Language creation and language change* (pp.329-374). Cambridge, MA: MIT Press.
Chaudenson, R. (1992). *Des îles, des hommes, des habues*. Paris: L'Harmattan.
Chaudenson, R. (1995). *Les Créoles*. Paris: Presses Universitaires France.
Chomsky, N. (1981). *Lectures on government and binding*. Dordrecht: Foris.
Chomsky, N. (1986). *Knowledge of language: its nature, origin, and use*. New York: Praeger.
Chomsky, N. (1995). *The minimalist program.* Cambridge, MA: MIT Press.
Clark, R. & Roberts, I. (1993). A computational approach to language learnability and language change. *Linguistic Inquiry*, 24, 299-345.
DeGraff, M. (2001b). On the origin of creoles: a Cartesian critique of Neo-Darwinian linguistics. *Linguistic Typology*, 5 (2-3), 213-310.
DeGraff, M. (2001c). Morphology in creole genesis: linguistics and ideology. In Kenstowicz, M. (Ed.), *Ken Hale: A life in language* - Current Studies in Linguistics 36 (pp.53-121). Cambridge, MA: MIT Press.
DeGraff, M. (2002). Morphology and word order in 'creolization' and beyond. In Cinque, G. & Kayne, R. (Eds.), *Handbook of Comparative Syntax*. New York: Oxford University Press.
Deuchar, M. & Quay, S. (2000). *Bilingual acquisition*. Oxford: Oxford University Press.
Epstein, J., & Axtell, R. (1996). *Growing artificial societies*. Cambridge, MA: MIT Press/Brookings Institute.
Epstein, S., Flynn, S. & Martohardjono, G. (1996). Second language acquisition: theoretical and experimental issues in contemporary research. *Behavioral and Brain Sciences*, 19, 677-758.
Fabb, N. (1992). Reduplication and object movement in Ewe and Fon. *Journal of African Languages and Linguistics*, 13, 1-41.
Goldin-Meadow, S. & Mylander, C. (1990). Beyond the input given: the child's role in the acquisition of language. *Language*, 66, 323-355.
Gross, D. (2000). When two become one: creating a composite grammar in creole formation. *International Journal of Bilingualism*, 4(1), 59-80.
Gumperz, J. (1971). *Language in social groups*. Stanford, California: Stanford University Press.
Hamers, J. & Blanc, M. (2000). *Bilinguality and Bilingualism*, 2nd ed. Cambridge: Cambridge University Press.
Holm, J. (2000). *An introduction to pidgins and creoles*. Cambridge: Cambridge University Press.
Hudson, C. & Newport, E. (1999). Creolization: Could Adults Really Have Done It All? In Greenhill, A., Littlefield, H., & Tano, C. (Eds.), *Proceedings of the Boston University Conference on Language Development*, 23(1), 265-276. Somerville, MA: Cascadilla Press.
Jackendoff, R. (1997). *The architecture of the language faculty*. Cambridge, MA: MIT Press.
Jackendoff, R. (2002). *Foundations of language.* Cambridge: Cambridge University Press.
Johnson, J. & Newport, E. (1989). Critical period effects in L2 language learning. *Cognitive Pschology*, 21, 60-99.
Johnson, J. & Newport, E. (1991). Critical period effects on universal properties of language: the status of subjacency in the acquisition of a second language. *Cognition*, 39, 215-258.

Lefebvre, C. (1993a). The role of relexification and syntactic reanalysis in Haitian Creole: methodological aspects of a research program. In Mufwene, S. (Ed.), *Africanisms in Afro-American language varieties* (pp. 254-279). Athens, GA: University of Georgia Press.

Lenneberg, E. (1967). *Biological foundations of language.* New York: Wiley Press.

Long, M. (1990). Maturational constraints on language development. *Studies in Second Language Acquisition* 12(3), 251-285.

Lightfoot, D. (1991). How to set parameters: arguments from language change. Cambridge, MA: MIT Press.

Lightfoot, D. (1998). *The development of language: acquisition, change, and evolution*. Oxford: Blackwell.

Lightfoot, D. (1999). Creoles and cues. In DeGraff, M. (Ed.), *Language creation and language change* (pp.431-452). Cambridge, MA: MIT Press.

Lumsden, J. (1999). Language acquisition and creolization. In DeGraff, M. (Ed.), *Language creation and language change* (pp.129-158). Cambridge, MA: MIT Press.

McWhorter, J. (1998). Identifying the creole prototype: vindicating a typological class. *Language,* 74(4), 788-818.

McWhorter, J. (2000). *The missing Spanish creoles: recovering the birth of plantation contact languages*. Berkeley: University of California Press.

Meisel, J. (1994, 2000). Early differentiation of languages in bilingual children. In Li, W. (Ed.), *The Bilingualism Reader*. London: Routledge.

Migge, B. (1998). Substrate influence on creole formation: the origin of *give*-type serial verb constructions in the Surinamese Plantation Creole. *Journal of Pidgin and Creole Language*, 13(2), 215-266.

Migge, B. (2000). The origin of the syntax and semantics of property items in Surinamese plantation creole. In McWhorter, J. (Ed.), *Language change and language contact in pidgins and creoles* (pp.201-234). Amsterdam: John Benjamins.

Mufwene, S. (1996). The founder principle in creole genesis. *Diachronica*, 13, 83-134.

Mufwene, S. (1999). On the language bioprogram hypothesis: hints from Tazie. In DeGraff, M. (Ed.), (pp.95-127). Cambridge, MA: MIT Press.

Muysken, P. & Smith, N. (1995). The study of pidgin and creole languages. In Arends, J., Muysken, P., & Smith N. (Eds.). *Pidgins and creoles: an introduction* (pp. 3-14). Amsterdam: John Benjamins.

O'Grady, W. (1997). *Syntactic development.* Chicago: University of Chicago Press.

Roberts, I. (1999). Verb movement and Markedness. In DeGraff, M. (Ed.), *Language creation and language change* (pp.287-328). Cambridge, MA: MIT Press.

Roberts, S. (2000). Nativization and the genesis of Hawaiian Creole. In. McWhorter, J. (Ed.), *Language change and language contact in pidgins and creoles* (pp.257-300). Amsterdam: John Benjamins.

Satterfield, T. (2001). Toward a sociogenetic solution: examining language formation processes through SWARM modeling. *Social Science Computer Review*, 19(3), 281-295.

Satterfield, T. & Peréz-Bazán, M. (in preparation). Re-thinking the dynamic emergence of systems in early bilingual development.

Schachter, J. (1996). Maturation and the issue of universal grammar in L2 acquisition. In Ritchie, W. & Bhatia, T. (Eds.), *Handbook of second language acquisition* (pp. 159-193). San Diego: Academic Press.

Seigel, J. (1987). *Language contact in a plantation environment*. Cambridge: Cambridge University Press.

Singler, J. (1996). Theories of creole genesis, sociohistorical considerations, and the evaluation of evidence: the case of Haitian Creole and the Relexification Hypothesis. *Journal of Pidgins and Creole Languages,* 11, 185-230.

Sprouse, R. & Vance, B. (1999). Explanations for the decline of null pronouns in certain Germanic and Romance languages. In DeGraff, M. (Ed*.), Language creation and language change* (pp. 257-284). Cambridge, MA: MIT Press.

Steels, L. (1997). The synthetic modeling of language origins. *Evolution of Communication Journal 1*. Amsterdam: John Benjamins.

Strozer, J. (1994). *Language Acquisition after Puberty.* Washington, D.C.: Georgetown University Press.

Thomason, S., & Kaufman, T. (1988). *Language contact, creolization, and genetic linguistics*. Berkeley, California: University of California.

Thomason, S. (1997). A typology of contact languages. In Spears, A. and Winford, D. (Eds.), *The structure and status of pidgins and creoles* (pp. 71-88). Amsterdam: John Benjamins.

Thomason, S. (2001). *Language Contact: an introduction*. Washington, D.C.: Georgetown University Press.

Valdman, A. (2000). Creole, the language of slavery. In Kadish, D. (Ed.), *Slavery in the Caribbean francophone world* (pp. 143-163). Athens, GA: University of Georgia Press.

Van den Berg, M. (2000). *"Mi no sal tron tongo:" Early Sranan in Court Records 1667-1767*. Masters Thesis, University of Nijmegen.

Weber-Fox, C. & Neville, H. (1996). Maturational constraints on functional specializations for language processing: ERP and behavioral evidence in bilingual speakers. *Journal of Cognitive Neuroscience*, 8, 231-256,
Wexler, K. (1998). Very early parameter setting and the unique checking constraint: A new explanation of the optional infinitive stage. *Lingua*, 106, 23-79.
Wexler, K. (1999). Maturation and growth of grammar. In Ritchie, W. & Bhatia, T. (Eds.) *Handbook of child language acquisition* (pp. 55-102). New York: Academic Press.
White, L. (1989). *Universal Grammar and Second Language Acquisition*. Amsterdam: John Benjamins.
Winford, D. (2000). Tense and Aspect in Sranan and the Creole Prototype. In McWhorter, J. (Ed.), *Language change and language contact in pidgins and creoles* (pp.383-442). Amsterdam: John Benjamins.

ISB4: Proceedings of the 4th International Symposium on Bilingualism

edited by James Cohen, Kara T. McAlister, Kellie Rolstad, and Jeff MacSwan

Cascadilla Press Somerville, MA 2005

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ISBN 978-1-57473-210-8 CD-ROM
ISBN 978-1-57473-107-1 library binding (5-volume set)

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